Virtual Imaging System

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ABSTRACT

The main purpose of this research project was to implement a combination of computer graphics and processing to generate displays that will aid in the visualization of the colour rendering properties of a range of light sources, including the new generation of high-output LEDs (light emitting diodes) that are becoming widely adopted in general lighting service. The CIE (International Commission on Illumination) has developed a colour appearance model CIECAM02 for use in colour imaging and colour management, and this model is utilized in this work.

This thesis describes the design and construction of a computer-based model that can be used as a research tool for the simulation and demonstration of the colour rendering properties of various artificial light sources. It is a comprehensive study of the colour models and measurement procedures currently in use in the lighting industry, as recommended by the CIE. This research project focused on the display of a set of surface colour patches as if they were illuminated by a specific light source, and the simultaneous display of two such sets to demonstrate the surface colour differences arising from the use of the two different light sources.

A VIS (virtual imaging system) has been developed to display the colour properties of a series of test colour samples under different light sources. This thesis describes the computer models developed for the representation and display of surface colours in general, and colour rendering in particular. The designed system computes and displays the colour of each sample from a knowledge of the light-source spectrum and the spectral reflectance of each surface. It can simultaneously display the colours resulting from illumination by two different sources. In addition, the system computes the colour appearance differences for two sets of colours using the CIECAM02 colour appearance model. Subjective and objective tests were taken to validate the computed results.

The VIS has been designed and implemented. It also has been tested by 21 observers and we believe that it will be a powerful research tool for the lighting industry, especially in relation to colour rendering.

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STATEMENT OF ORIGINALITY

‘I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the qualification of any other degree or diploma of a university or other institution of higher learning, except where due acknowledgment is made in the acknowledgments.’

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GLOSSARY

Colour Rendering It is the effect of an illuminant on the colour appearance of objects by conscious or subconscious comparison with their colour appearance under a reference illuminant.

Colour Rendering Index It is a specification of the colour rendering property of a light source. The CRI is calculated by comparing the colorimetric values for a given set of test colours illuminated by the test light source against the values for the same test colours illuminated by a reference illuminant with a colour temperature close to that of the test light source.

Colour Temperature It is a characteristic of visible light that has important applications in lighting, photography, videography, publishing, and other fields. The colour temperature of a light source is determined by comparing its chromaticity with that of an ideal black-body radiator.

Colorimetry In its strict sense is a tool used for making a prediction on whether two lights (visual stimuli) of different spectral power distribution will match in colour for certain given conditions of observation. The prediction is made by determining the tristimulus values of two visual stimuli. If the tristimulus values of a stimulus are identical to those of the other stimulus, a colour match will be observed by an average observer with normal colour version.

Colorimeter It is a device used for colorimetry. It measures the absorbance of different wavelengths of light in a solution.

Spectral Power Distribution Describes the power per unit area per unit wavelength of any radiometric or photometric quantity.

Colour Adaptation Changes in visual perception of colour with prolonged stimulation or adjustment of vision to degree of brightness or colour tone of illumination.

ABBREVIATIONS

CR	Colour Rendering
Ra	General Colour Rendering Index
Ri	Special Colour Rendering Index
Tc	Colour Temperature
SPD	Spectral Power Distribution
CIE	International Commission on Illumination.
LED	Light-emitting diode
ISO	International Organization for Standardization
VIS	Virtual Imaging System
CMS	Colour Manage System
CMCDS	Colour-Managed Computer Display System
RGB	Red, Green and Blue

1 INTRODUCTION

1.1 Background

During the past 30 years, the method of calculating the colour rendering index (CRI) has slowly developed. The currently recommended CRI calculation method was originally introduced in 1974, and it is described, with a few minor revisions, in the current publication CIE 13.3-1995[1] (The CIE is the International Commission on Illumination which is the main standardizing body in the field of lighting and related areas- and the acronym CIE comes from the French version of its name).

The potential use of LED (Light Emitting Diode) light sources as the predominant lighting in future clinical situations [2] means that there is a need to be able to assess their colour rendering properties. This is particularly critical in situations where clinicians will be making a visual judgment of a patients' conditions based on the appearance of their complexion. LEDs appear to offer economic and engineering advantages over existing light sources in terms of length of life and efficiency. However, because their spectral properties often differ significantly from those of existing sources, it follows that their colour rendering can also be difficult to predict [3].

White LED light sources are efficient, long-life, and compact. The luminous flux and the luminous efficacy of commercially available LED light sources are improving rapidly. High CIE colour rendering indices could be achieved by varying the types of LEDs used in the LED light sources. The conclusion of the relevant technical report of the CIE is that the CIE CRI is generally not able to give an accurate prediction of the colour rendering of white LED light sources. For all white-light LED applications, an up-to-date mathematical model for calculating colour rendering index, correlating well with visual experience is needed [3, 4].

For white LEDs to be used in general lighting, they should have an appropriate white colour and good colour rendering performance for illuminated objects. CR (Colour rendering) and energy efficiency are the two most important criteria for traditional light sources in general lighting [4]. CR is defined in the Glossary on page [5].

Davis *et* [6, 7] all used a multispectral camera to estimate the spectral reflectance of natural scenes pixel by pixel; and then the tristimulus values of the scene under a certain illuminant were reproduced on a calibrated CRT monitor. This technique was applied to visually evaluate the colour rendering properties of white LED light sources including nine RGB (Red, Green and Blue) LED clusters and one blue LED with a yellow phosphor. The semantic differential method was applied to evaluate the visual impression of five natural scenes under these illuminants. The authors concluded that a new colour rendering index was needed to fully describe the visual impression related to the colour rendering phenomenon. The present project is intended to replicate and extend this work – but using a modified technique that is based on independent spectral measurements to supplement the normal 3-band digital colour system instead of the (far more expensive) multi-spectral imaging.

This research project focuses on implementing a combination of computer graphics and processing to generate displays that will aid in the visualization of the colour rendering properties of a range of light sources. These sources will include the new generation of high-output LEDs that are becoming widely adopted in the general lighting service. The CIE has developed a colour appearance model CIECAM02 [8] for use in colour imaging and colour management, and it was intended to utilize this model in this work.

1.2 Objectives

A major objective of the work was to enable the user to study the colour rendering effects [9] of various light sources, by both computation and display of the colour differences between corresponding pairs of surface colours as they appear when illuminated by two different sources. This has necessitated a comprehensive study of the colour models and measurement procedures currently in use by the lighting industry, as recommended by the CIE – and these are briefly reviewed below.

The main objectives of this research are listed below:

1. To calibrate a suitable computer monitor to display colour images of repeatable quality.

2. To design a computer display model to display the colour rendering performance of different light sources.
3. To allow the user to select representative test light sources.
4. To allow the user to select appropriate test colour samples.
5. To allow the user to analyse the spectral reflectance of colour samples.
6. To allow the user to set up the monitor (by selecting gamma r and offset k1 values)
7. To allow the user simultaneously to view and compare the colour samples under two different light sources.
8. To allow the user to calculate RGB values of each displayed colour sample under the selected light source.
9. To allow the user to view the Ra (special colour rendering index) and Tc (colour temperature) of each selected light source.
10. To allow the user to plot and display the SPD of each selected light source.
11. To allow the user to view the spectral reflectance of each displayed colour sample.
12. To display the predicted colours as accurately as possible.
13. To compute colour differences between colour samples under two different (selected) sources, using the CIECAM02 colour appearance space [8].
14. To verify testing the results of step 13 by groups of observers.

1.3 Structure of the Thesis

Figure 1.1 displays the main structure of this thesis. The organization of the rest of the thesis is as follows: chapter two details all the theory of the technology. The VIS (virtual imaging system) are designed and explained in chapter three. The fourth chapter gives subjective and objective test methods of the VIS, and fifth chapter details test results of the designed VIS with the explanations. The research outcomes and conclusions of the thesis are located in chapter six, recommendations for future work are also given in this chapter.

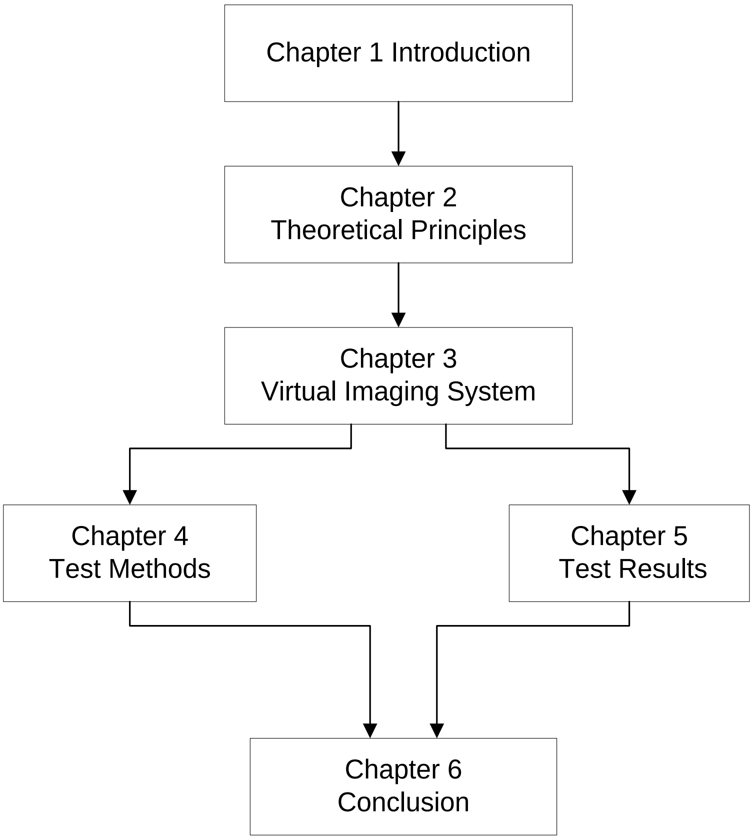


Figure 1.1-Thesis Structure

2 THEORETICAL PRINCIPLES

2.1 Introduction

This chapter introduces background information and theory relevant to this research project. All the required information and technologies which lead to the final research product will be described in this chapter. Parts of this literature review will refer to appendices for more details.

This chapter covers four main topics as follows: colorimetry, colour rendering and CRI, colour appearance model and colour temperature.

2.2 Colorimetry

Colorimetry is the measurement of colour, it is can be used as a tool to check whether two lights of different SPD will match in colour for certain given conditions of observation [11]. The first consistent system was recommended by CIE in 1931, while allows specification of colour matches for an average observer. This system is now certified by ISO (International Organization for Standardization) as an international standard. The precise definition of colorimetry is found in CIE Publication 15.2 [12]. This section describes the well-established techniques of basic colorimetry that form the foundation for colour appearance modelling.

2.2.1 Light Source and Illuminants

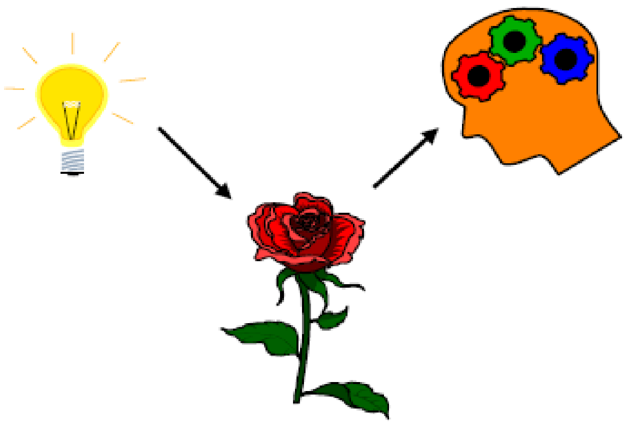


Figure 2.1-The fundamental components that lead to the perception of colour: a light source, a selectively reflecting surface (of an object) and a three-channel detector

The first component of the appearance of colour in Figure 2.1 is the light source. The electromagnetic energy, which is required to initiate visual responses, is providing by light sources. A light source is an actual physical emitter of visible energy, such as incandescent light bulb. An illuminant is simply a standardized table of values that represent a spectral power distribution typical of a particular light source .

2.2.1.1 CIE Standard Illuminantion

The CIE has recommended certain illuminants to be used for general colorimetry. These are defined by relative spectral power distributions; their details are given in Appendix 1. Figure 2.2 illustrates the SPDs of the CIE standard illuminants [13].

CIE standard illuminant A: This is a standardized representation of a typical incandescent source, it is a particular type of tungsten source that produces the relative spectral power distribution of the CIE illuminant A [13].

CIE standard illuminant D65: This is a standardized representation of a typical incandescent source, it is a particular type of daylight source. CIED65 is a statistical representation of an average daylight with a correlated colour temperature of approximately 6500 K [13].

Other illuminants D: CIE recommended that D65 be used whenever possible in the interest of standardization. When D65 cannot be used, CIE recommended the use of one of the daylight illuminants D50, D55, or D75. When none of these daylight illuminants can be used, a daylight illuminant at a nominal correlated colour temperature (CCT) can be calculated using the CIE published equations in CIE15_3, 1993 [11]. Illuminant D50 represents an average daylight with a CCT of 5003 K, D55 represents an average daylight with a CCT of 5503 K and D75 represents an average daylight with a CCT of 7507 K.

Illuminant B: Originally intended to represent direct sunlight with a correlated colour temperature of approximately 4900 K [13].

llluminant C: This is intended to represent average daylight with a correlated colour temperature of approximately 6800 K [13].

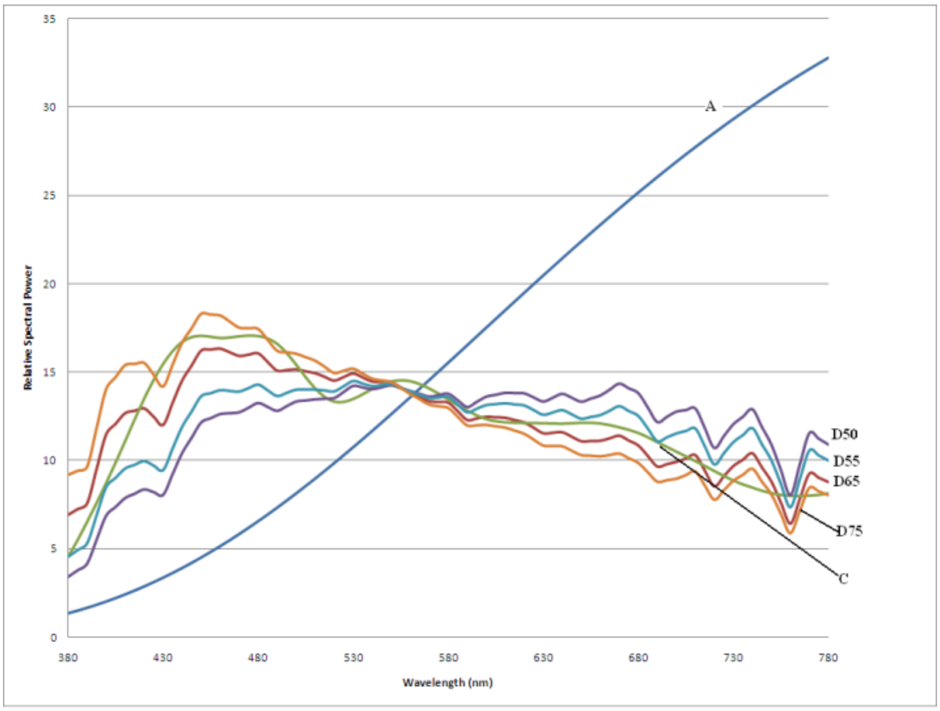


Figure 2.2-Spectral power distributions of CIE standard illuminants

2.2.1.2 LED light sources

A LED is a type of semiconductor diode. The LED effect is a form of electroluminescence where incoherent and narrow spectrum light is emitted from the p-n junction. It is usually a small area (less than 1 mm^2) light source, often with optics added to the package to shape its radiation pattern and improve efficiency. LEDs are widely used as indicator lights on electronic devices and increasingly in higher power applications such as flashlights and area lighting [14].

2.2.1.2.1 Development of LEDs

The LED was first created in the middle of 1920s by Russian Oleg Vladimirovich Losev. The first practical visible-spectrum (red) LED was developed in the 1960's. Other types of monochromatic LEDs, which include yellow-green, yellow, green and amber light LEDs, have been successively developed and marketed since this the first discovery. Meanwhile, their intensity radiant has been increasing gradually, and LEDs have become widely used in various application fields, such as display sources, indicator lamps, traffic signs, automobile lighting, and special fields of illumination [14, 15].

The first blue LED was developed in 1993 and the market for LEDs has rapidly become larger. A newly developed high efficiency phosphor is a combination of a blue LED and a white LED was developed and put into the market in 1996. Nowadays, these kinds of white LEDs are being investigated as application for general lighting fields. White light LEDs are expected to be used as the major light sources in the 21st Century. Table 2.1 displays the brief history of LED development [15].

Table 2.1-Brief History of commercial LED Development

Year	Development of LEDs
1967	1st LED (red light, GaAs+LaF3YbEr)
1975	Yellow light LED
1978	High brightness red light LED
1993	Blue light LED
1997	White light LED (blue LED + phosphor)
2001	White light LED (UV LED + phosphor)

White LEDs to be used for general lighting should have appropriate white colour and good colour rendering performance for illuminated objects. Colour rendering and energy efficiency have been the two most important criteria for traditional light sources in general lighting [3, 4].

2.2.1.2.2 Application areas of LEDs

LEDs were commonly used to replace incandescent indicators and seven-segment displays in the early days, first in expensive equipment such as laboratory and electronics test equipment, then later in such appliances as TVs, radios, telephones, calculators, and even watches. These red LEDs were bright enough only for use as indicators, as the light output was not enough to illuminate an area. Later, other colours became widely available and also appeared in appliances and equipment. The light output has been increased as the LED materials technology became more advanced, while maintaining the efficiency and the reliability at an acceptable level. These advantages lead that LEDs are becoming bright enough to be used for illumination in various applications such as lamps and other lighting fixtures, as well as in clinical situations.

The potential use of LED light sources as the predominant lighting in future clinical situations means that there is a need to be able to assess their colour rendering properties. This is particularly critical in situations where clinicians will be making visual judgment of patients’ conditions based on the appearance of their complexion. LEDs appear to offer economic and engineering advantages over existing light sources in terms of length of life and efficiency. However, because their spectral properties often differ significantly from those of existing sources, it follows that their colour rendering can also be difficult to predict [2].

2.2.2 Spectral power distribution (SPDs) of Illuminants Measurement

The SPD shows the brightness of an object at each wavelength of light. The wavelengths most commonly used are in the range from 380 nm to 780 nm, the range that the human eye can respond to [16].

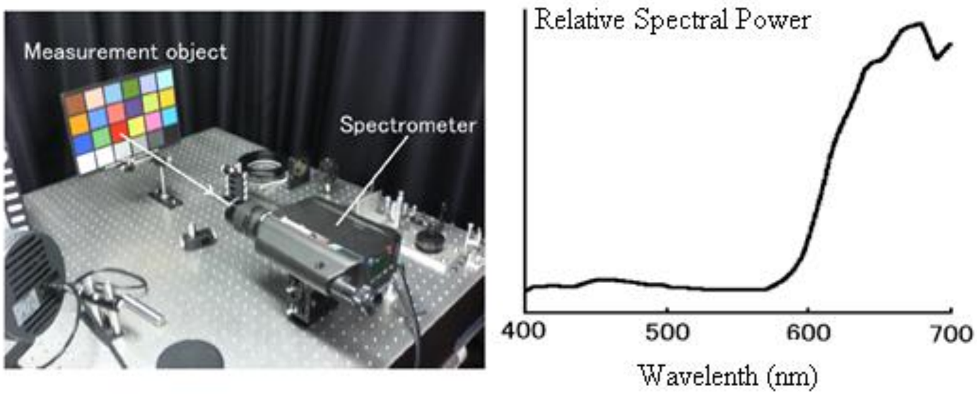


Figure 2.3-Left: The spectrometer and measurement object. Right: Acquired signal spectral of a red object under sunlight [16]

A typical SPD is shown on the right Figure 2.3. In order to understand the effect that a light source has on the colour of an illuminated surface, it is necessary to note that most ordinary surfaces in ones surroundings emit light by virtue of reflection.

The reflected spectrum is essentially the source spectrum as modified by the absorption and reflection properties of the surface. The process is modelled in Equation (2.1), and illustrated in Figure 2.4.

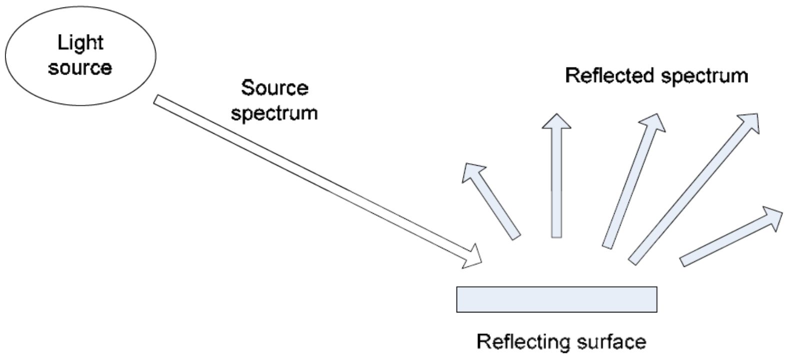


Figure 2.4-Schematic representation of reflection

$$\Phi_{r\lambda} = \Phi_{e\lambda}\rho_{\lambda} \qquad (2.1)$$

Where $\Phi_{r\lambda}$ = SPD of reflected light

$\Phi_{e\lambda}$ = SPD of emitter (light source)

ρ_{λ} = spectral reflectance of surface

(SPD = spectral power distribution)

In most normal viewing conditions, this reflected spectrum will evoke a colour response in the observer [16] that is governed not only by the reflectance of the surface of interest (as represented here) but also by the reflectances of all the surfaces in the field of view, especially surfaces that the viewer judges (either consciously or subconsciously) to be neutral in colour.

2.2.3 Colour Matching Functions (CMFs)

These colour-matching functions are given in the standard as values from 360 nm to 830 nm at 1 nm intervals with seven significant figures, and they define the CIE 1931 standard colorimetric observer [17]. The CIE also recommended 1931 and 1964 CMFs (colour matching functions) as the standard observers which are 2 degrees and 10 degrees [19, 20]. The CMFs illustrated in Figure 2.5 indicate the amount of the primaries required to match unit amount of power at each wavelength. This project decided to use the CIE 1931 (2 degrees) CMFs to complete the final design.

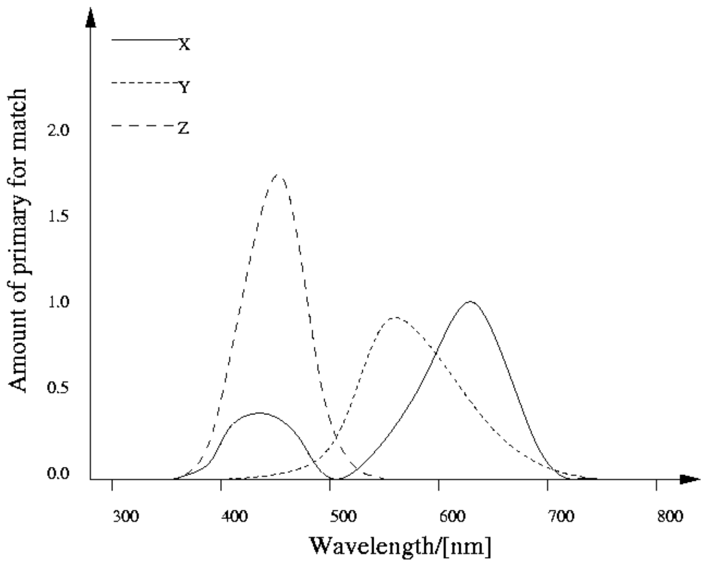


Figure 2.5-The CIE colour-matching functions for the 1931 Standard Colorimetric Observer

$$X = k\int R(\lambda)S(\lambda)\overline{x}(\lambda)d\lambda$$
$$Y = k\int R(\lambda)S(\lambda)\overline{y}(\lambda)d\lambda \qquad (2.2)$$
$$Z = k\int R(\lambda)S(\lambda)\overline{z}(\lambda)d\lambda$$

Where $k = 100 / \int S(\lambda)\overline{y}(\lambda)d\lambda$

$S(\lambda)$ = SPD of selected light source

$R(\lambda)$ = wavelength interval (usually 5 nm)

The tristimulus values X, Y, Z are in turn computed from knowledge of the light source spectrum and the reflectance spectrum of the surface colour sample, as set out in Equation (2.2) [20].

2.2.4 Chromaticity Diagrams

Chromaticity diagrams provide a convenient two dimensional representation of colours. A triplet of tristimulus values can be used to specify the colour of a stimulus. Brightness and chromaticity are the two main parts of a colour specification. In this case, the colour white is a bright colour, while the colour grey is considered to be a less bright version of that same chromaticity [21].

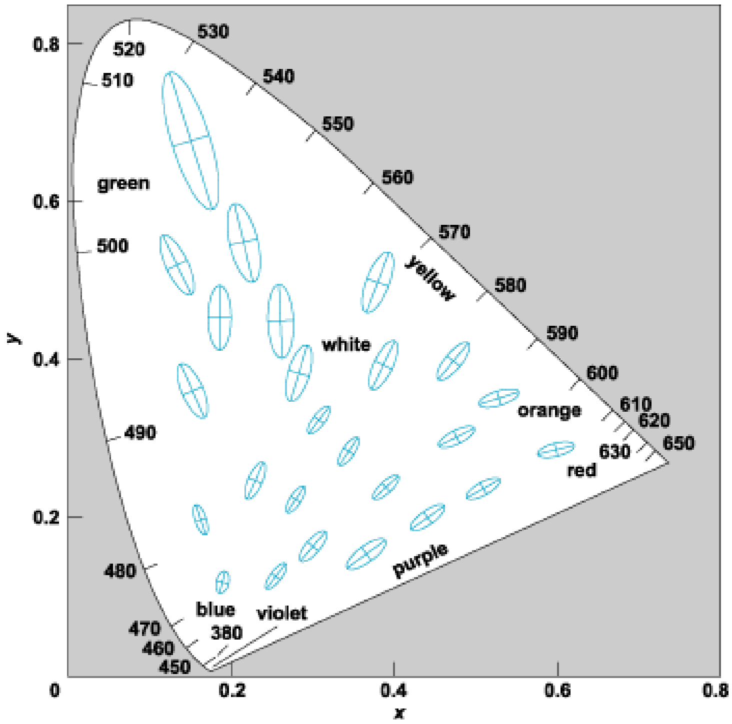


Figure 2.6-CIE 1931 Colour Space Chromaticity Diagram [22]

Figure 2.6 displays the CIE 1931 colour space chromaticity diagram. Chromaticity coordinates *(x, y)* can be calculated by using Equations (2.3) and (2.4). The trisitimulus value of *Y* approximately correlates with the brightness or lightness has been configured by CIE. The third chromaticity coordinate can always be obtained from the other two since the three always sum to unity. Therefore *z* can be calculated from *x* and *y* by use of Equation (2.6) [21].

$$x = \frac{X}{X + Y + Z} \tag{2.3}$$

$$y = \frac{Y}{X + Y + Z} \tag{2.4}$$

$$z = \frac{Z}{X + Y + Z} \tag{2.5}$$

$$z = 1 - x - y \tag{2.6}$$

Usually the *Y* tristimulus value is reported, since it contains the luminance information. The *Y* tristimulus value is very useful for calculating the other two tristimulus values from chromaticity coordinates. They are given in Equations (2.7) and (2.8).

$$X = \frac{xY}{y} \tag{2.7}$$

$$Z = \frac{(1.0 - x - y)Y}{y} \tag{2.8}$$

2.2.5 CIE Colour Spaces

Colour spaces are developed to provide uniform practices for the measurement of colour difference, something that cannot be done reliably in tristimulus or chromaticity spaces. In 1976, CIE recommended two colour spaces (CIELAB and CIELUV) as interim solutions to the problem of colour-difference specification. CIELAB has become almost universally used for colour specification and particularly colour-difference measurement since 1976. CIELAB is be used in this research project [11].

The CIELAB colour space can be calculated by Equations (2.9) through (2.13) for tristumulus values normalized to the white that are greater than 0.008856. *X, Y, Z* are the tristimulus values of the stimulus; Xn, Yn and Zn are the tristimulus values of the reference white; $L*$ represent lightness; $a*$ indicates redness to greenness; $b*$ indicates yellowness to blueness; C^*_{ab} means chroma; and h_{ab} means hue. These are displaying in Figure 2.7 Normally the range of $L*$ is from 0 to 100 which indicates darkness to brightness [11, 22].

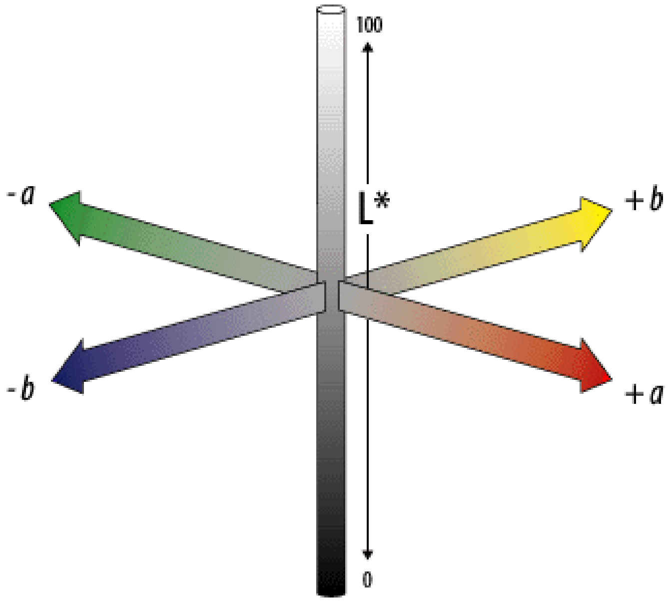


Figure 2.7-3D representation of the CIELAB L, a* and b*coordinates [23]

$$L* = 116(\frac{Y}{Yn})^{1/3} - 16 \tag{2.9}$$

$$a* = 500[(\frac{X}{Xn})^{1/3} - (\frac{Y}{Yn})^{1/3}] \tag{2.10}$$

$$b* = 200[(\frac{Y}{Yn})^{1/3} - (\frac{Z}{Zn})^{1/3}] \tag{2.11}$$

$$C^*_{ab} = \sqrt{(a*^2 + b*^2)} \qquad (2.12)$$

$$h_{ab} = \tan^{-1}(\frac{b*}{a*}) \qquad (2.13)$$

The CIELUV colour space can be calculated by use of Equations (2.14) through (2.18) for tristumulus values normalized to the white that are greater than 0.008856.

$$L* = 116(\frac{Y}{Yn})^{1/3} - 16 \qquad (2.14)$$

$$u* = 13L*(u' - u'_n) \qquad (2.15)$$

$$v* = 13L*(v' - v'_n) \qquad (2.16)$$

$$C^*_{ab} = \sqrt{(u*^2 + v*^2)} \qquad (2.17)$$

$$h_{uv} = \tan^{-1}(\frac{v*}{u*}) \qquad (2.18)$$

In these equations u' and v' are the chromaticity coordinates of the stimulus; u'_n and v'_n are the chromaticity coordinates of the white reference; $L*$ represents lightness; u^* indicates redness to greenness; v^* indicates yellowness to blueness; C^*_{ab} represents chroma; and h_{uv} means hue [11].

2.2.6 Colour-difference Specification

The colour difference ΔE^*_{ab} in CIELAB space is the distance between the coordinates for the two stimuli. This can be calculated by use of Equation (2.19). At the same time, it can also be expressed in terms of lightness, chroma and hue differences as illustrated in Equation (2.20) by use of the combination of Equations (2.19) and (2.21) [11].

$$\Delta E^*_{ab} = [\Delta L*^2 + \Delta a*^2 + \Delta b*^2]^{1/2} \qquad (2.19)$$

$$\Delta E^*_{ab} = [\Delta L*^2 + \Delta C^{*\,2}_{ab} + \Delta H^{*\,2}_{ab}]^{1/2} \qquad (2.20)$$

$$\Delta H^*_{ab} = [\Delta E^{*\,2}_{ab} - \Delta L^{*2} - \Delta C^{*\,2}_{ab}]^{1/2} \qquad (2.21)$$

2.3 Colour Rendering (CR) and Colour Rendering Index (CRI)

CR is defined as the “Effect of an illuminant on the colour appearance of objects by conscious or subconscious comparison with their colour appearance under a reference illuminant” [5].

As mentioned in chapter 1, the currently recommended colour rendering index (CRI) calculation method was originally introduced in 1974, and it is described, with a few minor revisions, in the current publication CIE 13.3-1995 [1]. The CIE first standarized a spectral band method for CR in 1948 but, in 1961, it was decided to regard the "test sample colour shift" method [3] as the fundamental method for CR appraisal. The CRI is measured by comparing the colour rendering of the test source to reference source under the same colour temperatures. Following the CIE, colour rendering is given as an index between 0 and 100, while the value can not exceed 100, it can be less than zero. Where 0 approximates "very poor" colour rendering and 100 approximates "very good" colour rendering [5, 24].

In an attempt to provide a basis for ranking light sources in terms of their colour rendering capabilities, the CIE has produced [CIE CRI doc] a "general" CRI *Ra*, and a set of "special" colour rendering indices, *Rn* (*n* = 1 … 14) for a specified set of test colours. These values can be obtained from Equation (2.22) and (2.23), where ΔEi is the colour difference on the 1964 U*V* W* uniform colour space [25].

$$Ri = 100 - 4.6\Delta Ei \qquad (2.22)$$

$$Ra = \frac{1}{8}\sum_{i=1}^{8} Ri \qquad (2.23)$$

Figure 2.8 illustrates the basis for this method of specification. It was first designed during the 1960s, at a time when fluorescent tubes were rapidly becoming the dominant light source internationally, and consumers were being presented with choices between high-efficiency low-CRI lamp types and low-efficiency high-CRI types. The CRI is a simple figure of merit, generally between 50 and 100 for fluorescent lamps, and it was intended to provide consumer guidance in the choice of the "right tube for the job". The basic structure of the CRI model has remained largely unchanged since its inception, with only relatively minor changes to the details of the calculation methods in the subsequent revisions.

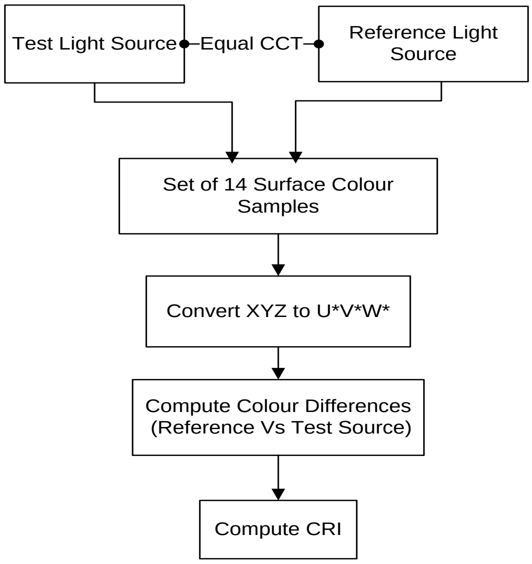


Figure 2.8-Block diagram to illustrate the CRI calculation process

Figure 2.9 displays the colour appearance under different light sources (left) and test swatches under different light (right). It can be seen that the same colour samples are look different under two different light cabinets, to achieve this performance normally need two light cabinets would be needed. A light booth that contains 4 kinds of light sources is expensive (around US$1490) and it is hard for the owner to add new light sources. The driving force for the development of this system is the wide range of new high-output LED sources now entering the market-place and being utilized in applications as diverse as operating-theatre lights and marine navigation beacons. In certain applications, colour rendering is critically important. Reported attempts to classify the colour rendering performance of LEDs using the existing CIE specifications and recommendations [26] have proved to be unsatisfactory and misleading. This has led the CIE to promote new research into colour rendering with the aim of establishing revised recommendations in the appropriate areas.

One objective of the final designed computer model in this research project is implementing the same performance as a lighting cabinet does, but at a cheaper price and with the ability for users to add new light sources.

Figure 2.9-Comparing the colour appearance under different light sources (left); Test swatches under different light (right) [26]

Table 2.2 and Table 2.3 show the group of the CIE colour rendering and colour rendering index for different application and for different light sources.

Table 2.2-CIE CR groups [26]

The CIE colour rendering groups			
Group	**R_a**	**Importance**	**Typical application**
1A	90...100	accurate colour matching	Galleries, medical examinations, colour mixing
1B	80...90	accurate colour judgement	Home, hotels, offices, schools
2	60...80	moderate colour rendering	Industry, offices, schools
3	40...60	accurate colour rendering is of little importance	Industry, sports halls
4	20...40	accurate colour rendering is of no importance	Traffic lighting

Table 2.3-CRI for different light sources [26]

Colour rendering index for different light sources	
Light source	**Colour rendering group**
Incandescent	1A
Metal halide	1A ... 2
Fluorescent	1A ... 3
High pressure sodium	1B ... 4
Low pressure sodium	4

2.4 Colour Appearance Model

2.4.1 Introduction

A colour appearance model includes the relative colour appearance at tributes of lightness, chroma, and hue. Reasonable predictors of these attributes of a model must include at least some form of a chromatic- adaptation transform. Models must be more complex to include predictors of brightness and colorfulness or to model luminance dependent effects such as the Stevens effect or the Hunt effect [11]. The CIE has developed a colour appearance model CIECAM02 for use in colour imaging and colour management, and it is intended to utilize this model in this work [8].

2.4.2 CAM02

One purpose of this project was to be able to investigate the correlation between the computed colour differences and the subjectively-judged colour differences as seen by a set of observers viewing the calibrated monitors. For this reason, the colour differences have been computed in CIECAM02 colour appearance space in an effort to enhance the correlation [8].

This space is based on the CIECAM02 colour appearance model [10], the origins and applications of which are explained in the relevant CIE publication 2003. A CIECAM02 colour appearance difference can be computed by use of Equation (2.24).

$$\Delta E_C = \sqrt{(\Delta J)^2 + (\Delta a_c)^2 + (\Delta b_c)^2} \qquad (2.24)$$

Where $a_c = C \times \cos(h)$,

$b_c = C \times \sin(h)$,

and [J, C, h] are the lightness, chroma and hue attributes, respectively, in the CIECAM02 model.

The appearance attributes [J, a_C, b_C] can be calculated from the CIE-1931 tristimulus values [X, Y, Z] by the use of a somewhat complex series of non-linear transformations described in the CIE specification. A number of parameters are used to model the viewing conditions experienced by the observers, as outlined below. These in turn are used to define the exact form of the non-linear relationships in the model. The procedure is outlined schematically in Figure 2.10 [27, 28, 29].

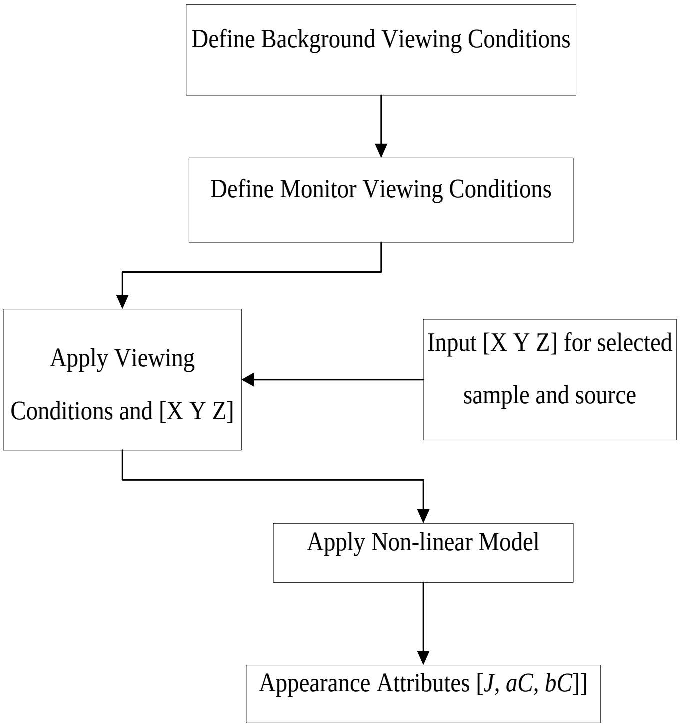


Figure 2.10-Colour display appearance model

2.5 Correlated Colour Temperature (CCT)

One important application of visible light in lighting, photography and videography is colour temperature. The colour temperature of a light source is measured and expressed by the resultant chromaticity coordinates (x, y). The colour of "white light" can be expressed by CCT (correlated colour temperature) in Kelvin (K) units. The CCT is measured as the heated black body radiator matches the colour of the light source's colour temperature and it is related to Planck's law for a black body source. Figure 2.11 shows that the lower colour temperatures (2700-3600 K), which look yellow-red, are considered as warm while high colour temperatures (3600-5500 K) are considered cool. Warm light is recommended for most general indoor uses while cool light is considered better for visual tasks [7, 26, 30, 31].

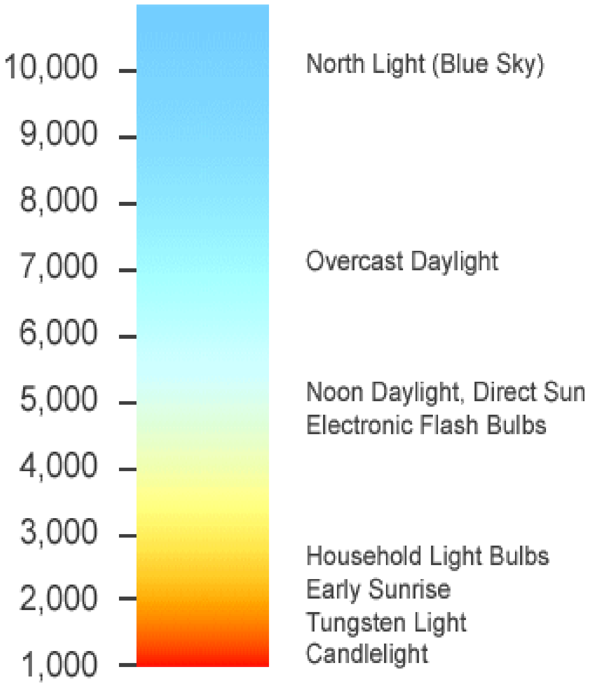


Figure 2.11-Colour temperatures in Kelvin scale [31]

3 VIRTUAL IMAGING SYSTEM

3.1 Introduction

This research project aimed to design a VIS (virtual imaging system), which uses a combination of computer graphics and image processing to generate displays that will aid in the visualization of the colour rendering properties of a range of light sources including the new generation of high output LEDs. This chapter details the design process of the VIS, and includes the selection of software, equipment section, design method and processes, data collection and final design model, as well as the testing of the final model.

3.2 Software Selection

Microsoft Paint, MATLAB GUI and BLENDER were initially considered for use as the research software. Table 3.1 compares Microsoft Paint, Blender and MATLAB GUI in ten difference areas. Because MATLAB contains colour imaging tool box and it can display better colour images than Microsoft Paint and Blender, it decided to use MATLAB to complete the system.

Table 3.1 - Comparison of Microsoft Paint, Blender and MATLAB GUI

	Paint	**Blender**	**MATLAB**
RGB Value	0-255	0-1.000	0-255
2D displaying	Yes	Yes	Yes
3D displaying	No	Yes	Yes
Material Choose Able	No	Yes	No
ImageSave Format	Bitmap,JPG,GIF..	Bitmap,JPG,GIF…>18	No
Control Colour	Edit colours button	F5 material and colour button	Property inspector
Colour imaging tool box	No	No	Yes
Background Colour	Can change	Can change	Can change
Implantation	No	F12, Rendering	GUI, Run
Image Displaying	Good	Good	Better

3.3 Equipment

The required equipment for the implementation of this system is listed below:

1. Desktop computer system support for:
   - ➢ MATLAB and Image processing toolbox (2006b or later version)
   - ➢ Microsoft Office

- Irfanview image viewer tool

2. Internet access, printing and photocopy facilities.
3. Ocean Optics® HR2000™ Fibre-optic Spectrometer
4. Philips model 170 B_4 CRT monitor

3.4 Research Method

The candidate was given access to a general-purpose colorimeter based on the commercially-available HR 2000 fibre-optic spectrometer. This permitted the measurement of the spectral reflectance properties of the selected surface colour samples. The fibre-optic spectrometer was also used to obtain SPD measurements of selected test sources.

The following steps were completed in this research:

1. Design of a computer display model to display the colour rendering performance of different light sources.
2. Selection of representative test light sources.
3. SPD measurement for selected light sources or use of standard SPD tables.
4. Selection of representative test colour samples.
5. Spectral reflectance measurement of selected colour samples, or use of standard reflectance tables.
6. Use of existing models of colour appearance to predict the colour appearance of samples under the different light sources.
7. Display of the predicted colours as accurately as possible.
8. Use of the computer monitor model to display the predicted colours as accurately as possible.
9. Use of the displayed colours for visual assessment of the colour rendering performance of different sources.
10. Subjective assessment of the displayed colours by group of observers.

3.5 The Computer Interface Design Process

After research and study of Matlab imaging processing [31, 32], the first designed VIS is displayed in Figure 3.1, it contains monitor set-up, Main GUI (colour-managed computer system) and Plot SPDs screens. Figure 3.2 illustrates the final designed VIS interface that includes Main GUI, Plot SPDs, and Plot Reflectance, as well as Manual screens. The development of VIS is explained in this section.

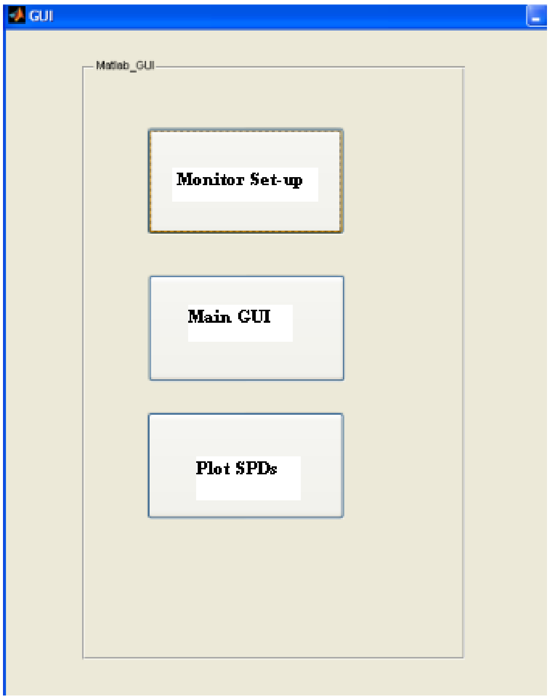


Figure 3.1-The first version of VIS

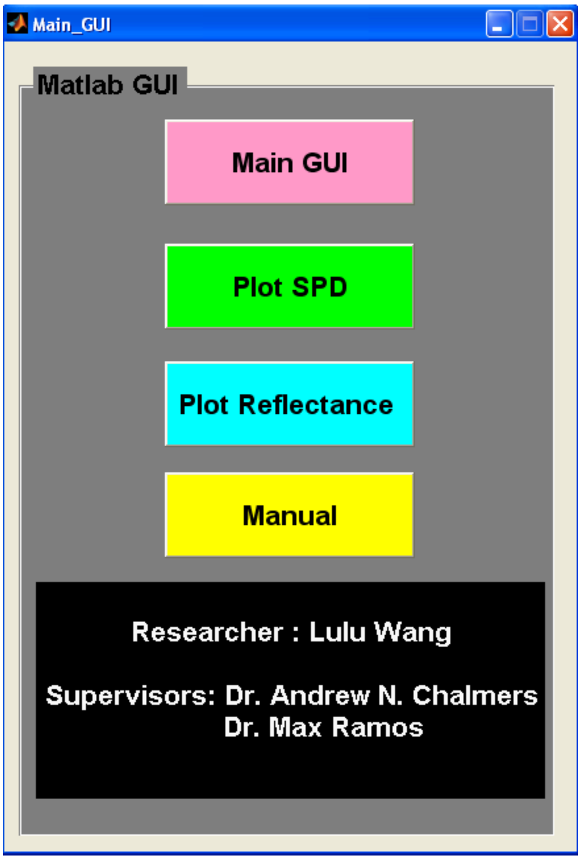


Figure 3.2-Final version of VIS

The CMCDS (colour-managed computer display system) is the most important part of the VIS. It displays and compares the test colour charts under reference and test light sources. The development of CMCDS consisted of 6 versions. The first version of CMCDS displays the same four colour charts under difference light sources and their position is showing in Figure 3.3. Because this version only can display colour samples under four light sources, a second CMCDS version was designed.

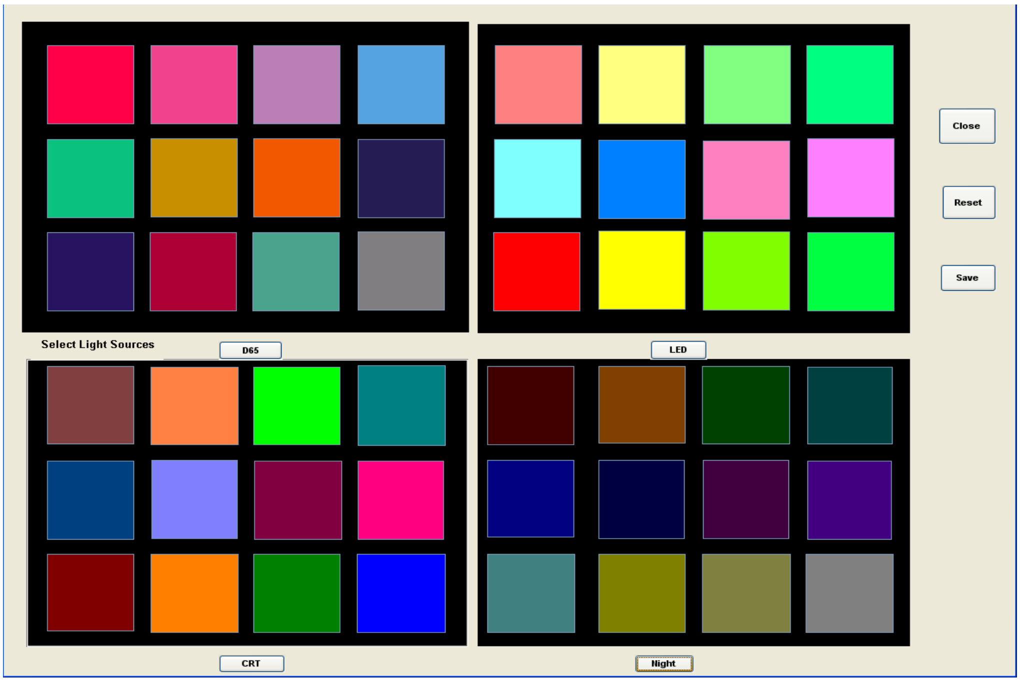


Figure 3.3-The first version of CMCDS

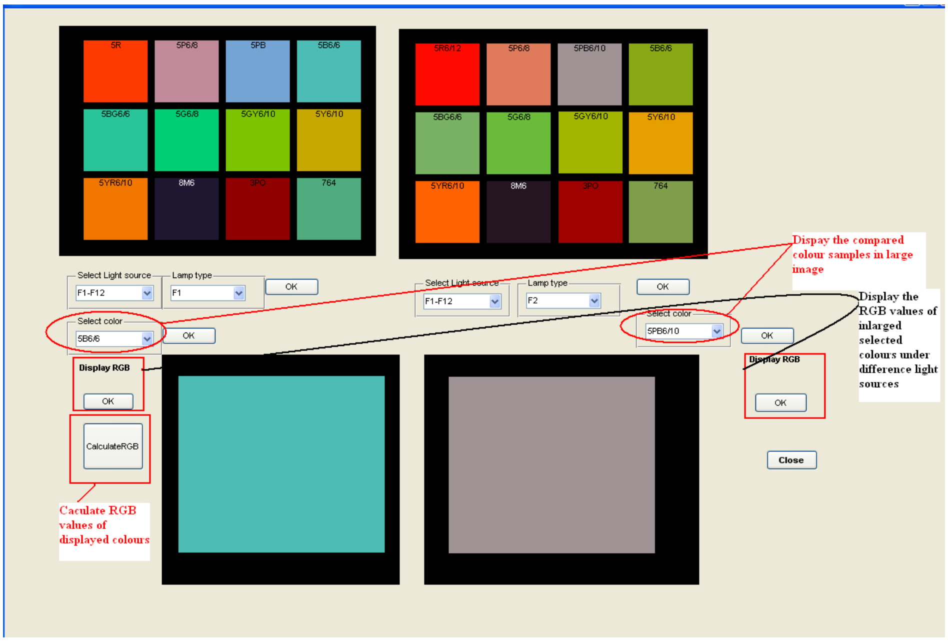


Figure 3.4-Second version of CMCDS

Figure 3.4 shows a screenshot of the second version of CMCDS. In this version, the number of colour charts has been reduced to two in order to allow the user to view and compare the colour samples more clearly. It also allows the user to select a colour sample from a dropdown box to view an enlarged version of the colour sample on the display. Additionally, this version added two new features. The Display RGB button allows the user to view the RGB values of the displayed colour samples under the test light source with the selected gamma and offset K1 values. The Calculate RGB button calculates all the RGB values of the displayed colour samples in a set for the selected light source. The second version also contains six additional light sources that can be selected. The light sources are now selected from a dropdown box as opposed to the buttons in version 1. This feature matches the CMCDS easier for the user and was extruded to cover other features as they were added in later versions.

The second version also introduced an intuitive graphical user interface design to the CMCDS. It guides the user through the process of selecting options by displaying items in the order they need to be chosen in. For example, when version 2 of CMCDS is first opened, the user only sees the option to select a light source. Once they have chosen a light source, the lamp type option then becomes available. After a lamp type is selected, the OK button then appears. After the OK button is clicked versions other options become available and so on.

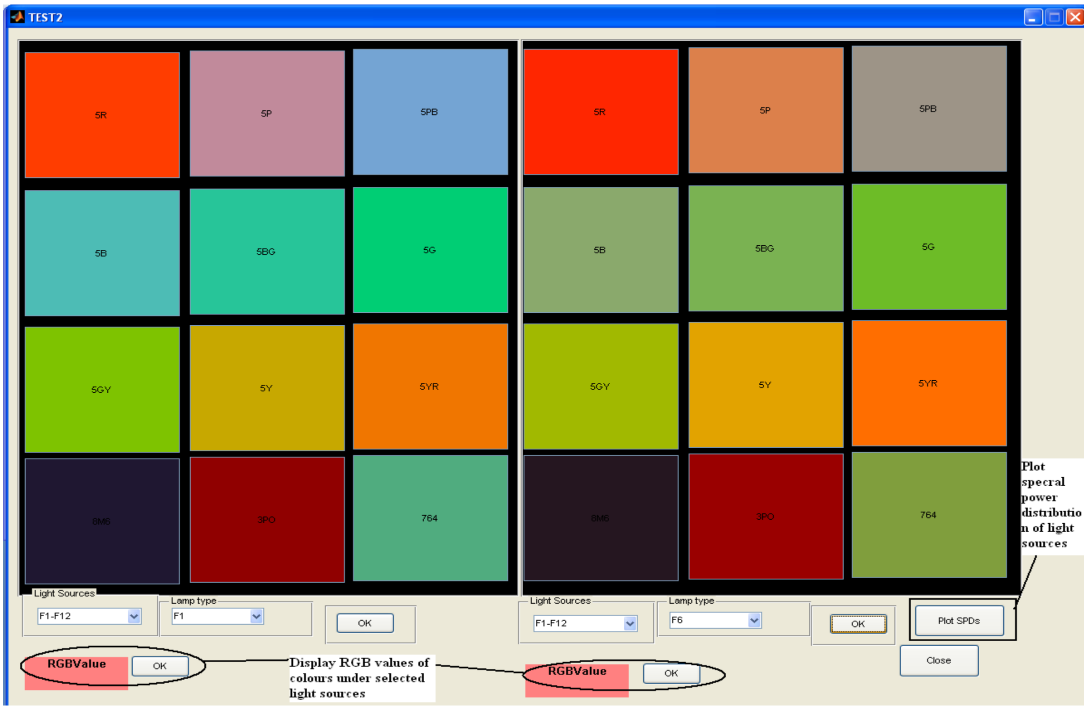


Figure 3.5-The third version of CMCDS

In the second version of CMCDS users had to manually enter the three RGB values for each of the 12 colour samples in a set. This process has to repeat each time a new light source was selected. Because of this, the third version of CMCDS (See Figure 3.5) has been developed to implement the test colour samples fully automatically. This version incorporates a database that containing 52 light sources, 46 of which are test illuminants and 6 are CIE standard illuminants. This version automatically displays the RGB values of the displayed colour samples under the selected light source.

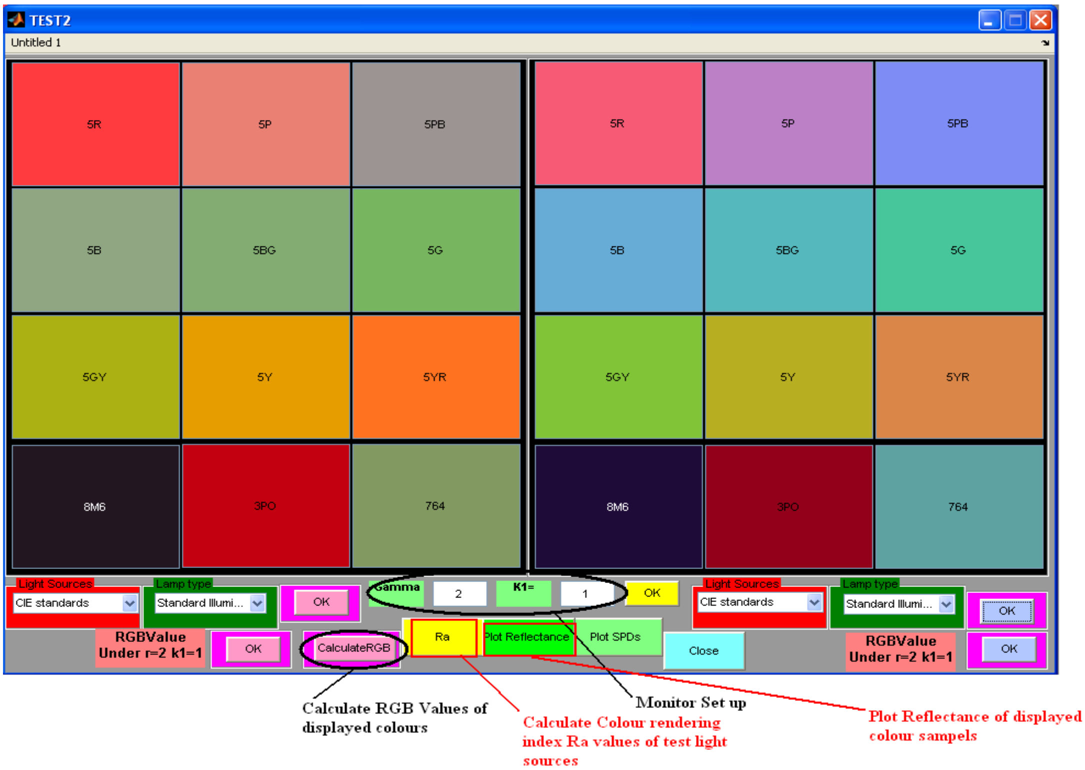


Figure 3.6-The fourth version of CMCDS

In order to display the colour samples accurately under difference light sources, a fourth version of the CMCDS was developed. Figure 3.6 shows the screenshot of this version. It contains an additional four features. These include:

1. The ability for a user to manually adjust the gamma and offset K1 values of the monitor from CMCDS.
2. The ability for the user to automatically calculate the colour rendering index and colour temperature of the selected light source by clicking the Ra button.
3. The ability for a user to automatically calculated the RGB values of the displayed colour samples under the selected light source by clicking Calculate RGB button.

The ability for a user to automatically plot the reflectances of the displayed colour samples on a graph.

Figure 3.7-The fifth version of CMS

For demonstrations relating to the CIE colour rendering model, the fifth version of the CMCDS implements the 14 specified test colour samples which are published by the CIED (See Figure 3.7).

Figure 3.8-Final version of colour management system (CMS)

The final version of the CMCDS adds two neutral grey colours, in additional to the 14 CIE published colours added in the fifth version. These two colours will act as scalier when user compares different colour samples. The screenshot of the final version of CMCDS is shown in Figure 3.8.

3.6 Development of The Virtual Imaging System (VIS)

In order to achieve the research objectives, the VIS has been designed by using of MATLAB GUI, the main structure of which is shown in Figure 3.9. The designed VIS contains three main components: SMS (spectral management system), CMCDS and RDS (reflectance display system). Additionally, four sub-systems are located in the colour-managed computer display system and they are named as monitor set-up, CMS (colour management system), CAM (colour appearance model) and CDM (colour difference model).

Three main modules in the final MATLAB GUI interface of VIS are called the Plot SPD_GUI (implement of SMS), Main GUI_GUI (implement of CMCDS) and Plot Reflectance _GUI (implement of RDS).

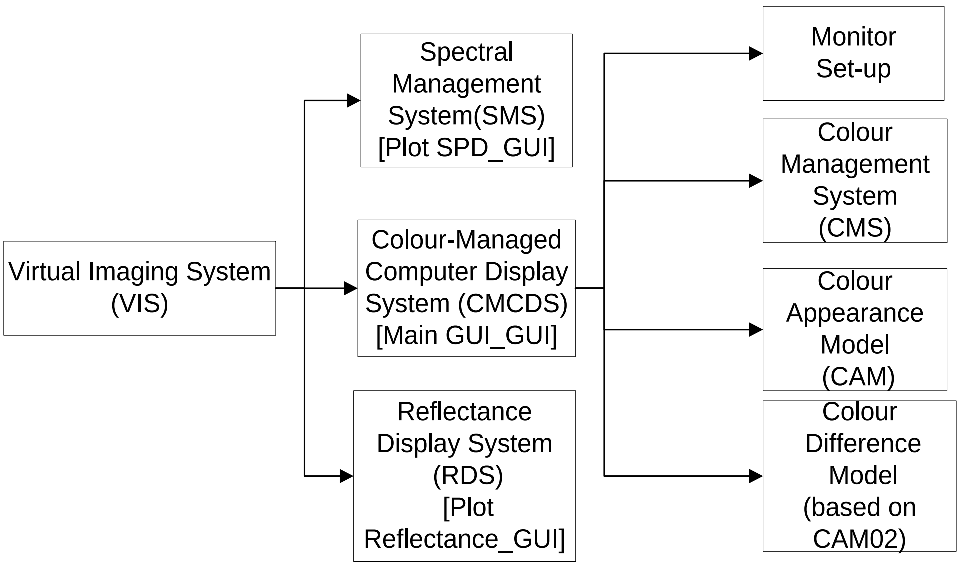


Figure 3.9-Main structure of VIS

Figure 3.10 explains the virtual prototyping system based on CIECAM02. To complete the final virtual imaging system, the user must first select display colour samples, followed by measuring the colour proprieties of test colour samples under different light sources, then using the collected data and light source spectrum with the calibrated CRT monitor information to convert the colour version to compute RGB values of displaying colour samples, next step is to set up designed MATLAB GUI model to display colour samples. Finally, some necessary adjustment of design system is required before achieve the final system.

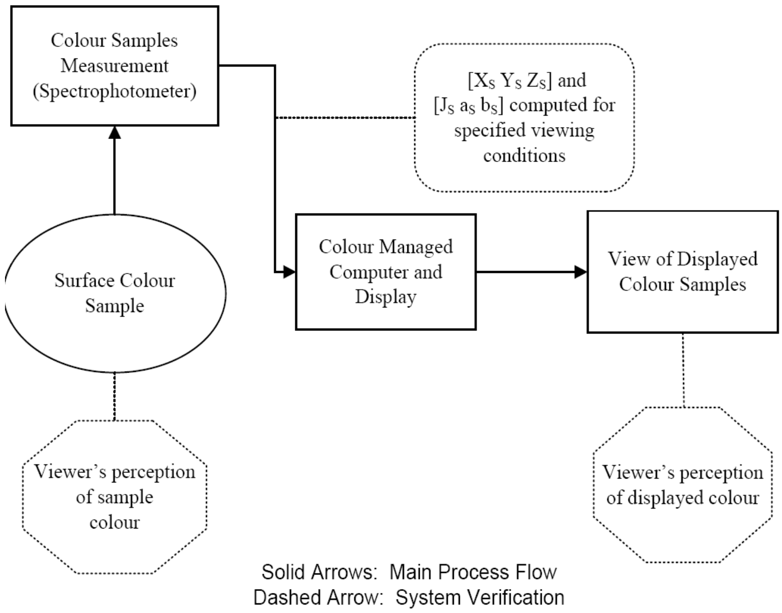


Figure 3.10-Virtual Prototyping system based on CIECAM02 [33]

3.6.1 Main GUI

The Main GUI contains the most important features of the application. It contains the selection of the test and reference light sources, calculation of the RGB values of the displayed colour samples, and calculating of the Ra and CCT values for the selected light source. It also provides links to plot the spectral power distribution of selected light sources and the spectral reflectance of the displayed colours, as well as incorporates features for monitor set-up and the CMCDS.

The CMCDS consists of five main features, they are monitor set-up (See Figure 3.11.), select test light and reference light sources (See Figure 3.12), display test colour samples (See Figure 3.8), display colour rendering index (Ra) and correlated colour temperature (T_C) values of each selected light sources (See Figure 3.12), calculate RGB values of the 16 displayed colour samples under selected illuminants (See Figure 3.14) and a link to the plot reflectance interface and the plot SPDs interface. For more information about the development processing of the Main GUI can refer to the code in Appendix V.13.

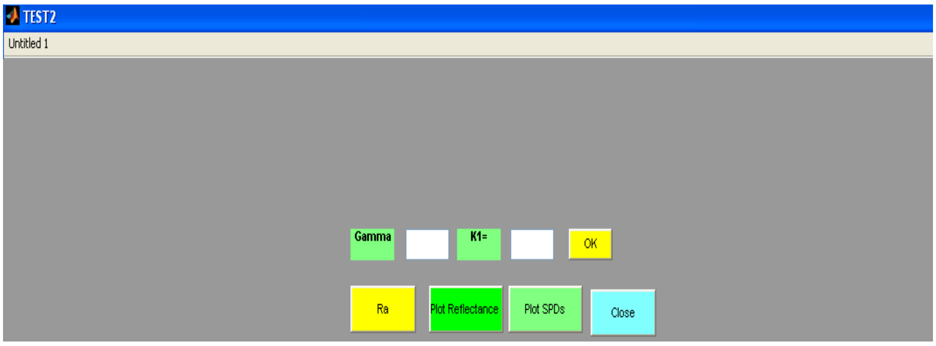


Figure 3.11-Monitor Set-up Screen

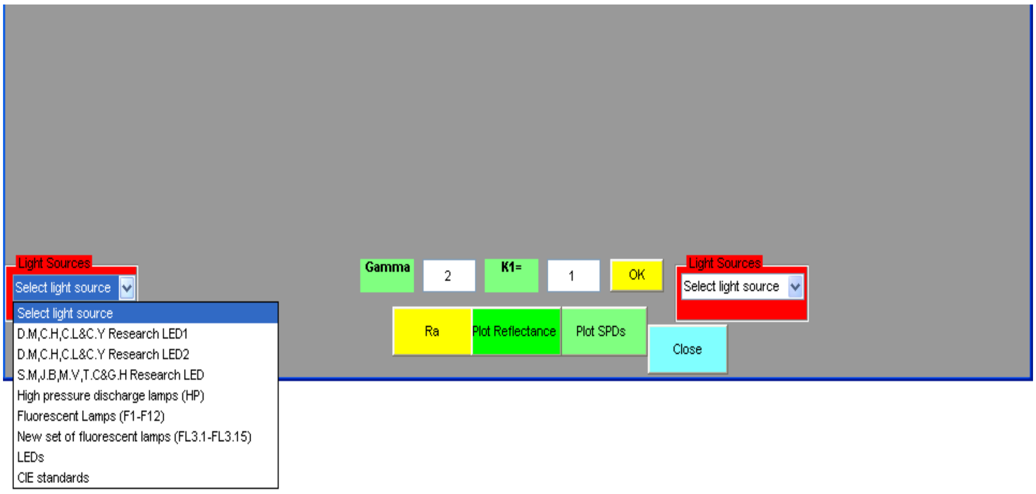
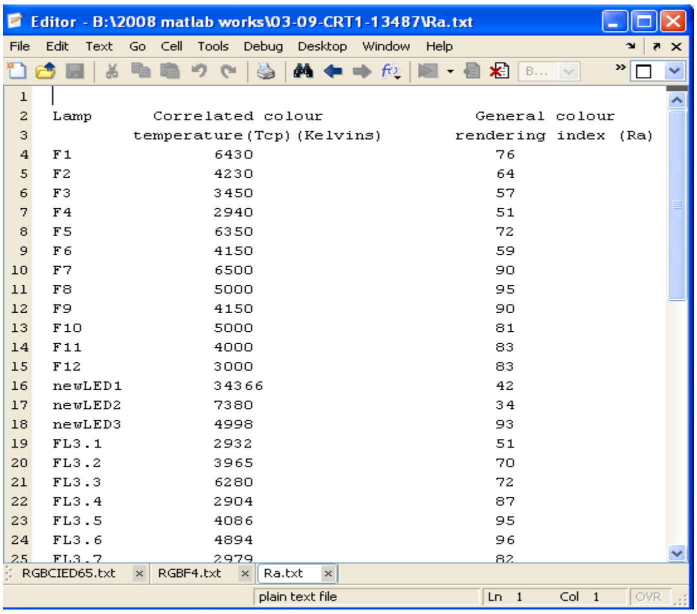


Figure 3.12-Select light sources



Lamp	Correlated colour temperature (Tcp) (Kelvins)	General colour rendering index (Ra)
F1	6430	76
F2	4230	64
F3	3450	57
F4	2940	51
F5	6350	72
F6	4150	59
F7	6500	90
F8	5000	95
F9	4150	90
F10	5000	81
F11	4000	83
F12	3000	83
newLED1	34366	42
newLED2	7380	34
newLED3	4998	93
FL3.1	2932	51
FL3.2	3965	70
FL3.3	6280	72
FL3.4	2904	87
FL3.5	4086	95
FL3.6	4894	96
FL3.7	2979	82

Figure 3.13-Display Ra and Tc of selected light sources

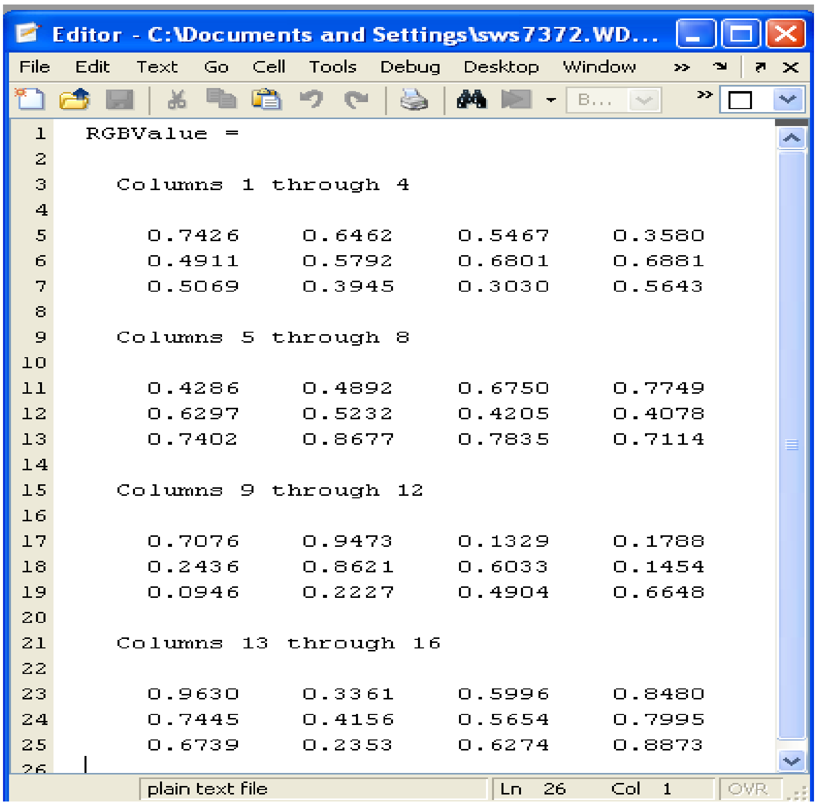


Figure 3.14-Calculate RGB values of the displayed 16 colour samples under CIED65

3.6.1.1 Monitor Calibration GUI (Monitor Set-up)

Monitor calibration is a very important and necessary step for the visual colour judgement of displayed colours. It was decided that this project would make use of CRT (cathode ray tube) monitors and the GOG (gain offsite gamma) model, as summarized in Equation (3.1). Users can choose computer gamma value (in the range 1.8 to 2.8) and offset K1 value (in the range 0.8 to 1.2) [34].

$$L_n = (K_1 D_n + K_2)^{\gamma} \qquad (3.1)$$

Where L_n = normalized luminance of screen primary

D_n = normalized digital pixel value

γ = monitor gamma

K_1 = monitor gain factor

K_2 = monitor offset

And $K_1 + K_2 = 1$.

Figure 3.11 shows the designed monitor set-up system, based on the GOG model. Figure 3.15 demonstrates that the same colour chart will look different with different K1 values even though the light source (CIE D65) gamma value (1.8).

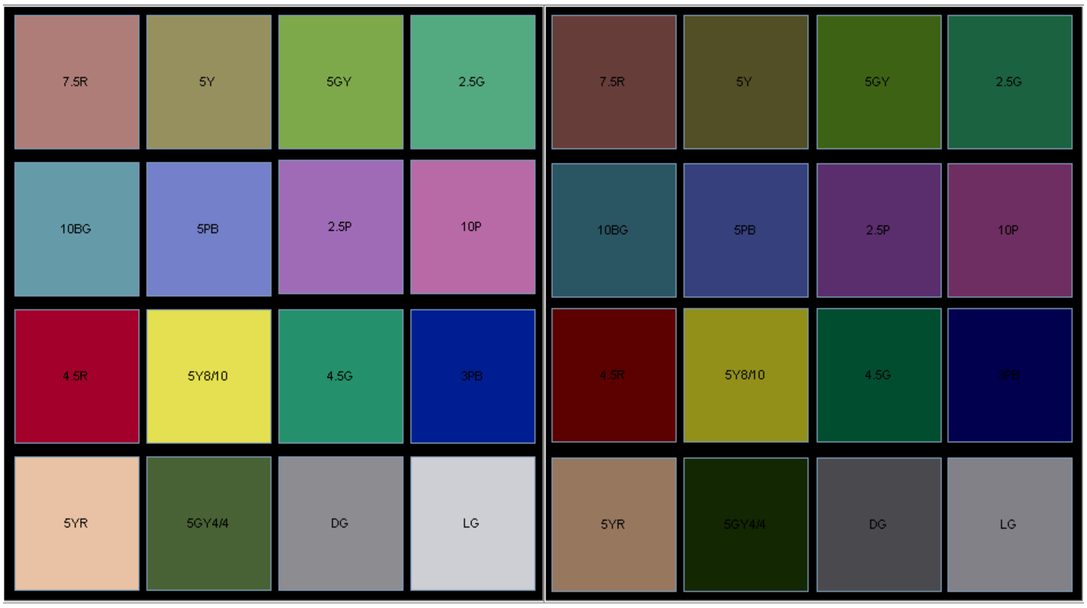


Figure 3.15-Test images under CIED65 with gamma=1.8 and K1=1(left side), K1=1.2(right side)

Two main functions used in MATLAB are gamma value (function rvalue) and K1 value function, which are created and called to receive and implement monitor gamma and offset K1 values automatically. And OK button was created to implement this feature. These codes are listing in Table 3.2 through to Table 3.4. For more information about the development processing of the Main GUI, refer to the code in Appendix V.13.

Table 3.2-Gamma value function

```
function rvalue_Callback(hObject, eventdata, handles)
r=get(handles.rvalue,'string');
r = str2num(r);
if (isempty(r) || r< 0 )
set(handles.rvalue,'Value',0);set(handles.rvalue,'String','0');
else set(handles.rvalue,'Value',r );end
```

Table 3.3-Offset K1 value function

```
function k1value_Callback(hObject, eventdata, handles)
k1=get(handles.k1value,'string');k1 = str2num(k1 );
if k1==0
errordlg('K1 can not be 0, please enter a new value');
else set(handles.k1value,'Value',k1 );end
```

Table 3.4-Gamma & K1 OK Button

```
Function S_OK_Callback(hObject, eventdata, handles)
set(handles.light_sources1,'visible','on');
set(handles.light_sources2,'visible','on');
```

3.6.1.2 Selection of Light Sources

The designed VIS contains two light source selection menus. The illuminant database contains 52 illuminants [12, 35, 36].They were divided into the 7 groups as listed below:

Group 1: CIE standard illuminants A, D65, C, D50, D55 and D75

Group 2: High pressure discharge lamps [Published in CIE15.3]

HP1: Standard high pressure sodium lamp

HP2: Colour enhanced high pressure sodium lamp

HP3-5: Three types of high pressure metal halide lamps

Group 3: Fluorescent lamps F1-12, published in CIE 15.2 as F1-F12

F1-6: standard

F7-9: broad-band

F10-12: narrow band fluorescent lamps

Group 4: New set of fluorescent lamps [Published in CIE15.3]

FL3.1-3: Standard halophosphate lamps

FL3.4-6: DeLuxe type lamps

FL3.7-8: Three band fluorescent lamps (A new set of fluorescent lamps)

FL3.9-11: Three band fluorescent lamps

FL3.12-14: Multi-band fluorescent lamps

FL3.15: D65 simulator lamp

Group 5: L.W research 3-, 4-, 5-, 6- and 7-BAND LEDs

Group 6: Philips Mixed LED sources for Tc of 3016K, 4000K, 4100K, 5500K and 6500K and Luxeon white LED

Group 7: New LED1, New LED 2, New LED 3

The illuminants in groups 1 to 4 are published in CIE publications [37]. According to research [36], the others are digitized from their SPDs for the range 380nm to 780nm at 5 nm intervals [32, 39]. The first group of the illuminants are standard CIE sources [38].

3.6.1.3 Selection of Colour Samples for Display

A set of colour samples, including 9 Munsell colours and 3 paint samples, was selected as the colour sample set for display at the beginning of this research. The 12 colour samples used were 5R 6/12, 5P6/8, 5PB6/10, 5B, 5BG6/6, 5G6/8, 5GY6/10, 5Y6/10, 5YR6/10, 8M6, 3PO, and 764. This colour sample set was measured and provided by Dr. Andrew N. Chalmers. (Refer to Appendix I.1) [27].

Table 3.5-The displayed test colour samples

Colour	Notation	Colour appearance under daylight
	7.5R6/4	Light greyish red
	5Y6/4	Dark greyish yellow
	5GY6/8	Strong yellow green
	2.5G6/6	Moderate yellowish green
	10BG6/4	Light bluish green
	5 PB 6/8	Light blue
	2.5 P 6/8	Light violet
	10P6/8	Light reddish purple
	4.5R4/13	Strong red
	5 Y 8/10	Strong yellow
	4.5G5/8	Strong green
	3PB3/11	Strong Blue
	5YR8/4	Light yellowish pink(light human complexion)
	5GY4/4	Moderate olive green (leaf green)
	DG	Dark grey
	LG	Light grey

The final VIS compares a set of 16 surface colours as listed in Table 3.5. These are the 14 CIE test colours with the addition of two synthetic neutral grey colours. The spectral reflectances of the test colours are tabulated for the wavelength range 380 nm to 780 nm (See Appendix I.2). The completed source code used to display the 16 selected colour samples is listed in Appendix V.1 to Appendix V.3.

3.6.2 Colour Management System (CMS)

The VIS displays and compares two colour charts under about 46 test light sources with 6 reference light source and the colour chart is made of 16 test colour samples which contain 14 CIE specified test colours and two neutral grey colour samples.

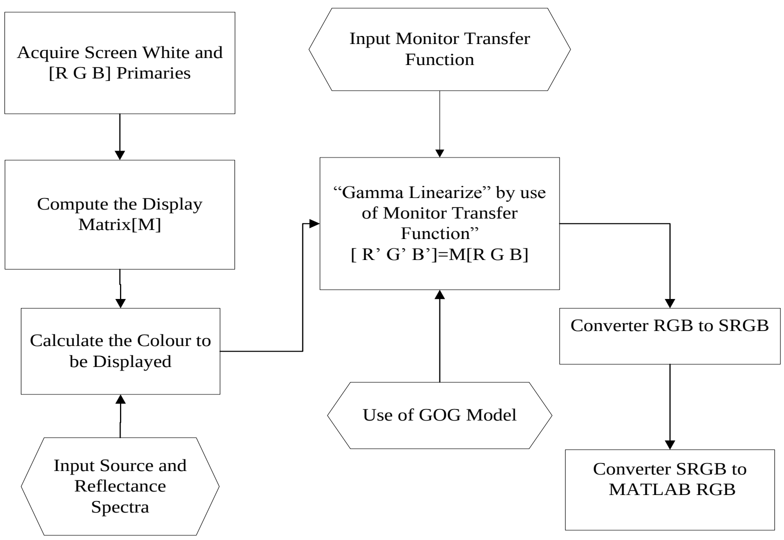


Figure 3.16-Colour management and display process

The conversion of the displaying colour samples is the major objective in design of the colour management system. Figure 3.16 explains the 6 steps of the conversion of the test colour samples and they are listed in steps 1 to 6.

1. Calibrate the CRT monitor to get primary screen RGB values of screen red, green and blue, as well as screen the white point.

2. Compute the matrix [M] by using of the achieved [R G B] primaries.

3. Calculate the displaying colours using the achieved matrix and input source.

4. Convert CIEXYZ to RGB by using the achieved results from the above steps.

5. Convert the RGB values of test colours to screen RGB values for each test colour sample using the GOG model.

6. Convert the screen RGB values to MATLAB displaying RGB to display the test colour samples.

Equation (3.2) is used to calculate the CIE XYZ, with the reflectance factor of the samples which were measured at intervals of 5 nm from 380 nm to 780 nm. Where ρ_λ is the reflectance factor of the samples at the wavelength λ (Appendix I-1 contains all the reflectance of the selected 16 test colour samples), Φ_λ is the value of the spectral power distribution of illuminate at the wavelength λ, and $\bar{x}_\lambda, \bar{y}_\lambda, \bar{z}_\lambda$ are CIE 1931 colour matching functions for the standard observer at the wavelength λ (and they are explained in Equation (3.2))

$$X = \sum_{380nm}^{780nm} \bar{x}_{\lambda} \rho_{\lambda} \Phi_{\lambda} \Delta\lambda$$
$$Y = \sum_{380nm}^{780nm} \bar{y}_{\lambda} \rho_{\lambda} \Phi_{\lambda} \Delta\lambda \qquad (3.2)$$
$$Z = \sum_{380nm}^{780nm} \bar{z}_{\lambda} \rho_{\lambda} \Phi_{\lambda} \Delta\lambda$$

Appendixes (I-2) to (I-9) contain all the selected 52 light sources in this work which include ranges of fluorescent tubes and high-intensity discharge lamps. Additionally, a number of LED spectra have been measured at Manukau Institute of Technology (MIT) by use of an Ocean Optics® HR2000™ fiber-optic spectrometer. Other values were obtained from published commercial [41] and research sources [42, 43].

The next stage is the calibration of the CRT monitor to achieve the 3x3 matrix factor M. Two 170 B_4 Philips CRT monitors were provided and calibrated in MIT. Steps 1 though to 4 are main steps in CRT monitor calibration.

1. Set up the computer system and spectrophotometer with running the Ocean Optics Spectra Suite software for about 6 hours

2. Use the spectrophotometer to measure the chromaticities x, y of the displays RGB primaries and white point. Ensure all the emission spectra of the display are between 380 nm to 780 nm.

3. Adjust the RGB primaries of the CRT monitor to achieve the best suitable chromaticity values.

4. Save the calibrated values.

The results of two calibrated CRT monitors are displayed in Table 3.6 and Table 3.7.

Table 3.6-Colour displays for CRT monitor

	Red	**Green**	**Blue**	**White**
x	0.5504	0.2705	0.1596	0.3123
y	0.3504	0.5955	0.1413	0.3398
z	0.0992	0.134	0.6991	0.3479
Y	6.88	13.48	4.29	23.01

Table 3.7-Colour displays for CRT monitor II

	Red	Green	Blue	White
x	0.5875	0.2746	0.1537	0.3173
y	0.3466	0.6129	0.1329	0.343
z	0.0659	0.111	0.7134	0.3398
Y	7.28	13.96	4.07	23.95

With use of the calibrated results from Table 3.6 and Table 3.7, the matrix of the coefficients used to calculate the display tristimulus values R, G, B from the CIE tristimulus values X, Y, Z can be computed by the use of Equations (3.3) through (3.6).

Where $\begin{bmatrix} x_r & x_g & x_b \\ y_r & y_g & y_b \\ z_r & z_g & z_b \end{bmatrix}$ and x_w, y_w, z_w are the calibrated [x, y, z] results of primaries and the screen white point. The matrixes of the calibrated CRT monitors are $M1 = \begin{bmatrix} 2.8521 & -1.2038 & -0.4078 \\ -1.7193 & 2.7466 & -0.1626 \\ -0.0672 & -0.2600 & 1.2910 \end{bmatrix}$ and $M2 = \begin{bmatrix} 2.7288 & -1.1551 & -0.3727 \\ -1.4563 & 2.4972 & -0.1515 \\ -0.0090 & -0.2206 & 1.2405 \end{bmatrix}$ They are displayed in Table 3.8 [1].

$$\begin{bmatrix} x_r & x_g & x_b \\ y_r & y_g & y_b \\ z_r & z_g & z_b \end{bmatrix} \begin{bmatrix} P_r \\ P_g \\ P_b \end{bmatrix} = \begin{bmatrix} x_w / y_w \\ 1 \\ z_w / y_w \end{bmatrix} \tag{3.3}$$

$$\begin{bmatrix} P_r \\ P_g \\ P_b \end{bmatrix} = \begin{bmatrix} x_w / y_w \\ 1 \\ z_w / y_w \end{bmatrix} / \begin{bmatrix} x_r & x_g & x_b \\ y_r & y_g & y_b \\ z_r & z_g & z_b \end{bmatrix} \tag{3.4}$$

$$\begin{aligned} X_r &= P_r x_r; X_g = P_g x_g; X_b = P_b x_b \\ Y_r &= P_r y_r; Y_g = P_g y_g; Y_z = P_b y_b \\ Z_r &= P_r z_r; Z_g = P_g z_g; Z_b = P_b z_b \end{aligned} \tag{3.5}$$

$$M = \begin{bmatrix} R_x & R_y & R_z \\ G_x & G_y & G_z \\ B_x & B_y & B_z \end{bmatrix} = \begin{bmatrix} X_r & X_g & X_b \\ Y_r & Y_g & Y_b \\ Z_r & Z_g & Z_b \end{bmatrix}^{-1} \tag{3.6}$$

Table 3.8-Matrix of calibrated CTR monitors I & II

	x1	y1	z1	x2	y2	z2
R	2.8521	-0.4078	-0.323	2.7288	-1.1551	-0.3727
G	-1.7193	2.7466	-0.1626	-1.4563	2.4972	-0.1515
B	-0.0672	-0.2600	1.2910	-0.0090	-0.2206	1.2405

The next step is to convert CIE XYZ to RGB value by using Equation (3.7) and then use of the GOG (gain-offset-gamma) model to transfer the computed RGB values [R, G, B] to screen RGB values [SR, SG, SB]. In this situation, Equations (3.8) through (3.10) are used to calculate the final screen displaying RGB values, where r is the monitor set-up gamma value, K1 is the monitor gain factor and K2 is the monitor offset. Normally, suitable gamma and offset K1 values are in the range of 1.8 to 2.8 and 0.8 to 1.2, additionally, K1+K2=1.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = [M] \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \tag{3.7}$$

$$SR = (\sqrt[r]{\frac{R}{255}} + K2)(\frac{255}{K1}) \tag{3.8}$$

$$SG = (\sqrt[r]{\frac{G}{255}} + K2)(\frac{255}{K1}) \tag{3.9}$$

$$SB = (\sqrt[r]{\frac{B}{255}} + K2)(\frac{255}{K1}) \tag{3.10}$$

This means the virtual imaging system may not display colour samples 100% accurately because of data conversion errors. Figure 3.17 shows the calculation process and conversion equations required for conversion in colour display process. In this research, part of the SPDs (Φ_λ) of the test light sources and the reflectances (ρ_λ) of the displayed colour samples, $\bar{x}_\lambda, \bar{y}_\lambda, \bar{z}_\lambda$ are obtained from the CIE publications [41] and research sources [42, 43] which are detailed in the above sections. For more data information can refer to Appendix (II-1) through (II-9). The last step is to convert screen [SR SG SB] to the values that can be readable by MATLAB [R G B]. Because of MATLAB can only read the RGB values of the displaying colour from 0 to 1, any inputted values outside this range will be automatically adjusted to 1 or 0. This means the virtual imaging system may not display colour samples 100% accurately because of data conversion errors.

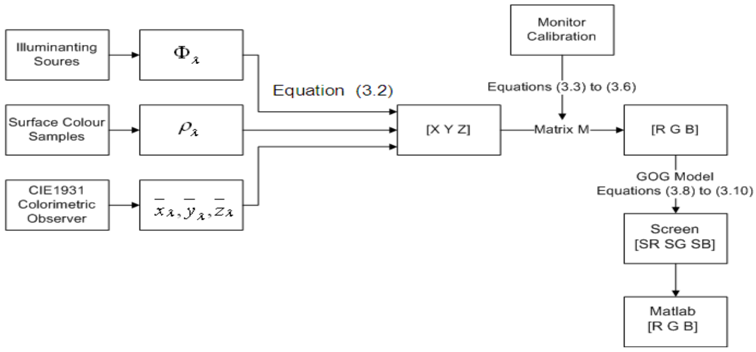


Figure 3.17-Flow chart of the colour display model

3.6.2.1 Compute Ra and Tc of Light Sources

To calculate Ra and Tc values, the CIE central bureau has provided two application software programs on a disk:

- ➢ CIE13_3D.EXE is a program that calculates the spectral colour rendering indices and the general colour rendering index on an IBM or DOS compatible PC running DOS 3.2 or higher.

- ➢ CIE13_3W.EXE is a modification of the above program to be run on an IBM PC 386 or 486 or compatible under MS-WINDOWS 3.1

This research decided to use of CIE CRI program to compute the general colour rendering index and colour temperature of the selected light sources. Figure 3.18 shows an example calculating the Ra and *Tc* values of L. W.4-Band LED light source using the CIE13_3W.EXE programme. Ra and Tc values of all selected light sources in this research project are computed using the same method.

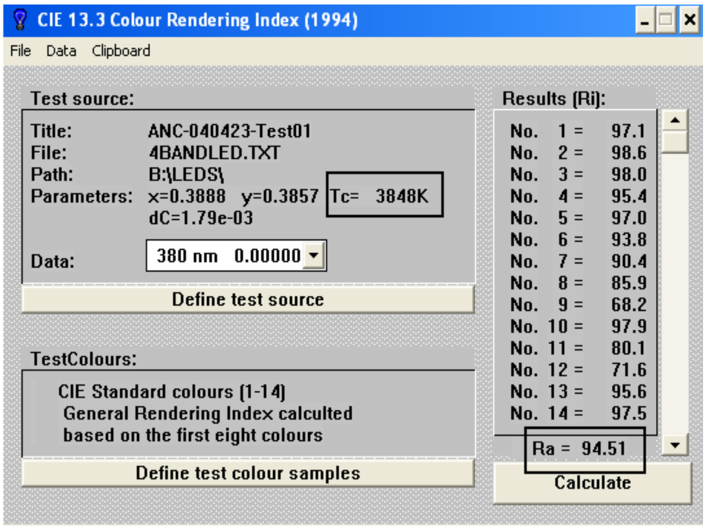


Figure 3.18-CIE13_3D.EXE program

3.6.3 SPD Displaying GUI (Plot SPD_GUI)

This section describes the design and implementation process of the SPD Displaying system (Plot SPD_GUI). The VIS contains SPDs of displayed light sources. The Plot SPD_GUI interface allows the user to choose and compare any two of the selected light source SPDs. Once the user has selected two light sources to compare, the SPD GUI will plot the comparison of the SPDs in wavelengths between 380 nm and 780 nm at 5 nm intervals. All SPDs of illuminants are tabulated in Appendixes (II.1) though (II.8).

Figure 3.19 shows an example of a comparison of SPDs of two illuminants (F1 and CIED65) that are implemented by use of the Plot SPD_GUI. For more information about the SPD Displaying GUI work processing, refer to the code (in Appendix V.14).

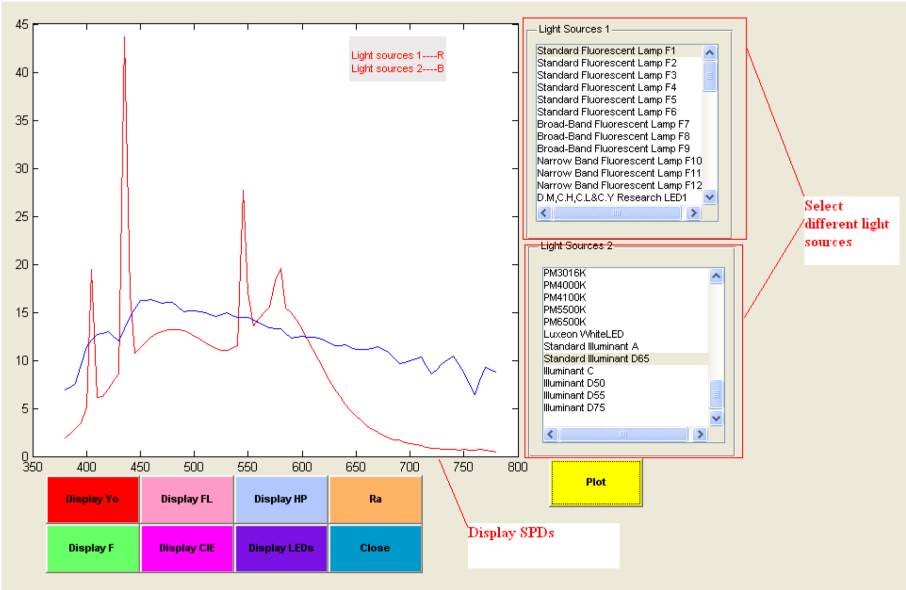


Figure 3.19-Display Spectral Power Distributions of illuminants

The user interface permits the user to select and display any two sources from the same database. To facilitate the comparisons of SPDs, all the test sources have been converted to the same power range and they have the same relative luminance value (Yo =292.82), which is the value given in the tabulated SPDs for the CIE standard illuminants.

3.6.4 Reflectance Plotting GUI (Plot Re_GUI)

Appendix I.2 contains all reflectances of the 16 colour samples in the database for the wavelength range 380nm to 780nm. Figure 3.20 illustrates the reflectances of displayed colour samples that are plotted by use of this data. Table 3.9 shows the Matlab code fragment for this function. Figure 3.20 shows the spectral reflectances for the CIE CR test colour samples. The completed code can be found in Appendix V.15.

Table 3.9-Plot reflectance function

```
function Re_Callback(hObject, eventdata, handles)
% hObject    handle to Re (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
set(handles.Reflection,'Visible','on');
axes(handles.Reflection);
imshow('Samples.bmp');
```

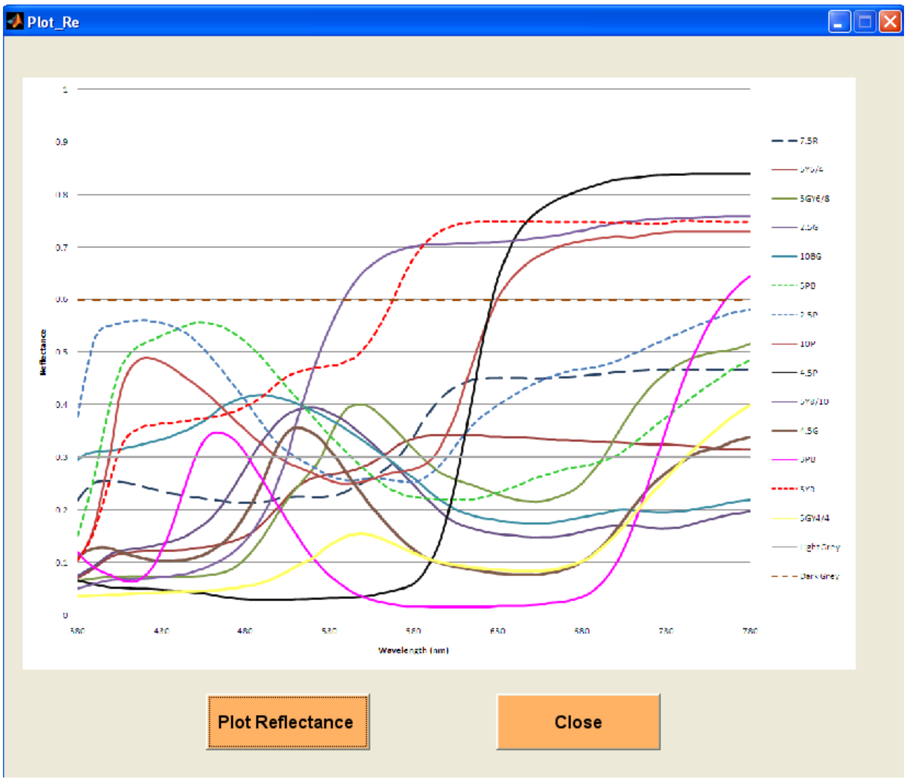


Figure 3.20-Plot reflectance of 16 test colour samples

3.7 Summary

A visual imaging system has successfully achieved the requirements of the research project. Figure 3.21 (a), (b), (c) and (d) are the four main user interfaces of the designed system, while (e) and (f) are the two main readout tables of the system.

The structure of the system is such that the SPD data for any new sources can easily be added to the data base, and their colour rendering performance computed and demonstrated. In a similar way, additional or alternative test colours can be added to the colour sample data-base as soon as their spectral reflectances have been measured.

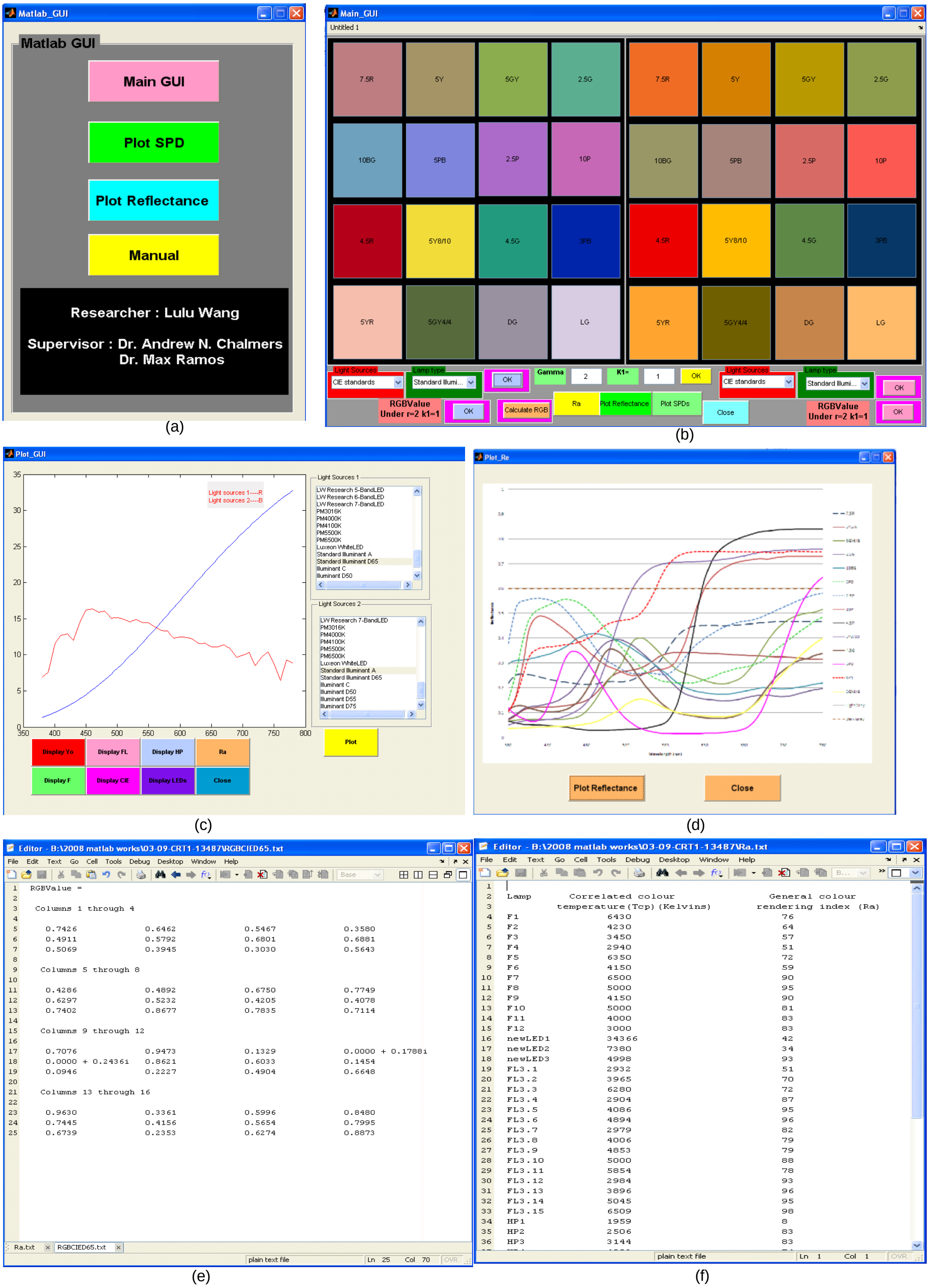


Figure 3.21-MATLAB GUI system interface

4 SUBJECTIVE TESTING

4.1 Introduction

This chapter details the subjective testing methods used during the testing phase of the virtual imaging system. Subjective testing was accomplished by human sight -- a group of observers who were selected to test the VIS were placed into three groups, each with a different test propose. The testing methods and results are detailed throughout the following section and the achieved results are explained at the end of the chapter.

4.2 Subjective Testing Method

According to research into [44, 45] "informal and formal subjective measurements have always been, and will continue be, used to evaluate system performance from the design lab to the operational environment. Even with all the excellent objective testing methods available today for analog and full-bandwidth digital video, it is important to have human observation of the pictures. There are impairments which are not easily measured yet are obvious to a human observer. This situation certainly has not changed with the addition of modern digital compression. Therefore, casual or informal subjective testing by a reasonably expert viewer remains an important part of system evaluation or monitoring." Observers are viewed the developed VIS and it is their opinion of the colour display quality which is important.

In addition to the selection of the subjective testing method there are a number of other procedural elements for which alternate approaches are available. These are such things as: viewing conditions, choice of observers, scaling method to score the opinions, reference conditions, signal sources for the test scenes, timing of the presentation of the various test scenes, selection of a range of test scenes, and analysis of the resulting scores.

4.2.1 Observers

According to Peter G. Engeldrum [46] the number of observers to use in scaling studies is typically governed by availably. Scaling studies in the imaging area are conducted with as few as 4 observers, and with as many as 50. A range of 10 to 30 is recommended for a typical scaling application. This is not intended to be a rigid rule, only a guideline. In this research, 21 non-expert observers have been selected and tested for their visual capabilities. The observers were shown a series of test scenes for about 10 to 30 minutes in a controlled environment and observers were divided into three groups according to different test purposes. In this quality of colour display test, 21 observers were selected.

4.2.2 Colour Vision Test

Every observer was given a colour blindness test before they started testing the VIS. To protect the privacy of all participants, these tests were taken individually. The test results showed that none of the observers selected suffer from colour vision deficiencies.

4.2.3 Colour Displays Test

All Participants were divided into three groups with different test proposes:

1. Group I (five people) tests the monitor set-up system which is contained in VIS and colour displayed by a range of light sources (including new research LEDs).
2. Group II (ten people) tests the developed CMS.
3. Group III (six people) uses the designed VIS to test the author's proposed "rules of colour rendering properties".

Figure 4.1-Test image shown to Group I

4.2.3.1 Group I (5 Observers) 60 Minutes

Observers in Group I viewed the fully developed VIS to compare the colour sample charts under 46 light sources with 5 reference sources (CIE Illuminants A, D50, D55, D65 and D75), and they gave score of the quality of each test colour sample on colour char. In the interests of simplicity and brevity in the subjective testing procedure, the test source and reference source do not always have the identical CCT. However, in each instance, the closest available reference is chosen from the above mentioned subset of CIE illuminants. This process took approximately 60 minutes per observer. Figure 4.1 shows a sample of an image shown to Group I.

There are two main purposes for the observers in Group I, they are to test the designed colour management system (especially the Monitor Set-up system) is working normally and to test light sources (especially the research LEDs) are provide good colour rendering.

To start the test, the calibrated Philips 170 B_4 CRT monitor displaying the developed VIS was provided, question sheet S1 was used for part I for the test and question sheet S2 was used for part II of the test. In part I, participants gave a score for each displayed colour under test light source compared with its reference source. The test method and processes are listed as below:

1. Run the VIS, keep the reference light source (CIE Illuminant D65) on the LEFT side of the monitor and keep the test light source (CIE Illuminant D65) on the RIGHT side of the monitor, select a gamma γ value=2.0 and a K1 value=1.0 to view the two compared colour images.
2. Run the VIS, keep the test light source (CIE Illuminant D65) on the RIGHT side of the monitor and keep the reference light source (CIE Illuminant D65) on the LEFT side of the monitor, then choose different gamma γ values (between 1.8 to 2.8) at an 0.1 interval with K1=1.0. Participants compared the displayed colour chart with reference light source and gave a score between +5 (best) to -5 (poorest) (See Appendix IV.1).
3. Keep the test light source (CIE Illuminant D65) on the RIGHT side of the monitor and keep the reference light source (CIE Illuminant D65) on the LEFT side of the monitor, then choose different K1 values (between 0.8 to 1.2) at 0.1 intervals with best gamma (selected by step 2) to compare the displayed colour

charts with reference light source and given score in 11 step grade, +5 to -5 scale labelled: best to poorest (See Appendix IV.1).

4. Determine the best results for gamma γ and offset K1 values.
5. Keep reference light source (CIE Illuminant D65) on the LEFT side of the monitor under the "best gamma and offset K1" values obtained in step 4.

Part II of the test has been done by 5 observers from Group I. They viewed and compared the 16 displayed colour samples under the 46 test light sources with 5 reference light sources. The differences between the colour samples were scored using the adjectival method to define "best" to "worst". Participants scored on a 7 step scale of +3 to -3 (+3 being best and -3 being worst). The total score of colour samples under all test light sources has been calculated and the average scores of the test light sources from Part II of the test have been calculated and analysed.

According to the CIE method calculates Ra by comparing the colour samples under the test light source with reference light source at the same Tc, the test light sources were separated into 5 groups referenced to their closest available Tc. The selected 5 reference light sources include CIE Illuminants A, D50, D55, D65 and D75.

Table 4.1 displays the grouped test light sources for Group I (More information in Appendix IV.2).

Table 4.1-Sources in groups based on their colour temperature

Sources Compatible with	**Reference Illuminant**	**Test Sources**
Illuminant A	CIE A	HP1
		HP2
		LW4BANDLED
		LW5BANDLED
		LW6BANDLED
		LW7BANDLED
		HP3
		F3
		F4
		F12
		FL3.1
		FL3.2
		FL3.4
		FL3.7
		FL3.12

		FL3.13
		PM3016K
Illuminant D50	CIE D50	LED3
		F2
		F6
		F8
		F9
		F10
		F11
		FL3.5
		FL3.6
		FL3.8
		FL3.9
		FL3.10
		FL3.14
		HP4
		HP5
		PM4000K
		PM4100K
Illuminant D55	D55	FL3.11
		PM5500K
		LuxenWhiteLED
Illuminant D65	D65	F1
		F5
		F7
		FL3.3
		FL3.15
		PM6500K
Illuminant D755	D75	LED1
		LED2
		LW3BANDLED

4.2.3.2 Group II (10 Observers) 30 Minutes

10 observers in Group II viewed and compared the displayed colour charts under 20 selected light sources in comparisons with three CIE standard illuminants as reference sources using the same method as the test in part II of Group I's test. The gamma γ and offset K1 values in the monitor colour management test were using the achieved results of Part I of Group I's test (γ =2.1 and K1=1.0). In order not to influence the observers' opinions, the observers in Group II were given no specific information concerning the test and reference light sources. The VIS was run by researcher, and observers only gave scores for each displayed colour comparison. Table 4.2 shows the score sheet used for Group II, where M1 to M20 refer to the selected 20 light sources from Group I. Those 20 light sources are selected because of they are achieved the higher score than others in Group I's test. The headers for columns 3 to 18 give the Munsell hues of 16 displayed colour samples.

The test processes for Group II are outlined below.

1. Use the pre-selected gamma and K1 values throughout the test.
2. Keep reference light sources on the LEFT side of the VIS screen.
3. Keep the test light source on the RIGHT side of the VIS screen.
4. Compare the 16 displayed colour samples on the colour charts under the test and reference light sources. The differences between colour samples are scored using the adjectival method. Participants rate the samples on a 7 grade scale, +3 to -3 (+3 being best and -3 being worst) (See Appendix IV.3).
5. Change reference and test light sources then repeat the steps 2 to 4.
6. Calculate the scores for each colour sample under each test light source, by finding the algebraic sum and the total magnitude of scored differences.

Table 4.2-Question sheet for Group II

Re	Test	7.5R	5Y	5GY	2.5G	10BG	5PB	2.5P	10P	4.5R	5Y8/10	4.5G	3PB	5YR	5GY4/4	DG	LG
CIE Illuminant A	M1																
	M2																
	M3																
	M4																
	M5																
	M6																
	M7																
	M8																
	M9																
	M10																
	M11																
CIE Illuminant D50	M12																
	M13																
	M14																
	M15																
	M16																
	M17																
CIE Illuminant D65	M18																
	M19																
	M20																

4.2.3.3 Group III (6 Observers) 15 Minutes

The main purpose of Group III was to test two hypotheses expressed in the following "two rules of colour rendering properties" proposed by the author.

1. The displayed colour sample looks "better" under a test light source with a larger Ra value when the test and reference light sources are at the same Tc.
2. The displayed colour sample looks "better" under a test light source with a higher Tc when the test and reference light sources have the same Ra.

Table 4.3 lists all the test light sources and reference light sources used for Group III. Table 4.3 (a) is based on the test light sources that have the same (or very close) Tc as the reference light sources while Table 4.3 (b) is based on the test light sources that have the same Ra with reference light sources. The test method and processes of Group III are same as those used on Group II.

Table 4.3Table 4.3-Question sheet for Group III.

(a)Light sources grouped by their colour temperatures.

Reference Illuminants	Test Illuminants	Nominal Colour Temperature (K)	Colour rendering index (Ra)
D50	F8	5000	95
D50	F10	5000	81
D50	FL3.10	5000	88
D55	PM5500K	5500	86
D65	F7	6500	90
D65	FL3.15	6500	98
PM4000K	F11	4000	83
PM4000K	HP4	4000	74
F12	PM3016K	3016	77
F12	FL3.12	2984	93

(b) Light sources grouped based on Ra

Reference Illuminants	Test Illuminants	Colour rendering index (Ra)	Nominal Colour Temperature (K)
F9	F7	90	6500
F12	F11	83	4000
F12	HP2	83	2506
F12	HP3	83	3144

4.3 Test Results

As detailed above, the VIS has been tested by 21 observers in three groups. Each group tests a different performance feature of the designed VIS. The results achieved by observers in three different groups are detailed in this section.

4.3.1 Test Results from Group I

Two tests were performed by Group I subjects. In test part I, 5 observers have done the monitor set up window test to select the best values of gamma and offset K1 for the displayed CRT monitor. One observer has done this test twice in order to get the best gamma value, and the achieved 6 results are listed in Table 4.4. The results show about 84% of people believe the designed VIS displays the best colour images under offset K1=1, however, every observer selected a different a gamma value. One explanation for this is the gamma value just slightly changes the displayed colours compared with the offset K1 value. Because of this, is much harder for human eyes to distinguish the colour differences. The test results also show that the displayed colours look much darker with a lower gamma value, whereas, the displayed colour samples looks much darker with higher offset K1 value. From the Table 4.4, the average gamma value =2.1 and the average offset K1 values=1. Those values are selected as a standard pair of settings for γ and K1 for all observers in part II test to use.

Table 4.4-Test results of monitor set-up

	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**	**Test 6**
Gamma	1.8	1.9	2	2.1	2.2	2.6
K1	1	1.1	1	1	1	1

In test part II, 5 observers were selected to view and compare the displayed colour samples under test illuminants with reference illuminants implemented by VIS. 46 test light sources were compared with 5 CIE standard light sources, which means the test light sources were grouped with the same (or a very close) colour temperature Tc to the reference illuminants (CIE Illuminants A, D50, D55, D65 and D75).

Table 4.5-Test results from Group I

		Test 1		Test 2		Test 3		Test 4		Test 5		Average	
Reference Illuminants	**Test Illuminants**	T	M	T	M	T	M	T	M	T	M	AT	AM
A	HP1	-40	40	-48	48	-35	35	-42	42	-38	38	-40.6	40.6
	HP2	-12	20	-47	47	-13	17	-21	21	-29	29	-24.4	26.8
	4BAND	16	16	40	40	-4	14	22	26	40	40	22.8	27.2
	5BAND	8	16	26	26	-2	10	6	10	45	45	16.6	21.4
	6BAND	-4	12	21	21	-2	10	6	10	45	45	13.2	19.6
	7BAND	4	20	-3	19	-10	18	2	10	30	30	4.6	19.4
	HP3	8	8	-4	10	-1	11	0	2	-16	16	-2.6	9.4
	F3	12	12	-7	17	-8	12	-4	6	-32	32	-7.8	15.8
	F4	-16	24	-17	23	-11	19	-4	6	-48	48	-19.2	24
	F12	-12	12	-4	10	0	10	-4	6	-48	48	-13.6	17.2
	FL3.1	-20	20	-9	17	-12	20	-4	6	-48	48	-18.6	22.2
	FL3.2	16	16	14	16	-3	14	-4	6	16	16	7.8	13.6
	FL3.4	-4	12	-9	9	-10	20	-4	6	-32	32	-11.8	15.8
	FL3.7	-12	12	-9	15	-7	13	-4	6	-16	16	-9.6	12.4
	FL3.12	4	4	-1	1	-5	5	0	0	0	0	-0.4	2
	FL3.13	20	20	18	20	-11	13	23	25	32	32	16.4	22
	PM3016	13	13	9	13	-1	13	8	10	32	32	12.2	16.2
D50	LED3	0	0	-1	3	-4	8	0	0	-16	16	-4.2	5.4
	F2	-16	16	-39	39			-30	30	-32	32	-23.4	23.4
	F6	-20	20	-31	31			-30	30	-48	48	-25.8	25.8
	F8	0	0	-8	8	-3	7	0	0	-15	15	-5.2	6
	F9	-12	12	-24	24	-9	13	-14	16	-32	32	-18.2	19.4
	F10	-12	12	-16	16	-8	15	-16	16	-16	16	-13.6	15
	F11	-16	16	-25	25	-9	12	-16	16	-32	32	-19.6	20.2
	FL3.5	-12	12	-26	26	0	10	-16	16	-32	32	-17.2	19.2
	FL3.6	0	0	-20	20	-1	3	-16	16	-16	16	-10.6	11
	FL3.8	-20	20	-30	30	-10	16	-32	32	-32	32	-24.8	26
	FL3.9	-16	16	-22	22	-7	13	-48	48	-16	16	-21.8	23
	FL3.10	-12	12	-9	9	-6	10	-32	32	-16	16	-15	15.8
	FL3.14	0	0	-7	7	-5	5	0	0	-16	16	-5.6	5.6
	HP4	-20	20	-33	33	-14	20	-32	32	-48	48	-29.4	30.6
	HP5	-12	12	-32	32	-10	14	-16	16	-32	32	-20.4	21.2
	PM4000	-4	12	-17	17	-5	11	-16	16	-32	32	-14.8	17.6
	PM4100	-11	13	-28	28	-10	16	-32	32	-48	48	-25.8	27.4
D55	FL3.11	-28	28	-48	48	-14	18	-48	48	-48	48	-37.2	38
	PM5500	-16	18	-48	48	-17	23	-48	48	-48	48	-35.4	37
	WHITELED	-19	17	-31	31	-17	21	-48	48	-48	48	-32.6	33
D65	F1	-12	12	-4	8	-7	11	-16	16	-48	48	-17.4	19
	F5	-16	16	-4	8	-9	17	-16	16	-48	48	-18.6	21
	F7	-1	1	-7	8	-6	8	-16	16	-16	48	-9.2	16.2
	FL3.3	-15	15	-9	13	-5	15	-32	32	-48	48	-21.8	24.6
	FL3.15	0	0	0	0	-1	3	0	0	-12	16	-2.6	3.8
	PM6500K	-29	29	-48	48	-32	32	-48	48	-48	48	-41	41
D75	LED1	-32	34	-42	42	-28	30	-48	48	-48	48	-39.6	40.4
	LED2	-36	36	-48	48	-29	31	-48	48	-48	48	-41.8	42.2
	3BAND	-24	24	-34	34	-20	20	-48	48	-48	48	-34.8	34.8

Based on the results displayed in Table 4.5, the obtained outcomes in Group (I) are as follows:

1. In light source group CIE A, Figure 4.2 shows L.W.4-, 5-, 6-, and 7-Band LEDs, FL3.13 PM3016 LED and FL3.2 achieved much higher Average Total (AT) scores than other illiminants (See Table 4.6).

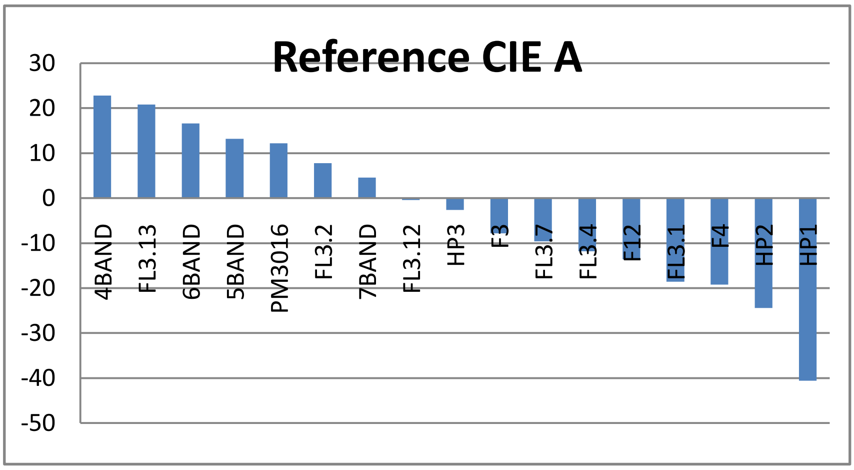


Figure 4.2-Group I total score for reference illuminants CIE A

Table 4.5 illustrates the test results from Group I, where T and M refer to the Total (algebraic) and Magnitude score of the colour differences samples. According to the CIE recommended calculation method for Ra (detailed in Chapter 1), Ra can be calculated by use of Equations (4.1) and (4.2), and the ΔE_i (colour difference) in Equation (4.1) refers to the rms Magnitude of the test results. It is can be seen that at the same colour temperature (Tc), if ΔE_i value increases, the R_i value will decrease and therefore, the value for R_a will decrease. Similarly, when comparing colour samples under two light sources at the same Tc, the test light source with a larger M (magnitude) should have a smaller R_a value and the colour images under such light source will look better than the colour images under light source with a smaller M [1, 34].

$$T = T_1 + T_2 + \ldots + T_n \quad (4.1)$$

$$M = |T_1 + T_2 + \ldots + T_n| \quad (4.2)$$

$$R_i = 100 - 4.6\Delta Ei \quad (4.3)$$

$$R_a = \frac{1}{8}\sum_{i=1}^{8} Ri \quad (4.4)$$

At the same time, when comparing the displayed colour samples under two light sources at the same Tc, the light source with a larger T value should have a larger Ra value, and as a result the displayed colour samples under such light source will look better than the displayed colour samples under light source with a smaller T value.

Based on the results displayed in Table 4.5, the obtained outcomes in Group (I) are as follows:

2. In light source group CIE A, Figure 4.2 shows L.W.4-, 5-, 6-, and 7-Band LEDs, FL3.13 PM3016 LED and FL3.2 achieved much higher Average Total (AT) scores than other illiminants (See Table 4.6).

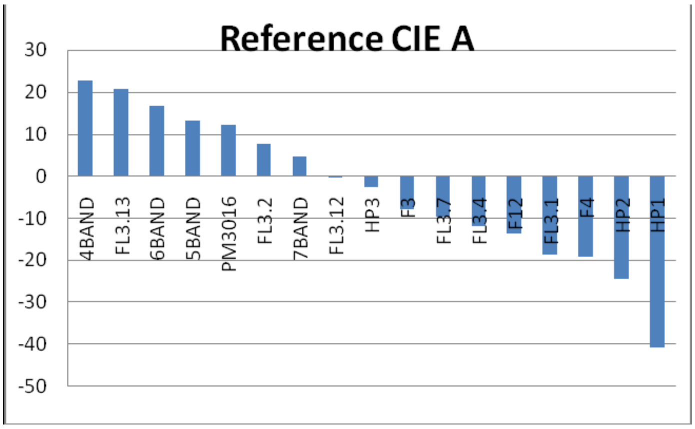


Figure 4.2-Group I total score for reference illuminants CIE A

3. Table 4.6 displays the rank of the test light sources in reference to the CIE illuminant A group. The Rank1 column displays the rank that the illuminants achieved based on their Tc and Ra, while the Rank2 column displays the rank of the test light sources by referring their AT and AM.

Table 4.6-Rank table for light sources compared with CIE Illuminat A

Test Illuminants	Tc (K)	Average Total(AT)	Average Magnitude(AM)	Rank1	Rank2	Ra from CIE CRI Program
4BAND	3848	22.8	27.2	1	1	95
FL3.13	3896	20.8	22	2	2	96
6BAND	3478	16.6	21.4	3	3	94
5BAND	3457	13.2	19.6	4	4	94
PM3016	3016	12.2	16.2	5	5	77
FL3.2	3965	7.8	13.6	6	6	70
7BAND	3492	4.6	19.4	7	7	92
FL3.12	2984	-0.4	2	8	8	93
HP3	3144	-2.6	9.4	9	9	83
F3	3450	-7.8	15.8	10	10	57
FL3.7	2979	-9.6	12.4	11	11	82
FL3.4	2904	-11.8	15.8	12	12	87
F12	3000	-13.6	17.2	13	13	83
FL3.1	2932	-18.6	22.2	14	14	51
F4	2940	-19.2	24	15	15	51
HP2	2506	-24.4	26.8	16	16	83
HP1	1959	-40.6	40.6	17	17	8

4. Figure 4.3 displays the rank of the illuminants (Rank1, blue) is same as the rank of the tested light sources (Rank2, red) in group CIE illuminant A.

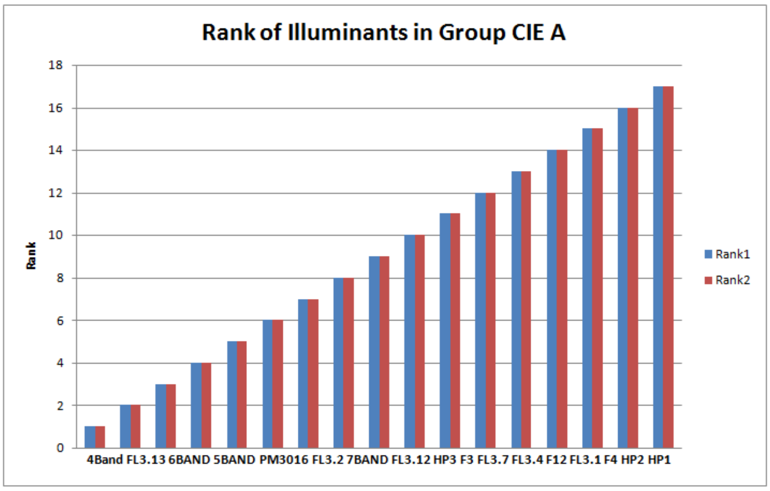


Figure 4.3-Ranking of illuminants in Group CIE A

5. Table 4.7 explains the rank of the test light sources in reference to the CIE D50 group. In this table, the Tc and Ra were calculated using CIE CRI program [48]. AT and AM columns refer to the test average total and magnitude scores respectively in Group I. The Rank1 column displays the rank of the illuminants which was achieved based on their Tc and Ra, while the Rank2 column displays the rank of the test light sources from their AT and AM.

Table 4.7-Rank table for light sources compared with CIE Illuminant D50

Test Illuminants	Tc (K)	Average Total (AT)	Average Magnitude (AM)	Rank1	Rank2	Ra from CIE CRI Program
FL3.14	5045	-1.4	1.4	1	1	95
LED3	4998	-4.2	5.4	2	2	93
F8	5000	-5.4	6.2	3	3	95
FL3.6	4894	-10.6	11	4	4	96
F10	5000	-13.6	15	5	5	81
PM4000	4000	-14.8	17.6	6	6	88
FL3.10	5000	-15	15.8	7	7	88
FL3.5	4086	-17.2	19.2	8	8	95
F9	4150	-18.2	19.4	9	9	90
F11	4000	-19.6	20.2	10	10	83
HP5	4039	-20.4	21.2	11	11	87
FL3.9	4853	-21.8	23	12	12	79
FL3.8	4006	-24.8	26	13	13	79
PM4100	4100	-25.8	27.4	14	14	90
HP4	4002	-29.4	30.6	15	15	74
F2	4230	-31	31	16	16	64
F6	4150	-31.8	31.8	17	17	59

6. Figure 4.4 displays the rank of the tested light sources (Rank2, red) verses the rank of the illuminants (Rank1, blue) (calculated by CIE CRI program) in group CIE illuminant D50. Figure 4.5 shows the AT values of illuminants (new LED 3,

FL3.14 and F8) are much larger than other light sources in the same group. Four light sources (New LED3, FL3.14, F8 and FL3.10) have larger AT values at the same (or very close) Tc were selected for Group II to test.

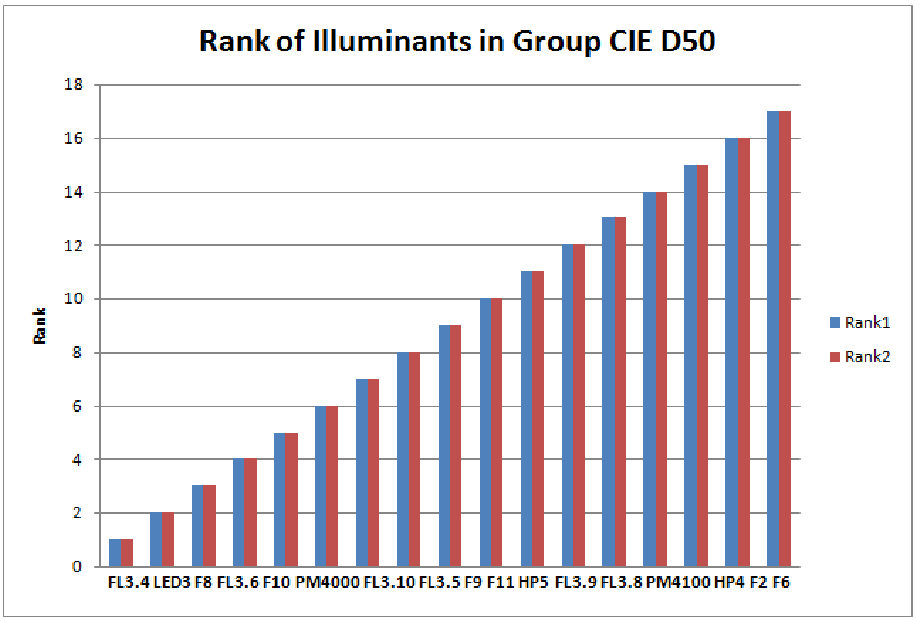


Figure 4.4-Ranking of illuminants in Group CIE D50

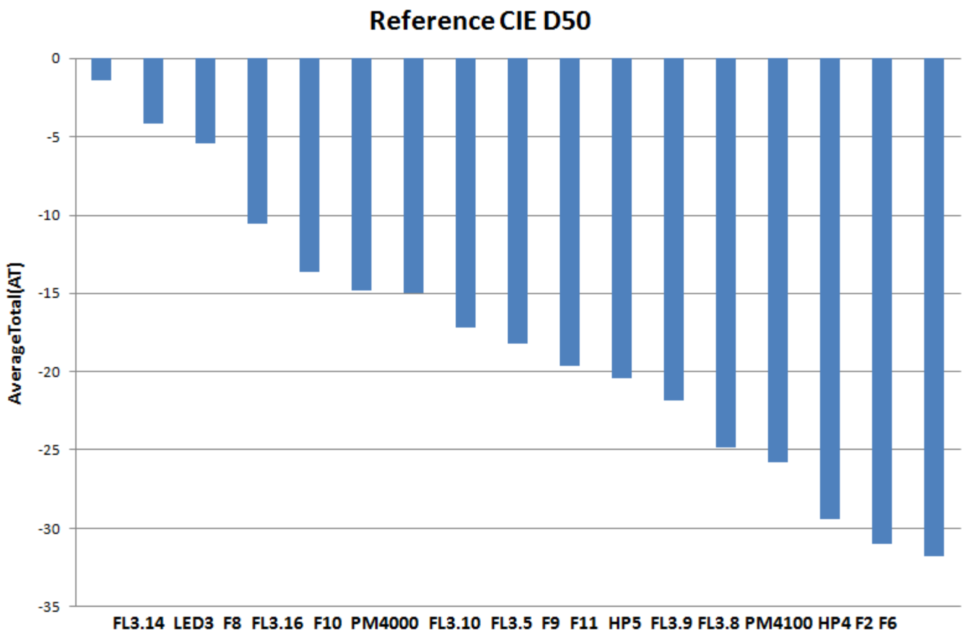


Figure 4.5-Group I average magnitude for illuminants in group CIE D50

7.

8. Table 4.8 lists the rank of the illuminants in group CIE D65, the best four light sources (which have large AT and smaller AM values) were selected for Group II to test. They are FL3.15, F7, F1 and F5.

Table 4.8-Rank table for light sources compared with CIE D65

Test Illuminants	Average Total	Average Magnitude	Rank	Ra from CIE CRI Program
FL3.15	-2.6	3.8	1	98
F7	-9.2	16.2	2	90
F1	-17.4	19	3	76
F5	-18.6	21	4	72
FL3.3	-21.8	24.6	5	72
PM6500K	-41	41	6	73

9. No light source have been selected from groups CIE Illuminants D55 and D75, because all light sources in these groups display very poor colour rendering.

4.3.2 Test Results from Group II

The results obtained from Group I show that the rank of the light sources which was achieved based on their Tc and Ra values match the rank of the light sources from their AT and AM. This means the designed VIS works properly. However, the testing time for each observer is takes 1 hour. In order to save observers‘ time and to test the VIS more fully, a shorter Group II test has been devised. In this test, 10 observers tested the selected 20 light sources using the same method as Group I observers did in part II. Table 4.9-9 displays the test results obtained from Group II.

Table 4.10 shows that the test light sources in each Tc group in Group II obtained the same rank as in Group I with the exception of the L.W. 5-Band LED and L.W.6-Band LED. However, the AT and AM values of these two light sources are very close (11.9 Vs 10.6, 12.9 Vs 12.6). Because both of these light sources have the same colour rendering index (Ra=94) and a very close (3457K and 3478K), it is very hard for subjects to tell the difference between them. The results obtained from Group II are very consistent with the results achieved by Group I. Therefore, the VIS has successfully achieved the implementation of a combination of computer graphics and processing to generate displays that aid in the visualization of the colour rendering properties of a range of light sources, including the new generation of high-output LEDs.

Table 4.9- Test results from Group I

		Test 1		**Test 2**		**Test 3**		**Test 4**		**Test 5**		**Test 6**		**Test 7**		**Test 8**		**Test 9**		**Test 10**	
Reference	**Test**	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M
A	**L.W 4-BAND**	25	25	22	24	18	18	16	16	20	20	22	22	22	22	16	16	22	24	16	20
	L.W 5-BAND	12	12	10	12	15	15	4	4	14	14	12	14	16	18	8	8	14	16	14	16
	L.W 6-BAND	12	12	10	12	15	15	4	4	14	14	12	14	7	9	1	15	15	17	16	14
	L.W 7-BAND	2	8	4	10	17	18	2	12	7	13	12	20	7	9	5	9	4	14	-2	27
	HP3	3	7	3	5	1	1	2	6	3	3	1	7	5	7	-3	11	4	8	-6	15
	FL3.2	5	7	4	8	8	8	3	5	3	5	8	14	6	14	6	8	10	14	8	20
	FL3.7	4	9	-10	10	1	3	1	7	-1	9	-7	13	-6	10	-1	11	-3	7	-3	19
	FL3.12	3	38	0	2	1	1	2	6	3	3	0	0	0	0	1	1	0	0	1	5
	FL3.13	12	12	15	17	10	10	11	11	13	13	21	21	20	20	22	22	14	16	27	29
	F12	0	0	-4	6	0	2	3	7	2	2	3	7	0	6	-6	14	-5	14	-6	14
	PM3016	4	4	7	7	8	8	5	7	8	8	5	7	8	12	14	14	14	14	-4	4
D50	**LED3**	0	0	-3	3	-3	3	-1	7	3	11	6	8	-1	1	-3	7	-3	3	-2	6
	F8	-2	2	-2	2	0	0	-4	8	-6	6	-6	8	0	0	-5	9	-2	2	4	14
	F9	-16	16	-14	14	-7	7	-14	16	-9	9	-18	20	-16	16	-23	23	-13	13	-16	16
	FL3.10	-4	4	-1	3	-2	6	-8	12	-2	4	-3	7	0	0	-10	14	-10	10	2	10
	FL3.14	-3	3	0	0	0	0	-4	8	0	0	0	0	0	0	1	1	1	1	0	8
D65	**F1**	0	0	-9	11	3	7	-5	15	-2	10	-7	11	-6	10	-12	16	-11	11	-12	16
	F5	-4	4	-12	14	3	7	-10	12	-4	8	-7	11	-4	14	-8	4	-14	14	-3	15
	F7	-3	3	-3	3	0	0	-11	13	-4	11	-6	6	-1	5	-4	17	-3	3	-4	4

Table 4.10-Comparison table of test light sources in Group I & II

(a)Light sources consistent with CIE Illuminant A

Source Compatible With	Reference Illuminant	Test Sources	Average Total(AT) (Group II)	AverageMagnitude (AM) (Group II)	Rank in Group II	Rank in Group I
Illuminant A	CIE-A	L.W.4-Band LED	19.9	20.7	1	1
	CIE-A	FL3.13	16.5	17.1	2	2
	CIE-A	L.W.5-Band LED	11.9	12.9	3	4
	CIE-A	L.W.6-Band LED	10.6	12.6	4	3
	CIE-A	PM3016	6.9	8.5	5	5
	CIE-A	FL3.2	6.1	10.3	6	6
	CIE-A	L.W.7-Band LED	5.8	14	7	7
	CIE-A	HP3	1.3	7	8	8
	CIE-A	FL3.12	1.1	5.6	9	9
	CIE-A	F12	-1.3	7.2	10	10
	CIE-A	FL3.7	-2.5	9.8	11	11

(b)Light sources consistent with CIE Illuminant D50

Source Compatible With	Reference Illuminant	Test Sources	Average Total(AT) (Group II)	Average Magnitude (AM) (Group II)	Rank in Group II	Rank in Group I
Illuminant D50	CIE-D50	FL3.14	-0.5	2.1	1	1
	CIE-D50	L.W.3-Band LED	-0.7	4.9	2	2
	CIE-D50	F8	-2.3	5.1	3	3
	CIE-D50	FL3.10	-3.8	7	4	4
	CIE-D50	F9	-14.6	15	5	5

(c)Light sources consistent with CIE Illuminant D65

Source Compatible With	Reference Illuminant	Test Sources	Average Total (AT) (Group II)	Average Magnitude (AM) (Group II)	Rank in Group II	Rank in Group I
Illuminant D65	CIE-D65	FL3.15	-4.6	6.1	1	1
	CIE-D65	F7	-4.9	7.1	2	2
	CIE-D65	F1	-6.1	10.7	3	3
	CIE-D65	F5	-6.3	10.3	4	4

4.3.3 Test Results from Group III

The methods used to analyses the test results from Group III are outlined below:

1. Compare the displayed colour samples under the reference light source with the test light source at the same colour temperature (Tc) but having a different colour rendering index (Ra)
2. Compare the displayed colour samples under the reference light source with the test light source having the same Ra , but different Tc.

Table 4.11 displays the results for the Tc and Ra values of the selected light sources in Group III. These were calculated using the CIE's CRI calculator (program) [48]. According to this table, the selected 15 test light sources were grouped as outlined below:

1) HP3, FL3.12 and PM3016 were compared with F12 (at the same Tc=3000K)
2) F11 and HP4 were compared with PM4000K LED (at the same Tc=4000K)
3) F8, FL3.10 and F10 were compared with CIED50 (at the same Tc=5000K)
4) PM5500K LED was compared with CIED55 (at the same Tc=5500K)
5) FL3.15 and F7 were compared with CIED65 (at the same Tc=6500K)
6) F7 was compared with F9, having the same Ra (90) but different Tc (6500K Vs 4150K)
7) HP2 and F11 were compared with F12, having the same Ra (83) but different Tc values (4000K, 2506K, 3000K).

Table 4.11-Ra and Tc of light sources in Group III evaluations

Lamp	Correlated colour temperature (Tcp) (Kelvin)	General colour rendering index (Ra)
F12	3000	83
FL3.12	2984	93
HP3	3144	74
PM4000K	4000	88
F11	4000	83
HP4	4002	74
D50	5002	100
F8	5000	95
FL3.10	5000	88
F10	5000	81
D55	5503	100
PM5500K	5500	86
D65	6505	100
FL3.15	6509	98
F7	6500	90
PM3016K	3016	77
HP2	2506	83
F9	4150	90

8) Table 4.12 (a) compares the calculated Ra of the illumiants under the same Tc and rank are based on their Ra value while Table 4.12 (b) compares the illuminants under the same calculated Ra but with a different Tc.

Table 4.12-Illuminants ranking table

(a)Lamps grouped according to Tc

Tcp	Lamp	Ra	Rank
3000K	FL3.12	93	1
3000K	F12	83	2
3000K	PM3016K	77	3
4000K	PM4000K	88	1
4000K	F11	83	2
4000K	HP4	74	3
5000K	D50	100	1
5000K	F8	95	2
5000K	FL3.10	88	3
5000K	F10	81	4
5500K	D55	100	1
5500K	PM5500K	86	2
6500K	D65	100	1
6500K	FL3.15	98	2
6500K	F7	90	3

(b)Lamps grouped by their Ra

Ra	Lamp	Rank
83	PM4000K	1
83	F11	2
83	HP2	3
90	F7	1
90	F9	2

Table 4.13 shows the scores obtained from Group III, where T and M refer to the Total and Magnitude score of the displayed colour samples under the test light sources and AT and AM refer to the Average Total and Magnitude score of the displayed colour samples in Group III. The test colour samples were compared against reference sources at the same Tc. Hence the AM values show inverse correlation with Ra.

Table 4.13-Test results by Group III

			Test 1		Test 2		Test 3		Test 4		Test 5		Test 6		Average	
Reference	**Test**	**Ra**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**AT**	**AM**
D50	**F8**	95	-3	7	-5	9	1	3	-8	16	-1	3	-2	2	**-3.0**	**6.7**
	FL3.10	88	-4	4	-6	8	-2	8	-14	18	-3	8	-3	3	**-5.3**	**8.2**
	F10	81	-6	10	-17	17	-6	10	-15	25	-6	10	-13	13	**-10.5**	**14.2**
D55	**PM5500**	86	-38	38	-24	24	-48	48	-25	27	-27	48	-7	13	**-28.2**	**33.0**
D65	**FL3.15**	98	0	0	0	0	0	6	-5	11	-2	6	0	4	**-1.2**	**4.5**
	F7	90	-3	3	-6	6	-2	2	0	13	-3	2	-1	5	**-2.5**	**5.2**
F9	**F7**	90	36	38	25	25	16	16	21	25	11	16	12	14	**20.2**	**22.3**
F12	**F11**	83	11	13	13	13	16	16	-6	24	17	10	4	4	**9.2**	**13.3**
	PM3016	77	9	11	10	16	8	10	4	26	5	16	6	8	**7.0**	**14.5**
	HP3	74	2	4	-2	4	-2	3	4	14	-1	3	0	0	**0.2**	**4.7**
	FL3.12	93	2	2	2	2	3	2	0	18	-5	2	2	2	**0.7**	**4.7**
	HP2	83	-6	8	-2	2	-3	3	8	20	-12	3	-5	5	**-3.3**	**6.8**
PM4000	**F11**	83	-16	16	-15	21	-10	10	13	25	-7	10	-12	14	**-7.8**	**16.0**
	HP4	74	-18	18	-20	20	-13	13	0	28	-6	13	-13	15	**-11.7**	**17.8**
F8	**FL3.10**	88	-2	2	-4	4	-2	2	-3	13	-1	2	-1	-1	**-2.2**	**3.7**

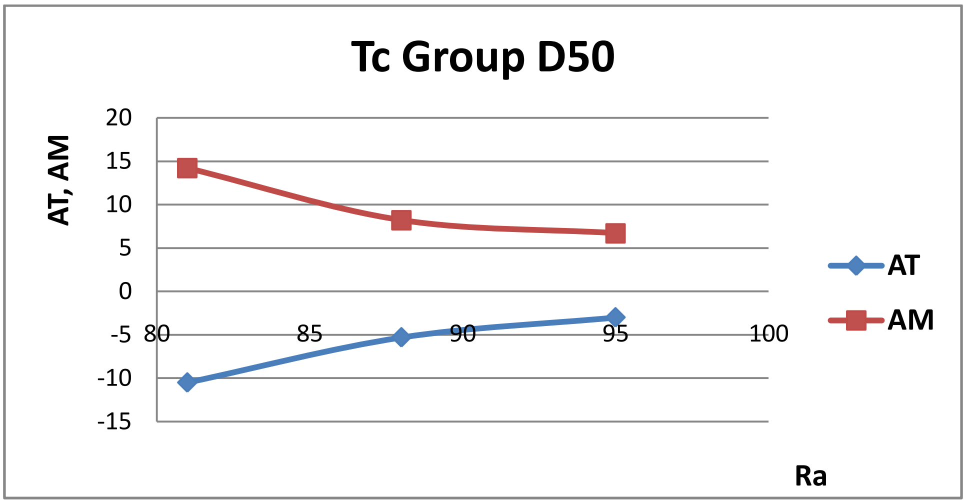


Figure 4.6 – Tc Group D50

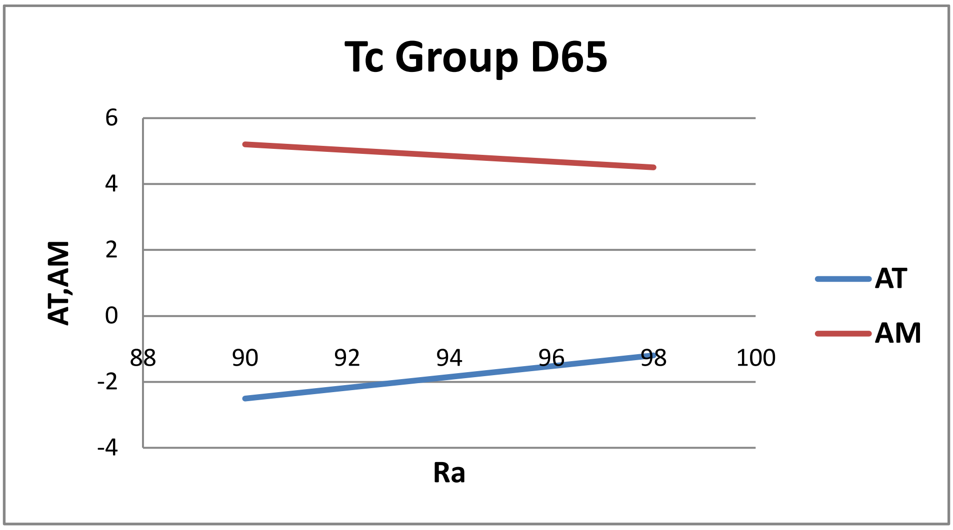


Figure 4.7 – Tc Group D65

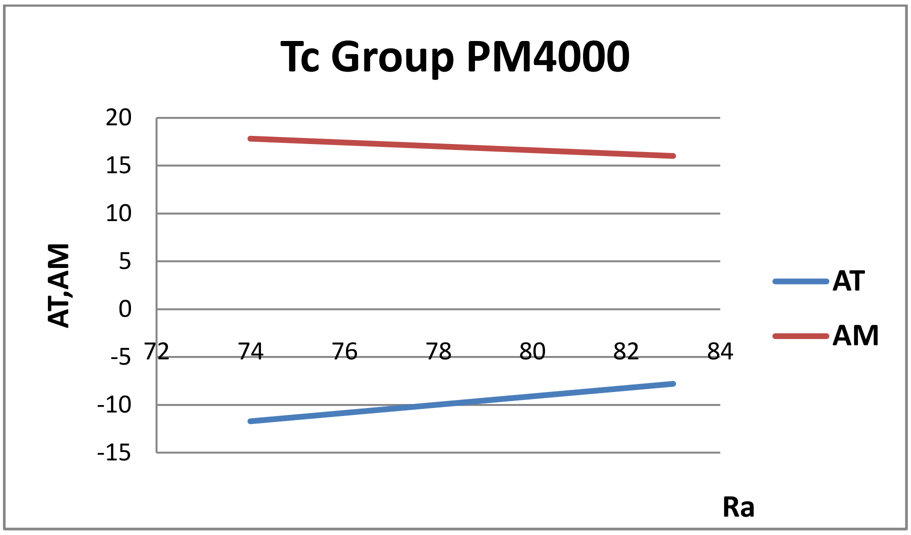


Figure 4.8 – Tc Group PM4000

Figures 4.6 to 4.8 compare the relationship between AT, AM and Ra of the tested light sources in each colour temperature group. The results show that AM value of the light source decreases when Ra value increases while the AT value increases when the Ra value increases. The following two rules have been proved:

> Rule 1: The displayed colour sample looks ―better‖ under a test light source with a larger Ra value when the test and reference light sources are at the same*Tc* .
>
> Rule 2: The displayed colour sample looks ―better‖ under a test light source with a higher *Tc* when the test and reference light sources have the same Ra.

Rule 1 has been proved by the data given in Table 4.12 (a) and diagrams plotted in Figures 4.6 to 4.8. When comparing colour samples under two light sources at the same Tc, the test light sources with larger T (total) value should have a larger Ra value and the colour images under such light source will look better than the same colour images under light source with smaller T value. In the same situation, the test light source with smaller M (magnitude) should have a larger Ra value and the colour images under such light source will look better than the same colour images under light source with larger M value.

Rule 2 has been proved by the data given in Table 4.12 (b). It is true that this only a small data set; however, it is difficult to identify sources with different colour temperatures that have the same CRI.

5 OBJECTIVE TESTING

5.1 Introduction

This chapter describes the objective testing of the VIS. The main task of the objective testing was to compute the colour appearance difference of the compared two colour samples. The colour appearance difference has been achieved from the file values and the measurements. The file values are based on CIECAM02 model and the measurements are completed with a spectrophotometer. The test method and the achieved results are detailed in this chapter.

5.2 Objective Testing Method

The objective testing includes two different test methods, one was to compute the colour difference of the displayed colour samples from the RGB values in their data files, the other was to measure and calculate the colour difference between two displayed colour samples on the monitor using the Ocean Optics HR 2000 spectrophotometer. In both cases, the results were to be computed using the CIECAM02 model. Test methods and processes are detailed in this section.

5.2.1 CIECAM02 Model

As described in Chapter 3, the system will normally be holding the [R', G', B'] values for each of the sample colours being displayed. These colours are computed separately for both the test and reference sources. The opportunity therefore exists to calculate the colour differences between corresponding pairs of samples being displayed for the two different sources. Figure 5.1 illustrates these steps.

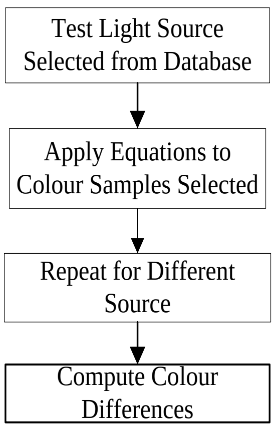


Figure 5.1-Colour difference computation model

Table 5.1 lists the 15 light sources that have been selected to compare with the four reference light sources grouped according to their Tc. The colour appearance difference from file values for samples under these light source pairs has been computed using the CIECAMO2 model. The following sources listed in Table 5.1 were chosen to provide illustrations of the calculation method.

Table 5.1-Sources used in colour appearance difference computation

Reference Illuminant	Test Sources	Nominal Tc (K)	∆E(F)
CIE-A	F12	3000	14.317
	FL3.7	2979	16.229
	FL3.4	2904	18.0822
	PM3016K	3016	23.1369
	F4	2940	24.0478
PM4000K	F11	4000	20.7263
	FL3.8	4000	22.7458
	HP4	4002	23.382
CIE-D50	F8	5000	0.578021
	FL3.10	5000	5.241996
	F10	5000	9.826677
CIE-D65	FL3.15	6500	2.76822
	F7	6500	8.06
	F1	6500	16.8605
	F5	6500	21.5753

5.2.2 Measurement

In order to test the comparisons of the different sources, the measurement method was used to measure the tristimulus values XYZ of the displayed colour samples on the CRT monitor and calculate the colour difference from these measured values. The measured colour difference is then compared with the calculated colour difference based on digital file values. The Ocean Optics HR2000 spectrophotometer was used to measure the trisitmulus XYZ values of the displayed colour samples on the CRT monitor under the test light sources and each respective reference light source.

5.2.3 The CECAM02 Model

In research paper [50], it is recognized that, at this time, there is no formally approved colour space for either the CIECAM02 or the CIECAM97s model. This research project selected to use CIECAM02 model (as explained in Section 2.4.2). Input data for the CIECAM02 model are as follows:

[X,Y,Z]—the relative tristimulus values of the test colour stimulus in the source conditions.

[Xw, Yw, Zw]—the relative tristimulus values of the source white in the source conditions, here the tristimulus values of D65 white, normalized to make Yw=100.

L_A – the adapting field luminance. This research assume L_A =16 cd/m^2.

Y – the relative luminance of the source background in the source conditions.

c – the impact of the surround = 0.69 for average surround, or = 0.59 for dim surround. This project selected c=0.69.

Nc – a chromatic induction factor = 1.0 for average surround, or = 0.9 for dim surround. In this research, Nc =1.0.

F – a factor for the degree of adaptation = 1.0 for average surround, or = 0.9 for dim surround. This research project selected F=1.0.

In this research project, the output for each sample has been computed in terms of the CIECAM02 Lightness, Chroma and Hue [*J*,*C*, *h*] , following the procedures specified in [51]. These have then been converted into rectangular coordinates [J, a_c, b_c] for the three-dimensional colour space discussed earlier, using Equation (5.1):

$$\begin{aligned} a_c &= C\cos(h) \\ b_c &= C\sin(h) \end{aligned} \qquad (5.1)$$

5.2.4 **GOG Model for the display**

To display colours on the CRT (cathode ray tube) monitor, there is a nonlinear transformation between the luminance reproduced on the screen and the corresponding input voltage, as expressed by the GOG model (More details in section 3.6.1.1). The implementation of the non-linear monitor response has been achieved in this model by use of the transformation given in Equation (5.2):

$$\begin{aligned} P' &= (1.15P - 0.15)^{\gamma} \qquad & (1.15P - 0.15) \geq 0 \\ P' &= 0 \qquad & (1.15P - 0.15) \prec 0 \end{aligned} \qquad (5.2)$$

Where P represents the normalized primary-colour content [R G B] (respectively) obtained from the numerical pixel values in the digitized version of image. The term P' gives the transformed primary-colour content $[R' \quad G' \quad B']$ (respectively) used as input to the next stage of the model. [50]

A set of nine LED sources and one fluorescent lamp were separated into five groups based on their nominal colour temperatures as shown in Table 5.2. The ten tested light sources are compared with the five different references having the closest nominal colour temperature in each instance. The fourth and fifth columns are comparing the colour difference obtained from the file values and measurement.

Table 5.2-Measure Group I

Sources Compatible With	**CIE Reference Illuminant**	**Test Sources**	**CIECAM02 Colour Difference**	
			$\Delta E_{RMS(F)}$	$\Delta E_{RMS(M)}$
Illuminant A	A	L.W 4-Band LED	23.14	21.16
		L.W.6-Band LED	15.41	12.89
Illuminant D50	D50	LED3	5.53	5.24
		PM4100	23.33	15.48
Illuminant D55	D55	PM5500	23.04	18.92
		WHITE LED	29.93	26.27
Illuminant D65	D65	F7	8.06	5.90
		PM6500	38.72	31.03
Illuminant D75	D75	NEW LED2	48.89	39.44
		L.W 3-Band LED	26.65	26.26

5.3 Objective Testing Results

5.3.1 Testing results from CIECAM02 Model

As mentioned in Chapter 2, a colour appearance difference model based on the CIECAM02 has been selected to compute the colour appearance difference (ΔE_C) of the displayed colour samples under test and reference light sources. The rank of the test light sources was based on the colour rendering properties of light sources which are detailed in Chapter 4. The RMS error in

Table 5.3 refers to the rms colour appearance difference (ΔE_{RMS}) of the 16 displayed colour samples in this research project (See Equation (5.3)). If the light sources are in the same light source group, the light source with smaller RMS Error value should have a larger Ra value, i.e. the displayed colour sample under such a light source should look better than under a light source with a larger RMS Error. Therefore, in the same illuminant group, the light source with smaller RMS Error value should get a smaller rank number. Rank numbers in

Table 5.3 are listed from smallest to largest and indicate the CR performance of the the light sources, from best to poorest [2].

$$\Delta E_{RMS} = \sqrt{\sum_{i=1}^{16} \Delta E_C / 16} \qquad (5.3)$$

Table 5.3-Colour appearance difference tables

(a)Computed results in reference CIEA group

Reference Illuminant	Test Illuminant	Correlated colour temperature(Tcp) (Kelvin)	Ra	Rank1	$\Delta E_{RMS(F)}$ from File Values	Rank2
A	F12	3000	83	2	14.317	1
	FL3.7	2979	82	1	16.229	2
	FL3.4	2904	87	3	18.0822	3
	PM3016K	3016	77	4	23.1369	4
	F4	2940	51	6	24.0478	5
	FL3.1	2932	51	5	26.163	6

(b)Computed results in reference PM4000K LED group

Reference Illuminant	Test Illuminant	Correlated colour temperature(Tcp) (Kelvin)	Ra	Rank1	$\Delta E_{RMS(F)}$ from File Values	Rank2
PM4000K	F11	4000	83	1	20.7263	1
	FL3.8	4006	79	2	22.7458	2
	HP4	4002	74	3	23.382	3

(c)Computed results in reference CIED50 group

Source Compatible With	Reference Illuminant	Test Sources	Correlated colour temperature (Tcp) (Kelvin)	Ra	Rank1	$\Delta E_{RMS(F)}$ from File Values	Rank2
Illuminant D50	**CIE-D50**	F8	5000	95	1	0.578021	1
	CIE-D50	FL3.10	5000	88	2	5.241996	2
	CIE-D50	F10	5000	81	3	9.826677	3
	CIE-D50	F9	4150	90	4	34.4335	4

(d)Computed results in reference CIED65 group

Source Compatible With	Reference Illuminant	Test Sources	Correlated colour temperature (Tcp) (Kelvin)	Ra	Rank1	$\Delta E_{RMS(F)}$ from File Values	Rank2
Illuminant D65	**CIE-D65**	FL3.15	6509	98	1	2.76822	1
	CIE-D65	F7	6500	90	2	8.06	2
	CIE-D65	F1	6430	76	3	16.8605	3
	CIE-D65	F5	6350	72	4	21.5753	4

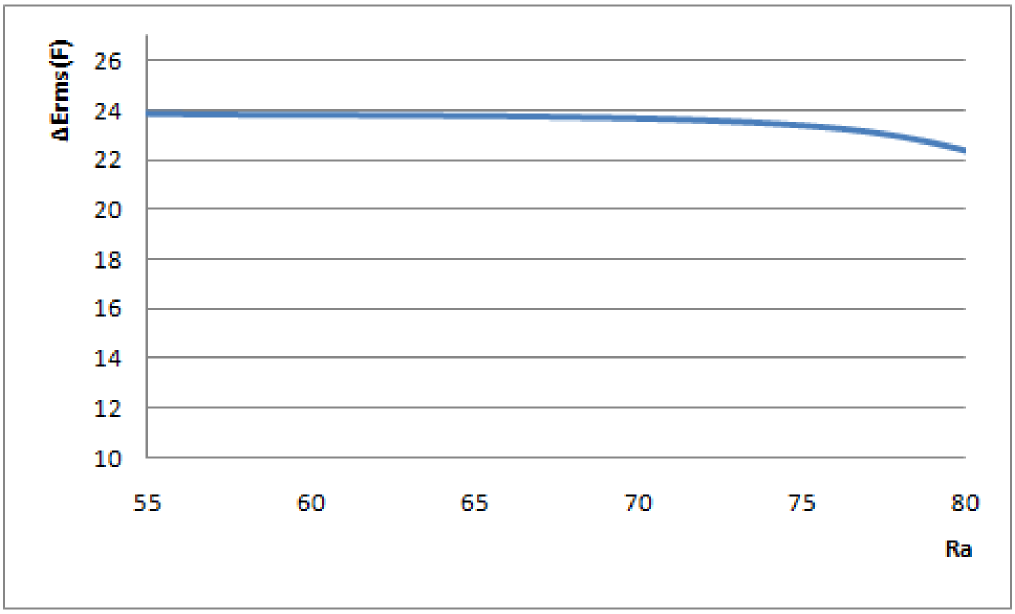


Figure 5.2- **RMS Error and Ra in Group CIE A**

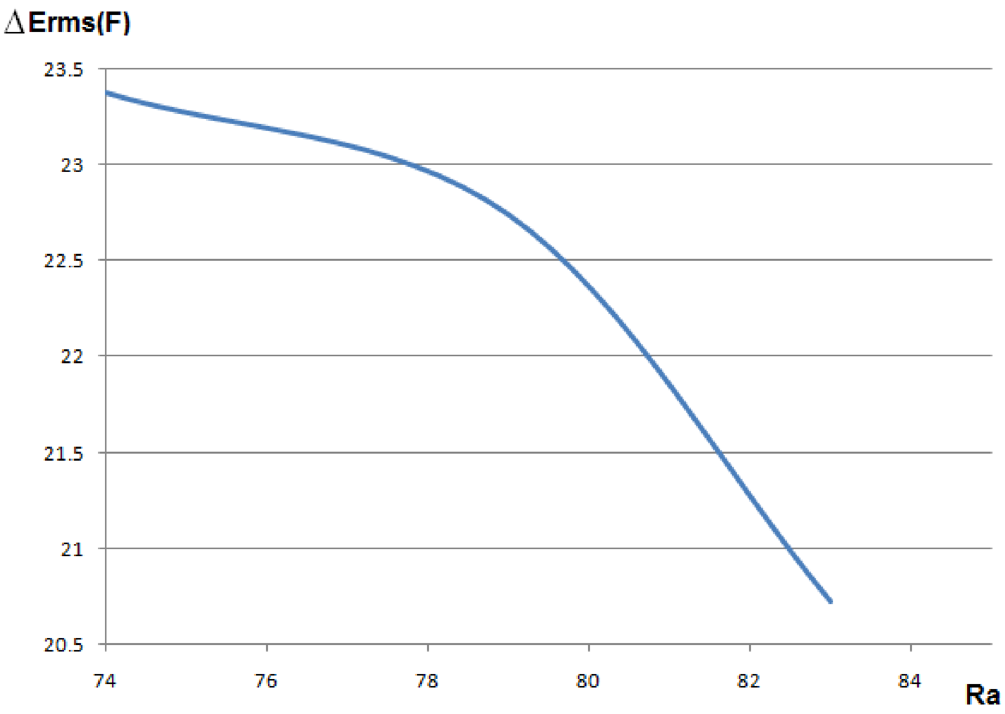


Figure 5.3- **RMS Error and Ra in Group PM4000K**

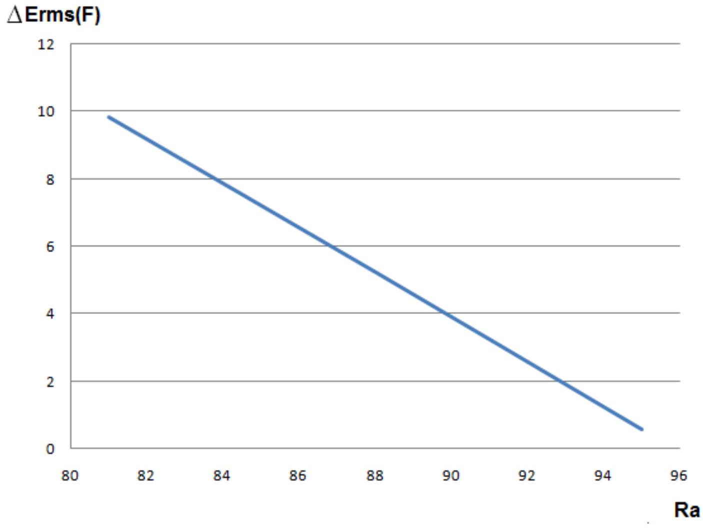


Figure 5.4- **RMS Error and Ra in Group CIE D50**

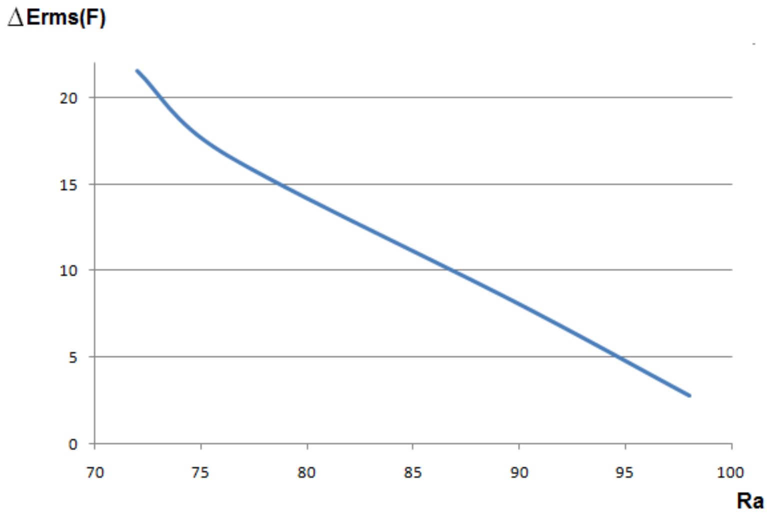


Figure 5.5- **RMS Error and Ra in Group CIE D65**

Figures 5.2 to 5.5 plot the relationship of colour appearance difference from file values ($\Delta E_{RMS(F)}$) and colour rendering (R_a) of the light sources in the same colour temperature (T_c) group. These diagrams are plotted based on the computed results that are displayed in Table 5.3. Light sources of CIE illuminant A group, are included in Figure 5.2 and it is noted that their colour temperatures were in the range 2904 K to 3016 K. It is can be seen that :

1. Comparing the colour images under the test and reference illuminants at the same (or very close) T_c, $\Delta E_{RMS(F)}$ will decreases if R_a increases (See Figures 5.2 to 5.4).

2. Comparing the same colour images under the test and reference illuminants at the same (or very close) T_c, the rank of the light sources computed from the $\Delta E_{RMS(F)}$ is the same as the rank calculated from CIE CRI program (See Table 5.3 (b),(c),(d)).

5.3.2 Test Results From Measurement

The measurement method of testing the VIS by use of HR 2000 spectrophotometer has been detailed in above. In this section, the measured results of the test light sources are displayed and analysed. Table 5.4 illustrates the measurement results and the ranks of the test light sources in the different lighting groups are compared from the measurements, CAM02 model, subjective test and Ra.

The fourth and fifth columns in Table 5.4 display the colour appearance difference (ΔE_{RMS}) under the compared light sources from the file values and measurements. These results can be calculated by use of Equation (5.3). R1, R2, R3 and R4 are comparing the rank of the light sources from each light group which was achieved using four different test methods; they are from file value, measurement, observers' test results and Ra of light sources.

Table 5.4-Comparison table of the Measurement results

			Colour Difference		**Rank Order**					
Sources Compatible With	**Reference Illuminant**	**Test Sources**	$\Delta E_{RMS(F)}$	$\Delta E_{RMS(M)}$	**R1 (F)**	**R2 (M)**	**R3 (O)**	**R4 (Ra)**	Tc	**Ra**
"Warm" White (<4000K)	CIE-A	4 BAND	23.14	21.16	2	2	2	2	3848	95
		6 BAND	15.41	12.89	1	1	1	1	3478	94
4000-5000K range	CIE-D50	LED3	5.53	5.24	1	1	1	1	4998	93
		PM4100	23.33	15.48	2	2	2	2	4100	90
5000-6000K range	CIE-D55	PM5500	23.04	18.92	1	1	1	1	5500	86
		White LED	29.93	26.27	2	2	2	2	5782	66
6000-6500K range	CIE-D65	F7	8.06	5.90	1	1	1	1	6500	90
		PM6500	38.72	31.03	2	2	2	2	6500	73
"Cold" White (>7000K)	CIE-D75	NEW LED2	48.89	39.44	2	2	2	2	7380	34
		3 BAND	26.65	26.26	1	1	1	1	9528	93

M=Measurement, F=File Values, M=Measurement; O=Observer, R=Rank,

ERMS=Error RMS, Ra=Colour rendering index; Tc = Colour tempearture

Figure shows the linear relationship between the CAM02 ΔE_{rms} and the measurement ΔE_{rms}. The equation for the regression line, and the high correlation coefficient, show good agreement between the two sets of data.

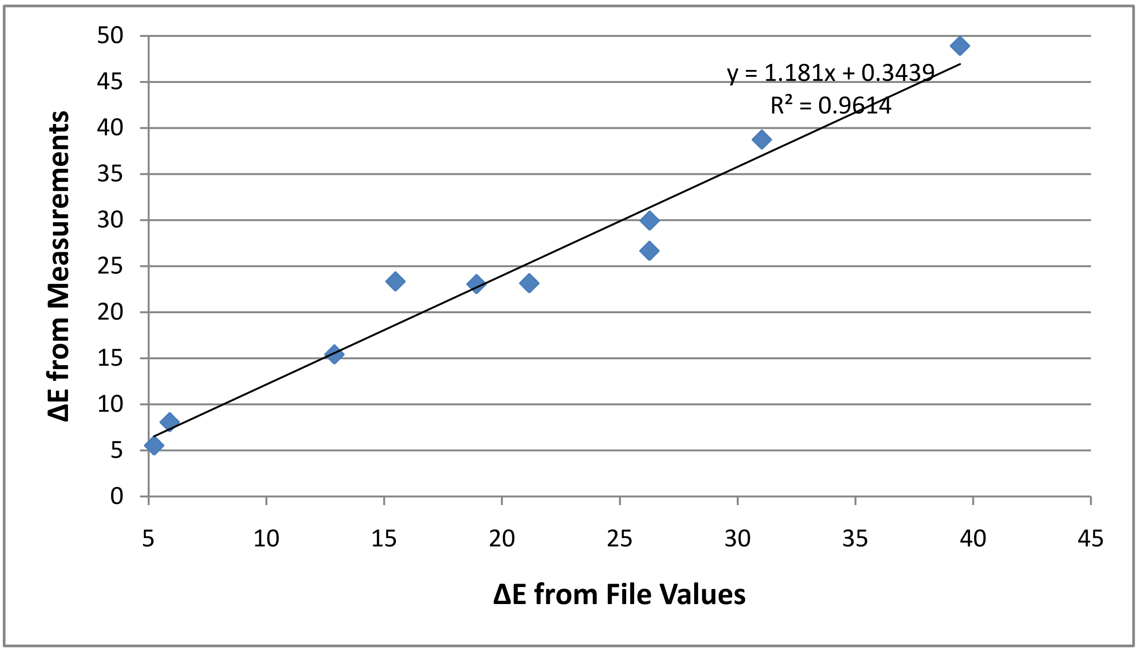


Figure 5.6-Colour difference from measurement and file values

The achieved results in Table 5.4 and Figure 5.6 show that :

1. In each test lighting group, ranks of the colour appearance difference compared with the four different test methods are the same (See R1,R2,R3 and R4 in Table 5.4).
2. Most of the colour appearance difference values between the test and reference colour samples computed from the file values are very close to that value from the measurements (See Table 5.4), except PM4100K and F7.
3. The correlation coefficient, R^2 is 0.9614, which is very close to 1. This indicates the excellent linear reliability between file values based on CAM02 model and measurements (See Figure 5.6). This means the two sets of data are correlated.

6 CONCLUSIONS

6.1 Introduction

The objective of this thesis was to develop a VIS that implements a combination of computer graphics and processing to generate displays that aid in the visualization of the colour rendering properties of a range of light sources, including new generation high-output LEDs that are becoming widely adopted in general lighting service. In this chapter, the main aspects of the research are summarized and recommendations are given for future work.

6.2 Discussion of Test Results

6.2.1 Test Results from subjective test (Refer to Chapter 4)

The results of the subjective test show that the designed VIS has the features that enable users to set up monitors to display colour images, and to select, view and compare the effects of different light sources and reference illuminants.

In part I of the Group I subjective test observers were required to select the best gamma and offset K1 values to provide that they perceived as ―good‖ image display conditions. Their average selections were 2.1 for gamma and 1.0 for K1. These values were selected as the standard settings for γ and K1 for rest of the subjective tests and for the calculations that were used to derive comparison data sets.

The results obtained from Group I show that the rank of the light sources which was based on their Tc and Ra values, matched the rank of the light sources assessed from their AT (Average Total) and AM (Average Magnitude). This means the designed VIS as required performance.

The results obtained from Group II are very consistent with the results achieved by Group I. Therefore, the VIS has successfully achieved the implementation of a combination of computer graphics and processing to generate displays that aid in the visualization of the colour rendering properties of a range of light sources, including the new generation of high-output LEDs.

The following "two rules of colour rendering properties" proposed by the author have been proved from subjective test.

1. The displayed colour sample looks "better" under a test light source with a larger Ra value when the test and reference light sources are at the same Tc.
2. The displayed colour sample looks "better" under a test light source with a higher Tc when the test and reference light sources have the same Ra.

6.2.2 Test Results from Objective Test (Refer to Chapter 5)

The achieved results from CIE CAM02 model in objective test show that:

1. Comparing the colour images under the test and reference illuminants at the same (or very close) T_c, $\Delta E_{RMS(F)}$ will decreases if R_a increases.
2. Comparing the same colour images under the test and reference illuminants at the same (or very close) T_c, the rank of the light sources computed from the $\Delta E_{RMS(F)}$ is the same as the rank calculated from CIE CRI program.

The rank orders of the colour appearance differences from file values and measurements are the same. The correlation coefficient between measurements and file values is 0.9614, which means results from measurements are very close to results computed from file values

Measurement errors could have arisen from the ingress of stray light and from imperfect light coupling between the CRT screen and the cosine-corrected sampling aperture used on the fibre-optic input to the HR2000. However, stray light was kept to practical minimum by conducting measurement in a darkened room (using dark-coloured curtain).

6.3 Outcomes of the Research Project

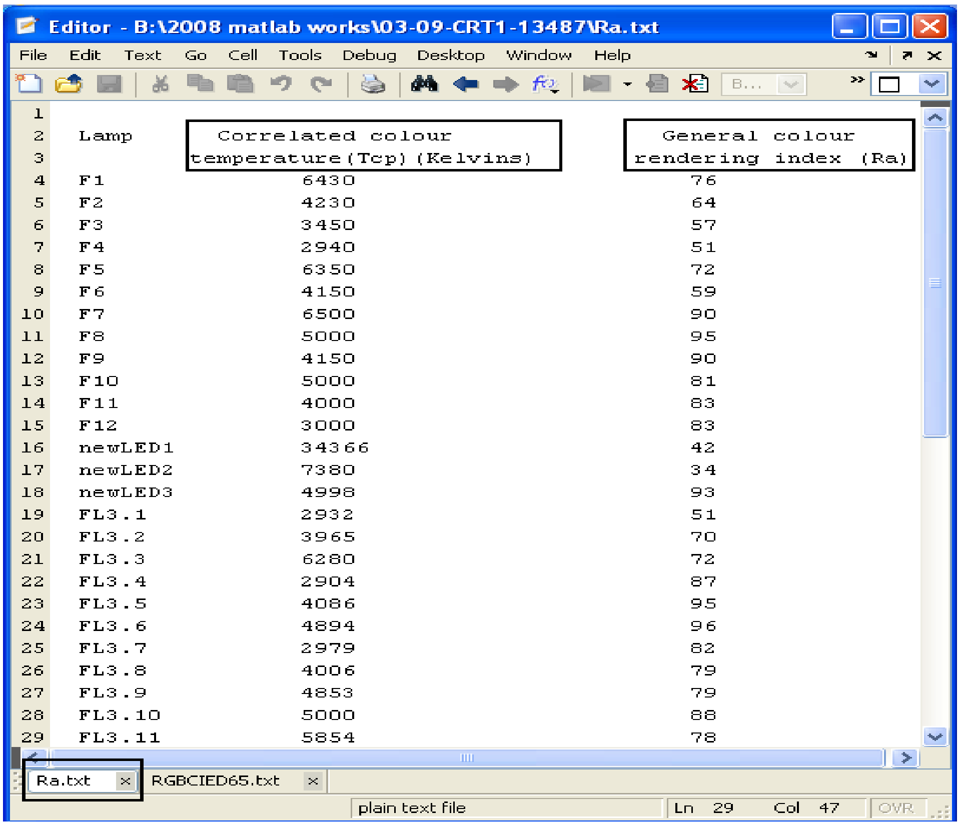
A VIS has been successfully developed as explained in Chapter 3, using MATLAB GUI. The designed MATLAB GUI application interface has been tested on a CRT monitor by 21 observers. At the time, the colour appearance difference model based on CIECAM02 was used to compute the colour appearance difference of the VIS. The outcomes of this research project are outlined as below:

1. A colour-managed computer display system that allows the user to utilize the system functionality to:
   a. Set up monitors for display (See Figure 6.2).
   b. Select light sources (from the data-base of 52 illuminants including high output LEDs).
   c. View and compare the test colour images under various test light sources (See Figure 6.2).
   d. Compute Ra and Tc of the test light source. (See Figure 6.3).
   e. Compute the [RGB] values of each displayed colour sample under different light sources. (See Figure 6.4).
   f. Compute CIECAM02 colour appearance differences.

2. A spectrum display system (SPD_GUI) has been developed to allow the user to view the SPDs of test light sources (See Figure 6.5).
3. A spectral reflectance display system (Re_GUI) has been developed to allow the user to view the reflectance of each colour sample (See Figure 6.6).
4. The structure of the system is such that the SPD data for any new sources can easily be added to the data base, and their colour rendering performance computed and analyzed.
5. In a similar way, additional or alternative test colours can be added to the colour sample data-base as soon as their spectral reflectances have been measured.

Figure 6.1-MATLAB GUI

Figure 6.2-Main GUI

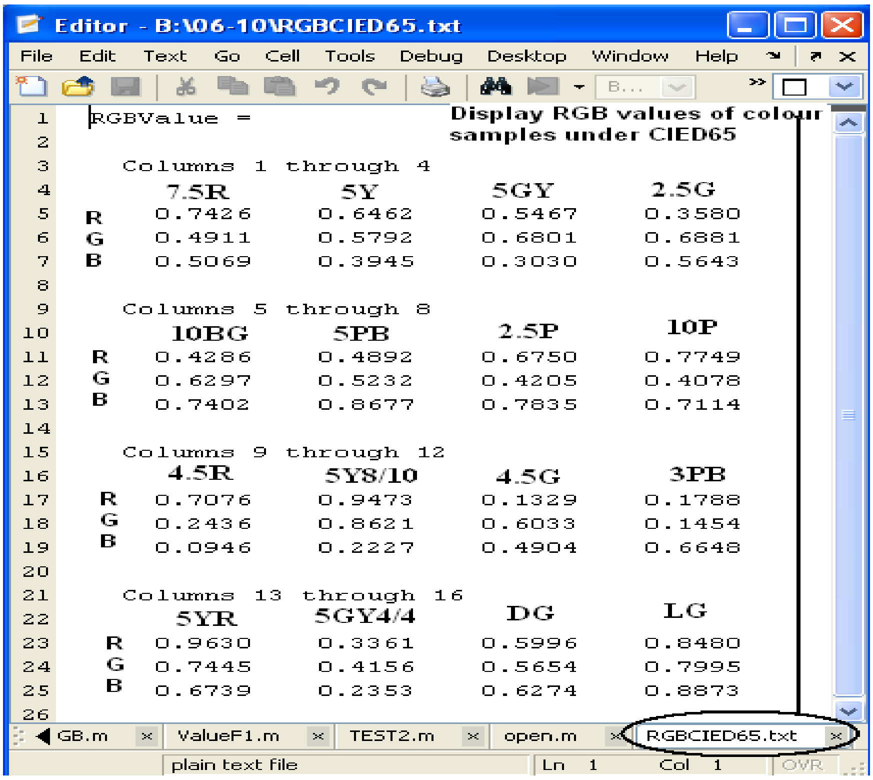


Editor - B:\2008 matlab works\03-09-CRT1-13487\Ra.txt

Lamp	Correlated colour temperature (Tcp) (Kelvins)	General colour rendering index (Ra)
F1	6430	76
F2	4230	64
F3	3450	57
F4	2940	51
F5	6350	72
F6	4150	59
F7	6500	90
F8	5000	95
F9	4150	90
F10	5000	81
F11	4000	83
F12	3000	83
newLED1	34366	42
newLED2	7380	34
newLED3	4998	93
FL3.1	2932	51
FL3.2	3965	70
FL3.3	6280	72
FL3.4	2904	87
FL3.5	4086	95
FL3.6	4894	96
FL3.7	2979	82
FL3.8	4006	79
FL3.9	4853	79
FL3.10	5000	88
FL3.11	5854	78

Ra.txt | RGBCIED65.txt | plain text file | Ln 29 Col 47 | OVR

Figure 6.3-List of available source spectra



Editor - B:\06-10\RGBCIED65.txt

RGBValue =

Display RGB values of colour samples under CIED65

Columns 1 through 4

	7.5R	5Y	5GY	2.5G
R	0.7426	0.6462	0.5467	0.3580
G	0.4911	0.5792	0.6801	0.6881
B	0.5069	0.3945	0.3030	0.5643

Columns 5 through 8

	10BG	5PB	2.5P	10P
R	0.4286	0.4892	0.6750	0.7749
G	0.6297	0.5232	0.4205	0.4078
B	0.7402	0.8677	0.7835	0.7114

Columns 9 through 12

	4.5R	5Y8/10	4.5G	3PB
R	0.7076	0.9473	0.1329	0.1788
G	0.2436	0.8621	0.6033	0.1454
B	0.0946	0.2227	0.4904	0.6648

Columns 13 through 16

	5YR	5GY4/4	DG	LG
R	0.9630	0.3361	0.5996	0.8480
G	0.7445	0.4156	0.5654	0.7995
B	0.6739	0.2353	0.6274	0.8873

GB.m | ValueF1.m | TEST2.m | open.m | RGBCIED65.txt | plain text file | Ln 1 Col 1 | OVR

Figure 6.4-Calculate RGB of displayed colours

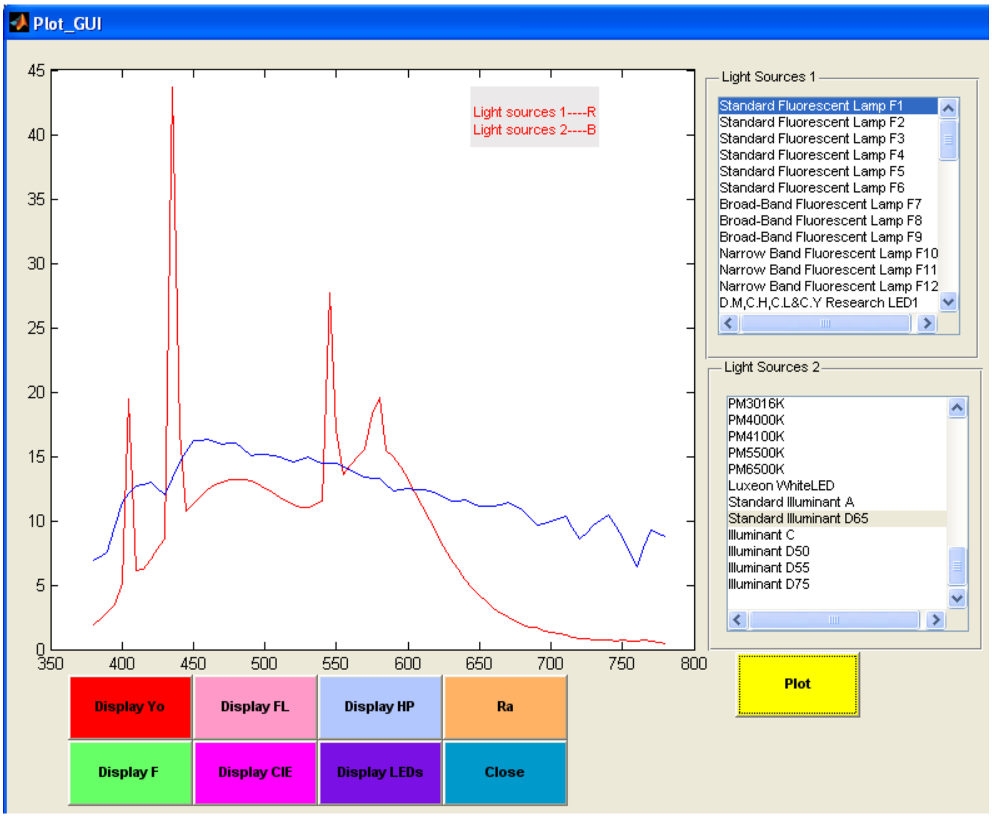


Figure 6.5-Graph of current source SPDs

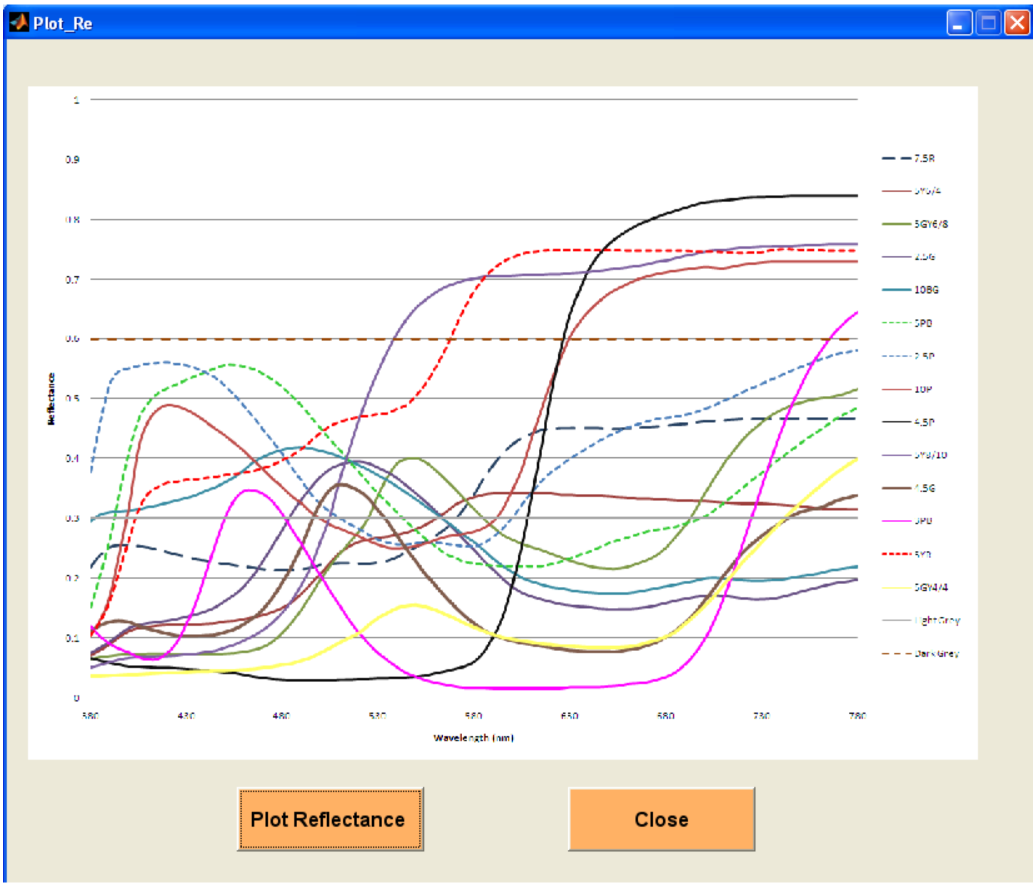


Figure 6.6-Graph of current reflectance spectra

6.4 Conclusion

The designed VIS has been tested using four different methods, the test results from the subjective and objective testing proved that a virtual imaging system has been successfully implemented. The VIS system allows the user to display and compare the 16 displayed colour samples under test and reference light sources.

The measurements using the HR2000 spectrophotometer show that after completion of the validation steps outlined in Chapter 3, it is possible to draw meaningful and valid conclusions regarding the colour rendering performance of new sources such as high output LEDs (or any other new lamps). However, the measured results and the calculated colour difference based on the CAM02 model show that not all of the new research LED light sources display colour samples as expected, especially the Philips Mixed 4100K LED and F7 lamp.

The VIS system can be extended by adding furtuer source SPDs into the existing data base. In a similar way, additional or alternative test colours can be added to the colour sample database as soon as their spectral reflectances have been measured.

6.5 Recommendation

It is a requirement of the project to verify that, as far as is technically feasible; the colour appearance differences displayed in the virtual images are accurate representations of the “real-life” experience.

The results in Chapter 4 demonstrate that the observers’ responses to the different source SPDs were largely in agreement with Ra. The measurement results in Chapter 5 show that some of the new research LEDs, especially Philips Mixed LEDs do not display colour samples as expected.

APPENDICES

APPENDIX I- REFLECTANCES

Appendix I. 1- Reflectance of 12 test colour samples

λ (nm)	5R 6/12	5P6/8	5PB6/10	5B	5BG6/6	5G6/8	5GY6/10	5Y6/10	5R 6/12	5YR6/10	8M6	3PO	764
380	0.27	0.42	0.67	0.47	0.36	0.5	0.17	-0.14	-0.06	0.18	0.03	0.08	0.74
385	0.54	0.75	1.04	0.87	0.83	0.62	0.51	0.36	0.33	0.41	0.18	0.01	0.43
390	0.46	0.7	0.74	0.82	0.72	0.43	0.38	0.17	0.22	0.19	0.02	0.05	0.52
395	0.45	0.7	0.79	0.88	0.75	0.47	0.3	0.1	0.1	0.18	0.04	0	0.43
400	0.35	0.59	0.77	0.82	0.64	0.41	0.29	0.06	0.05	0.11	0.02	0	0.36
405	0.28	0.54	0.74	0.79	0.58	0.33	0.23	0.05	0.06	0.08	0.02	0.01	0.3
410	0.25	0.48	0.73	0.79	0.52	0.31	0.2	0.06	0.06	0.08	0.02	0.01	0.27
415	0.22	0.44	0.66	0.75	0.5	0.29	0.18	0.04	0.04	0.07	0.02	0.01	0.24
420	0.22	0.42	0.65	0.75	0.5	0.28	0.18	0.05	0.05	0.06	0.03	0.01	0.24
425	0.2	0.4	0.63	0.76	0.48	0.28	0.18	0.03	0.02	0.05	0.03	0.01	0.25
430	0.21	0.4	0.63	0.76	0.5	0.29	0.18	0.03	0.03	0.06	0.03	0	0.25
435	0.2	0.4	0.62	0.77	0.5	0.3	0.18	0.03	0.03	0.05	0.04	0.01	0.26
440	0.2	0.4	0.6	0.78	0.52	0.31	0.19	0.03	0.03	0.05	0.04	0.01	0.26
445	0.19	0.4	0.59	0.79	0.53	0.32	0.21	0.03	0.03	0.06	0.05	0.01	0.27
450	0.19	0.4	0.57	0.79	0.54	0.34	0.22	0.03	0.04	0.06	0.04	0.01	0.28
455	0.19	0.39	0.56	0.8	0.55	0.37	0.23	0.04	0.04	0.06	0.05	0.01	0.3
460	0.19	0.39	0.54	0.8	0.57	0.4	0.25	0.04	0.04	0.07	0.05	0.01	0.31
465	0.18	0.37	0.51	0.79	0.58	0.43	0.27	0.04	0.03	0.07	0.04	0.01	0.32
470	0.18	0.36	0.49	0.77	0.59	0.45	0.29	0.04	0.03	0.07	0.04	0	0.34
475	0.17	0.34	0.47	0.75	0.6	0.48	0.31	0.05	0.03	0.08	0.04	0.01	0.35
480	0.17	0.33	0.45	0.73	0.6	0.51	0.34	0.05	0.04	0.09	0.04	0.01	0.36
485	0.17	0.31	0.44	0.7	0.6	0.53	0.37	0.06	0.03	0.1	0.03	0.01	0.37
490	0.16	0.3	0.42	0.67	0.6	0.54	0.4	0.08	0.04	0.11	0.03	0.01	0.38
495	0.16	0.29	0.4	0.64	0.6	0.55	0.43	0.1	0.04	0.12	0.02	0.01	0.38
500	0.16	0.28	0.38	0.6	0.59	0.55	0.46	0.13	0.05	0.13	0.02	0.01	0.37
505	0.15	0.26	0.37	0.56	0.58	0.54	0.49	0.17	0.06	0.14	0.02	0.01	0.37
510	0.15	0.25	0.36	0.53	0.56	0.53	0.51	0.22	0.09	0.15	0.01	0.01	0.37

Appendix I.1 Continued

λ (nm)	5R 6/12	5P6/8	5PB6/10	5B	5BG6/6	5G6/8	5GY6/10	5Y6/10	5R 6/12	5YR6/10	8M6	3PO	764
515	0.15	0.23	0.35	0.5	0.55	0.52	0.52	0.29	0.14	0.16	0.01	0.01	0.37
520	0.15	0.22	0.34	0.47	0.53	0.5	0.52	0.37	0.2	0.16	0.01	0.01	0.36
525	0.15	0.22	0.33	0.44	0.5	0.49	0.52	0.44	0.27	0.16	0.01	0.01	0.36
530	0.15	0.22	0.32	0.41	0.48	0.47	0.5	0.49	0.33	0.17	0.01	0.01	0.35
535	0.15	0.22	0.31	0.38	0.45	0.45	0.49	0.52	0.37	0.17	0.01	0.01	0.35
540	0.15	0.21	0.3	0.36	0.43	0.43	0.47	0.52	0.4	0.18	0.01	0.01	0.34
545	0.16	0.2	0.3	0.33	0.39	0.4	0.45	0.5	0.42	0.19	0.01	0.01	0.33
550	0.17	0.2	0.31	0.31	0.37	0.38	0.42	0.48	0.43	0.21	0.01	0.01	0.32
555	0.18	0.19	0.31	0.3	0.34	0.36	0.4	0.45	0.43	0.24	0.01	0.01	0.31
560	0.19	0.18	0.32	0.28	0.31	0.33	0.37	0.42	0.44	0.28	0.01	0.01	0.29
565	0.21	0.18	0.32	0.27	0.28	0.31	0.34	0.39	0.44	0.33	0.01	0.01	0.28
570	0.23	0.2	0.31	0.25	0.26	0.29	0.31	0.36	0.44	0.39	0.01	0.01	0.26
575	0.28	0.23	0.31	0.24	0.25	0.27	0.28	0.33	0.43	0.44	0.01	0.01	0.25
580	0.35	0.3	0.3	0.23	0.24	0.25	0.26	0.31	0.43	0.49	0.01	0.02	0.23
585	0.45	0.39	0.29	0.23	0.23	0.23	0.23	0.29	0.43	0.53	0.01	0.03	0.21
590	0.55	0.48	0.29	0.22	0.22	0.21	0.2	0.27	0.43	0.57	0.01	0.05	0.2
595	0.64	0.57	0.3	0.22	0.21	0.2	0.18	0.26	0.43	0.59	0.01	0.09	0.18
600	0.73	0.64	0.33	0.22	0.21	0.18	0.16	0.25	0.43	0.61	0.01	0.13	0.17
605	0.8	0.69	0.37	0.21	0.2	0.18	0.15	0.24	0.43	0.62	0.01	0.17	0.16
610	0.86	0.72	0.42	0.21	0.2	0.17	0.14	0.23	0.43	0.63	0.01	0.23	0.15
615	0.9	0.74	0.46	0.22	0.19	0.17	0.13	0.23	0.42	0.63	0.01	0.3	0.15
620	0.92	0.75	0.51	0.22	0.19	0.16	0.12	0.23	0.42	0.63	0.01	0.38	0.14
625	0.94	0.76	0.54	0.22	0.19	0.16	0.12	0.22	0.42	0.63	0.01	0.45	0.14
630	0.95	0.76	0.57	0.23	0.2	0.16	0.12	0.22	0.42	0.63	0.01	0.51	0.14

Appendix I.1 Continued

λ (nm)	5R 6/12	5P6/8	5PB6/10	5B	5BG6/6	5G6/8	5GY6/10	5Y6/10	5R 6/12	5YR6/10	8M6	3PO	764
635	0.96	0.76	0.6	0.23	0.2	0.15	0.11	0.22	0.42	0.63	0.01	0.55	0.14
640	0.97	0.77	0.61	0.24	0.21	0.15	0.11	0.23	0.42	0.63	0.01	0.59	0.13
645	0.97	0.76	0.63	0.25	0.21	0.15	0.1	0.23	0.42	0.63	0.01	0.62	0.13
650	0.97	0.76	0.64	0.26	0.21	0.15	0.1	0.24	0.42	0.63	0.01	0.63	0.13
655	0.97	0.76	0.66	0.27	0.22	0.15	0.1	0.25	0.41	0.63	0.01	0.65	0.13
660	0.97	0.76	0.67	0.28	0.22	0.15	0.1	0.26	0.41	0.63	0.01	0.66	0.13
665	0.97	0.76	0.68	0.29	0.22	0.15	0.1	0.26	0.41	0.62	0.01	0.68	0.13
670	0.98	0.76	0.7	0.3	0.22	0.15	0.1	0.27	0.41	0.62	0.01	0.69	0.14
675	0.98	0.76	0.71	0.31	0.21	0.15	0.1	0.29	0.41	0.62	0.01	0.69	0.14
680	0.98	0.76	0.72	0.32	0.21	0.16	0.1	0.31	0.41	0.62	0.01	0.7	0.15
685	0.97	0.75	0.73	0.32	0.2	0.16	0.1	0.33	0.4	0.61	0.01	0.7	0.15
690	0.98	0.75	0.74	0.33	0.2	0.17	0.11	0.35	0.4	0.61	0.01	0.71	0.16
695	0.98	0.75	0.75	0.34	0.2	0.17	0.11	0.36	0.4	0.61	0.01	0.71	0.16
700	0.98	0.75	0.76	0.35	0.2	0.17	0.12	0.37	0.4	0.61	0.01	0.71	0.16
705	0.98	0.75	0.77	0.36	0.2	0.17	0.12	0.38	0.4	0.61	0.01	0.71	0.16
710	0.98	0.74	0.77	0.37	0.21	0.17	0.12	0.39	0.39	0.6	0.01	0.72	0.16
715	0.98	0.74	0.78	0.38	0.21	0.17	0.12	0.42	0.39	0.6	0.01	0.72	0.16
720	0.98	0.74	0.79	0.4	0.21	0.17	0.12	0.46	0.39	0.61	0.01	0.72	0.16
725	0.98	0.73	0.79	0.41	0.21	0.16	0.12	0.51	0.39	0.6	0.01	0.72	0.16
730	0.98	0.74	0.79	0.43	0.22	0.16	0.12	0.55	0.39	0.6	0.01	0.72	0.16
735	0.98	0.74	0.8	0.44	0.22	0.16	0.13	0.58	0.39	0.6	0.01	0.72	0.16
740	0.98	0.74	0.8	0.46	0.24	0.17	0.13	0.62	0.39	0.6	0.01	0.72	0.17
745	0.98	0.74	0.8	0.49	0.26	0.17	0.14	0.65	0.39	0.59	0.01	0.72	0.17
750	0.98	0.73	0.81	0.51	0.28	0.18	0.15	0.68	0.38	0.59	0.01	0.72	0.18
755	0.98	0.74	0.8	0.53	0.29	0.19	0.16	0.7	0.38	0.59	0.01	0.72	0.18
760	0.98	0.73	0.81	0.55	0.3	0.19	0.16	0.73	0.39	0.59	0.01	0.72	0.19
765	0.98	0.73	0.8	0.58	0.32	0.2	0.17	0.75	0.38	0.59	0.01	0.72	0.19
770	0.98	0.73	0.81	0.6	0.33	0.2	0.17	0.77	0.39	0.59	0.02	0.72	0.19
775	0.97	0.73	0.81	0.61	0.33	0.2	0.17	0.77	0.38	0.59	0.02	0.73	0.2
780	0.98	0.73	0.82	0.63	0.34	0.2	0.17	0.79	0.39	0.58	0.02	0.72	0.19

Appendix I. 2 - Reflectance of 16 test colour samples

λ (nm)	**7.5R**	**5Y6/4**	**5GY6/8**	**2.5G**	**10BG**	**5PB**	**2.5P**	**10P**	**4.5P**	**5Y8/10**	**4.5G**	**3PB**	**5YR**	**5GY4/4**	**Dark Grey**	**Light Grey**
380	0.219	0.07	0.065	0.074	0.295	0.151	0.378	0.104	0.066	0.05	0.111	0.12	0.104	0.036	0.3	0.6
385	0.239	0.079	0.068	0.083	0.306	0.203	0.459	0.129	0.062	0.054	0.121	0.103	0.127	0.036	0.3	0.6
390	0.252	0.089	0.07	0.093	0.31	0.265	0.524	0.17	0.058	0.059	0.127	0.09	0.161	0.037	0.3	0.6
395	0.256	0.101	0.072	0.105	0.312	0.339	0.546	0.24	0.055	0.063	0.129	0.082	0.211	0.038	0.3	0.6
400	0.256	0.111	0.073	0.116	0.313	0.41	0.551	0.319	0.052	0.066	0.127	0.076	0.264	0.039	0.3	0.6
405	0.254	0.116	0.073	0.121	0.315	0.464	0.555	0.416	0.052	0.067	0.121	0.068	0.313	0.039	0.3	0.6
410	0.252	0.118	0.074	0.124	0.319	0.492	0.559	0.462	0.051	0.068	0.116	0.064	0.341	0.04	0.3	0.6
415	0.248	0.12	0.074	0.126	0.322	0.508	0.56	0.482	0.05	0.069	0.112	0.065	0.352	0.041	0.3	0.6
420	0.244	0.121	0.074	0.128	0.326	0.517	0.561	0.49	0.05	0.069	0.108	0.075	0.359	0.042	0.3	0.6
425	0.24	0.122	0.073	0.131	0.33	0.524	0.558	0.488	0.049	0.07	0.105	0.093	0.361	0.042	0.3	0.6
430	0.237	0.122	0.073	0.135	0.334	0.531	0.556	0.482	0.048	0.072	0.104	0.123	0.364	0.043	0.3	0.6
435	0.232	0.122	0.073	0.139	0.339	0.538	0.551	0.473	0.047	0.073	0.104	0.16	0.365	0.044	0.3	0.6
440	0.23	0.123	0.073	0.144	0.346	0.544	0.544	0.462	0.046	0.076	0.105	0.207	0.367	0.044	0.3	0.6
445	0.226	0.124	0.073	0.151	0.352	0.551	0.535	0.45	0.044	0.078	0.106	0.256	0.369	0.045	0.3	0.6
450	0.225	0.127	0.074	0.161	0.36	0.556	0.522	0.439	0.042	0.083	0.11	0.3	0.372	0.045	0.3	0.6
455	0.222	0.128	0.075	0.172	0.369	0.556	0.506	0.426	0.041	0.088	0.115	0.331	0.374	0.046	0.3	0.6
460	0.22	0.131	0.077	0.186	0.381	0.554	0.488	0.413	0.038	0.095	0.123	0.346	0.376	0.047	0.3	0.6
465	0.218	0.134	0.08	0.205	0.394	0.549	0.469	0.397	0.035	0.103	0.134	0.347	0.379	0.048	0.3	0.6
470	0.216	0.138	0.085	0.229	0.403	0.541	0.448	0.382	0.033	0.113	0.148	0.341	0.384	0.05	0.3	0.6
475	0.214	0.143	0.094	0.254	0.41	0.531	0.429	0.366	0.031	0.125	0.167	0.328	0.389	0.052	0.3	0.6
480	0.214	0.15	0.109	0.281	0.415	0.519	0.408	0.352	0.03	0.142	0.192	0.307	0.397	0.055	0.3	0.6
485	0.214	0.159	0.126	0.308	0.418	0.504	0.385	0.337	0.029	0.162	0.219	0.282	0.405	0.057	0.3	0.6
490	0.216	0.174	0.148	0.332	0.419	0.488	0.363	0.325	0.028	0.189	0.252	0.257	0.416	0.062	0.3	0.6
495	0.218	0.19	0.172	0.352	0.417	0.469	0.341	0.31	0.028	0.219	0.291	0.23	0.429	0.067	0.3	0.6
500	0.223	0.207	0.198	0.37	0.413	0.45	0.324	0.299	0.028	0.262	0.325	0.204	0.443	0.075	0.3	0.6
505	0.225	0.225	0.221	0.383	0.409	0.431	0.311	0.289	0.029	0.305	0.347	0.178	0.454	0.083	0.3	0.6
510	0.226	0.242	0.241	0.39	0.403	0.414	0.301	0.283	0.03	0.365	0.356	0.154	0.461	0.092	0.3	0.6
515	0.226	0.253	0.26	0.394	0.396	0.395	0.291	0.276	0.03	0.416	0.353	0.129	0.466	0.1	0.3	0.6
520	0.225	0.26	0.278	0.395	0.389	0.377	0.283	0.27	0.031	0.465	0.346	0.109	0.469	0.108	0.3	0.6

Appendix I.2-Continued

λ (nm)	7.5R	5Y6/4	5GY6/8	2.5G	10BG	5PB	2.5P	10P	4.5P	5Y8/10	4.5G	3PB	5YR	5GY4/4	Dark Grey	Light Grey
525	0.225	0.264	0.302	0.392	0.381	0.358	0.273	0.262	0.031	0.509	0.333	0.09	0.471	0.121	0.3	0.6
530	0.227	0.267	0.339	0.385	0.372	0.341	0.265	0.256	0.032	0.546	0.314	0.075	0.474	0.133	0.3	0.6
535	0.23	0.269	0.37	0.377	0.363	0.325	0.26	0.251	0.032	0.581	0.294	0.062	0.476	0.142	0.3	0.6
540	0.236	0.272	0.392	0.367	0.353	0.309	0.257	0.25	0.033	0.61	0.271	0.051	0.483	0.15	0.3	0.6
545	0.245	0.276	0.399	0.354	0.342	0.293	0.257	0.251	0.034	0.634	0.248	0.041	0.49	0.154	0.3	0.6
550	0.253	0.282	0.4	0.341	0.331	0.279	0.259	0.254	0.035	0.653	0.227	0.035	0.506	0.155	0.3	0.6
555	0.262	0.289	0.393	0.327	0.32	0.265	0.26	0.258	0.037	0.666	0.206	0.029	0.526	0.152	0.3	0.6
560	0.272	0.299	0.38	0.312	0.308	0.253	0.26	0.264	0.041	0.678	0.188	0.025	0.553	0.147	0.3	0.6
565	0.283	0.309	0.365	0.296	0.296	0.241	0.258	0.269	0.044	0.687	0.17	0.022	0.582	0.14	0.3	0.6
570	0.298	0.322	0.349	0.28	0.284	0.234	0.256	0.272	0.048	0.693	0.153	0.019	0.618	0.133	0.3	0.6
575	0.318	0.329	0.332	0.263	0.271	0.227	0.254	0.274	0.052	0.698	0.138	0.017	0.651	0.125	0.3	0.6
580	0.341	0.335	0.315	0.247	0.26	0.225	0.254	0.278	0.06	0.701	0.125	0.017	0.68	0.118	0.3	0.6
585	0.367	0.339	0.299	0.229	0.247	0.222	0.259	0.284	0.076	0.704	0.114	0.017	0.701	0.112	0.3	0.6
590	0.39	0.341	0.285	0.214	0.232	0.221	0.27	0.295	0.102	0.705	0.106	0.016	0.717	0.106	0.3	0.6
595	0.409	0.341	0.272	0.198	0.22	0.22	0.284	0.316	0.136	0.705	0.1	0.016	0.729	0.101	0.3	0.6
600	0.424	0.342	0.264	0.185	0.21	0.22	0.302	0.348	0.19	0.706	0.096	0.016	0.736	0.098	0.3	0.6
605	0.435	0.342	0.257	0.175	0.2	0.22	0.324	0.384	0.256	0.707	0.092	0.016	0.742	0.095	0.3	0.6
610	0.442	0.342	0.252	0.169	0.194	0.22	0.344	0.434	0.336	0.707	0.09	0.016	0.745	0.093	0.3	0.6
615	0.448	0.341	0.247	0.164	0.189	0.22	0.362	0.482	0.418	0.707	0.087	0.016	0.747	0.09	0.3	0.6
620	0.45	0.341	0.241	0.16	0.185	0.223	0.377	0.528	0.505	0.708	0.085	0.016	0.748	0.089	0.3	0.6
625	0.451	0.339	0.235	0.156	0.183	0.227	0.389	0.568	0.581	0.708	0.082	0.016	0.748	0.087	0.3	0.6
630	0.451	0.339	0.229	0.154	0.18	0.233	0.4	0.604	0.641	0.71	0.08	0.018	0.748	0.086	0.3	0.6
635	0.451	0.338	0.224	0.152	0.177	0.239	0.41	0.629	0.682	0.711	0.079	0.018	0.748	0.085	0.3	0.6
640	0.451	0.338	0.22	0.151	0.176	0.244	0.42	0.648	0.717	0.712	0.078	0.018	0.748	0.084	0.3	0.6
645	0.451	0.337	0.217	0.149	0.175	0.251	0.429	0.663	0.74	0.714	0.078	0.018	0.748	0.084	0.3	0.6
650	0.45	0.336	0.216	0.148	0.175	0.258	0.438	0.676	0.758	0.716	0.078	0.019	0.748	0.084	0.3	0.6
655	0.45	0.335	0.216	0.148	0.175	0.263	0.445	0.685	0.77	0.718	0.078	0.02	0.748	0.084	0.3	0.6
660	0.451	0.334	0.219	0.148	0.175	0.268	0.452	0.693	0.781	0.72	0.081	0.023	0.747	0.085	0.3	0.6
665	0.451	0.332	0.224	0.149	0.177	0.273	0.457	0.7	0.79	0.722	0.083	0.024	0.747	0.087	0.3	0.6

Appendix I.2-Continued

λ (nm)	7.5R	5Y6/4	5GY6/8	2.5G	10BG	5PB	2.5P	10P	4.5P	5Y8/10	4.5G	3PB	5YR	5GY4/4	Dark Grey	Light Grey
670	0.453	0.332	0.23	0.151	0.18	0.278	0.462	0.705	0.797	0.725	0.088	0.026	0.747	0.092	0.3	0.6
675	0.454	0.331	0.238	0.154	0.183	0.281	0.466	0.709	0.803	0.729	0.093	0.03	0.747	0.096	0.3	0.6
680	0.455	0.331	0.251	0.158	0.186	0.283	0.468	0.712	0.809	0.731	0.102	0.035	0.747	0.102	0.3	0.6
685	0.457	0.33	0.269	0.162	0.189	0.286	0.47	0.715	0.814	0.735	0.112	0.043	0.747	0.11	0.3	0.6
690	0.458	0.329	0.288	0.165	0.192	0.291	0.473	0.717	0.819	0.739	0.125	0.056	0.747	0.123	0.3	0.6
695	0.46	0.328	0.312	0.168	0.195	0.296	0.477	0.719	0.824	0.742	0.141	0.074	0.746	0.137	0.3	0.6
700	0.462	0.328	0.34	0.17	0.199	0.302	0.483	0.721	0.828	0.746	0.161	0.097	0.746	0.152	0.3	0.6
705	0.463	0.327	0.366	0.171	0.2	0.313	0.489	0.72	0.83	0.748	0.182	0.128	0.746	0.169	0.3	0.6
710	0.464	0.326	0.39	0.17	0.199	0.325	0.496	0.719	0.831	0.749	0.203	0.166	0.745	0.188	0.3	0.6
715	0.465	0.325	0.412	0.168	0.198	0.338	0.503	0.722	0.833	0.751	0.223	0.21	0.744	0.207	0.3	0.6
720	0.466	0.324	0.431	0.166	0.196	0.351	0.511	0.725	0.835	0.753	0.242	0.257	0.743	0.226	0.3	0.6
725	0.466	0.324	0.447	0.164	0.195	0.364	0.518	0.727	0.836	0.754	0.257	0.305	0.744	0.243	0.3	0.6
730	0.466	0.324	0.46	0.164	0.195	0.376	0.525	0.729	0.836	0.755	0.27	0.354	0.745	0.26	0.3	0.6
735	0.466	0.323	0.472	0.165	0.196	0.389	0.532	0.73	0.837	0.755	0.282	0.401	0.748	0.277	0.3	0.6
740	0.467	0.322	0.481	0.168	0.197	0.401	0.539	0.73	0.838	0.755	0.292	0.446	0.75	0.294	0.3	0.6
745	0.467	0.321	0.488	0.172	0.2	0.413	0.546	0.73	0.839	0.755	0.302	0.485	0.75	0.31	0.3	0.6
750	0.467	0.32	0.493	0.177	0.203	0.425	0.553	0.73	0.839	0.756	0.31	0.52	0.749	0.325	0.3	0.6
755	0.467	0.318	0.497	0.181	0.205	0.436	0.559	0.73	0.839	0.757	0.314	0.551	0.748	0.339	0.3	0.6
760	0.467	0.316	0.5	0.185	0.208	0.447	0.565	0.73	0.839	0.758	0.317	0.577	0.748	0.353	0.3	0.6
765	0.467	0.315	0.502	0.189	0.212	0.458	0.57	0.73	0.839	0.759	0.323	0.599	0.747	0.366	0.3	0.6
770	0.467	0.315	0.505	0.192	0.215	0.469	0.575	0.73	0.839	0.759	0.33	0.618	0.747	0.379	0.3	0.6
775	0.467	0.314	0.51	0.194	0.217	0.477	0.578	0.73	0.839	0.759	0.334	0.633	0.747	0.39	0.3	0.6
780	0.467	0.314	0.516	0.197	0.219	0.485	0.581	0.73	0.839	0.759	0.338	0.645	0.747	0.399	0.3	0.6

APPENDIX II-SPDs

Appendix II. 1- Relative spectral power distributions of illuminants representing typical fluorescent lamps

λ (nm)	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
380	1.87	1.18	0.82	0.57	1.87	1.05	2.56	1.21	0.9	1.11	0.91	0.96
385	2.36	1.48	1.02	0.7	2.35	1.31	3.18	1.5	1.12	0.8	0.63	0.64
390	2.94	1.84	1.26	0.87	2.92	1.63	3.84	1.81	1.36	0.62	0.46	0.4
395	3.47	2.15	1.44	0.98	3.45	1.9	4.53	2.13	1.6	0.57	0.37	0.33
400	5.17	3.44	2.57	2.01	5.1	3.11	6.15	3.17	2.59	1.48	1.29	1.19
405	19.49	15.69	14.36	13.75	18.91	14.8	19.37	13.08	12.8	12.16	12.68	12.48
410	6.13	3.85	2.7	1.95	6	3.43	7.37	3.83	3.05	2.12	1.59	1.12
415	6.24	3.74	2.45	1.59	6.11	3.3	7.05	3.45	2.56	2.7	1.79	0.94
420	7.01	4.19	2.73	1.76	6.85	3.68	7.71	3.86	2.86	3.74	2.46	1.08
425	7.79	4.62	3	1.93	7.58	4.07	8.41	4.42	3.3	5.14	3.33	1.37
430	8.56	5.06	3.28	2.1	8.31	4.45	9.15	5.09	3.82	6.75	4.49	1.78
435	43.67	34.98	31.85	30.28	40.76	32.61	44.14	34.1	32.62	34.39	33.94	29.05
440	16.94	11.81	9.47	8.03	16.06	10.74	17.52	12.42	10.77	14.86	12.13	7.9
445	10.72	6.27	4.02	2.55	10.32	5.48	11.35	7.68	5.84	10.4	6.95	2.65
450	11.35	6.63	4.25	2.7	10.91	5.78	12	8.6	6.57	10.76	7.19	2.71
455	11.89	6.93	4.44	2.82	11.4	6.03	12.58	9.46	7.25	10.67	7.12	2.65
460	12.37	7.19	4.59	2.91	11.83	6.25	13.08	10.24	7.86	10.11	6.72	2.49
465	12.75	7.4	4.72	2.99	12.17	6.41	13.45	10.84	8.35	9.27	6.13	2.33
470	13	7.54	4.8	3.04	12.4	6.52	13.71	11.33	8.75	8.29	5.46	2.1
475	13.15	7.62	4.86	3.08	12.54	6.58	13.88	11.71	9.06	7.29	4.79	1.91
480	13.23	7.65	4.87	3.09	12.58	6.59	13.95	11.98	9.31	7.91	5.66	3.01
485	13.17	7.62	4.85	3.09	12.52	6.56	13.93	12.17	9.48	16.64	14.29	10.83
490	13.13	7.62	4.88	3.14	12.47	6.56	13.82	12.28	9.61	16.73	14.96	11.88
495	12.85	7.45	4.77	3.06	12.2	6.42	13.64	12.32	9.68	10.44	8.97	6.88
500	12.52	7.28	4.67	3	11.89	6.28	13.43	12.35	9.74	5.94	4.72	3.43
505	12.2	7.15	4.62	2.98	11.61	6.2	13.25	12.44	9.88	3.34	2.33	1.49
510	11.83	7.05	4.62	3.01	11.33	6.19	13.08	12.55	10.04	2.35	1.47	0.92
515	11.5	7.04	4.73	3.14	11.1	6.3	12.93	12.68	10.26	1.88	1.1	0.71
520	11.22	7.16	4.99	3.41	10.96	6.6	12.78	12.77	10.48	1.59	0.89	0.6
525	11.05	7.47	5.48	3.9	10.97	7.12	12.6	12.72	10.63	1.47	0.83	0.63
530	11.03	8.04	6.25	4.69	11.16	7.94	12.44	12.6	10.78	1.8	1.18	1.1
535	11.18	8.88	7.34	5.81	11.54	9.07	12.33	12.43	10.96	5.71	4.9	4.56
540	11.53	10.01	8.78	7.32	12.12	10.49	12.26	12.22	11.18	40.98	39.59	34.4
545	27.74	24.88	23.82	22.59	27.78	25.22	29.52	28.96	27.71	73.69	72.84	65.4
550	17.05	16.64	16.14	15.11	17.73	17.46	17.05	16.51	16.29	33.61	32.61	29.48
555	13.55	14.59	14.59	13.88	14.47	15.63	12.44	11.79	12.28	8.24	7.52	7.16
560	14.33	16.16	16.63	16.33	15.2	17.22	12.58	11.76	12.74	3.38	2.83	3.08
565	15.01	17.56	18.49	18.68	15.77	18.53	12.72	11.77	13.21	2.47	1.96	2.47
570	15.52	18.62	19.95	20.64	16.1	19.43	12.83	11.84	13.65	2.14	1.67	2.27
575	18.29	21.47	23.11	24.28	18.54	21.97	15.46	14.61	16.57	4.86	4.43	5.09
580	19.55	22.79	24.69	26.26	19.5	23.01	16.75	16.11	18.14	11.45	11.28	11.96
585	15.48	19.29	21.41	23.28	15.39	19.41	12.83	12.34	14.55	14.79	14.76	15.32
590	14.91	18.66	20.85	22.94	14.64	18.56	12.67	12.53	14.65	12.16	12.73	14.27
595	14.15	17.73	19.93	22.14	13.72	17.42	12.45	12.72	14.66	8.97	9.74	11.86
600	13.22	16.54	18.67	20.91	12.69	16.09	12.19	12.92	14.61	6.52	7.33	9.28

λ (nm)	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
605	12.19	15.21	17.22	19.43	11.57	14.64	11.89	13.12	14.5	8.31	9.72	12.31
610	11.12	13.8	15.65	17.74	10.45	13.15	11.6	13.34	14.39	44.12	55.27	68.53
615	10.03	12.36	14.04	16	9.35	11.68	11.35	13.61	14.4	34.55	42.58	53.02
620	8.95	10.95	12.45	14.42	8.29	10.25	11.12	13.87	14.47	12.09	13.18	14.67
625	7.96	9.65	10.95	12.56	7.32	8.95	10.95	14.07	14.62	12.15	13.16	14.38
630	7.02	8.4	9.51	10.93	6.41	7.74	10.76	14.2	14.72	10.52	12.26	14.71
635	6.2	7.32	8.27	9.52	5.63	6.69	10.42	14.16	14.55	4.43	5.11	6.46
640	5.42	6.31	7.11	8.18	4.9	5.71	10.11	14.13	14.4	1.95	2.07	2.57
645	4.73	5.43	6.09	7.01	4.26	4.87	10.04	14.34	14.58	2.19	2.34	2.75
650	4.15	4.68	5.22	6	3.72	4.16	10.02	14.5	14.88	3.19	3.58	4.18
655	3.64	4.02	4.45	5.11	3.25	3.55	10.11	14.46	15.51	2.77	3.01	3.44
660	3.2	3.45	3.8	4.36	2.83	3.02	9.87	14	15.47	2.29	2.48	2.81
665	2.81	2.96	3.23	3.69	2.49	2.57	8.65	12.58	13.2	2	2.14	2.42
670	2.47	2.55	2.75	3.13	2.19	2.2	7.27	10.99	10.57	1.52	1.54	1.64
675	2.18	2.19	2.33	2.64	1.93	1.87	6.44	9.98	9.18	1.35	1.33	1.36
680	1.93	1.89	1.99	2.24	1.71	1.6	5.83	9.22	8.25	1.47	1.46	1.49
685	1.72	1.64	1.7	1.91	1.52	1.37	5.41	8.62	7.57	1.79	1.94	2.14
690	1.67	1.53	1.55	1.7	1.48	1.29	5.04	8.07	7.03	1.74	2	2.34
695	1.43	1.27	1.27	1.39	1.26	1.05	4.57	7.39	6.35	1.02	1.2	1.42
700	1.29	1.1	1.09	1.18	1.13	0.91	4.12	6.71	5.72	1.14	1.35	1.61
705	1.19	0.99	0.96	1.03	1.05	0.81	3.77	6.16	5.25	3.32	4.1	5.04
710	1.08	0.88	0.83	0.88	0.96	0.71	3.46	5.63	4.8	4.49	5.58	6.98
715	0.96	0.76	0.71	0.74	0.85	0.61	3.08	5.03	4.29	2.05	2.51	3.19
720	0.88	0.68	0.62	0.64	0.78	0.54	2.73	4.46	3.8	0.49	0.57	0.71
725	0.81	0.61	0.54	0.54	0.72	0.48	2.47	4.02	3.43	0.24	0.27	0.3
730	0.77	0.56	0.49	0.49	0.68	0.44	2.25	3.66	3.12	0.21	0.23	0.26
735	0.75	0.54	0.46	0.46	0.67	0.43	2.06	3.36	2.86	0.21	0.21	0.23
740	0.73	0.51	0.43	0.42	0.65	0.4	1.9	3.09	2.64	0.24	0.24	0.28
745	0.68	0.47	0.39	0.37	0.61	0.37	1.75	2.85	2.43	0.24	0.24	0.28
750	0.69	0.47	0.39	0.37	0.62	0.38	1.62	2.65	2.26	0.21	0.2	0.21
755	0.64	0.43	0.35	0.33	0.59	0.35	1.54	2.51	2.14	0.17	0.24	0.17
760	0.68	0.46	0.38	0.35	0.62	0.39	1.45	2.37	2.02	0.21	0.32	0.21
765	0.69	0.47	0.39	0.36	0.64	0.41	1.32	2.15	1.83	0.22	0.26	0.19
770	0.61	0.4	0.33	0.31	0.55	0.33	1.17	1.89	1.61	0.17	0.16	0.15
775	0.52	0.33	0.28	0.26	0.47	0.26	0.99	1.61	1.38	0.12	0.12	0.1
780	0.43	0.27	0.21	0.19	0.4	0.21	0.81	1.32	1.12	0.09	0.09	0.05

Appendix II. 2- High pressure discharge lamps

	HP1	HP2	HP3	HP4	HP5
380	0.38	0.53	0.63	1.96	0.07
385	0.44	0.55	1.50	2.66	1.42
390	0.50	0.68	2.17	3.99	2.30
395	0.54	0.74	2.51	5.16	2.99
400	0.62	0.87	2.59	4.94	2.99
405	0.86	1.10	4.26	9.53	5.83
410	0.76	1.19	5.26	10.89	7.62
415	0.84	1.44	6.04	12.76	10.31
420	0.96	1.80	8.61	17.10	12.51
425	1.04	2.05	5.92	12.11	11.12
430	1.18	2.50	4.64	7.67	8.40
435	1.48	3.36	7.06	17.64	10.00
440	1.58	3.21	5.26	8.99	8.43
445	1.14	3.05	4.86	7.13	7.81
450	2.58	4.52	4.58	6.15	8.10
455	1.34	4.01	5.24	6.75	9.06
460	0.86	3.03	5.86	8.16	10.20
465	4.16	5.05	5.06	6.75	9.84
470	2.60	5.61	5.63	7.06	9.81
475	1.34	3.20	4.81	6.51	9.22
480	0.28	2.08	4.36	5.89	9.15
485	0.30	2.22	4.10	5.23	7.89
490	0.64	2.69	4.61	5.99	8.88
495	3.64	4.52	5.40	6.57	9.23
500	11.25	9.94	6.19	6.72	9.91
505	0.58	3.44	6.14	8.23	11.95
510	0.42	3.42	5.43	6.59	9.69
515	2.68	5.45	5.91	6.43	9.68
520	0.42	4.00	6.84	6.89	9.74
525	0.40	4.31	6.00	6.02	8.85
530	0.44	4.67	8.24	8.23	10.88
535	0.46	5.13	34.63	37.42	25.79
540	0.52	5.94	28.27	20.27	16.25
545	1.02	8.62	13.00	24.79	13.47
550	2.28	19.66	6.77	8.49	9.70
555	3.10	25.12	6.85	6.95	10.28
560	4.16	26.91	6.66	6.36	9.78
565	11.13	29.94	10.56	10.93	13.70
570	50.81	33.22	14.86	11.49	16.17
575	11.23	19.76	9.59	14.09	13.20
580	22.36	6.09	9.84	13.90	11.89
585	59.60	0.23	19.21	9.87	13.51
590	28.51	0.08	17.08	36.67	25.67
595	66.97	0.33	35.04	32.43	26.37
600	37.88	4.28	30.75	21.87	20.34
605	23.56	15.22	24.04	14.48	15.41
	HP1	**HP2**	**HP3**	**HP4**	**HP5**
610	15.99	25.23	19.78	14.12	13.25
615	21.62	32.40	18.05	11.62	15.42
620	9.37	32.01	14.01	8.83	12.10
625	7.63	31.64	13.37	10.04	13.05
630	6.49	30.74	11.52	8.16	11.57
635	5.67	29.48	10.61	7.58	11.24
640	5.07	28.12	9.97	7.34	10.87
645	4.60	26.99	9.63	7.66	11.27
650	4.08	25.51	8.55	6.25	9.15
655	3.96	24.93	10.13	7.06	10.16
660	3.56	23.60	9.68	9.12	11.33
665	3.36	22.79	8.25	7.16	10.40
670	3.84	23.62	8.69	17.98	16.86
675	3.60	23.03	8.10	7.20	9.50
680	2.74	20.57	7.03	6.51	9.49
685	2.00	18.11	6.99	7.85	12.36
690	1.64	16.67	4.94	4.65	6.90
695	1.52	15.89	4.94	5.06	7.75
700	1.40	15.39	4.30	4.00	6.20
705	1.36	14.97	3.90	3.51	5.09
710	1.30	14.62	3.70	3.25	4.58
715	1.28	14.30	3.51	3.04	4.16
720	1.22	14.03	3.47	3.03	4.21
725	1.20	13.81	3.42	3.04	4.16
730	1.16	13.50	3.26	2.85	3.74
735	1.16	13.34	3.21	2.53	3.51
740	1.16	13.26	3.32	2.95	3.92
745	1.16	13.03	3.16	2.64	3.28
750	1.28	13.14	3.53	3.53	4.75
755	1.20	12.95	4.09	4.68	7.08
760	1.12	12.82	3.32	3.20	4.27
765	6.39	16.61	3.56	4.89	6.92
770	5.57	17.25	3.21	4.41	6.04
775	1.18	12.79	2.97	3.22	3.94
780	1.34	12.98	2.92	2.58	3.12

Appendix II. 3-Relative spectral power distributions of illuminants representing new set of fluorescent lamps.

λ (nm)	FL3.1	FL3.2	FL3.3	FL3.4	FL3.5	FL3.6	FL3.7
380	0.4780	1.1600	1.7880	0.6920	0.9440	1.1060	0.7580
385	0.5860	1.3980	2.2420	0.7720	1.1640	1.3260	0.5120
390	0.7640	1.7400	2.8160	0.8820	1.4360	1.6140	0.3820
395	0.8460	1.9780	3.2960	0.9020	1.6780	1.8900	0.2840
400	0.9940	2.3180	3.9260	0.9720	1.9920	2.2560	0.3020
405	17.2600	18.9060	23.2660	14.2440	11.7720	12.2940	14.7280
410	2.3300	4.1600	6.4140	1.7440	3.1560	3.5600	1.4740
415	1.4180	3.3040	5.9440	1.0720	3.0200	3.4940	0.9380
420	1.5680	3.6600	6.6780	1.1220	3.4600	4.0240	1.0660
425	1.7180	4.0660	7.3880	1.1820	3.9320	4.6100	1.3500
430	1.8880	4.4000	8.0660	1.2840	4.4860	5.2740	1.7020
435	39.3080	46.3800	52.5320	38.5540	35.2000	37.2020	36.3620
440	2.1880	5.1620	9.3740	1.5540	5.7340	6.7880	2.3420
445	2.2760	5.5260	9.9580	1.6740	6.3840	7.5960	2.3920
450	2.3780	5.8200	10.4920	1.8440	7.0760	8.4240	2.4360
455	2.4740	6.1220	10.9620	2.0360	7.7460	9.2760	2.3800
460	2.5620	6.3840	11.3620	2.2360	8.3960	10.0600	2.2320
465	2.6300	6.6220	11.6880	2.4560	8.9840	10.7900	2.2440
470	2.6780	6.7660	11.9040	2.6760	9.4980	11.3880	1.9660
475	2.7120	6.9400	12.0240	2.9080	9.9160	11.8960	1.7880
480	2.7180	7.0040	12.0480	3.1480	10.2420	12.2720	2.4160
485	2.7120	7.0440	11.9760	3.4180	10.4720	12.5360	10.5120
490	2.8140	7.1620	11.9760	3.9200	10.7980	12.8680	11.0840
495	2.6780	7.0280	11.7200	4.2100	10.7560	12.7800	6.3380
500	2.6580	7.0280	11.5700	4.7920	10.8080	12.7700	3.2060
505	2.6500	6.9800	11.2580	5.5540	10.7760	12.6480	1.3440
510	2.7060	6.9400	10.9620	6.5360	10.7240	12.4920	0.9180
515	2.8480	7.0040	10.6840	7.6580	10.6500	12.2820	0.7340
520	3.1480	7.2260	10.5400	8.7520	10.6180	12.0940	0.6040
525	3.6520	7.5840	10.5000	9.5440	10.5760	11.8960	0.6420
530	4.4560	8.1240	10.6600	10.0540	10.5980	11.7300	0.9800
535	5.5940	8.9400	10.9780	10.3560	10.6300	11.5860	3.8100
540	7.1400	9.9260	11.5220	10.5360	10.7340	11.4980	35.5280
545	29.7960	30.8320	36.5500	33.4720	33.5860	35.0340	69.4680
550	11.3100	12.4420	13.0540	11.0580	11.1220	11.4540	23.3600
555	13.7360	13.7840	13.8820	11.3880	11.3640	11.4980	6.3740
560	15.9980	15.1660	14.6560	11.8600	11.6780	11.5980	3.2740
565	18.2940	16.3900	15.3120	12.4300	12.0440	11.7520	2.9840
570	20.2640	17.3900	15.7340	13.0520	12.4420	11.9280	2.8240
575	24.6320	20.7080	19.1480	16.8520	16.2900	15.7540	5.9000

λ (nm)	FL3.1	FL3.2	FL3.3	FL3.4	FL3.5	FL3.6	FL3.7
580	25.9060	21.9880	19.4440	17.8440	16.9920	16.2520	12.2800
585	23.0100	18.3900	15.3580	15.1580	13.7420	12.6360	17.0100
590	22.6960	17.9700	14.6720	15.8380	14.1400	12.8580	12.9720
595	22.0160	17.4300	13.8660	16.5600	14.6020	13.1560	13.0020
600	20.8560	16.6520	12.8460	17.1520	14.9380	13.3540	10.6340
605	19.5960	15.7860	11.7840	17.7240	15.2520	13.5540	6.8440
610	17.9200	14.7860	10.6760	18.2240	15.5360	13.7200	85.4540
615	16.1480	13.7680	9.5820	18.6860	15.7340	13.8200	40.2200
620	14.3840	12.6880	8.5220	19.3780	16.0280	14.0300	11.7260
625	12.7000	11.7680	7.5480	20.2900	16.3420	14.3380	14.4020
630	11.0920	10.7680	6.6220	20.7300	16.4160	14.3940	17.6380
635	9.5940	9.8860	5.8080	20.0600	15.9960	13.9620	4.0140
640	8.2780	9.1080	5.0580	19.5780	15.6300	13.6100	2.6200
645	7.1000	8.3060	4.4200	19.3180	15.3040	13.3320	2.5840
650	6.0640	7.6620	3.8620	21.2420	15.8400	13.9400	4.9080
655	5.1580	6.9240	3.3680	21.9940	15.9020	14.0740	3.1880
660	4.3680	6.3600	2.9360	23.4980	16.2160	14.4940	2.7120
665	3.7060	5.8040	2.5780	19.2080	14.1520	12.4600	2.6760
670	3.1340	5.3440	2.2740	16.0300	12.5160	10.8900	1.6840
675	2.6440	4.8440	1.9940	14.0840	11.3740	9.8400	1.3140
680	2.2280	4.4380	1.7640	13.0020	10.5660	9.1200	1.4360
685	1.8800	4.0820	1.5720	12.0300	9.8220	8.4800	1.9800
690	1.7300	3.8200	1.5560	11.2080	9.2560	8.0040	2.2940
695	1.3500	3.3580	1.2600	10.1840	8.4480	7.2960	1.7760
700	1.1380	3.0260	1.1340	9.2520	7.7160	6.6560	0.6100
705	0.9740	2.7640	1.0300	8.5200	7.1180	6.1680	4.4080
710	0.8580	2.5260	0.9820	7.7700	6.5520	5.6600	8.5580
715	0.7080	2.2780	0.8620	7.0180	5.9220	5.1300	2.8800
720	0.6060	2.0640	0.7980	6.3460	5.3780	4.6660	0.3760
725	0.5240	1.8420	0.7340	5.7540	4.9060	4.2460	0.3200
730	0.4560	1.7780	0.6860	5.1520	4.4340	3.8580	0.2840
735	0.3880	1.5000	0.6380	4.6320	4.0040	3.4820	0.2100
740	0.3400	1.3420	0.5900	4.2600	3.6900	3.2620	0.2460
745	0.3000	1.2220	0.5500	3.7100	3.2180	2.8420	0.3520
750	0.2720	1.0800	0.5260	3.5480	3.1240	2.8080	0.1480
755	0.2320	0.9600	0.4860	2.9480	2.6200	2.3100	0.1040
760	0.9820	1.7400	1.4280	2.5860	2.3380	2.0780	0.8200
765	0.1900	0.8020	0.4380	2.7260	2.4840	2.2560	0.0920
770	0.3000	0.8180	0.5420	2.0860	1.8860	1.7020	0.1980
775	0.1780	0.6600	0.4000	1.9340	1.7920	1.6480	0.0860
780	0.1360	0.5640	0.3600	1.6140	1.4780	1.4040	0.0000

Appendix II. 4 -Relative spectral power distributions of illuminants representing new set of fluorescent lamps.

λ (nm)	FL3.8	FL3.9	FL3.10	FL3.11	FL3.12	FL3.13	FL3.14	FL3.15
380	0.836	0.754	0.195	0.770	0.324	0.446	0.574	8.784
385	0.586	0.528	0.000	0.582	0.412	0.584	0.738	8.374
390	0.458	0.412	0.000	0.512	0.542	0.782	0.974	7.847
395	0.396	0.374	0.000	0.518	0.622	0.910	1.164	7.144
400	0.488	0.510	0.539	0.726	0.734	1.092	1.434	8.901
405	14.140	14.336	16.603	14.908	14.920	15.480	14.442	17.012
410	2.038	2.410	1.704	2.938	1.776	2.250	2.738	6.588
415	1.958	2.714	1.454	3.444	0.954	1.538	2.224	4.538
420	2.642	3.920	2.439	0.998	0.944	1.658	2.486	4.451
425	3.558	5.466	3.908	6.880	0.944	1.796	2.780	4.978
430	4.596	7.078	5.495	8.914	0.988	2.002	3.164	8.638
435	38.286	42.364	35.238	45.616	30.058	40.890	40.198	41.490
440	6.352	9.804	13.117	12.306	1.216	2.750	4.344	17.773
445	6.670	10.366	9.599	13.062	1.426	3.376	5.266	10.043
450	6.774	10.500	10.404	13.270	1.820	4.346	6.570	11.302
455	6.578	10.146	10.678	12.874	2.352	5.592	8.160	12.590
460	6.120	9.386	10.701	11.962	2.992	6.984	9.846	13.732
465	5.656	8.484	10.263	10.848	3.708	8.392	11.478	14.699
470	4.962	7.432	9.599	9.484	4.496	9.724	13.052	15.548
475	4.320	6.368	8.927	8.220	5.352	10.866	14.398	16.163
480	4.680	6.388	9.114	8.008	6.332	11.898	15.650	16.602
485	13.798	15.548	17.228	17.108	8.186	13.582	17.770	16.748
490	14.170	15.890	20.456	17.310	9.166	14.002	18.334	16.836
495	8.458	9.586	14.516	10.694	9.200	13.280	17.362	16.426
500	4.534	5.248	8.880	6.182	9.052	12.414	16.084	16.045
505	2.216	2.630	5.339	3.482	8.632	11.390	14.764	15.431
510	1.532	1.760	4.362	2.512	8.326	10.540	13.824	14.845
515	1.214	1.340	3.815	2.020	7.950	9.708	12.738	14.113
520	1.014	1.076	3.369	1.696	7.566	8.960	11.688	13.498
525	0.976	0.986	2.939	1.548	7.232	8.350	10.714	12.825
530	1.252	1.212	2.822	1.716	7.050	7.954	9.932	12.239
535	4.058	3.952	4.393	4.278	7.408	8.100	9.688	11.829
540	40.934	43.188	30.165	44.024	11.972	11.854	14.512	12.561
545	78.050	82.426	78.168	83.470	36.706	36.818	40.084	29.749
550	27.138	28.478	28.562	29.226	11.806	11.812	13.000	17.012
555	6.914	6.948	8.262	7.334	9.586	9.990	9.498	10.834
560	3.142	2.952	2.329	3.302	9.734	10.180	8.828	10.775
565	2.520	2.198	1.602	2.512	10.538	10.902	8.942	10.863
570	2.210	1.850	1.438	2.162	11.448	11.666	9.202	11.039
575	5.010	4.700	4.760	5.062	15.550	15.498	12.704	14.347
580	10.996	10.610	13.500	10.662	17.562	17.156	14.346	15.372

λ (nm)	FL3.8	FL3.9	FL3.10	FL3.11	FL3.12	FL3.13	FL3.14	FL3.15
585	16.568	16.380	17.017	16.150	16.110	15.240	12.704	11.771
590	11.644	10.984	14.633	10.712	16.966	15.746	12.826	11.829
595	10.612	9.560	7.934	8.804	17.368	15.790	12.748	12.063
600	8.288	7.330	5.675	6.610	18.288	16.296	13.364	12.239
605	5.052	4.364	4.041	4.052	19.302	16.914	14.130	12.444
610	65.978	57.138	44.290	46.722	21.050	17.550	15.858	12.532
615	32.258	27.988	38.607	23.640	21.348	17.912	16.154	12.649
620	10.838	10.674	14.516	10.332	21.706	18.272	16.718	12.678
625	13.260	12.860	11.108	12.254	21.384	17.800	16.518	12.620
630	14.286	12.808	10.951	11.030	20.308	16.734	15.520	12.503
635	3.148	2.758	4.682	2.590	19.040	15.652	14.494	12.298
640	2.044	1.812	2.095	1.786	17.868	14.638	13.668	12.005
645	2.136	1.966	2.454	1.954	16.590	13.522	12.764	11.683
650	4.064	3.720	4.885	3.424	15.156	12.284	11.714	11.273
655	2.826	2.676	4.518	2.602	13.730	11.098	10.636	10.834
660	2.344	2.198	5.276	2.090	12.340	9.956	9.594	10.307
665	2.350	2.154	4.033	2.066	11.046	8.892	8.628	9.838
670	1.574	1.514	2.368	1.540	9.716	7.826	7.638	9.282
675	1.276	1.238	1.227	1.268	8.580	6.890	6.770	8.725
680	1.446	1.418	1.344	1.470	7.548	6.056	5.988	8.111
685	1.788	1.708	1.204	1.644	6.586	5.274	5.248	7.613
690	1.958	1.754	1.337	1.586	5.930	4.776	4.780	7.086
695	1.452	1.282	0.860	1.140	5.038	4.020	4.066	6.529
700	0.518	0.452	0.219	0.446	4.338	3.480	3.484	5.915
705	3.406	3.004	2.853	2.486	3.856	3.058	3.128	5.475
710	6.738	5.878	5.894	4.848	3.472	2.724	2.868	4.890
715	2.404	2.044	1.829	1.748	2.948	2.336	2.442	4.451
720	0.336	0.284	0.039	0.278	2.572	2.062	2.130	3.982
725	0.300	0.246	0.031	0.246	2.256	1.822	1.886	3.660
730	0.262	0.220	0.031	0.220	1.994	1.606	1.668	3.309
735	0.202	0.168	0.023	0.168	1.776	1.426	1.504	3.016
740	0.232	0.194	0.023	0.188	1.556	1.262	1.346	2.723
745	0.318	0.270	0.016	0.246	1.408	1.134	1.216	2.460
750	0.158	0.130	0.016	0.136	1.260	1.022	1.104	2.196
755	0.134	0.026	0.008	0.104	1.110	0.910	1.000	1.932
760	0.964	0.844	0.008	0.920	2.030	1.812	1.894	1.698
765	0.122	0.020	0.000	0.090	0.900	0.748	0.816	1.493
770	0.250	0.136	0.000	0.208	0.962	0.808	0.886	1.347
775	0.158	0.032	0.000	0.090	0.744	0.628	0.678	1.200
780	0.116	0.000	0.000	0.000	0.656	0.550	0.634	1.083

Appendix II. 5 - L.W. research 3-, 4-, 5-, 6-, 7-Band LED

	3-Band	4-Band	5-Band	6-Band	7-Band
380	0.000	0.000	0.000	0.000	0.000
385	0.000	0.000	0.000	0.000	0.000
390	0.000	0.000	0.000	0.000	0.000
395	0.000	0.000	0.000	0.000	0.000
400	0.000	0.000	0.000	0.000	0.000
405	0.000	0.000	0.000	0.000	0.000
410	0.000	0.000	0.000	0.000	0.000
415	0.000	0.000	0.000	0.122	0.048
420	0.295	0.146	0.091	0.270	0.121
425	0.547	0.271	0.169	0.545	0.243
430	1.684	0.833	0.519	1.274	0.589
435	3.494	1.729	1.076	2.185	1.041
440	6.736	3.333	2.075	4.347	2.061
445	10.946	5.416	3.372	8.469	3.901
450	22.314	11.040	6.874	11.355	5.630
455	37.892	18.747	11.672	11.804	6.653
460	40.418	19.997	12.450	7.813	5.236
465	30.734	15.206	9.467	5.546	3.875
470	19.619	9.790	6.268	4.103	2.999
475	14.062	7.082	4.669	3.148	2.539
480	11.031	5.624	3.848	2.698	2.392
485	8.757	4.583	3.372	2.511	2.613
490	8.084	4.374	3.502	2.754	3.385
495	8.319	4.729	4.215	3.727	4.968
500	9.431	5.624	5.490	5.387	7.017
505	12.167	7.437	7.570	7.709	9.409
510	17.388	10.686	10.976	11.291	12.688
515	23.914	14.790	15.347	15.964	16.982
520	32.334	19.997	20.751	21.585	22.170
525	33.681	20.830	21.615	22.485	22.814
530	32.334	19.997	20.751	21.585	21.784
535	28.966	17.914	18.589	19.337	19.429
540	23.914	14.790	15.347	15.964	15.988
545	18.862	11.665	12.104	12.591	12.566
550	14.820	9.165	9.511	9.893	9.843
555	11.452	7.082	7.349	7.645	7.580
560	9.094	5.971	6.139	6.352	6.292
565	7.073	5.763	5.750	5.846	5.777
570	5.726	6.076	5.884	5.874	5.786
575	4.951	8.166	7.626	7.437	7.302
580	3.705	14.442	12.969	12.310	12.088

	3-Band	4-Band	5-Band	6-Band	7-Band
585	2.695	23.191	20.664	19.430	19.079
590	1.684	35.412	31.385	29.361	28.831
595	1.347	33.120	29.526	27.656	27.156
600	1.330	19.310	17.876	16.927	16.621
605	1.406	9.749	10.073	9.811	9.634
610	1.684	5.555	7.436	7.626	7.488
615	2.947	4.860	7.954	8.432	8.279
620	5.473	5.902	10.937	11.804	11.591
625	12.631	11.457	21.226	22.953	22.538
630	18.946	16.074	27.412	29.408	28.877
635	33.681	27.774	31.126	31.478	30.910
640	42.102	34.717	28.532	26.982	26.494
645	33.681	27.774	21.615	20.142	19.779
650	18.946	15.623	12.666	11.936	11.720
655	12.631	10.415	8.214	7.682	7.543
660	8.420	6.944	5.361	4.984	4.894
665	5.473	4.513	3.329	3.054	2.999
670	2.947	2.430	1.859	1.724	1.693
675	1.684	1.389	1.038	0.956	0.938
680	0.968	0.799	0.497	0.431	0.423
685	0.421	0.347	0.216	0.187	0.184
690	0.000	0.000	0.000	0.070	0.062
695	0.000	0.000	0.000	0.057	0.050
700	0.000	0.000	0.000	0.000	0.000
705	0.000	0.000	0.000	0.000	0.000
710	0.000	0.000	0.000	0.000	0.000
715	0.000	0.000	0.000	0.000	0.000
720	0.000	0.000	0.000	0.000	0.000
725	0.000	0.000	0.000	0.000	0.000
730	0.000	0.000	0.000	0.000	0.000
735	0.000	0.000	0.000	0.000	0.000
740	0.000	0.000	0.000	0.000	0.000
745	0.000	0.000	0.000	0.000	0.000
750	0.000	0.000	0.000	0.000	0.000
755	0.000	0.000	0.000	0.000	0.000
760	0.000	0.000	0.000	0.000	0.000
765	0.000	0.000	0.000	0.000	0.000
770	0.000	0.000	0.000	0.000	0.000
775	0.000	0.000	0.000	0.000	0.000
780	0.000	0.000	0.000	0.000	0.000

Appendix II. 6- Philips Mixture LEDs & Luxeon white LED

λ (nm)	PM3016K	PM4000K	PM4100K	PM5500K	PM6500K	Luxeon white
380	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
385	0.0000	0.0000	0.0000	0.0000	0.0000	0.2848
390	0.0000	0.0000	0.0000	0.0000	0.0000	0.2848
395	0.0000	0.0000	0.0000	0.0000	0.0000	0.2848
400	0.0203	0.0139	0.0129	0.0058	0.0006	0.5696
405	-0.0083	-0.0113	-0.0134	-0.0183	-0.0238	0.8547
410	0.0046	0.0094	0.0076	0.0092	0.0075	1.4244
415	0.0314	0.0348	0.0346	0.0356	0.0356	3.1341
420	0.0462	0.0447	0.0443	0.0444	0.0443	7.4074
425	0.0810	0.0834	0.0731	0.0919	0.0922	11.6667
430	0.1016	0.1080	0.0872	0.1266	0.1280	22.2222
435	0.2356	0.2651	0.2154	0.3231	0.3339	37.0370
440	0.6051	0.6831	0.5494	0.8321	0.8567	35.6111
445	1.3455	1.5360	1.2233	1.8836	1.9393	22.2222
450	2.8949	3.3096	2.6377	4.0668	4.1931	14.8148
455	5.8196	6.6528	5.3053	8.1740	8.4288	7.4074
460	10.3688	11.8700	9.4660	14.5868	15.0414	5.1281
465	14.8597	17.0119	13.5667	20.9080	21.5612	3.7037
470	16.5925	18.9985	15.1504	23.3582	24.0929	2.5630
475	15.1322	17.3337	13.8297	21.3206	21.9999	2.2778
480	12.4408	14.2353	11.3888	17.4912	18.0541	2.2778
485	9.8269	11.2461	9.0523	13.8047	14.2676	2.5630
490	7.5118	8.5963	7.0301	10.5296	10.9240	2.8481
495	5.8387	6.6803	5.6745	8.1411	8.5258	4.5593
500	5.2403	5.9977	5.4527	7.2397	7.7181	5.9815
505	5.9282	6.7924	6.6456	8.1131	8.8327	7.4074
510	8.1320	9.3092	9.5806	11.0254	12.1867	9.9630
515	11.6597	13.3365	14.0699	15.7180	17.5043	11.9630
520	15.5302	17.7765	18.9491	20.9226	23.3812	13.6667
525	18.2934	20.9437	22.4172	24.6357	27.5680	14.8148
530	18.9942	21.7377	23.3044	25.5523	28.6039	15.6704
535	17.8488	20.4276	21.9204	24.0139	26.8928	16.5259
540	15.7454	18.0370	19.3645	21.2155	23.7686	17.0926
545	13.4304	15.3839	16.5164	18.0886	20.2620	17.0926
550	10.9786	12.5617	13.4786	14.7475	16.5042	17.0926
555	8.5670	9.7926	10.4915	11.4699	12.8141	17.0926
560	6.5967	7.5157	8.0212	8.7328	9.7035	17.0926
565	5.2771	5.9460	6.2788	6.7315	7.3512	17.0926
570	4.8359	5.3322	5.4963	5.6613	5.9048	16.5259
575	5.6641	6.0451	6.0020	5.7583	5.4891	15.6704
580	8.2608	8.5403	8.1943	7.2991	6.2345	15.6667
585	12.4295	12.6049	11.8783	10.1222	8.0256	15.1000
590	18.8219	18.8591	17.6200	14.6654	11.1522	14.5296
595	24.3798	24.0643	22.4135	18.4323	13.7690	14.2444
600	23.1322	21.9916	20.4778	16.6650	12.3893	13.3889
605	18.0861	15.6877	14.6379	11.6577	8.6727	12.2507

λ (nm)	PM3016K	PM4000K	PM4100K	PM5500K	PM6500K	Luxeon white
610	17.0921	13.0987	12.2550	9.4227	6.9949	11.9667
615	21.5885	15.3118	14.3421	10.7300	7.9160	11.1111
620	31.8360	21.8167	20.4416	15.0666	11.0493	9.9704
625	41.8168	28.3652	26.5753	19.4866	14.2481	9.1185
630	41.3706	27.9911	26.2261	19.2098	14.0414	8.2630
635	28.2415	19.1064	17.9055	13.1164	9.5934	7.4074
640	14.6389	9.9136	9.2935	6.8186	4.9992	6.5519
645	7.1169	4.8374	4.5350	3.3483	2.4716	5.9815
650	3.2505	2.2224	2.0832	1.5506	1.1537	5.4148
655	1.5961	1.0942	1.0238	0.7681	0.5743	4.8444
660	0.8172	0.5731	0.5370	0.4155	0.3209	4.2741
665	0.4411	0.3120	0.2937	0.2286	0.1790	3.9889
670	0.2647	0.1902	0.1770	0.1386	0.1064	3.4185
675	0.1644	0.1280	0.1181	0.1028	0.0853	3.1333
680	0.1122	0.0927	0.0858	0.0814	0.0728	2.5630
685	0.0909	0.0774	0.0711	0.0679	0.0600	2.2778
690	0.0698	0.0617	0.0581	0.0533	0.0469	1.9926
695	0.0570	0.0504	0.0479	0.0430	0.0376	1.7111
700	0.0000	0.0000	0.0000	0.0000	0.0000	1.4244
705	0.0000	0.0000	0.0000	0.0000	0.0000	1.1396
710	0.0000	0.0000	0.0000	0.0000	0.0000	1.1396
715	0.0000	0.0000	0.0000	0.0000	0.0000	1.1396
720	0.0000	0.0000	0.0000	0.0000	0.0000	0.8548
725	0.0000	0.0000	0.0000	0.0000	0.0000	0.8548
730	0.0000	0.0000	0.0000	0.0000	0.0000	0.8548
735	0.0000	0.0000	0.0000	0.0000	0.0000	0.5696
740	0.0000	0.0000	0.0000	0.0000	0.0000	0.5696
745	0.0000	0.0000	0.0000	0.0000	0.0000	0.5696
750	0.0000	0.0000	0.0000	0.0000	0.0000	0.5696
755	0.0000	0.0000	0.0000	0.0000	0.0000	0.2849
760	0.0000	0.0000	0.0000	0.0000	0.0000	0.2849
765	0.0000	0.0000	0.0000	0.0000	0.0000	0.2849
770	0.0000	0.0000	0.0000	0.0000	0.0000	0.2849
775	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
780	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Appendix II. 7 - Relative spectral power distributions of CIE illuminants

λ (nm)	A	D65	C	D50	D55	D75
380	1.3292	6.9242	4.5380	3.4132	4.5390	9.1730
385	1.4791	7.2479	5.4900	3.7883	4.9220	9.3971
390	1.6400	7.5716	6.5180	4.1635	5.3060	9.6213
395	1.8122	9.5187	7.5870	5.5180	6.8980	11.8192
400	1.9958	11.4659	8.7050	6.8727	8.4900	14.0172
405	2.1913	12.0707	9.8750	7.3747	9.0200	14.7023
410	2.3985	12.6756	11.0840	7.8769	9.5500	15.3876
415	2.6177	12.8104	12.3120	8.1222	9.7600	15.4498
420	2.8490	12.9452	13.4900	8.3677	9.9710	15.5119
425	3.0923	12.4776	14.5490	8.2133	9.7160	14.8445
430	3.3478	12.0100	15.4570	8.0588	9.4600	14.1772
435	3.6153	13.2696	16.1920	9.2440	10.6930	15.4221
440	3.8949	14.5293	16.7080	10.4293	11.9250	16.6671
445	4.1864	15.3704	16.9760	11.2950	12.7880	17.4793
450	4.4897	16.2117	17.0520	12.1607	13.6510	18.2915
455	4.8046	16.2674	16.9970	12.3953	13.8230	18.2464
460	5.1310	16.3231	16.9280	12.6297	13.9950	18.2014
465	5.4687	16.1186	16.9560	12.6824	13.9560	17.8552
470	5.8173	15.9142	17.0240	12.7351	13.9180	17.5092
475	6.1766	15.9878	17.0640	12.9957	14.1150	17.4734
480	6.5464	16.0614	17.0380	13.2565	14.3120	17.4375
485	6.9263	15.5687	16.9030	13.0373	13.9870	16.8174
490	7.3159	15.0760	16.5980	12.8180	13.6620	16.1975
495	7.7150	15.1135	16.0760	13.0801	13.8440	16.1154
500	8.1230	15.1512	15.4160	13.3423	14.0250	16.0333
505	8.5398	15.0437	14.7110	13.4043	14.0260	15.8348
510	8.9647	14.9362	14.0680	13.4662	14.0270	15.6362
515	9.3974	14.7275	13.5880	13.5021	13.9780	15.2895
520	9.8376	14.5189	13.3250	13.5381	13.9280	14.9427
525	10.2846	14.7196	13.3090	13.8845	14.2220	15.0655
530	10.7381	14.9205	13.4770	14.2308	14.5170	15.1883
535	11.1977	14.6930	13.7430	14.1372	14.3700	14.9026
540	11.6628	14.4655	14.0400	14.0435	14.2230	14.6168
545	12.1331	14.4406	14.2950	14.1523	14.2830	14.5215
550	12.6080	14.4158	14.4670	14.2612	14.3440	14.4263
555	13.0870	14.1355	14.5310	14.0998	14.1370	14.0891
560	13.5698	13.8552	14.4800	13.9383	13.9300	13.7519
565	14.0559	13.6013	14.3170	13.7805	13.7360	13.4505
570	14.5447	13.3473	14.0680	13.6226	13.5420	13.1491
575	15.0358	13.3095	13.7720	13.7051	13.5790	13.0525

λ (nm)	A	D65	C	D50	D55	D75
580	15.5287	13.2716	13.4490	13.7874	13.6170	12.9561
585	16.0232	12.7796	13.1230	13.4097	13.1760	12.4599
590	16.5187	12.2876	12.8160	13.0321	12.7370	11.9638
595	17.0146	12.3791	12.5440	13.3240	12.9450	11.9796
600	17.5109	12.4706	12.3350	13.6160	13.1530	11.9954
605	18.0067	12.4423	12.2160	13.7261	13.2030	11.9207
610	18.5019	12.4141	12.1560	13.8364	13.2530	11.8459
615	18.9961	12.2825	12.1280	13.8205	13.1890	11.6700
620	19.4887	12.1508	12.1150	13.8047	13.1250	11.4940
625	19.9795	11.8453	12.1100	13.5734	12.8620	11.1616
630	20.4682	11.5398	12.1010	13.3420	12.5990	10.8292
635	20.9542	11.5683	12.0820	13.5605	12.7310	10.8072
640	21.4374	11.5967	12.0740	13.7789	12.8620	10.7854
645	21.9174	11.3423	12.1000	13.5566	12.6200	10.5359
650	22.3940	11.0879	12.1290	13.3343	12.3770	10.2866
655	22.8665	11.1009	12.1290	13.5102	12.4790	10.2537
660	23.3351	11.1139	12.0880	13.6860	12.5810	10.2210
665	23.7991	11.2568	11.9940	14.0215	12.8340	10.2965
670	24.2586	11.3998	11.8680	14.3568	13.0870	10.3720
675	24.7131	11.1231	11.7300	14.0871	12.8090	10.1075
680	25.1624	10.8464	11.5510	13.8174	12.5310	9.8431
685	25.6064	10.2532	11.3050	12.9984	11.8150	9.3120
690	26.0447	9.6600	11.0290	12.1794	11.0990	8.7809
695	26.4771	9.7908	10.7590	12.4736	11.3190	8.8651
700	26.9036	9.9216	10.4920	12.7680	11.5400	8.9492
705	27.3240	10.1114	10.2260	12.8575	11.6790	9.1551
710	27.7379	10.3012	9.9560	12.9471	11.8190	9.3609
715	28.1453	9.4183	9.6810	11.8297	10.8010	8.5614
720	28.5461	8.5354	9.3920	10.7121	9.7840	7.7620
725	28.9401	9.1091	9.1170	11.3852	10.4150	8.2983
730	29.3271	9.6828	8.8560	12.0581	11.0470	8.8345
735	29.7070	10.0431	8.6360	12.4811	11.4430	9.1721
740	30.0798	10.4035	8.4570	12.9040	11.8400	9.5096
745	30.4454	9.6072	8.2780	11.9040	10.9260	8.7861
750	30.8035	8.8109	8.1410	10.9039	10.0130	8.0626
755	31.1542	7.6211	8.0450	9.4726	8.6840	6.9616
760	31.4976	6.4313	7.9900	8.0413	7.3540	5.8607
765	31.8333	7.8437	7.9760	9.7996	8.9650	7.1489
770	32.1615	9.2560	8.0030	11.5580	10.5770	8.4371
775	32.4821	9.0189	8.0450	11.2341	10.2900	8.2289
780	32.7948	8.7818	8.1270	10.9100	10.0040	8.0207

Appendix II. 8 -New LEDs

λ (nm)	**New LED1**	**New LED2**	**New LED3**
380	0.0000	1.5138	0.0000
385	0.0000	1.5138	0.0000
390	0.0000	1.5138	0.0000
395	0.0000	1.5138	0.0000
400	0.0000	1.5138	0.0000
405	0.0000	1.5138	0.1305
410	0.0000	1.5138	0.0000
415	0.0000	1.5138	0.2612
420	3.0144	1.5138	0.7835
425	8.4449	2.1631	1.9580
430	18.7000	2.3792	3.9175
435	34.3856	3.2438	7.0514
440	72.3840	4.5414	11.0995
445	81.4348	6.9206	14.3641
450	61.5305	10.1644	15.6698
455	42.2246	16.2204	15.4087
460	25.9369	20.1134	14.3641
465	24.1305	23.7894	12.4043
470	15.0797	19.4642	10.8383
475	15.6856	17.7342	9.7934
480	12.0652	12.9758	8.8796
485	13.2695	10.8136	8.0960
490	15.0797	8.6506	9.7934
495	18.7000	6.7045	12.4040
500	25.3348	5.4068	15.6698
505	34.3856	4.7576	17.8898
510	33.1775	4.7576	17.7587
515	37.7216	5.4068	16.9744
520	34.9877	6.3215	16.3218
525	24.1305	9.5159	15.6698
530	22.3203	13.1928	14.3638
535	13.2695	17.7342	13.9722
540	10.8572	23.1410	13.5806
545	9.0471	28.1155	13.0581
550	4.8246	32.8731	12.4053
555	3.6203	32.4408	11.7524
560	3.0144	27.0340	11.3607
565	1.2080	25.3033	11.3607
570	1.2080	18.1665	11.7524
575	1.2080	12.3274	12.4053
580	1.2080	11.4620	13.7112
585	3.0144	6.9206	15.0170
590	3.6203	5.6229	16.4534
595	9.0471	4.5414	16.9757
600	13.2695	3.8930	16.9757
605	19.3021	3.0276	16.5840
610	27.7471	2.8115	16.3227
615	31.3674	2.3792	15.0170
620	33.1775	2.3792	14.1029
625	30.1631	2.1631	12.4053
630	21.1123	1.9469	11.7524
635	15.0797	1.7299	10.4466
640	9.6529	1.7299	9.1408
645	6.0326	1.5138	8.4878
650	3.0144	1.5138	7.4431
655	2.4123	1.5138	6.6597
660	1.2080	1.5138	5.8761
665	0.0000	1.5138	5.2230
670	0.0000	1.5138	4.5704
675	0.0000	1.5138	4.1786
680	0.0000	1.5138	3.5247
685	0.0000	1.5138	3.0033
690	0.0000	1.5138	2.6115
695	0.0000	1.5138	2.3505
700	0.0000	1.5138	1.9587
705	0.0000	1.5138	0.0000
710	0.0000	1.5138	0.0000
715	0.0000	1.5138	0.0000
720	0.0000	1.5138	0.0000
725	0.0000	1.5138	0.0000
730	0.0000	1.5138	0.0000
735	0.0000	1.5138	0.0000
740	0.0000	1.5138	0.0000
745	0.0000	1.5138	0.0000
750	0.0000	1.5138	0.0000
755	0.0000	1.5138	0.0000
760	0.0000	1.5138	0.0000
765	0.0000	1.5138	0.0000
770	0.0000	1.5138	0.0000
775	0.0000	1.5138	0.0000
780	0.0000	1.5138	0.0000

APPENDIX III-OBSERVERS

Appendix III. 1-CIE1931 Colorimetric Observer

λ (nm)	x (λ)	y (λ)	z (λ)
380	0.001	0.000	0.001
385	0.002	0.000	0.001
390	0.004	0.000	0.002
395	0.008	0.000	0.004
400	0.014	0.000	0.007
405	0.023	0.001	0.011
410	0.044	0.001	0.020
415	0.078	0.002	0.036
420	0.134	0.004	0.068
425	0.215	0.007	0.110
430	0.284	0.012	0.207
435	0.329	0.017	0.371
440	0.348	0.023	0.646
445	0.348	0.030	1.039
450	0.336	0.038	1.386
455	0.319	0.048	1.623
460	0.291	0.060	1.747
465	0.251	0.074	1.783
470	0.195	0.091	1.772
475	0.142	0.113	1.744
480	0.096	0.139	1.669
485	0.058	0.169	1.528
490	0.032	0.208	1.288
495	0.015	0.259	1.042
500	0.005	0.323	0.813
505	0.002	0.407	0.616
510	0.009	0.503	0.465
515	0.029	0.608	0.353
520	0.063	0.710	0.272
525	0.110	0.793	0.212
530	0.166	0.862	0.158
535	0.226	0.915	0.112
540	0.290	0.954	0.078
545	0.3597	0.9803	0.0573
550	0.4334	0.995	0.0422
555	0.5121	1	0.0298
560	0.5945	0.995	0.0203
565	0.6784	0.9786	0.0134
570	0.7621	0.952	0.0087
575	0.8425	0.9154	0.0057
580	0.9163	0.87	0.0039
585	0.9786	0.8163	0.0027

λ (nm)	x (λ)	y (λ)	z (λ)
590	1.0263	0.757	0.0021
595	1.0567	0.6949	0.0018
600	1.0622	0.631	0.0017
605	1.0456	0.5668	0.0014
610	1.0026	0.503	0.0011
615	0.9384	0.4412	0.001
620	0.8544	0.381	0.0008
625	0.7514	0.321	0.0006
630	0.6424	0.265	0.0003
635	0.5419	0.217	0.0002
640	0.4479	0.175	0.0002
645	0.3608	0.1382	0.0001
650	0.2835	0.107	0
655	0.2187	0.0816	0
660	0.1649	0.061	0
665	0.1212	0.0446	0
670	0.0874	0.032	0
675	0.0636	0.0232	0
680	0.0468	0.017	0
685	0.0329	0.0119	0
690	0.0227	0.0082	0
695	0.0158	0.0057	0
700	0.0114	0.0041	0
705	0.0081	0.0029	0
710	0.0058	0.0021	0
715	0.0041	0.0015	0
720	0.0029	0.001	0
725	0.002	0.0007	0
730	0.0014	0.0005	0
735	0.001	0.0004	0
740	0.0007	0.0002	0
745	0.0005	0.0002	0
750	0.0003	0.0001	0
755	0.0002	0.0001	0
760	0.0002	0.0001	0
765	0.0001	0	0
770	0.0001	0	0
775	0.0001	0	0
780	0	0	0

APPENDIX IV-SUBJECTIVE TEST SHEETS

Appendix IV. 1- Monitor Set-up Test

S1-Monitor set up test table

Participant Number: ___________

Please circle your age group:

16-30 31-50 Over 50

Please keep CIED65 as the reference light source (keep on right side), and CIED65 (keep on left side) as the test light source.

Please keep K1 value =1.0 and change gamma value from 1.8 to 2.8 at 0.1 interval and give a grade between -5 (poorest) and +5 to represent best.

Table IV 1-Monitor Set-up gamma

Gamma	1.8	1.9	2	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
Reference											

Please keep the best gamma value (which you selected above) and change K1 value from 0.8 to 1.2 at 0.1 interval and give an 11 grade, +5 to -5 which from best to poorest.

Table IV 2-Monitor Set-up K1

K1	0.8	0.9	1.0	1.1	1.2
Reference					

S2

Participant Number: ___________

Please circle your age group:

16-30 31-50 Over 50

Grade scale

Much better	+3
Better	+2
Slightly better	+1
Test same	0
Slightly worse	-1
Worse	-2
Much worse	-3

Adjectival method table for Group I

Please keep the test light source on the left side and keep the reference light source on the right side. Please give a grade for the 14 colour samples in under 52 lamp sources. Use the 7 grade scale (+3 to -3) given above. You do not need to calculate the total score.

Table IV 3- Group I test

Re	Test	7.5R	5Y	5GY	2.5G	10B	5PB	2.5P	10P	4.5R	5Y8/10	4.5G	3PB	5YR	5GY4/4	DG	LG	Total
A	**HP1**																	
	HP2																	
	LW4BANDLED																	
	LW5BANDLED																	
	LW6BANDLED																	
	LW7BANDLED																	
	HP3																	
	F3																	
	F4																	
	F12																	
	FL3.1																	
	FL3.2																	
	FL3.4																	
	FL3.7																	
	FL3.12																	
	FL3.13																	
	PM3016K																	
D50	**LED3**																	
	F2																	
	F6																	
	F8																	
	F9																	
	F10																	
	F11																	
	FL3.5																	
	FL3.6																	
	FL3.8																	
	FL3.9																	
	FL3.10																	
	FL3.14																	

Table IV 4 continued

Re	Test	7.5R	5Y	5GY	2.5G	10B	5PB	2.5P	10P	4.5R	5Y8/10	4.5G	3PB	5YR	5GY4/4	DG	LG	Total	5YR
D50	HP4																		
	HP5																		
	PM4000K																		
	PM4100K																		
D55	FL3.11																		
	PM5500K																		
	LuxenWhiteLED																		
D65	F1																		
	F5																		
	F7																		
	FL3.3																		
	FL3.15																		
	PM6500K																		
D75	LED1																		
	LED2																		
	LW3BANDLED																		

S3

Participant Number: ___________

Please circle your age group:

16-30 31-50 Over 50

Grade scale

Much better	+3
Better	+2
Slightly better	+1
Test same	0
Slightly worse	-1
Worse	-2
Much worse	-3

Adjectival method table for Group II

Please keep the test image on the left side and keep the reference image on the right side Please give a grade for the 14 colour samples in test images compare with reference images. Use the 7 grade scale (+3 to -3) given above. You do not need to calculate the total score.

Table IV 5-Group II test

Reference	Test	7.5R	5Y	5GY	2.5G	10B	5PB	2.5P	10P	4.5R	5Y8/10	4.5G	3PB	5YR	5GY4/4	DG	LG	Total	M
A	4-Band																		
	5-band																		
	6-band																		
	7-band																		
	HP3																		
	FL3.2																		
	FL3.7																		
	FL3.12																		
	FL3.13																		
	F12																		
	PM3016K																		
D50	LED3																		
	F8																		
	F9																		
	FL3.10																		
	FL3.14																		
D65	F1																		
	F5																		
	F7																		
	FL3.15																		

Appendix IV. 4-. Group II Test

S4

Participant Number: ___________

Please circle your age group:

16-30	31-50	Over 50

Grade scale

Much better	+3
Better	+2
Slightly better	+1
Test same	0
Slightly worse	-1
Worse	-2
Much worse	-3

Adjectival method table for Group II

Please keep the test image on the left side and keep the reference image on the right side Please give a grade for the 14 colour samples in test images compare with reference images. Use the 7 grade scale (+3 to -3) given above. You do not need to calculate the total score.

Table IV 6-Group II test 2

Reference	Test	7.5R	5Y	5GY	2.5G	10BG	5PB	2.5P	10P	4.5R	5Y8/10	4.5G	3PB	5YR	5GY4/4	DG	LG	Total	M
A	4-Band																		
A	5-band																		
5-BAND	6-band																		
A	7-band																		
A	HP3																		
A	FL3.2																		
A	FL3.7																		
A	FL3.12																		
A	FL3.13																		
HP3	F12																		
A	PM3016K																		
D50	LED3																		
D50	F8																		
F8	F9																		
FL3.14	FL3.10																		
D50	FL3.14																		
D65	F1																		
F1	F5																		
D65	F7																		
D65	FL3.15																		

Appendix IV. 5-Group III Test

S5

Participant Number: ___________

Please circle your age group:

16-30 31-50 Over 50

Grade scale

Much better	+3
Better	+2
Slightly better	+1
Test same	0
Slightly worse	-1
Worse	-2
Much worse	-3

Adjectival method table for Group III

Please keep the test image on the left side and keep the reference image on the right side Please give a grade for the 14 colour samples in test images compare with reference images. Use the 7 grade scale (+3 to -3) given above. You do not need to calculate the total score.

Table IV 7-Group III test

Reference	Test	7.5R	5Y	5GY	2.5G	10BG	5PB	2.5P	10P	4.5R	5Y8/10	4.5G	3PB	5YR	5GY4/4	DG	LG	Total	Magnitude
D50	**F8**																		
	F10																		
	FL3.10																		
D55	**PM5500**																		
D65	**F7**																		
	FL3.15																		
F9	**F7**																		
F12	**F11**																		
F12	**HP2**																		
F12	**HP3**																		
F12	**PM3016K**																		
	FL3.12																		
PM4000	**F11**																		
PM4000	**HP4**																		
F8	**Fl3.10**																		

APPENDIX V-MATLAB CODE

Appendix V. 1- Displaycolour.m

```
function [R,G,B]=displaycolor(SR0,SG0,SB0)
if(SR0>1)&&(SG0>1)&&(0<=SB0<=1) R=1,G=1,B=SB0;
elseif (SR0>1)&&(SG0>1)&&(SB0<0) R=1;G=1;B=0;
elseif(SR0>1)&&(0<=SG0<=1)&&(SB0>1) R=1;G=SG0;B=1;
elseif(SR0>1)&&(0<=SG0<=1)&&(SB0<0) R=1;G=SG0;B=0;
elseif(SR0>1)&&(SG0<0)&&(0<=SB0<=1) R=1;G=0;B=SB0;
elseif (SR0>1)&&(SG0<0)&&(SB0<0) R=1;G=0;B=0;
elseif  (SR0>1)&&(SG0<0)&&(SB0>1) R=1;G=0;B=1;
elseif(SR0<0)&&(SG0>1)&&(0<=SB0<=1) R=0;G=1;B=SB0;
elseif (SR0<0)&&(SG0>1)&&(SB0<0) R=0;G=1;B=0;
elseif (SR0<0)&&(SG0>1)&&(SB0>1) R=0;G=1;B=1;
elseif (SR0<0)&&(0<=SG0<=1)&&(SB0>1) R=0;G=SG0;B=1;
elseif  (SR0<0)&&(SG0<0)&&(SB0<0) R=0;G=0;B=0;
elseif(SR0<0)&&(0<=SG0<=1)&&(SB0<0) R=0;G=SG0;B=SB0;
elseif(SR0<0)&&(0<=SG0<=1)&&(0<=SB0<=1) R=0;G=SG0;B=SB0;
elseif(SR0<0)&&(SG0<0)&&(0<=SB0<=1) R=0;G=0;B=SB0;
elseif  (SR0<0)&&(SG0<0)&&(SB0>1) R=0;G=0;B=1;
elseif(SG0>1)&&(SR0>1)&&(0<=SB0<=1) R=1;G=1;B=SB0;
elseif (SG0>1)&&(SR0>1)&&(B0<0) R=1;G=1;B=0;
elseif (SG0>1)&&(SR0>1)&&(SB0>1) R=1;G=1;B=1;
elseif(SG0>1)&&(0<=SR0<=1)&&(SB0>1) R=SR0;G=1;B=1;
elseif(SG0>1)&&(0<=SR0<=1)&&(SB0<0) R=SR0;G=1;B=0;
elseif(SG0>1)&&(0<=SR0<=1)&&(0<=SB0<=1) R=SR0;G=1;B=SB0;
elseif(SG0>1)&&(SR0<0)&&(0<=SB0<=1) R=0;G=1;B=SB0;
elseif  (SG0>1)&&(SR0<0)&&(SB0<0) R=0;G=1;B=0;
elseif  (SG0>1)&&(SR0<0)&&(SB0>1) R=0;G=1;B=1;
elseif(SG0<0)&&(SR0>1)&&(0<=SB0<=1) R=1;G=0;B=SB0;
elseif (SG0<0)&&(SR0>1)&&(SB0<0) R=1;G=0;B=0;
elseif (SG0<0)&&(SR0>1)&&(SB0>1) R=1;G=0;B=1;
elseif(SG0<0)&&(0<=SR0<=1)&&(SB0>1) R=SR0;G=0;B=SB0;
elseif(SG0<0)&&(0<=SR0<=1)&&(SB0<0) R=SR0;G=0;B=0;
elseif(SG0<0)&&(0<=SR0<=1)&&(0<=SB0<=1) R=SR0;G=0;B=SB0;
elseif(SG0<0)&&(SR0<0)&&(0<=SB0<=1) R=0;G=0;B=SB0;
elseif (SG0<0)&&(SR0<0)&&(SB0>1) R=0;G=0;B=1;
elseif  (SG0<0)&&(SR0<0)&&(SB0<0) R=0;G=0;B=0;
elseif(SB0>1)&&(SR0>1)&&(0<=SG0<=1) R=1;G=SG0;B=1;
elseif (SB0>1)&&(SR0>1)&&(SG0>1) R=1;G=1;B=1;
elseif (SB0>1)&&(SR0>1)&&(SG0<0) R=1;G=0;B=1;
elseif(SB0>1)&&(0<=SR0<=1)&&(SG0>1) R=SR0;G=SG0;B=1;
elseif(SB0>1)&&(0<=SR0<=1)&&(SG0<0) R=SR0;G=0;B=1;
elseif(SB0>1)&&(0<=SR0<=1)&&(0<=SG0<=1) R=SR0;G=SG0;B=1;
elseif(SB0>1)&&(SR0<0)&&(0<=SG0<=1) R=0;G=SG0;B=1;
elseif  (SB0>1)&&(SR0<0)&&(SG0>1) R=0;G=1;B=1;
elseif  (SB0>1)&&(SR0<0)&&(SG0<0) R=0;G=0;B=1;
```

```
elseif(SB0<0)&&(SR0>1)&&(0<=SG0<=1) R=1;G=SG0;B=0;
elseif (SB0<0)&&(SR0>1)&&(SG0<0) R=1;G=0;B=0;
elseif (SB0<0)&&(SR0>1)&&(SG0>1) R=1;G=1;B=0;
elseif(SB0<0)&&(0<=SR0<=1)&&(SG0>1) R=SR0;G=1;B=0;
elseif(SB0<0)&&(0<=SR0<=1)&&(SG0<0) R=SR0;G=0;B=0;
elseif(SB0<0)&&(0<=SR0<=1)&&(0<=SG0<=1) R=SR0;G=SG0;B=0;
elseif(SB0<0)&&(SR0<0)&&(0<=SG0<=1)R=0;G=SG0;B=0;
elseif  (SB0<0)&&(SR0<0)&&(SG0<0) R=0;G=0;B=0;
elseif  (SB0<0)&&(SR0<0)&&(SG0>1) R=0;G=1;B=0;
elseif(0<=SR0<=1)&&(0<=SG0<=1)&&(SB0>1) R=SR0;G=SG0;B=1;
elseif(0<=SR0<=1)&&(0<=SG0<=1)&&(SB0<0) R=SR0;G=SG0;B=0;
elseif(0<=SR0<=1)&&(SG0>1)&&(0<=SB0<=1) R=SR0;G=1;B=SB0;
elseif(0<=SR0<=1)&&(SG0>1)&&(SB0>1) R=SR0;G=1;B=1;
elseif(0<=SR0<=1)&&(SG0>1)&&(SB0<0) R=SR0;G=1;B=0;
elseif(0<=SR0<=1)&&(SG0<0)&&(SB0<0) R=SR0;G=0;B=0;
elseif(0<=SR0<=1)&&(SG0<0)&&(SB0>1) R=SR0;G=0;B=1;
elseif(SR0>1)&&(0<=SG0<=1)&&(0<=SB0<=1) R=1;G=SG0;B=SB0;
elseif (SR0>1)&&(SG0>1)&&(SB0>1) R=1;G=1;B=1;
elseif(0<=SR0<=1)&&(0<=SG0<=1)&&(0<=SB0<=1) R=SR0,G=SG0;B=SB0;
elseR=SR0;G=0;B=SB0;
end
```

Appendix V. 2-Backgroundcolour.m

```
%SR0,SR1,SR2,SR3,SR4,SR5,SR6,SR7,SR8,SR9,SR10,SR11,SR12,SR13,SR14,SR15 mean the red value of the 16 displayed colour samples
%SG0,SG1,SG2,SG3,SG4,SG5,SG6,SG7,SG8,SG9,SG10,SG11,SG12,SG13,SG14,SG15 mean the green value of the 16 displayed colour samples
%SB0,SB1,SB2,SB3,SB4,SB5,SB6,SB7,SB8,SB9,SB10,SB11,SB12,SB13,SB14,SB15 mean the blue value of the 16 displayed colour samples

function [R0]=BackgroundcolorSR0(SR0)
if SR0>1
   R0=1;
elseif SR0<0
   R0=0;
else
   R0=SR0;
end
function [R1]=BackgroundcolorSR1(SR1)
if SR1>1
   R1=1;
elseif SR1<0
   R1=0;
else
   R1=SR1;
end
function [R2]=BackgroundcolorSR2(SR2)
if SR2>1
   R2=1;
elseif SR2<0
   R2=0;
else
   R2=SR2;
end
function [R3]=BackgroundcolorSR3(SR3)
if SR3>1
   R3=1;
elseif SR3<0
   R3=0;
else
   R3=SR3;
end
function [R4]=BackgroundcolorSR4(SR4)
if SR4>1
   R4=1;
elseif SR4<0
   R4=0;
else
   R4=SR4;
end
function [R5]=BackgroundcolorSR5(SR5)
if SR5>1
   R5=1;
elseif SR5<0
   R5=0;
else
   R5=SR5;
end
function [R6]=BackgroundcolorSR6(SR6)
if SR6>1
   R6=1;
elseif SR6<0
   R6=0;
else
   R6=SR6;
end
function [R7]=BackgroundcolorSR7(SR7)
if SR7>1
   R7=1;
elseif SR7<0
   R7=0;
else
   R7=SR7;
end
function [R8]=BackgroundcolorSR8(SR8)
if SR8>1
   R8=1;
elseif SR8<0
   R8=0;
else
   R8=SR8;
end
function [R9]=BackgroundcolorSR9(SR9)
if SR9>1
   R9=1;
elseif SR9<0
   R9=0;
else
   R9=SR9;
end
function
[R10]=BackgroundcolorSR10(SR10)
if SR10>1
   R10=1;
elseif SR10<0
   R10=0;
else
   R10=SR10;
end
```

```
function
[R11]=BackgroundcolorSR11(SR11)
if SR11>1
   R11=1;
elseif SR11<0
   R11=0;
else
   R11=SR11;
end
function
[R12]=BackgroundcolorSR12(SR12)
if SR12>1
   R12=1;
elseif SR12<0
   R12=0;
else
   R12=SR12;
end
function
[R13]=BackgroundcolorSR13(SR13)
if SR13>1
   R13=1;
elseif SR13<0
   R13=0;
else
   R13=SR13;
end
function
[R14]=BackgroundcolorSR14(SR14)
if SR14>1
   R14=1;
elseif SR14<0
   R14=0;
else
   R14=SR14;
end
function
[R15]=BackgroundcolorSR15(SR15)
if SR15>1
   R15=1;
elseif SR15<0
   R15=0;
else
   R15=SR15;
end
function [G0]=BackgroundcolorSG0(SG0)
if SG0>1
   G0=1;
elseif SG0<0
   G0=0;
else
   G0=SG0;
end
function [G1]=BackgroundcolorSG1(SG1)
if SG1>1
   G1=1;
elseif SG1<0
   G1=0;
else
   G1=SG1;
end
function [G2]=BackgroundcolorSG2(SG2)
if SG2>1
   G2=1;
elseif SG2<0
   G2=0;
else
   G2=SG2;
end
function [G3]=BackgroundcolorSG3(SG3)
if SG3>1
   G3=1;
elseif SG3<0
   G3=0;
else
   G3=SG3;
end
function [G4]=BackgroundcolorSG4(SG4)
if SG4>1
   G4=1;
elseif SG4<0
   G4=0;
else
   G4=SG4;
end
function [G5]=BackgroundcolorSG5(SG5)
if SG5>1
   G5=1;
elseif SG5<0
   G5=0;
else
   G5=SG5;
end
function [G6]=BackgroundcolorSG6(SG6)
if SG6>1
   G6=1;
elseif SG6<0
   G6=0;
else
   G6=SG6;
end
function [G7]=BackgroundcolorSG7(SG7)
if SG7>1
   G7=1;
elseif SG7<0
   G7=0;
else
   G7=SG7;
end
function [G8]=BackgroundcolorSG8(SG8)
if SG8>1
   G8=1;
```

```
elseif SG8<0
   G8=0;
else
   G8=SG8;
end
function [G9]=BackgroundcolorSG9(SG9)
if SG9>1
   G9=1;
elseif SG9<0
   G9=0;
else
   G9=SG9;
end
function
[G10]=BackgroundcolorSG10(SG10)
if SG10>1
   G10=1;
elseif SG10<0
   G10=0;
else
   G10=SG10;
end
function
[G11]=BackgroundcolorSG11(SG11)
if SG11>1
   G11=1;
elseif SG11<0
   G11=0;
else
   G11=SG11;
end
function
[G12]=BackgroundcolorSG12(SG12)
if SG12>1
   G12=1;
elseif SG12<0
   G12=0;
else
   G12=SG12;
end
function
[G13]=BackgroundcolorSG13(SG13)
if SG13>1
   G13=1;
elseif SG13<0
   G13=0;
else
   G13=SG13;
end
function
[G14]=BackgroundcolorSG14(SG14)
if SG14>1
   G14=1;
elseif SG14<0
   G14=0;
else
   G14=SG14;
end
function
[G15]=BackgroundcolorSG15(SG15)
if SG15>1
   G15=1;
elseif SG15<0
   G15=0;
else
   G15=SG15;
end
function [B0]=BackgroundcolorSB0(SB0)
if SB0>1
   B0=1;
elseif SB0<0
   B0=0;
else
   B0=SB0;
end
function [B1]=BackgroundcolorSB1(SB1)
if SB1>1
   B1=1;
elseif SB1<0
   B1=0;
else
   B1=SB1;
end
function [B2]=BackgroundcolorSB2(SB2)
if SB2>1
   B2=1;
elseif SB2<0
   B2=0;
else
   B2=SB2;
end
function [B3]=BackgroundcolorSB3(SB3)
if SB3>1
   B3=1;
elseif SB3<0
   B3=0;
else
   B3=SB3;
end
function [B4]=BackgroundcolorSB4(SB4)
if SB4>1
   B4=1;
elseif SB4<0
   B4=0;
else
   B4=SB4;
end
function [B5]=BackgroundcolorSB5(SB5)
if SB5>1
   B5=1;
elseif SB5<0
   B5=0;
```

```
else
   B5=SB5;
end
function [B6]=BackgroundcolorSB6(SB6)
if SB6>1
   B6=1;
elseif SB6<0
   B6=0;
else
   B6=SB6;
end
function [B7]=BackgroundcolorSB7(SB7)
if SB7>1
   B7=1;
elseif SB7<0
   B7=0;
else
   B7=SB7;
end
function [B8]=BackgroundcolorSB8(SB8)
if SB8>1
   B8=1;
elseif SB8<0
   B8=0;
else
   B8=SB8;
end
function [B9]=BackgroundcolorSB9(SB9)
if SB9>1
   B9=1;
elseif SB9<0
   B9=0;
else
   B9=SB9;
end
function
[B10]=BackgroundcolorSB10(SB10)
if SB10>1
   B10=1;
elseif SB10<0
   B10=0;
else
   B10=SB10;
end
function
[B11]=BackgroundcolorSB11(SB11)
if SB11>1
   B11=1;
elseif SB11<0
   B11=0;
else
   B11=SB11;
end
function
[B12]=BackgroundcolorSB12(SB12)
if SB12>1
   B12=1;
elseif SB12<0
   B12=0;
else
   B12=SB12;
end
function
[B13]=BackgroundcolorSB13(SB13)
if SB13>1
   B13=1;
elseif SB13<0
   B13=0;
else
   B13=SB13;
end
function
[B14]=BackgroundcolorSB14(SB14)
if SB14>1
   B14=1;
elseif SB14<0
   B14=0;
else
   B14=SB14;
end
function
[B15]=BackgroundcolorSB15(SB15)
if SB15>1
   B15=1;
elseif SB15<0
   B15=0;
else
   B15=SB15;
end
```

Appendix V. 3-Musell.m

```
%This file display reflectances of the 16 displayed colour samples in this research project.
function [Musell_color,M0,M1, M2, M3, M4 ,M5, M6, M7, M8, M9, M10, M11 ,M12,M13,M14,M15]=Musell(c)
Musell_color=[ Musell_color means the reflectance of displayed 16 colour samples in this project, they are listed in Appendix I-2];
if c==1
M0=Musell_color(:,1);
elseif c==2
M1=Musell_color(:,2);
elseif c==3
M2=Musell_color(:,3);
elseif c==4
M3=Musell_color(:,4);
elseif c==5
M4=Musell_color(:,5);
elseif c==6
M5=Musell_color(:,6);
elseif c==7
M6=Musell_color(:,7);
elseif c==8
M7=Musell_color(:,8);
elseif c==9
M8=Musell_color(:,9);
elseif c==10
M9=Musell_color(:,10);
elseif c==11
M10=Musell_color(:,11);
elseif c==12
M11=Musell_color(:,12);
elseif c==13
M12=Musell_color(:,13);
elseif c==14
M13=Musell_color(:,14);
elseif c==15
M14=Musell_color(:,15);
else
M15=Musell_color(:,16);
end
```

Appendix V. 4-CIExyz.m

```
%This file displays the CIE1931 xyz  colorimetry observer
function [x,y,z]=CIExyz
xyz=[Displaying in Appendix III.1];
```

Appendix V. 5-SPD.m

```
%This file contains the SPDs of the light sources (F1 to F12, and NEW LEDs 1 to 3)
function [F]=SPD()
F=[ F equals the SPD of light sources F1 to F12 and New LED light sources 1 to 3. The SPDs of light sources' data tables are displayed in Appendix II.1 and Appendix II.8.];
```

Appendix V. 6-SPD2.m

```
% This file contains all the SPDs of light sources (FL3.1 to FL3.15), which are defined as F2.
function [F2]=SPD2()
F2=[ In this function, F equals the SPD of light sources FL3.1 to FL3.15 and the SPDs of light sources are displayed in Appendix II.7.];
```

Appendix V. 7-SPD3.m&SPD4.m

```
%F3=SPD3 means the SPDs of light sources (HP1 to HP5), F4=SPD4 means the SPDs of light sources(L.W. research 3-,4-,5-,6-,7-Band LEDs)

function [F3]=SPD3()
F3=[Displaying in Appendix II.2];

function [F4]=SPD4()
F4=[Displaying in Appendix II.5];
```

Appendix V. 8-SPD5.m&SPD6.m

```
%F5=SPD5, means the SPDs the light sources
(PM3016K,PM4000K,PM4100K,PM5500K,PM6500K LEDs),
F6=SPD6 means SPDs of CIE standard light source.
function [F5]=SPD5()
F5=[Displayed in Appendix II.6];
function [F6]=SPD6()
F6=[Displaying in Appendix II.7];
```

%F7=SPD7 means SPDs of the light sources for LED3000K, CIE2950K, High efficacy lighting.

```
function [F7]=SPD7()
F7=[0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.11   13.70   0.00
0.30   13.70   0.00
0.61   13.70   0.00
1.21   13.70   0.00
2.21   13.70   0.00
3.68   13.70   0.00
4.87   13.70   0.00
4.65   13.70   0.00
3.48   13.70   0.00
2.75   13.70   0.00
2.23   13.70   0.00
1.80   13.70   0.00
1.61   13.70   0.00
1.54   13.70   0.00
1.58   13.70   0.00
1.79   13.70   0.00
2.23   13.70   0.00
2.94   13.70   0.00
3.04   13.70   0.00
5.36   13.70   0.00
6.87   13.70   0.00
8.54   13.70   0.00
10.21   13.70   0.00
12.07   13.70   0.00
13.55   13.70   0.00
15.11   13.70   0.00
16.49   13.70   23.02
17.50   13.70   23.02
18.22   13.70   23.02
18.83   13.70   23.02
19.23   13.70   23.02
19.32   13.70   23.02
19.40   13.70   23.02
19.39   13.70   23.02
19.21   13.70   23.02
18.83   13.70   23.02
18.24   13.70   23.02
17.44   13.70   23.02
16.29   13.70   23.02
15.24   13.70   23.02
14.33   13.70   23.02
13.23   13.70   23.02
12.21   13.70   23.02
11.26   13.70   23.02
10.43   13.70   23.02
9.36   13.70   23.02
8.45   13.70   23.02
7.57   13.70   0.00
6.70   13.70   0.00
5.94   13.70   0.00
5.20   13.70   0.00
4.56   13.70   0.00
3.97   13.70   0.00
3.39   13.70   0.00
2.98   13.70   0.00
2.63   13.70   0.00
2.23   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00
0.00   13.70   0.00]; 
```

```
%This file implements the calculate function of RGB values of each displayed colour sample, this will display colours. SR0,1,…15, SG0,1,…,15 and SB0,1,…,15  are the screen Red, Green and Blue values of the displayed 16 colour samples,
function [RGBValue SR0 SG0 SB0 SR1 SG1 SB1  SR2 SG2 SB2 SR3 SG3 SB3 SR4 SG4 SB4 SR5 SG5 SB5 SR6 SG6 SB6 SR7 SG7 SB7 SR8 SG8 SB8 SR9 SG9 SB9 SR10 SG10 SB10 SR11 SG11 SB11 SR12 SG12 SB12 SB13 SR13 SG13 SR14 SG14 SB14 SR15 SG15 SB15 ]=calculateRGB(r,k1,F1)

global X0 Y0 Z0 x y z
%Reflectances of displayed colour samples.
Musell_color =[Diaplaying in Appendix II.2];
M0=Musell_color(:,1);
M1=Musell_color(:,2);
M2=Musell_color(:,3);
M3=Musell_color(:,4);
M4=Musell_color(:,5);
M5=Musell_color(:,6);
M6=Musell_color(:,7);
M7=Musell_color(:,8);
M8=Musell_color(:,9);
M9=Musell_color(:,10);
M10=Musell_color(:,11);
M11=Musell_color(:,12);
M12=Musell_color(:,13);
M13=Musell_color(:,14);
M14=Musell_color(:,15);
M15=Musell_color(:,16);
%CIE1931 colour matching functions.
xyz=[Displaying in Appendix III.1];
x=xyz(:,1);y=xyz(:,2);z=xyz(:,3);
%D is the matrix that achieved by calibration CRT monitor.
D=[ 2.8521   -1.2038   -0.4078
   -1.7193    2.7466   -0.1626
   -0.0672   -0.2600    1.2910];
%calculate trisitimuls XYZ values
X0=F1.*M0.*x;
Y0=F1.*M0.*y;
Z0=F1.*M0.*z;
%%calculate the toatal trisitimuls XYZ values from the wavelength 380nm to780nm.
a0=sum(X0);
b0=sum(Y0);
c0=sum(Z0);
d0=[a0;b0;c0];
%Compute RGB values of the colour samples from tristimulues values.
V0=D*d0;
R0=V0(1,1);
G0=V0(2,1);
B0=V0(3,1);
%Compute displaying screen RGB values of the displayed colour samples by use of GOG modle.
SR0=(((R0/255).^(1/r))+(1-k1)).*(255/k1);
SG0=(((G0/255).^(1/r))+(1-k1)).*(255/k1);
SB0=(((B0/255).^(1/r))+(1-k1)).*(255/k1);
X1=F1.*M1.*x;
Y1=F1.*M1.*y;
Z1=F1.*M1.*z;
a1=sum(X1);
b1=sum(Y1);
c1=sum(Z1);
d1=[a1;b1;c1];
V1=D*d1;
R1=V1(1,1);
G1=V1(2,1);
B1=V1(3,1);
SR1=(((R1/255).^(1/r))+(1-k1)).*(255/k1);
SG1=(((G1/255).^(1/r))+(1-k1)).*(255/k1);
SB1=(((B1/255).^(1/r))+(1-k1)).*(255/k1);
X2=F1.*M2.*x;
Y2=F1.*M2.*y;
Z2=F1.*M2.*z;
a2=sum(X2);
b2=sum(Y2);
c2=sum(Z2);
d2=[a2;b2;c2];
V2=D*d2;
R2=V2(1,1);
G2=V2(2,1);
B2=V2(3,1);
SR2=(((R2/255).^(1/r))+(1-k1)).*(255/k1);
SG2=(((G2/255).^(1/r))+(1-k1)).*(255/k1);
SB2=(((B2/255).^(1/r))+(1-k1)).*(255/k1);
X3=F1.*M3.*x;
Y3=F1.*M3.*y;
Z3=F1.*M3.*z;
a3=sum(X3);
b3=sum(Y3);
c3=sum(Z3);
d3=[a3;b3;c3];
V3=D*d3;
R3=V3(1,1);
G3=V3(2,1);
B3=V3(3,1);
```

```
SR3=(((R3/255).^(1/r))+(1-k1))*(255/k1);
SG3=(((G3/255).^(1/r))+(1-k1))*(255/k1);
SB3=(((B3/255).^(1/r))+(1-k1))*(255/k1);
X4=F1.*M4.*x;
Y4=F1.*M4.*y;
Z4=F1.*M4.*z;
a4=sum(X4);
b4=sum(Y4);
c4=sum(Z4);
d4=[a4;b4;c4];
V4=D*d4;
R4=V4(1,1);
G4=V4(2,1);
B4=V4(3,1);
SR4=(((R4/255).^(1/r))+(1-k1))*(255/k1);
SG4=(((G4/255).^(1/r))+(1-k1))*(255/k1);
SB4=(((B4/255).^(1/r))+(1-k1))*(255/k1);
X5=F1.*M5.*x;
Y5=F1.*M5.*y;
Z5=F1.*M5.*z;
a5=sum(X5);
b5=sum(Y5);
c5=sum(Z5);
d5=[a5;b5;c5];
V5=D*d5;
R5=V5(1,1);
G5=V5(2,1);
B5=V5(3,1);
SR5=(((R5/255).^(1/r))+(1-k1))*(255/k1);
SG5=(((G5/255).^(1/r))+(1-k1))*(255/k1);
SB5=(((B5/255).^(1/r))+(1-k1))*(255/k1);
X6=F1.*M6.*x;
Y6=F1.*M6.*y;
Z6=F1.*M6.*z;
a6=sum(X6);
b6=sum(Y6);
c6=sum(Z6);
d6=[a6;b6;c6];
V6=D*d6;
R6=V6(1,1);
G6=V6(2,1);
B6=V6(3,1);
SR6=(((R6/255).^(1/r))+(1-k1))*(255/k1);
SG6=(((G6/255).^(1/r))+(1-k1))*(255/k1);
SB6=(((B6/255).^(1/r))+(1-k1))*(255/k1);
X7=F1.*M7.*x;
Y7=F1.*M7.*y;
Z7=F1.*M7.*z;
a7=sum(X7);
b7=sum(Y7);
c7=sum(Z7);
d7=[a7;b7;c7];
V7=D*d7;
R7=V7(1,1);
G7=V7(2,1);
B7=V7(3,1);
SR7=(((R7/255).^(1/r))+(1-k1))*(255/k1);
SG7=(((G7/255).^(1/r))+(1-k1))*(255/k1);
SB7=(((B7/255).^(1/r))+(1-k1))*(255/k1);
X8=F1.*M8.*x;
Y8=F1.*M8.*y;
Z8=F1.*M8.*z;
a8=sum(X8);
b8=sum(Y8);
c8=sum(Z8);
d8=[a8;b8;c8];
V8=D*d8;
R8=V8(1,1);
G8=V8(2,1);
B8=V8(3,1);
SR8=(((R8/255).^(1/r))+(1-k1))*(255/k1);
SG8=(((G8/255).^(1/r))+(1-k1))*(255/k1);
SB8=(((B8/255).^(1/r))+(1-k1))*(255/k1);
X9=F1.*M9.*x;
Y9=F1.*M9.*y;
Z9=F1.*M9.*z;
a9=sum(X9);
b9=sum(Y9);
c9=sum(Z9);
d9=[a9;b9;c9];
V9=D*d9;
R9=V9(1,1);
G9=V9(2,1);
B9=V9(3,1);
SR9=(((R9/255).^(1/r))+(1-k1))*(255/k1);
SG9=(((G9/255).^(1/r))+(1-k1))*(255/k1);
SB9=(((B9/255).^(1/r))+(1-k1))*(255/k1);
X10=F1.*M10.*x;
Y10=F1.*M10.*y;
Z10=F1.*M10.*z;
a10=sum(X10);
b10=sum(Y10);
c10=sum(Z10);
d10=[a10;b10;c10];
V10=D*d10;
R10=V10(1,1);
G10=V10(2,1);
B10=V10(3,1);
SR10=(((R10/255).^(1/r))+(1-k1))*(255/k1);
SG10=(((G10/255).^(1/r))+(1-k1))*(255/k1);
SB10=(((B10/255).^(1/r))+(1-k1))*(255/k1);
X11=F1.*M11.*x;
Y11=F1.*M11.*y;
Z11=F1.*M11.*z;
a11=sum(X11);
b11=sum(Y11);
c11=sum(Z11);
d11=[a11;b11;c11];
V11=D*d11;
R11=V11(1,1);
```

```
G11=V11(2,1);
B11=V11(3,1);
SR11=(((R11/255).^(1/r))+(1-k1))*(255/k1);
SG11=(((G11/255).^(1/r))+(1-k1))*(255/k1);
SB11=(((B11/255).^(1/r))+(1-k1))*(255/k1);
X12=F1.*M12.*x;
Y12=F1.*M12.*y;
Z12=F1.*M12.*z;
a12=sum(X12);
b12=sum(Y12);
c12=sum(Z12);
d12=[a12;b12;c12];
V12=D*d12;
R12=V12(1,1);
G12=V12(2,1);
B12=V12(3,1);
SR12=(((R12/255).^(1/r))+(1-k1))*(255/k1);
SG12=(((G12/255).^(1/r))+(1-k1))*(255/k1);
SB12=(((B12/255).^(1/r))+(1-k1))*(255/k1);
X13=F1.*M13.*x;
Y13=F1.*M13.*y;
Z13=F1.*M13.*z;
a13=sum(X13);
b13=sum(Y13);
c13=sum(Z13);
d13=[a13;b13;c13];
V13=D*d13;
R13=V13(1,1);
G13=V13(2,1);
B13=V13(3,1);
SR13=(((R13/255).^(1/r))+(1-k1))*(255/k1);
SG13=(((G13/255).^(1/r))+(1-k1))*(255/k1);
SB13=(((B13/255).^(1/r))+(1-k1))*(255/k1);
X14=F1.*M14.*x;
Y14=F1.*M14.*y;
Z14=F1.*M14.*z;
a14=sum(X14);
b14=sum(Y14);
c14=sum(Z14);
d14=[a14;b14;c14];
V14=D*d14;
R14=V14(1,1);
G14=V14(2,1);
B14=V14(3,1);
SR14=(((R14/255).^(1/r))+(1-k1))*(255/k1);
SG14=(((G14/255).^(1/r))+(1-k1))*(255/k1);
SB14=(((B14/255).^(1/r))+(1-k1))*(255/k1);
X15=F1.*M15.*x;
Y15=F1.*M15.*y;
Z15=F1.*M15.*z;
a15=sum(X15);
b15=sum(Y15);
c15=sum(Z15);
d15=[a15;b15;c15];
V15=D*d15;
R15=V15(1,1);
G15=V15(2,1);
B15=V15(3,1);
SR15=(((R15/255).^(1/r))+(1-k1))*(255/k1);
SG15=(((G15/255).^(1/r))+(1-k1))*(255/k1);
SB15=(((B15/255).^(1/r))+(1-k1))*(255/k1);
%Transfer the displaying screen RGB values of displayed colour samples to Matlab RGB values.
RGBValue=[abs(SR0/255),abs(SR1/255),abs(SR2/255),abs(SR3/255),abs(SR4/255),abs(SR5/255),abs(SR6/255),abs(SR7/255),abs(SR8/255),abs(SR9/255),abs(SR10/255),abs(SR11/255),abs(SR12/255),abs(SR13/255),abs(SR14/255),abs(SR15/255);abs(SG0/255),abs(SG1/255),abs(SG2/255),abs(SG3/255),abs(SG4/255),abs(SG5/255),abs(SG6/255),abs(SG7/255),abs(SG8/255),abs(SG9/255),abs(SG10/255),abs(SG11/255),abs(SG12/255),abs(SG13/255),abs(SG14/255),abs(SG15/255);abs(SB0/255),abs(SB1/255),abs(SB2/255),abs(SB3/255),abs(SB4/255),abs(SB5/255),abs(SB6/255),abs(SB7/255),abs(SB8/255),abs(SB9/255),abs(SB10/255),abs(SB11/255),abs(SB12/255),abs(SB13/255),abs(SB14/255),abs(SB15/255)];
```

```
% Displaying the selected 16 colour samples on the left side of the designed VIS, it is called colour 1.
%DISPLAY 7.5R
SR0=RGBValue(1,1);
SG0=RGBValue(2,1);
SB0=RGBValue(3,1);
R0=BackgroundcolorSR0(SR0);
G0=BackgroundcolorSG0(SG0);
B0=BackgroundcolorSB0(SB0);
set(handles.B_7R,
'Backgroundcolor',[R0,G0,B0]);
%DISPLAY 5Y6/4
SR1=RGBValue(1,2);
SG1=RGBValue(2,2);
SB1=RGBValue(3,2);
R1=BackgroundcolorSR0(SR1);
G1=BackgroundcolorSG1(SG1);
B1=BackgroundcolorSB1(SB1);
set(handles.B_5Y,
'Backgroundcolor',[R1,G1,B1]);
%DISPLAY 5GY
SR2=RGBValue(1,3);
SG2=RGBValue(2,3);
SB2=RGBValue(3,3);
R2=BackgroundcolorSR2(SR2);
G2=BackgroundcolorSG2(SG2);
B2=BackgroundcolorSB2(SB2);
set(handles.B_5GY,
'Backgroundcolor',[R2,G2,B2]);
%DISPLAT 2.5G
SR3=RGBValue(1,4);
SG3=RGBValue(2,4);
SB3=RGBValue(3,4);
R3=BackgroundcolorSR3(SR3);
G3=BackgroundcolorSG3(SG3);
B3=BackgroundcolorSB3(SB3);
set(handles.B_2G,
'Backgroundcolor',[R3,G3,B3]);
%DISPLAY 10BG
SR4=RGBValue(1,5);
SG4=RGBValue(2,5);
SB4=RGBValue(3,5);
R4=BackgroundcolorSR4(SR4);
G4=BackgroundcolorSG4(SG4);
B4=BackgroundcolorSB4(SB4);
set(handles.B_10BG,
'Backgroundcolor',[R4,G4,B4]);
%DISPLAY 5PB
SR5=RGBValue(1,6);
SG5=RGBValue(2,6);
SB5=RGBValue(3,6);
R5=BackgroundcolorSR5(SR5);
G5=BackgroundcolorSG5(SG5);
B5=BackgroundcolorSB5(SB5);
set(handles.B_5PB,
'Backgroundcolor',[R5,G5,B5]);
%DISPLAY 2.5P
SR6=RGBValue(1,7);
SG6=RGBValue(2,7);
SB6=RGBValue(3,7);
R6=BackgroundcolorSR6(SR6);
G6=BackgroundcolorSG6(SG6);
B6=BackgroundcolorSB6(SB6);
set(handles.B_2P,
'Backgroundcolor',[R6,G6,B6]);
%DISPLAY 10P
SR7=RGBValue(1,8);
SG7=RGBValue(2,8);
SB7=RGBValue(3,8);
R7=BackgroundcolorSR7(SR7);
G7=BackgroundcolorSG7(SG7);
B7=BackgroundcolorSB7(SB7);
set(handles.B_10P,
'Backgroundcolor',[R7,G7,B7]);
%DISPLAY 4.5R
SR8=RGBValue(1,9);
SG8=RGBValue(2,9);
SB8=RGBValue(3,9);
R8=BackgroundcolorSR8(SR8);
G8=BackgroundcolorSG8(SG8);
B8=BackgroundcolorSB8(SB8);
set(handles.B_4R,
'Backgroundcolor',[R8,G8,B8]);
%DISPLAY 5Y
SR9=RGBValue(1,10);
SG9=RGBValue(2,10);
SB9=RGBValue(3,10);
R9=BackgroundcolorSR9(SR9);
G9=BackgroundcolorSG9(SG9);
B9=BackgroundcolorSB9(SB9);
set(handles.B_5Y8,
'Backgroundcolor',[R9,G9,B9]);
```

```
%DISPLAY 4.5G
SR10=RGBValue(1,11);
SG10=RGBValue(2,11);
SB10=RGBValue(3,11);
R10=BackgroundcolorSR10(SR10);
G10=BackgroundcolorSG10(SG10);
B10=BackgroundcolorSB10(SB10);
set(handles.B_4G,
'Backgroundcolor',[R10,G10,B10]);
%DISPLAY 3PB
SR11=RGBValue(1,12);
SG11=RGBValue(2,12);
SB11=RGBValue(3,12);
R11=BackgroundcolorSR11(SR11);
G11=BackgroundcolorSG11(SG11);
B11=BackgroundcolorSB11(SB11);
set(handles.B_3PB,
'Backgroundcolor',[R11,G11,B11]);
%DISPLAY 5YR
SR12=RGBValue(1,13);
SG12=RGBValue(2,13);
SB12=RGBValue(3,13);
R12=BackgroundcolorSR12(SR12);
G12=BackgroundcolorSG12(SG12);
B12=BackgroundcolorSB12(SB12);
set(handles.B_5YR,
'Backgroundcolor',[R12,G12,B12]);
%DISPLAY 5GY4/4
SR13=RGBValue(1,14);
SG13=RGBValue(2,14);
SB13=RGBValue(3,14);
R13=BackgroundcolorSR13(SR13);
G13=BackgroundcolorSG13(SG13);
B13=BackgroundcolorSB13(SB13);
set(handles.B_5GY4,
'Backgroundcolor',[R13,G13,B13]);
%DISPLAY LIGHT GREY
SR14=RGBValue(1,15);
SG14=RGBValue(2,15);
SB14=RGBValue(3,15);
R14=BackgroundcolorSR14(SR14);
G14=BackgroundcolorSG14(SG14);
B14=BackgroundcolorSB14(SB14);
set(handles.B_DG,
'Backgroundcolor',[R14,G14,B14]);
%DISPLAY DARK GREY
SR15=RGBValue(1,16);
SG15=RGBValue(2,16);
SB15=RGBValue(3,16);
R15=BackgroundcolorSR15(SR15);
G15=BackgroundcolorSG15(SG15);
B15=BackgroundcolorSB15(SB15);
set(handles.B_LG,
'Backgroundcolor',[R15,G15,B15]);
```

Appendix V. 12–Colour 2.m

```
% Displaying the selected 16 colour samples on the right side of the designed VIS, it is called colour 2.
%DISPLAY 7.5R
SR0=RGBValue(1,1);
SG0=RGBValue(2,1);
SB0=RGBValue(3,1);
R0=BackgroundcolorSR0(SR0);
G0=BackgroundcolorSG0(SG0);
B0=BackgroundcolorSB0(SB0);
set(handles.B_7R_2,'
Backgroundcolor',[R0,G0,B0]);
%DISPLAY 5Y6/4
SR1=RGBValue(1,2);
SG1=RGBValue(2,2);
SB1=RGBValue(3,2);
R1=BackgroundcolorSR0(SR1);
G1=BackgroundcolorSG1(SG1);
B1=BackgroundcolorSB1(SB1);
set(handles.B_5Y_2,
'Backgroundcolor',[R1,G1,B1]);
%DISPLAY 5GY
SR2=RGBValue(1,3);
SG2=RGBValue(2,3);
SB2=RGBValue(3,3);
R2=BackgroundcolorSR2(SR2);
G2=BackgroundcolorSG2(SG2);
B2=BackgroundcolorSB2(SB2);
set(handles.B_5GY_2,
'Backgroundcolor',[R2,G2,B2]);
%DISPLAT 2.5G
SR3=RGBValue(1,4);
SG3=RGBValue(2,4);
SB3=RGBValue(3,4);
R3=BackgroundcolorSR3(SR3);
G3=BackgroundcolorSG3(SG3);
B3=BackgroundcolorSB3(SB3);
set(handles.B_2G_2,
'Backgroundcolor',[R3,G3,B3]);
%DISPLAY 10BG
SR4=RGBValue(1,5);
SG4=RGBValue(2,5);
SB4=RGBValue(3,5);
R4=BackgroundcolorSR4(SR4);
G4=BackgroundcolorSG4(SG4);
B4=BackgroundcolorSB4(SB4);
set(handles.B_10BG_2,
'Backgroundcolor',[R4,G4,B4]);
%DISPLAY 5PB
SR5=RGBValue(1,6);
SG5=RGBValue(2,6);
SB5=RGBValue(3,6);
R5=BackgroundcolorSR5(SR5);
G5=BackgroundcolorSG5(SG5);
B5=BackgroundcolorSB5(SB5);
set(handles.B_5PB_2,
'Backgroundcolor',[R5,G5,B5]);
%DISPLAY 2.5P
SR6=RGBValue(1,7);
SG6=RGBValue(2,7);
SB6=RGBValue(3,7);
R6=BackgroundcolorSR6(SR6);
G6=BackgroundcolorSG6(SG6);
B6=BackgroundcolorSB6(SB6);
set(handles.B_2P_2,
'Backgroundcolor',[R6,G6,B6]);
%DISPLAY 10P
SR7=RGBValue(1,8);
SG7=RGBValue(2,8);
SB7=RGBValue(3,8);
R7=BackgroundcolorSR7(SR7);
G7=BackgroundcolorSG7(SG7);
B7=BackgroundcolorSB7(SB7);
set(handles.B_10P_2,
'Backgroundcolor',[R7,G7,B7]);
%DISPLAY 4.5R
SR8=RGBValue(1,9);
SG8=RGBValue(2,9);
SB8=RGBValue(3,9);
R8=BackgroundcolorSR8(SR8);
G8=BackgroundcolorSG8(SG8);
B8=BackgroundcolorSB8(SB8);
set(handles.B_4R_2,
'Backgroundcolor',[R8,G8,B8]);
%DISPLAY 5Y
SR9=RGBValue(1,10);
SG9=RGBValue(2,10);
SB9=RGBValue(3,10);
R9=BackgroundcolorSR9(SR9);
G9=BackgroundcolorSG9(SG9);
B9=BackgroundcolorSB9(SB9);
set(handles.B_5Y8_2,
'Backgroundcolor',[R9,G9,B9]);
%DISPLAY 4.5G
SR10=RGBValue(1,11);
```

```
SG10=RGBValue(2,11);
SB10=RGBValue(3,11);
R10=BackgroundcolorSR10(SR10);
G10=BackgroundcolorSG10(SG10);
B10=BackgroundcolorSB10(SB10);
set(handles.B_4G_2,
'Backgroundcolor',[R10,G10,B10]);
%DISPLAY 3PB
SR11=RGBValue(1,12);
SG11=RGBValue(2,12);
SB11=RGBValue(3,12);
R11=BackgroundcolorSR11(SR11);
G11=BackgroundcolorSG11(SG11);
B11=BackgroundcolorSB11(SB11);
set(handles.B_3PB_2,
'Backgroundcolor',[R11,G11,B11]);
%DISPLAY 5YR
SR12=RGBValue(1,13);
SG12=RGBValue(2,13);
SB12=RGBValue(3,13);
R12=BackgroundcolorSR12(SR12);
G12=BackgroundcolorSG12(SG12);
B12=BackgroundcolorSB12(SB12);
set(handles.B_5YR_2,
'Backgroundcolor',[R12,G12,B12]);
%DISPLAY 5GY4/4
SR13=RGBValue(1,14);
SG13=RGBValue(2,14);
SB13=RGBValue(3,14);
R13=BackgroundcolorSR13(SR13);
G13=BackgroundcolorSG13(SG13);
B13=BackgroundcolorSB13(SB13);
set(handles.B_5GY4_2,
'Backgroundcolor',[R13,G13,B13]);
%DISPLAY LIGHT GREY
SR14=RGBValue(1,15);
SG14=RGBValue(2,15);
SB14=RGBValue(3,15);
R14=BackgroundcolorSR14(SR14);
G14=BackgroundcolorSG14(SG14);
B14=BackgroundcolorSB14(SB14);
set(handles.B_DG_2,
'Backgroundcolor',[R14,G14,B14]);
%DISPLAY DARK GREY
SR15=RGBValue(1,16);
SG15=RGBValue(2,16);
SB15=RGBValue(3,16);
R15=BackgroundcolorSR15(SR15);
G15=BackgroundcolorSG15(SG15);
B15=BackgroundcolorSB15(SB15);
set(handles.B_LG_2,
'Backgroundcolor',[R15,G15,B15]);
```

%The code lising in this file implements the Main_GUI

```
function varargout = TEST2(varargin) % The Main_GUI is namedTest 2
% TEST2 M-file for TEST2.fig
%      TEST2, by itself, creates a new TEST2 or raises the existing
%      singleton*.
%      H = TEST2 returns the handle to a new TEST2 or the handle to
%      the existing singleton*.
%      TEST2('CALLBACK',hObject,eventData,handles,...) calls the local
%      function named CALLBACK in TEST2.M with the given input arguments.
%      TEST2('Property','Value',...) creates a new TEST2 or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before TEST2_OpeningFunction gets called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to TEST2_OpeningFcn via varargin.
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
% See also: GUIDE, GUIDATA, GUIHANDLES
% Edit the above text to modify the response to help TEST2
% Last Modified by GUIDE v2.5 26-Sep-2008 14:15:12
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @TEST2_OpeningFcn, ...
                   'gui_OutputFcn',  @TEST2_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
   gui_State.gui_Callback = str2func(varargin{1});
end
if nargout
   [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
   gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT
% --- Executes just before TEST2 is made visible.
function TEST2_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
% Update handles structure
guidata(hObject, handles);
% --- Outputs from this function are returned to the command line.
function varargout = TEST2_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
varargout{1} = handles.output;
% --- Executes on button press in B_7R.Create a function can display the 7R colour smaple.
function B_7R_Callback(hObject, eventdata, handles)
if handles.F1_OK_Button1
      set(handles.color1,'visible','on');
      set(handles.color1,'backgroundcolor',[1 0 0]);
elseif handles.F2_OK_Button1
   set(handles.color1,'visible','on');
   set(handles.color1,'backgroundcolor',[1 1 0]);
end
% --- Executes on button press in B_4R.
function B_5PB_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_10BG.
```

```
function B_10BG_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_2P.
function B_2P_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_4R.
function B_4R_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_5Y8.
function B_5Y8_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_4G.
function B_4G_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_5YR.
function B_5YR_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_5GY4.
function B_5GY4_Callback(hObject, eventdata, handles)
% --- Executes on button press in B_3PB.
function B_3PB_Callback(hObject, eventdata, handles)
% --- Executes on selection change in light_group1.This allows the user to select light sources from light
ing box that located in the left side of the VIS.
function light_group1_Callback(hObject, eventdata, handles)
switch get(handles.light_group1,'Value')
   case 1
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.lamp_grou
p1,handles.LED1_OK_Button1,handles.LED2_OK_Button1,handles.F_OK1,handles.FL_OK1,handles.H
P_OK1,handles.LED_OK1];
     set(sets,'visible','off');
   case 2
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.lamp_grou
p1,handles.LED2_OK_Button1,handles.LED3_OK_Button1,handles.F_OK1,handles.FL_OK1,handles.H
P_OK1,handles.LED_OK1];
     set(sets,'visible','off');
     set(handles.LED1_OK_Button1,'visible','on');
   case 3
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.lamp_grou
p1,handles.LED1_OK_Button1,handles.LED3_OK_Button1,handles.F_OK1,handles.FL_OK1,handles.H
P_OK1,handles.LED_OK1,];
     set(sets,'visible','off');
     set(handles.LED2_OK_Button1,'visible','on');
   case 4
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.lamp_grou
p1,handles.LED1_OK_Button1,handles.LED2_OK_Button1,handles.F_OK1,handles.FL_OK1,handles.H
P_OK1,handles.LED_OK1];
     set(sets,'visible','off');
     set(handles.LED3_OK_Button1,'visible','on');
   case 5
       set(handles.lamp_group1,'visible','on');
       set(handles.Ltype5,'visible','on');
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.LED1_OK
_Button1,handles.LED2_OK_Button1,handles.LED3_OK_Button1,handles.Ltype2,handles.Ltype1,handl
es.Ltype7,handles.Ltype9,handles.LED_OK1,handles.F_OK1,handles.FL_OK1];
       set(sets,'visible','off');
   case 6
       set(handles.lamp_group1,'visible','on');
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.LED1_OK
_Button1,handles.LED2_OK_Button1,handles.LED3_OK_Button1,handles.Ltype2,handles.Ltype5,handl
es.Ltype7,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.Ltype9];
       set(sets,'visible','off');
       set(handles.Ltype1,'visible','on');
   case 7
        set(handles.lamp_group1,'visible','on');
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.LED1_OK
_Button1,handles.LED2_OK_Button1,handles.LED3_OK_Button1,handles.Ltype1,handles.Ltype5,handl
es.Ltype7,handles.LED_OK1,handles.F_OK1,handles.HP_OK1,handles.Ltype9];
```

```
        set(sets,'visible','off');
        set(handles.Ltype2,'visible','on');
    case 8
        set(handles.lamp_group1,'visible','on');
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.LED1_OK_Button1,handles.LED2_OK_Button1,handles.LED3_OK_Button1,handles.Ltype1,handles.Ltype2,handles.Ltype5,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.Ltype9];
        set(sets,'visible','off');
        set(handles.Ltype7,'visible','on');
    case 9
        set(handles.lamp_group1,'visible','on');
sets=[handles.CIE_OK1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4,handles.LED1_OK_Button1,handles.LED2_OK_Button1,handles.LED3_OK_Button1,handles.Ltype1,handles.Ltype2,handles.Ltype5,handles.Ltype7,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,];
        set(sets,'visible','off');
        set(handles.Ltype9,'visible','on');
    otherwise
end
% --- Executes during object creation, after setting all properties.
function light_group1_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function light_group1_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on selection change in Ltype1.This allows the user to select different type of light source from lighting box that are located in left side of theVIS.
function Ltype1_Callback(hObject, eventdata, handles)
switch get(handles.Ltype1,'Value')
        case 1
sets=[handles.CIE_OK1,handles.LED_OK1,handles.F_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Button1,handles.F10_OK_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
      case 2
        set(handles.F_OK1,'visible','on');
        set(handles.F1_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Button1,handles.F10_OK_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
       case 3
       set(handles.F_OK1,'visible','on');
sets=[handles.CIE_OK1,handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.Ltype5,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F1_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Button1,handles.F10_OK_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
       set(handles.F2_OK_Button1,'visible','on');
       set(sets,'visible','off');
        case 4
        set(handles.F_OK1,'visible','on');
        set(handles.F3_OK_Button1, 'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F1_OK_Button1,handles.F2_OK_Button1,handles.F4_OK_Button1,handles.F5_OK_Button1,handles.F6_
```

```
OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Button1,handles.F10_O
K_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 5
        set(handles.F_OK1,'visible','on');
        set(handles.F4_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F1
_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F5_OK_Button1,handles.F6_O
K_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Button1,handles.F10_OK
_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 6
        set(handles.F_OK1,'visible','on');
        set(handles.F5_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F
1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F6_
OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Button1,handles.F10_O
K_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 7
        set(handles.F_OK1,'visible','on');
        set(handles.F6_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F
1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_
OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Button1,handles.F10_O
K_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 8
        set(handles.F_OK1,'visible','on');
        set(handles.F7_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.HP_OK1,handles.FL_OK1,handle
s.RGB1,handles.F1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Bu
tton1,handles.F5_OK_Button1,handles.F6_OK_Button1,handles.F8_OK_Button1,handles.F9_OK_Butto
n1,handles.F10_OK_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 9
        set(handles.F_OK1,'visible','on');
        set(handles.F8_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F
1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_
OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F9_OK_Button1,handles.F10_O
K_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 10
        set(handles.F_OK1,'visible','on');
        set(handles.F9_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F
1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_
OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F10_O
K_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 11
        set(handles.F_OK1,'visible','on');
        set(handles.F10_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F
1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_
OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_O
K_Button1,handles.F11_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 12
        set(handles.F_OK1,'visible','on');
```

```
        set(handles.F11_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F
1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_
OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_O
K_Button1,handles.F10_OK_Button1,handles.F12_OK_Button1];
        set(sets,'visible','off');
    case 13
        set(handles.F_OK1,'visible','on');
        set(handles.F12_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.FL_OK1,handles.RGB1,handles.F
1_OK_Button1,handles.F2_OK_Button1,handles.F3_OK_Button1,handles.F4_OK_Button1,handles.F5_
OK_Button1,handles.F6_OK_Button1,handles.F7_OK_Button1,handles.F8_OK_Button1,handles.F9_O
K_Button1,handles.F10_OK_Button1,handles.F11_OK_Button1];
        set(sets,'visible','off');
    otherwise
end
% --- Executes during object creation, after setting all properties.
function Ltype1_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on selection change in Ltype2.This allows the user to select different type of light sources
in FL lighting box on left side of the VIS.
function Ltype2_Callback(hObject, eventdata, handles)
switch get(handles.Ltype2,'Value')
      case 1
sets=[handles.CIE_OK1,handles.LED_OK1,handles.FL_OK1,handles.HP_OK1,handles.F_OK1,handles.
RGB1,handles.FL1_OK_Button1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK
_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_
OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.
FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1]
;
        set(sets,'visible','off');
       case 2
        set(handles.FL_OK1,'visible','on');
        set(handles.FL1_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL
2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.
FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handl
es.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Butto
n1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 3
        set(handles.FL_OK1,'visible','on');
        set(handles.FL2_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL
1_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.
FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handl
es.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Butto
n1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 4
        set(handles.FL_OK1,'visible','on');
        set(handles.FL3_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL
2_OK_Button1,handles.FL1_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.
FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handl
es.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Butto
n1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 5
```

```
        set(handles.FL_OK1,'visible','on');
        set(handles.FL4_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL1_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 6
        set(handles.FL_OK1,'visible','on');
        set(handles.FL5_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL1_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 7
        set(handles.FL_OK1,'visible','on');
        set(handles.FL6_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL1_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 8
        set(handles.FL_OK1,'visible','on');
        set(handles.FL7_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL1_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 9
        set(handles.FL_OK1,'visible','on');
        set(handles.FL8_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL1_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 10
        set(handles.FL_OK1,'visible','on');
        set(handles.FL9_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL1_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 11
        set(handles.FL_OK1,'visible','on');
        set(handles.FL10_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL1_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
```

```
        set(sets,'visible','off');
    case 12
        set(handles.FL_OK1,'visible','on');
        set(handles.FL11_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL1_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 13
        set(handles.FL_OK1,'visible','on');
        set(handles.FL12_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL1_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 14
        set(handles.FL_OK1,'visible','on');
        set(handles.FL13_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL1_OK_Button1,handles.FL14_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 15
        set(handles.FL_OK1,'visible','on');
        set(handles.FL14_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL1_OK_Button1,handles.FL15_OK_Button1];
        set(sets,'visible','off');
    case 16
        set(handles.FL_OK1,'visible','on');
        set(handles.FL15_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.RGB1,handles.FL1_OK_Button1,handles.FL2_OK_Button1,handles.FL3_OK_Button1,handles.FL4_OK_Button1,handles.FL5_OK_Button1,handles.FL6_OK_Button1,handles.FL7_OK_Button1,handles.FL8_OK_Button1,handles.FL9_OK_Button1,handles.FL10_OK_Button1,handles.FL11_OK_Button1,handles.FL12_OK_Button1,handles.FL13_OK_Button1,handles.FL14_OK_Button1];
        set(sets,'visible','off');
    otherwise
end
% --- Executes during object creation, after setting all properties.
function Ltype2_CreateFcn(hObject, eventdata, handles)
% hObject    handle to Ltype2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called
% Hint: popupmenu controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in F1_OK_Button1.Displaying colour samples under light source F1 on the left side of the VIS.
function F1_OK_Button1_Callback(hObject, eventdata, handles)
```

```
SPD();F=SPD;F1=F(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F1_RGB1,handle
s.RGBF1];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.R
GBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,han
dles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11
_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED2_RGB1,handles.LED3_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F2_OK_Button1. Displaying colour samples under light source F2 on
the left side of the VIS.
function F2_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F2_RGB1,handle
s.RGBF2];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF1,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.R
GBF11,handles.RGBF12,handles.F1_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,han
dles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11
_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F3_OK_Button1. Displaying colour samples under light source F4 on
the left side of the VIS.
function F3_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F3_RGB1,handle
s.RGBF3];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF1,handles.RGBF4,handle
s.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.R
GBF11,handles.RGBF12,handles.F2_RGB1,handles.F1_RGB1,handles.F4_RGB1,handles.F5_RGB1,han
dles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11
_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F4_OK_Button1. Displaying colour samples under light source F4 on
the left side of the VIS.
function F4_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,4);
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F4_RGB1,handle
s.RGBF4];
set(sets1,'visible','on');
```

```
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF1,handles.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.RGBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F1_RGB1,handles.F5_RGB1,handles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F5_OK_Button1. Displaying colour samples under light source F5 on the left side of the VIS.
function F5_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F5_RGB1,handles.RGBF5];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handles.RGBF1,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.RGBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F1_RGB1,handles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F6_OK_Button1. Displaying colour samples under light source F6 on the left side of the VIS.
function F6_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,6);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F6_RGB1,handles.RGBF6];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handles.RGBF5,handles.RGBF1,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.RGBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,handles.F1_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F7_OK_Button1. Displaying colour samples under light source F7 on the left side of the VIS.
function F7_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,7);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F7_RGB1,handles.RGBF7];
set(sets1,'visible','on');
```

```
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF1,handles.RGBF6,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.R
GBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,han
dles.F1_RGB1,handles.F6_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11
_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F10_OK_Button1. Displaying colour samples under light source F10 on
the left side of the VIS.
function F10_OK_Button1_Callback(hObject, eventdata, handles)
% hObject    handle to F10_OK_Button1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
SPD();F=SPD;F1=F(:,10);
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F10_RGB1,handl
es.RGBF10];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF1,handles.RG
BF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,hand
les.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F1_RGB1,handles.F11_R
GB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');

%Create and Call a set of colour sample on the Left side of theVIS and it contains 16 colour
samples .function color1_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function color1_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_7R_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_5P_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_5PB_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_10BG_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_5BG_CreateFcn(hObject, eventdata, handles)
```

```
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_2P_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_4R_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_5Y8_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_5YR_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_5GY4_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_3PB_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

%Create and Call a set of colour sample on the Right side of theVIS and it contains 16 colour samples .
function color2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function color2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_7R_2_Callback(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5P_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5P_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5PB_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5PB_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_10BG_2_Callback(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
```

```
function B_5BG_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5BG_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_2P_2_Callback(hObject, eventdata, handles)
% hObject    handle to B_2P_2 (see GCBO)
% --- Executes during object creation, after setting all properties.
function B_2P_2_CreateFcn(hObject, eventdata, handles)
% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_4R_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_4R_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5Y8_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5Y8_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_4G_2_Callback(hObject, eventdata, handles)
% hObject    handle to B_4G_2 (see GCBO)
% --- Executes during object creation, after setting all properties.
function B_4G_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_3PB_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_3PB_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5YR_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5YR_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5GY4_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5GY4_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in LED1_OK_Button1.Display the left set colour samples under LED1
light source.
function LED1_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,13);
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.LED1_RGB1,han
dles.RGBLED1];
set(sets1,'visible','on');
sets=[handles.RGB5,handles.RGBCIE_Button1,handles.RGBLED3,handles.RGBHP_Button1,handles.R
GBFL_Button1,handles.RGBLED_Button1,handles.RGBF1,handles.RGBLED2,handles.RGBF2,handles.
```

```
RGBF3,handles.RGBF4,handles.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGB
F9,handles.RGBF10,handles.RGBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4
_RGB1,handles.F5_RGB1,handles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,h
andles.F10_RGB1,handles.F11_RGB1,handles.F12_RGB1,handles.F1_RGB1,handles.LED3_RGB1,han
dles.LED2_RGB1];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
% --- Executes on button press in LED2_OK_Button1. Display the left set colour samples under LED2
light source.
function LED2_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,14);
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.LED2_RGB1,han
dles.RGBLED2];
set(sets1,'visible','on');
sets=[handles.RGB5,handles.RGBCIE_Button1,handles.RGBLED3,handles.RGBHP_Button1,handles.R
GBFL_Button1,handles.RGBLED_Button1,handles.RGBLED1,handles.RGBF1,handles.RGBF2,handles.
RGBF3,handles.RGBF4,handles.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGB
F9,handles.RGBF10,handles.RGBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4
_RGB1,handles.F5_RGB1,handles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,h
andles.F10_RGB1,handles.F11_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,
handles.F1_RGB1];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
% --- Executes on selection change in light_group2.This allows the user to select light source buttons
which are located on the right side of the VIS.
function light_group2_Callback(hObject, eventdata, handles)
switch get(handles.light_group2,'Value')
   case 1
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.lamp_group2,handles.LED1_OK_Button2,ha
ndles.LED2_OK_Button2,handles.LED3_OK_Button2,handles.F_OK2,handles.FL_OK2,handles.HP_O
K2,handles.LED_OK2,handles.Ltype10,];
     set(sets,'visible','off');
   case 2
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.lamp_group2,handles.LED2_OK_Button2,ha
ndles.LED3_OK_Button2,handles.F_OK2,handles.FL_OK2,handles.HP_OK2,handles.LED_OK2];
     set(sets,'visible','off');
     set(handles.LED1_OK_Button2,'visible','on');
   case 3
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.lamp_group2,handles.LED1_OK_Button2,ha
ndles.LED3_OK_Button2,handles.F_OK2,handles.FL_OK2,handles.HP_OK2,handles.LED_OK2];
    set(sets,'visible','off');
     set(handles.LED2_OK_Button2,'visible','on');
   case 4
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.lamp_group2,handles.LED1_OK_Button2,ha
ndles.LED2_OK_Button2,handles.F_OK2,handles.FL_OK2,handles.HP_OK2,handles.LED_OK2];
    set(sets,'visible','off');
     set(handles.LED3_OK_Button2,'visible','on');
  case 5
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.LED1_OK_Button2,handles.LED2_OK_But
ton2,handles.LED3_OK_Button2,handles.Ltype3,handles.Ltype4,handles.Ltype8,handles.FL_OK2,handl
es.F_OK2,handles.LED_OK2,handles.Ltype10,];
       set(sets,'visible','off');
       set(handles.lamp_group2,'visible','on');
       set(handles.Ltype6,'visible','on');
 case 6
```

```
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.LED3_OK_Button2,handles.Ltype6,handles.Ltype4,handles.Ltype8,handles.FL_OK2,handles.HP_OK2,handles.LED_OK2,handles.Ltype10,];
        set(handles.lamp_group2,'visible','on');
        set(sets,'visible','off');
        set(handles.Ltype3,'visible','on');
    case 7
         set(handles.lamp_group2,'visible','on');
         set(handles.Ltype4,'visible','on');
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.LED3_OK_Button2,handles.Ltype6,handles.Ltype3,handles.Ltype8,handles.F_OK2,handles.HP_OK2,handles.LED_OK2,handles.Ltype10,];
        set(sets,'visible','off');
    case 8
         set(handles.lamp_group2,'visible','on');
         set(handles.Ltype8,'visible','on');
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.LED3_OK_Button2,handles.Ltype6,handles.Ltype3,handles.Ltype4,handles.FL_OK2,handles.HP_OK2,handles.F_OK2,handles.Ltype10,];
        set(sets,'visible','off');
    case 9
        set(handles.lamp_group2,'visible','on');
         set(handles.Ltype10,'visible','on');
sets=[handles.RGBCIE_Button2,handles.CIE_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.LED3_OK_Button2,handles.Ltype8,handles.Ltype6,handles.Ltype3,handles.Ltype4,handles.FL_OK2,handles.HP_OK2,handles.F_OK2];
        set(sets,'visible','off');
    otherwise
end
% --- Executes during object creation, after setting all properties. This allows the user to select different type of light sources from lighting box that located on the right side of the VIS.
function light_group2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on selection change in Ltype4.Allows the user to select light sources type in right side of the designed VIS.
function Ltype4_Callback(hObject, eventdata, handles)
switch get(handles.Ltype4,'Value')
    case 1
sets=[handles.HP_OK2,handles.F_OK2,handles.FL1_OK_Button2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,handles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 2
        set(handles.FL_OK2,'visible','on');
        set(handles.FL1_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,handles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 3
        set(handles.FL_OK2,'visible','on');
        set(handles.FL2_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL1_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,ha
```

```
ndles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Bu
tton2];
        set(sets,'visible','off');
    case 4
         set(handles.FL_OK2,'visible','on');
        set(handles.FL3_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL1_OK_Button2,handles.FL
4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.
FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,ha
ndles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Bu
tton2];
        set(sets,'visible','off');
    case 5
         set(handles.FL_OK2,'visible','on');
         set(handles.FL4_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL
1_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.
FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,ha
ndles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Bu
tton2];
         set(sets,'visible','off');
    case 6
         set(handles.FL_OK2,'visible','on');
        set(handles.FL5_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL
4_OK_Button2,handles.FL1_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.
FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,ha
ndles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Bu
tton2];
        set(sets,'visible','off');
    case 7
         set(handles.FL_OK2,'visible','on');
        set(handles.FL6_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL
4_OK_Button2,handles.FL5_OK_Button2,handles.FL1_OK_Button2,handles.FL7_OK_Button2,handles.
FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,ha
ndles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Bu
tton2];
        set(sets,'visible','off');
    case 8
         set(handles.FL_OK2,'visible','on');
        set(handles.FL7_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL
4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL1_OK_Button2,handles.
FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,ha
ndles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Bu
tton2];
        set(sets,'visible','off');
    case 9
         set(handles.FL_OK2,'visible','on');
        set(handles.FL8_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL
4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.
FL1_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,ha
ndles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Bu
tton2];
        set(sets,'visible','off');
    case 10
         set(handles.FL_OK2,'visible','on');
        set(handles.FL9_OK_Button2,'visible','on');
```

```
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL1_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,handles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 11
         set(handles.FL_OK2,'visible','on');
        set(handles.FL10_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL1_OK_Button2,handles.FL11_OK_Button2,handles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 12
         set(handles.FL_OK2,'visible','on');
        set(handles.FL11_OK_Button2,'visible','on');

sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL1_OK_Button2,handles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 13
         set(handles.FL_OK2,'visible','on');
        set(handles.FL12_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,handles.FL1_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 14
         set(handles.FL_OK2,'visible','on');
        set(handles.FL13_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,handles.FL12_OK_Button2,handles.FL1_OK_Button2,handles.FL14_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 15
         set(handles.FL_OK2,'visible','on');
        set(handles.FL14_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,handles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL1_OK_Button2,handles.FL15_OK_Button2];
        set(sets,'visible','off');
    case 16
         set(handles.FL_OK2,'visible','on');
        set(handles.FL15_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL2_OK_Button2,handles.FL3_OK_Button2,handles.FL4_OK_Button2,handles.FL5_OK_Button2,handles.FL6_OK_Button2,handles.FL7_OK_Button2,handles.FL8_OK_Button2,handles.FL9_OK_Button2,handles.FL10_OK_Button2,handles.FL11_OK_Button2,handles.FL12_OK_Button2,handles.FL13_OK_Button2,handles.FL14_OK_Button2,handles.FL1_OK_Button2];
        set(sets,'visible','off');
```

```
    otherwise
end
% --- Executes during object creation, after setting all properties.
 function Ltype4_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on selection change in Ltype3. It is allows the user to choose different light sources from
F1 to F12 on right side of the VIS.
function Ltype3_Callback(hObject, eventdata, handles)
switch get(handles.Ltype3,'Value')
    case 1
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handl
es.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.
F5_OK_Button2,handles.F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9
_OK_Button2,handles.F10_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 2
        set(handles.F_OK2,'visible','on');
        set(handles.F1_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_
OK_Button2,handles.F5_OK_Button2,handles.F6_OK_Button2,handles.F7_OK_Button2,handles.F8_O
K_Button2,handles.F9_OK_Button2,handles.F10_OK_Button2,handles.F11_OK_Button2,handles.F12_
OK_Button2];
        set(sets,'visible','off');
    case 3
        set(handles.F_OK2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handl
es.F1_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.
F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F1
0_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
     set(handles.F2_OK_Button2,'visible','on');
    case 4
        set(handles.F_OK2,'visible','on');
        set(handles.F3_OK_Button2, 'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handl
es.F1_OK_Button2,handles.F2_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.
F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F1
0_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 5
        set(handles.F_OK2,'visible','on');
        set(handles.F4_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handl
es.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F5_OK_Button2,handles.
F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F1
0_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 6
        set(handles.F_OK2,'visible','on');
        set(handles.F5_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handl
es.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.
F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F1
0_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 7
        set(handles.F_OK2,'visible','on');
        set(handles.F6_OK_Button2,'visible','on');
```

```
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F10_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 8
        set(handles.F_OK2,'visible','on');
        set(handles.F7_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.F6_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F10_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 9
        set(handles.F_OK2,'visible','on');
        set(handles.F8_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.F6_OK_Button2,handles.F7_OK_Button2,handles.F9_OK_Button2,handles.F10_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 10
        set(handles.F_OK2,'visible','on');
        set(handles.F9_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F10_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 11
        set(handles.F_OK2,'visible','on');
        set(handles.F10_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F11_OK_Button2,handles.F12_OK_Button2];
        set(sets,'visible','off');
    case 12
        set(handles.F_OK2,'visible','on');
       set(handles.F11_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F10_OK_Button2,handles.F12_OK_Button2];
       set(sets,'visible','off');
    case 13
        set(handles.F_OK2,'visible','on');
        set(handles.F12_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.FL_OK2,handles.LED1_OK_Button2,handles.LED2_OK_Button2,handles.F1_OK_Button2,handles.F2_OK_Button2,handles.F3_OK_Button2,handles.F4_OK_Button2,handles.F5_OK_Button2,handles.F6_OK_Button2,handles.F7_OK_Button2,handles.F8_OK_Button2,handles.F9_OK_Button2,handles.F10_OK_Button2,handles.F11_OK_Button2];
        set(sets,'visible','off');
     otherwise
end
% --- Executes during object creation, after setting all properties.
function Ltype3_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
```

```
% --- Executes on button press in LED1_OK_Button2.Display a set of colour samples on the right side of
the VIS under LED1 light source.
function LED1_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,13);
sets1=[handles.C2,handles.RGBValue2,handles.LED1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.RGBHP_Button2,handles.RGBFL_Button2,handles.RGBLED_Button2,handles.F2_RGB2,
handles.LED2_RGB2,handles.LED3_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F4_RGB2,ha
ndles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10
_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in LED2_OK_Button2. Display a set of colour samples on the right side
of the VIS under LED2 light source.
function LED2_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,14);sets1=[handles.C2,handles.RGBValue2,handles.LED2_RGB2,handles.RGBF_
button2];
set(sets1,'visible','on');
sets=[handles.RGBHP_Button2,handles.RGBFL_Button2,handles.RGBLED_Button2,handles.LED1_RG
B2,handles.LED3_RGB2,handles.F2_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F4_RGB2,ha
ndles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10
_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F1_OK_Button2 Display a set of colour samples on the right side of the
VIS under F1 light source.
function F1_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,1);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RG
B2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handl
es.F11_RGB2,handles.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F2_OK_Button2. Display a set of colour samples on the right side of
the VIS under F2 light source.
function F2_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,2);
sets1=[handles.C2,handles.RGBValue2,handles.F2_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_
RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,ha
ndles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
Appendix V.12;
% --- Executes on button press in F3_OK_Button2 Display a set of colour samples on the right side of the
VIS under F3 light source.
function F3_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,3);
```

```
sets1=[handles.C2,handles.RGBValue2,handles.F3_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F2_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F4_OK_Button2. Display a set of colour samples on the right side of the VIS under F4 light source.
function F4_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,4);
sets1=[handles.C2,handles.RGBValue2,handles.F4_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F2_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F5_OK_Button2. Display a set of colour samples on the right side of the VIS under F5 light source.
function F5_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,5);
sets1=[handles.C2,handles.RGBValue2,handles.F5_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F2_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F6_OK_Button2. Display a set of colour samples on the right side of the VIS under F6 light source.
function F6_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,6);
sets1=[handles.C2,handles.RGBValue2,handles.F6_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F2_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F7_OK_Button2. Display a set of colour samples on the right side of the VIS under F7 light source.
function F7_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,7);
sets1=[handles.C2,handles.RGBValue2,handles.F7_RGB2,handles.RGBF_button2];
```

```
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_
RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F2_RGB2,handles.F8_RGB2,ha
ndles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F8_OK_Button2. Display a set of colour samples on the right side of
the VIS under F8 light source.
function F8_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,8);
sets1=[handles.C2,handles.RGBValue2,handles.F8_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_
RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F2_RGB2,ha
ndles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F9_OK_Button2. Display a set of colour samples on the right side of
the VIS under F9 light source.
function F9_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,9);
sets1=[handles.C2,handles.RGBValue2,handles.F9_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_
RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,ha
ndles.F2_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F10_OK_Button2 .Display a set of colour samples on the right side of
the VIS under F10 light source.
function F10_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,10);
sets1=[handles.C2,handles.RGBValue2,handles.F10_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_
RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,ha
ndles.F9_RGB2,handles.F2_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F11_OK_Button2. Display a set of colour samples on the right side of
the VIS under F11 light source.
function F11_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,11);
sets1=[handles.C2,handles.RGBValue2,handles.F11_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
```

```
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F2_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in F12_OK_Button2. Display a set of colour samples on the right side of the VIS under F12 light source.
function F12_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,12);
sets1=[handles.C2,handles.RGBValue2,handles.F12_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.LED3_RGB2,handles.LED2_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F2_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets2,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in Plot_Button.Plot SPDs of the selected light sources
function Plot_Button_Callback(hObject, eventdata, handles)
Plot_GUI;
% --- Executes on button press in Close_Button. Close the Main_GUi.
function Close_Button_Callback(hObject, eventdata, handles)
close TEST2;
% --- Executes on button press in F1_RGB1. Open RGBF1.txt file to display the RGBvalues of the displayed 16 colour samples under light source F1.
function F1_RGB1_Callback(hObject, eventdata, handles)
open('RGBF1.txt');
% --- Executes on button press in F2_RGB1. Open RGBF2.txt file to display the RGBvalues of the displayed 16 colour samples under light source F2.
function F2_RGB1_Callback(hObject, eventdata, handles)
open('RGBF2.txt');
% --- Executes on button press in F3_RGB1. Open RGBF3.txt file to display the RGBvalues of the displayed 16 colour samples under light source F3.
function F3_RGB1_Callback(hObject, eventdata, handles)
open('RGBF3.txt');
% --- Executes on button press in F4_RGB1. Open RGBF4.txt file to display the RGBvalues of the displayed 16 colour samples under light source F4.
function F4_RGB1_Callback(hObject, eventdata, handles)
open('RGBF4.txt');
% --- Executes on button press in F5_RGB1. Open RGBF5.txt file to display the RGBvalues of the displayed 16 colour samples under light source F5.
function F5_RGB1_Callback(hObject, eventdata, handles)
open('RGBF5.txt');
% --- Executes on button press in F6_RGB1. Open RGBF6.txt file to display the RGBvalues of the displayed 16 colour samples under light source F6.
function F6_RGB1_Callback(hObject, eventdata, handles)
open('RGBF6.txt');
% --- Executes on button press in F7_RGB1. Open RGBF7.txt file to display the RGBvalues of the displayed 16 colour samples under light source F7.
function F7_RGB1_Callback(hObject, eventdata, handles)
open('RGBF7.txt');
% --- Executes on button press in F8_RGB1. Open RGBF8.txt file to display the RGBvalues of the displayed 16 colour samples under light source F8.
function F8_RGB1_Callback(hObject, eventdata, handles)
```

```
open('RGBF8.txt');
%Open RGBF9.txt file to display the RGBvalues of the displayed 16 colour samples under light source F9.
function F9_RGB1_Callback(hObject, eventdata, handles)
open('RGBF9.txt');
% --- Executes on button press in F10_RGB1. Open RGBF10.txt file to display the RGBvalues of the displayed 16 colour samples under light source F10.
function F10_RGB1_Callback(hObject, eventdata, handles)
open('RGBF10.txt');
% --- Executes on button press in F11_RGB1. Open RGBF11.txt file to display the RGBvalues of the displayed 16 colour samples under light source F11.
function F11_RGB1_Callback(hObject, eventdata, handles)
open('RGBF11.txt');
% --- Executes on button press in F12_RGB1. Open RGBF12.txt file to display the RGBvalues of the displayed 16 colour samples under light source F12.
function F12_RGB1_Callback(hObject, eventdata, handles)
open('RGBF12.txt');
% --- Executes on button press in LED1_RGB1. Open LED1_RGB1.txt file to display the RGBvalues of the displayed 16 colour samples under light source LED1.
function LED1_RGB1_Callback(hObject, eventdata, handles)
open('RGB_LED1.txt');
% --- Executes on button press in LED2_RGB1. Open LED2_RGB1.txt file to display the RGBvalues of the displayed 16 colour samples under light source LED2
function LED2_RGB1_Callback(hObject, eventdata, handles)
open('RGB_LED2.txt');
% --- Executes on button press in F1_RGB2. Open F1.txt file to display the RGBvalues of the displayed 16 colour samples under light source F1 on the right side of the VIS.
function F1_RGB2_Callback(hObject, eventdata, handles)
open('RGBF1.txt');
% --- Executes on button press in F2_RGB2. Open F2.txt file to display the RGBvalues of the displayed 16 colour samples under light source F2 on the right side of the VIS.
function F2_RGB2_Callback(hObject, eventdata, handles)
open('RGBF2.txt');
% --- Executes on button press in F3_RGB2. Open F3.txt file to display the RGBvalues of the displayed 16 colour samples under light source F3 on the right side of the VIS.
function F3_RGB2_Callback(hObject, eventdata, handles)
open('RGBF3.txt');
% --- Executes on button press in F4_RGB2. Open F4.txt file to display the RGBvalues of the displayed 16 colour samples under light source F4 on the right side of the VIS.
function F4_RGB2_Callback(hObject, eventdata, handles)
open('RGBF4.txt');
% --- Executes on button press in F5_RGB2. Open F5.txt file to display the RGBvalues of the displayed 16 colour samples under light source F5 on the right side of the VIS.
function F5_RGB2_Callback(hObject, eventdata, handles)
open('RGBF5.txt');
% --- Executes on button press in F6_RGB2. Open F6.txt file to display the RGBvalues of the displayed 16 colour samples under light source F6 on the right side of the VIS.
function F6_RGB2_Callback(hObject, eventdata, handles)
open('RGBF6.txt');
% --- Executes on button press in F7_RGB2. Open F7.txt file to display the RGBvalues of the displayed 16 colour samples under light source F7 on the right side of the VIS.
function F7_RGB2_Callback(hObject, eventdata, handles)
open('RGBF7.txt');
% --- Executes on button press in F8_RGB2. Open F8.txt file to display the RGBvalues of the displayed 16 colour samples under light source F8 on the right side of the VIS.
function F8_RGB2_Callback(hObject, eventdata, handles)
open('RGBF8.txt');
% --- Executes on button press in F9_RGB2. Open F9.txt file to display the RGBvalues of the displayed 16 colour samples under light source F9 on the right side of the VIS.
function F9_RGB2_Callback(hObject, eventdata, handles)
open('RGBF9.txt');
```

```
% --- Executes on button press in F10_RGB2. Open F10.txt file to display the RGBvalues of the
displayed 16 colour samples under light source F10 on the right side of the VIS.
function F10_RGB2_Callback(hObject, eventdata, handles)
open('RGBF10.txt');
% --- Executes on button press in F11_RGB2. Open F11.txt file to display the RGBvalues of the
displayed 16 colour samples under light source F11 on the right side of the VIS.
function F11_RGB2_Callback(hObject, eventdata, handles)
open('RGBF11.txt');
% --- Executes on button press in F12_RGB2. Open F12.txt file to display the RGBvalues of the
displayed 16 colour samples under light source F12 on the right side of the VIS.
function F12_RGB2_Callback(hObject, eventdata, handles)
open('RGBF12.txt');
% --- Executes on button press in LED1_RGB2. Open LED1_RGB2.txt file to display the RGBvalues of
the displayed 16 colour samples under light source LED1 on the right side of the VIS.
function LED1_RGB2_Callback(hObject, eventdata, handles)
open('RGB_LED1.txt');
% --- Executes on button press in LED2_RGB2. Open LED2_RGB2.txt file to display the RGBvalues of
the displayed 16 colour samples under light source LED2 on the right side of the VIS.
function LED2_RGB2_Callback(hObject, eventdata, handles)
open('RGB_LED2.txt');
% The rvalue function allows the user to enter gamma value for monitor set-up performance.
function rvalue_Callback(hObject, eventdata, handles)
r=get(handles.rvalue,'string');
r = str2num(r);
if (isempty(r) || r< 0 )
   set(handles.rvalue,'Value',0);
   set(handles.rvalue,'String','0');
else
   set(handles.rvalue,'Value',r );
end
% --- Executes during object creation, after setting all properties.
function rvalue_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
% The rvalue function allows the user to enter offset K1 value for monitor set-up performance.
function k1value_Callback(hObject, eventdata, handles)
k1=get(handles.k1value,'string');
k1 = str2num(k1 );
if k1==0
    errordlg('K1 can not be 0, please enter a new value');
else
set(handles.k1value,'Value',k1 );
end
% --- Executes during object creation, after setting all properties.
function k1value_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in S_OK. This function allows the user to select light sources from left
and right side of the VIS
function S_OK_Callback(hObject, eventdata, handles)
set(handles.light_sources1,'visible','on');
set(handles.light_sources2,'visible','on');
% --- Executes on button press in RGBF1.Compute the RGB values of the displayed 16 colour samples
under light source F1,F2,F3,…F12
function RGBF1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF2.
```

```
function RGBF2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF4.
function RGBF4_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF5.
function RGBF5_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF6.
function RGBF6_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,6);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF7.
function RGBF7_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,7);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF8.
function RGBF8_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,8);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF9.
function RGBF9_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,9);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
disp(RGBValue);
% --- Executes on button press in RGBF10.
function RGBF10_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,10);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
disp(RGBValue);
% --- Executes on button press in RGBF11.
function RGBF11_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,11);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBF12.
function RGBF12_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,12);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBLED1.
function RGBLED1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,13);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBLED2.
function RGBLED2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,14);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
```

```
% --- Executes on button press in RGBF3.
function RGBF3_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in FL15_OK_Button1.It is allows the user to view the displayed 16 colour
samples under light source FL3.15 on the left side of the VIS.
function FL15_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,15);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL15];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL2];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL1_RGB1,handles.FL14_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL15_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL14_OK_Button1. It is allows the user to view the displayed 16
colour samples under light source FL3.14 on the left side of the VIS.
function FL14_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,14);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL14];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL2,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL1_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL14_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL13_OK_Button1. It is allows the user to view the displayed 16
colour samples under light source FL3.13 on the left side of the VIS.
function FL13_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,13);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL13];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL2,h
andles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
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sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL1_RGB1,handles.FL14_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL13_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL12_OK_Button1. It is allows the user to view the displayed 16
colour samples under light source FL3.12 on the left side of the VIS.
function FL12_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,12);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL12];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL2,handles.RGBFL11,handles.RGBFL13,h
andles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL1_RGB1,handles.FL11_RGB1,
handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL12_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL10_OK_Button1. It is allows the user to view the displayed 16
colour samples under light source FL3.10 on the left side of the VIS.
function FL10_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,10);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL10];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL2,handles.RGBFL9,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,h
andles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL1_RGB1,handles.FL9_RGB1,handles.FL11_RGB1,handles.FL12_RGB1,
handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL10_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL8_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source FL3.8 on the left side of the VIS.
function FL8_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,8);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL8];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL2,handles.
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RGBFL7,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL1_RGB1,
handles.FL7_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL8_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL6_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source FL3.6 on the left side of the VIS.
function FL6_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,6);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL6];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL2,handles.RGBFL5,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL1_RGB1,handles.FL5_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL6_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL4_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source FL3.4 on the left side of the VIS.
function FL4_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL4];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL2,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL1_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL4_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL3_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source FL3.3 on the left side of the VIS.
function FL3_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL3];
set(sets1,'visible','on');
```

```
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL2,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL1_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL3_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL2_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source FL3.2 on the left side of the VIS.
function FL2_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL2];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL1_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL2_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL1_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source FL3.1 on the left side of the VIS.
function FL1_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL1];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL2,handles.RGBFL3,handles.RGBFL4,handles.RGBFL5,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL5_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL1_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL15_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source FL3.15 on the RIGHT side of the VIS.
function FL15_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,15);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
```

```
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL1_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL15_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL14_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source FL3.14 on the RIGHT side of the VIS.
function FL14_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,14);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL1_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL14_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix.V.12;
% --- Executes on button press in FL13_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source FL3.13 on the RIGHT side of the VIS.
function FL13_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,13);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL1_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL13_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL12_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source FL3.12 on the RIGHT side of the VIS.
function FL12_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,12);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
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```
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL1_RGB2,
handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL12_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL11_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source FL3.11 on the RIGHT side of the VIS.
function FL11_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,11);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL1_RGB2,handles.FL12_RGB2,
handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL11_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL10_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source FL3.10 on the RIGHT side of the VIS.
function FL10_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,10);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL1_RGB2,handles.FL11_RGB2,handles.FL12_RGB2,
handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL10_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL9_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source FL3.9 on the RIGHT side of the VIS.
function FL9_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,9);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
```

```
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL1_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL9_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL8_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source FL3.8 on the RIGHT side of the VIS.
function FL8_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,8);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL1_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL8_RGB2];
set(sets3,'visible','on');
% --- Executes on button press in FL7_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source FL3.7 on the RIGHT side of the VIS.
function FL7_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,7);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL1_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL7_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL6_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source FL3.6 on the RIGHT side of the VIS.
function FL6_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,6);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
```

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sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL1_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL6_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL3_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source FL3.3 on the RIGHT side of the VIS.
function FL3_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,3);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL1_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL3_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in FL2_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source FL3.2 on the RIGHT side of the VIS.
function FL2_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,2);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL1_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL2_RGB2];
set(sets3,'visible','on');
% --- Executes on button press in FL1_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source FL3.1 on the RIGHT side of the VIS.
function FL1_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,1);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
```

```
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2,handles.FL2_RGB
2,handles.FL3_RGB2,handles.FL4_RGB2,handles.FL5_RGB2,handles.FL6_RGB2,handles.FL7_RGB2,
handles.FL8_RGB2,handles.FL9_RGB2,handles.FL10_RGB2,handles.FL11_RGB2,handles.FL12_RGB
2,handles.FL13_RGB2,handles.FL14_RGB2,handles.FL15_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button2,handles.FL1_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in HP1_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source HP1  on the LEFT side of the VIS.
function HP1_OK_Button1_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB3,handles.RGBHP1];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB2,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
B5,handles.RGBCIE_Button1,handles.RGBF_button1,handles.RGBHP2,handles.RGBHP3,handles.RGB
HP4,handles.RGBHP5];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBLED_Button1,handles.HP2_RGB
1,handles.HP3_RGB1,handles.HP4_RGB1,handles.HP5_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button1,handles.HP1_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in HP2_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source HP2  on the LEFT side of the VIS.
function HP2_OK_Button1_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB3,handles.RGBHP3];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB2,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BF_button1,handles.RGBHP2,handles.RGBHP1,handles.RGBHP4,handles.RGBHP5];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBLED_Button1,handles.HP2_RGB
1,handles.HP1_RGB1,handles.HP4_RGB1,handles.HP5_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button1,handles.HP3_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in HP4_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source HP4  on the LEFT side of the VIS.
function HP4_OK_Button1_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB3,handles.RGBHP4];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB2,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BF_button1,handles.RGBHP2,handles.RGBHP3,handles.RGBHP1,handles.RGBHP5];
set(sets,'visible','off');
```

```
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBLED_Button1,handles.HP2_RGB
1,handles.HP3_RGB1,handles.HP1_RGB1,handles.HP5_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button1,handles.HP4_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in HP5_OK_Button1. It is allows the user to view the displayed 16 colour
samples under light source HP5 on the LEFT side of the VIS.
function HP5_OK_Button1_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB3,handles.RGBHP5];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB2,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BF_button1,handles.RGBHP2,handles.RGBHP3,handles.RGBHP4,handles.RGBHP1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBLED_Button1,handles.HP2_RGB
1,handles.HP3_RGB1,handles.HP4_RGB1,handles.HP1_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button1,handles.HP5_RGB1];
set(sets3,'visible','on');
% --- Executes on selection change in Ltype5.It is allows the user to choose different light sources from
HP light box on the Right side of the VIS.
function Ltype5_Callback(hObject, eventdata, handles)
switch get(handles.Ltype5,'Value')
   case 1
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.
RGB1,handles.HP1_OK_Button1,handles.HP2_OK_Button1,handles.HP3_OK_Button1,handles.HP4_O
K_Button1,handles.HP5_OK_Button1];
       set(sets,'visible','off');
   case 2
       set(handles.HP_OK1,'visible','on');
       set(handles.HP1_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.HP
2_OK_Button1,handles.HP3_OK_Button1,handles.HP4_OK_Button1,handles.HP5_OK_Button1];
       set(sets,'visible','off');
   case 3
       set(handles.HP_OK1,'visible','on');
       set(handles.HP2_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.FL_OK1,handles.RGB1,handles.HP1_OK_Button1,
handles.HP3_OK_Button1,handles.HP4_OK_Button1,handles.HP5_OK_Button1];
       set(sets,'visible','off');
   case 4
       set(handles.HP_OK1,'visible','on');
       set(handles.HP3_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.HP
2_OK_Button1,handles.HP1_OK_Button1,handles.HP4_OK_Button1,handles.HP5_OK_Button1];
       set(sets,'visible','off');
   case 5
       set(handles.HP_OK1,'visible','on');
       set(handles.HP4_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.LED_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.HP
2_OK_Button1,handles.HP3_OK_Button1,handles.HP1_OK_Button1,handles.HP5_OK_Button1];
       set(sets,'visible','off');
   case 6
       set(handles.HP_OK1,'visible','on');
       set(handles.HP5_OK_Button1,'visible','on');

sets=[handles.CIE_OK1,handles.LED_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.HP
2_OK_Button1,handles.HP3_OK_Button1,handles.HP4_OK_Button1,handles.HP1_OK_Button1];
```

```
        set(sets,'visible','off');
    otherwise
end
% --- Executes during object creation, after setting all properties.
function Ltype5_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in HP1_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source HP1  on the RIGHT side of the VIS.
function HP1_OK_Button2_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,1);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBLED_Button2,handles.HP2_RGB
2,handles.HP3_RGB2,handles.HP4_RGB2,handles.HP5_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button2,handles.HP1_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in HP2_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source HP2  on the RIGHT side of the VIS.
function HP2_OK_Button2_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,2);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBLED_Button2,handles.HP1_RGB
2,handles.HP3_RGB2,handles.HP4_RGB2,handles.HP5_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button2,handles.HP2_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in HP3_OK_Button2. It is allows the user to view the displayed 16 colour
samples under light source HP3  on the RIGHT side of the VIS.
function HP3_OK_Button2_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,3);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBLED_Button2,handles.HP2_RGB
2,handles.HP1_RGB2,handles.HP4_RGB2,handles.HP5_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button2,handles.HP3_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
```

```
Appendix V.12;
% --- Executes on button press in HP4_OK_Button2. It is allows the user to view the displayed 16 colour samples under light source HP4 on the RIGHT side of the VIS.
function HP4_OK_Button2_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,4);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBLED_Button2,handles.HP2_RGB
2,handles.HP3_RGB2,handles.HP1_RGB2,handles.HP5_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button2,handles.HP4_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in HP5_OK_Button2. It is allows the user to view the displayed 16 colour samples under light source HP5 on the RIGHT side of the VIS.
function HP5_OK_Button2_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,5);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBLED_Button2,handles.HP2_RGB
2,handles.HP3_RGB2,handles.HP4_RGB2,handles.HP1_RGB2];
set(sets2,'visible','off');
sets3=[handles.RGBHP_Button2,handles.HP5_RGB2];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on selection change in Ltype6.It is allows the user to choose different light sources from HP light box on the RIGHT side of the VIS.
function Ltype6_Callback(hObject, eventdata, handles)
switch get(handles.Ltype6,'Value')
   case 1
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.HP1_OK_Button2,handles.HP2_OK_
Button2,handles.HP3_OK_Button2,handles.HP4_OK_Button2,handles.HP5_OK_Button2];
       set(sets,'visible','off');
   case 2
       set(handles.HP_OK2,'visible','on');
       set(handles.HP1_OK_Button2,'visible','on');
sets=[handles.F_OK2,handles.FL_OK2,handles.HP2_OK_Button2,handles.HP3_OK_Button2,handles.H
P4_OK_Button2,handles.HP5_OK_Button2];
       set(sets,'visible','off');
   case 3
       set(handles.HP_OK2,'visible','on');
       set(handles.HP2_OK_Button2,'visible','on');
sets=[handles.F_OK2,handles.FL_OK2,handles.HP1_OK_Button2,handles.HP3_OK_Button2,handles.H
P4_OK_Button2,handles.HP5_OK_Button2];
       set(sets,'visible','off');
   case 4
       set(handles.HP_OK2,'visible','on');
       set(handles.HP3_OK_Button2,'visible','on');
```

```
sets=[handles.F_OK2,handles.FL_OK2,handles.HP2_OK_Button2,handles.HP1_OK_Button2,handles.H
P4_OK_Button2,handles.HP5_OK_Button2];
        set(sets,'visible','off');
    case 5
        set(handles.HP_OK2,'visible','on');
        set(handles.HP4_OK_Button2,'visible','on');
sets=[handles.F_OK2,handles.FL_OK2,handles.HP2_OK_Button2,handles.HP3_OK_Button2,handles.H
P1_OK_Button2,handles.HP5_OK_Button2];
        set(sets,'visible','off');
    case 6
        set(handles.HP_OK2,'visible','on');
        set(handles.HP5_OK_Button2,'visible','on');
sets=[handles.F_OK2,handles.FL_OK2,handles.HP2_OK_Button2,handles.HP3_OK_Button2,handles.H
P4_OK_Button2,handles.HP1_OK_Button2];
        set(sets,'visible','off');
    otherwise
end
% --- Executes during object creation, after setting all properties.
function Ltype6_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in LED3Band_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source L.W 3-band LED on the RIGHT side of the VIS.
function LED3Band_OK_Button2_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,1);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED4BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LEDPM4000,handles.LEDPM
4100,handles.LEDPM5500,handles.LEDPM6500,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LED3BAND];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in LED4Band_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source L.W 4-band LED on the RIGHT side of the VIS.
function LED4Band_OK_Button2_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,2);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED3BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LEDPM4000,handles.LEDPM
4100,handles.LEDPM5500,handles.LEDPM6500,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LED4BAND];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
```

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% --- Executes on button press in LED5Band_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source L.W 5-band LED on the RIGHT side of the VIS.
function LED5Band_OK_Button2_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,3);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED3BAND
,handles.LED4BAND,handles.LED6BAND,handles.LED7BAND,handles.LEDPM4000,handles.LEDPM
4100,handles.LEDPM5500,handles.LEDPM6500,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LED5BAND];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in LED7Band_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source L.W 7-band LED on the RIGHT side of the VIS.

function LED7Band_OK_Button2_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,5);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED3BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED4BAND,handles.LEDPM3016,handles.LEDPM
4000,handles.LEDPM4100,handles.LEDPM5500,handles.LEDPM6500,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LED7BAND];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in PM3016_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source Philips Mixed 3016K LED on the RIGHT side of the VIS.
function PM3016_OK_Button2_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,1);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED4BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LED3BAND,handles.LEDPM
4000,handles.LEDPM4100,handles.LEDPM5500,handles.LEDPM6500,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LEDPM3016];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in PM4000_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source Philips Mixed 4000 K LED on the RIGHT side of the VIS.
function PM4000_OK_Button2_Callback(hObject, eventdata, handles)
```

```
SPD5();F5=SPD5;F1=F5(:,2);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED4BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LEDPM3016,handles.LEDPM
4000,handles.LEDPM4100,handles.LED3BAND,handles.LEDPM5500,handles.LEDPM6500,handles.LE
DWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LEDPM4000];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in PM4100_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source Philips Mixed 4100K LED on the RIGHT side of the VIS.
function PM4100_OK_Button2_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,3);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED4BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LEDPM4000,handles.LED3B
AND,handles.LEDPM3016,handles.LEDPM5500,handles.LEDPM6500,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LEDPM4100];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in PM5500_OK_Button2. It is allows the user to view the displayed 16
colour samples under light source Philips Mixed 5500K LED on the RIGHT side of the VIS.
function PM5500_OK_Button2_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,4);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED4BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LED3BAND,handles.LEDPM
3016,handles.LEDPM6500,handles.LEDPM4100,handles.LEDPM4000,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LEDPM5500];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGB4BAND];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGB
CIE_Button1,handles.RGB3BAND,handles.RGB5BAND,handles.RGB7BAND,handles.RGBPM3016K,
handles.RGBPM4000K,handles.RGBPM4100K,handles.RGBPM5500K,handles.RGBPM6500K,handles.
RGBWHITE];
```

```
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBHP_Button1,handles.LED3BAND_RGB1,handles.LED5BAND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,handles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM4100K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LED4BAND_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in LED5Band_OK_Button1. It is allows the user to view the displayed 16 colour samples under light source L.W.5-band LED on the LEFT side of the VIS.
function LED5Band_OK_Button1_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGB5BAND];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGBCIE_Button1,handles.RGB4BAND,handles.RGB3BAND,handles.RGB7BAND,handles.RGB6BAND,handles.RGBPM3016K,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGBPM5500K,handles.RGBPM6500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED3BAND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,handles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM4100K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LED5BAND_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in LED6Band_OK_Button1. . It is allows the user to view the displayed 16 colour samples under light source L.W.6-band LED on the LEFT side of the VIS.
function LED6Band_OK_Button1_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGB6BAND];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGBCIE_Button1,handles.RGB4BAND,handles.RGB3BAND,handles.RGB7BAND,handles.RGB5BAND,handles.RGBPM3016K,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGBPM5500K,handles.RGBPM6500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED3BAND_RGB1,handles.LED5BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,handles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM4100K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LED6BAND_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in LED7Band_OK_Button1. . It is allows the user to view the displayed 16 colour samples under light source L.W.7-band LED on the LEFT side of the VIS.
function LED7Band_OK_Button1_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix. V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGB7BAND];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGBCIE_Button1,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGB3BAND,ha
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ndles.RGBPM3016K,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGBPM5500K,handles.R
GBPM6500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBHP_Button1,handles.LED4BAND
_RGB1,handles.LED5BAND_RGB1,handles.LED6BAND_RGB1,handles.LED3BAND_RGB1,handles.
LEDPM4000K_RGB1,handles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM4
100K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LED7BAND_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in PM3016K_OK_Button1. . It is allows the user to view the displayed 16
colour samples under light source Philips Mixed 3016K LED on the LEFT side of the VIS.
function PM3016K_OK_Button1_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGBPM3016K];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGB
CIE_Button1,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGB7BAND,ha
ndles.RGB3BAND,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGBPM5500K,handles.RG
BPM6500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED5B
AND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LED6BAND_RGB1,ha
ndles.LED3BAND_RGB1,handles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDP
M4100K_RGB1,handles.LEDPM4000K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LEDPM3016K_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in PM4000K_OK_Button1. It is allows the user to view the displayed 16
colour samples under light source Philips Mixed 4000K LED on the LEFT side of the VIS.
function PM4000K_OK_Button1_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix.V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGBPM4000K];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGB
CIE_Button1,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGB7BAND,ha
ndles.RGBPM3016K,handles.RGBPM4100K,handles.RGB3BAND,handles.RGBPM5500K,handles.RG
BPM6500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED5B
AND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,h
andles.LED3BAND_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM4100K_RGB1,handles.LED
PM6500K_RGB1,handles.LEDPM3016K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LEDPM4000K_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in PM4100K_OK_Button1. It is allows the user to view the displayed 16
colour samples under light source Philips Mixed 4100K LED on the LEFT side of the VIS.
function PM4100K_OK_Button1_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGBPM4100K];
set(sets1,'visible','on');
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sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGBCIE_Button1,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGB7BAND,handles.RGBPM3016K,handles.RGBPM4000K,handles.RGBPM6500K,handles.RGBPM5500K,handles.RGB3BAND,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED5BAND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,handles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM3016K_RGB1,handles.LED3BAND_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LEDPM4100K_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in PM5500K_OK_Button1. It is allows the user to view the displayed 16 colour samples under light source Philips Mixed 5500K LED on the LEFT side of the VIS.
function PM5500K_OK_Button1_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGBPM5500K];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGBCIE_Button1,handles.RGB5,handles.RGBCIE_Button1,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGB7BAND,handles.RGBPM3016K,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGB3BAND,handles.RGBPM6500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED5BAND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,handles.LEDPM6500K_RGB1,handles.LED3BAND_RGB1,handles.LEDPM4100K_RGB1,handles.LEDPM3016K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LEDPM5500K_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in PM6500K_OK_Button1. It is allows the user to view the displayed 16 colour samples under light source Philips Mixed 6500K LED on the LEFT side of the VIS.
function PM6500K_OK_Button1_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGBPM6500K];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGBCIE_Button1,handles.RGB5,handles.RGBCIE_Button1,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGB7BAND,handles.RGBPM3016K,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGB3BAND,handles.RGBPM5500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED5BAND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,handles.LEDPM5500K_RGB1,handles.LED3BAND_RGB1,handles.LEDPM4100K_RGB1,handles.LEDPM3016K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LEDPM6500K_RGB1];
set(sets3,'visible','on');
% --- Executes on selection change in Ltype8.It is allows the user to select light sources from Philips Mixed LEDs lighting box on the RIGHT side of the VIS.
function Ltype8_Callback(hObject, eventdata, handles)
switch get(handles.Ltype8,'Value')
   case 1
sets=[handles.LED_OK2,handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED3Band_OK_Button2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Butt
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on2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.PM4000_OK_Button2,han
dles.PM4100_OK_Button2,handles.PM5500_OK_Button2,handles.PM6500_OK_Button2,handles.White
LED_OK_Button2,handles.LED2950K_OK_Button2,handles.LED3000K_OK_Button2];
        set(sets,'visible','off');
    case 2
        set(handles.LED_OK2,'visible','on');
        set(handles.LED3Band_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED
5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM301
6_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_But
ton2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,
handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 3
        set(handles.LED_OK2,'visible','on');
        set(handles.LED4Band_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED3Band_OK_Button2,handles.LED
5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM301
6_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_But
ton2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,
handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 4
        set(handles.LED_OK2,'visible','on');
        set(handles.LED5Band_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED
3Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM301
6_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_But
ton2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,
handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 5
        set(handles.LED_OK2,'visible','on');
        set(handles.LED6Band_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED
3Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM301
6_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_But
ton2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,
handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 6
        set(handles.LED_OK2,'visible','on');
        set(handles.LED7Band_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED
5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED3Band_OK_Button2,handles.PM301
6_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_But
ton2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,
handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 7
        set(handles.LED_OK2,'visible','on');
        set(handles.PM3016_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED
5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.LED3B
and_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_
Button2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Butto
n2,handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 8
        set(handles.LED_OK2,'visible','on');
        set(handles.PM4000_OK_Button2,'visible','on');
```

```
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.LED3Band_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_Button2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 9
        set(handles.LED_OK2,'visible','on');
        set(handles.PM4100_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.PM4000_OK_Button2,handles.LED3Band_OK_Button2,handles.PM5500_OK_Button2,handles.PM6500_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 10
        set(handles.LED_OK2,'visible','on');
        set(handles.PM5500_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM6500_OK_Button2,handles.LED3Band_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 11
        set(handles.LED_OK2,'visible','on');
        set(handles.PM6500_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_Button2,handles.LED3Band_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2,handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 12
        set(handles.LED_OK2,'visible','on');
        set(handles.WhiteLED_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_Button2,handles.PM6500_OK_Button2,handles.LED3Band_OK_Button2,handles.LED2950K_OK_Button2,handles.LED3000K_OK_Button2];
        set(sets,'visible','off');
    case 13
        set(handles.LED_OK2,'visible','on');
        set(handles.LED3000K_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_Button2,handles.PM6500_OK_Button2,handles.LED3Band_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED2950K_OK_Button2];
        set(sets,'visible','off');
    case 14
        set(handles.LED_OK2,'visible','on');
        set(handles.LED2950K_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED4Band_OK_Button2,handles.LED5Band_OK_Button2,handles.LED6Band_OK_Button2,handles.LED7Band_OK_Button2,handles.PM3016_OK_Button2,handles.PM4000_OK_Button2,handles.PM4100_OK_Button2,handles.PM5500_OK_Button2,handles.PM6500_OK_Button2,handles.LED3Band_OK_Button2,handles.WhiteLED_OK_Button2,handles.LED3000K_OK_Button2];
        set(sets,'visible','off');
    otherwise
```

```
end
% --- Executes during object creation, after setting all properties.
function Ltype8_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on selection change in Ltype7.It is allows the uer to select light soure from LED lighting
box on the LEFT side of the VIS.
function Ltype7_Callback(hObject, eventdata, handles)
switch get(handles.Ltype7,'Value')
    case 1
sets=[handles.CIE_OK1,handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.
RGB1,handles.LED3Band_OK_Button1,handles.LED4Band_OK_Button1,handles.LED5Band_OK_Butt
on1,handles.LED6Band_OK_Button1,handles.LED7Band_OK_Button1,handles.PM3016K_OK_Button1
,handles.PM4000K_OK_Button1,handles.PM5500K_OK_Button1,handles.PM4100K_OK_Button1,hand
les.WhiteLED_OK_Button1,handles.PM6500K_OK_Button1,handles.LED2950K_OK_Button1,handles.
LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 2
        set(handles.LED_OK1,'visible','on');
        set(handles.LED3Band_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.PM4100K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 3
        set(handles.LED_OK1,'visible','on');
        set(handles.LED4Band_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
3Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.PM4100K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 4
        set(handles.LED_OK1,'visible','on');
        set(handles.LED5Band_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED3Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.PM4100K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 5
        set(handles.LED_OK1,'visible','on');
        set(handles.LED6Band_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED3Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.PM4100K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 6
        set(handles.LED_OK1,'visible','on');
        set(handles.LED7Band_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED3B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
```

```
OK_Button1,handles.PM4100K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 7
        set(handles.LED_OK1,'visible','on');
        set(handles.PM3016K_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.LED3Band_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.PM4100K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 8
        set(handles.LED_OK1,'visible','on');
        set(handles.PM4000K_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.LED3Band_OK_Button1,handles.PM5500K_
OK_Button1,handles.PM4100K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 9
        set(handles.LED_OK1,'visible','on');
        set(handles.PM4100K_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.LED3Band_
OK_Button1,handles.PM5500K_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 10
        set(handles.LED_OK1,'visible','on');
        set(handles.PM5500K_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM4100K_
OK_Button1,handles.LED3Band_OK_Button1,handles.WhiteLED_OK_Button1,handles.PM6500K_OK
_Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
   case 11
        set(handles.LED_OK1,'visible','on');
        set(handles.PM6500K_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM4100K_
OK_Button1,handles.PM5500K_OK_Button1,handles.LED3Band_OK_Button1,handles.WhiteLED_OK
_Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 12
        set(handles.LED_OK1,'visible','on');
        set(handles.WhiteLED_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.LED3Band_OK_Button1,handles.PM4100K_OK_Button1,handles.PM6500K_OK_
Button1,handles.LED2950K_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    case 13
        set(handles.LED_OK1,'visible','on');
        set(handles.LED3000K_OK_Button1,'visible','on');
```

```
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.LED3Band_OK_Button1,handles.PM4100K_OK_Button1,handles.PM6500K_OK_
Button1,handles.WhiteLED_OK_Button1,handles.LED2950K_OK_Button1];
        set(sets,'visible','off');
    case 14
        set(handles.LED_OK1,'visible','on');
        set(handles.LED2950K_OK_Button1,'visible','on');
sets=[handles.CIE_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED
4Band_OK_Button1,handles.LED5Band_OK_Button1,handles.LED6Band_OK_Button1,handles.LED7B
and_OK_Button1,handles.PM3016K_OK_Button1,handles.PM4000K_OK_Button1,handles.PM5500K_
OK_Button1,handles.LED3Band_OK_Button1,handles.PM4100K_OK_Button1,handles.PM6500K_OK_
Button1,handles.WhiteLED_OK_Button1,handles.LED3000K_OK_Button1];
        set(sets,'visible','off');
    otherwise
end
% --- Executes during object creation, after setting all properties.
function Ltype7_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in WhiteLED_OK_Button2.Display a set of 16 colour samples under
white LED light source on the RIGHT side of the VIS.
function WhiteLED_OK_Button2_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,6);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED4BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LEDPM4000,handles.LED3B
AND,handles.LEDPM5500,handles.LEDPM6500,handles.LEDPM4100];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LEDWHITE];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in WhiteLED_OK_Button1. Display a set of 16 colour samples under
white LED light source on the LEFT side of the VIS.
function WhiteLED_OK_Button1_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,6);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGBWHITE];
set(sets1,'visible','on');
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB5,handles.RGB
CIE_Button1,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGB7BAND,ha
ndles.RGBPM3016K,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGBPM5500K,handles.R
GBPM6500K,handles.RGB3BAND];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED5B
AND_RGB1,handles.LED6BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,h
andles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM4100K_RGB1,handles.LE
D3BAND_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LEDWHITE_RGB1];
```

```
set(sets3,'visible','on');
% --- Executes on button press in RGBFL1.Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.1.
function RGBFL1_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL2. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.2.
function RGBFL2_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL3. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.3.
function RGBFL3_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL4. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.4.
function RGBFL4_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL5. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.5.
function RGBFL5_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL6. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.6.
function RGBFL6_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,6);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL7. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.7.
function RGBFL7_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,7);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL8. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.8.
function RGBFL8_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,8);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL9. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.9.
function RGBFL9_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,9);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL10. Compute the RGB values of the displayed 16 colours in
Matlab by press the OK button under light source FL3.10.
function RGBFL10_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,10);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
```

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% --- Executes on button press in RGBFL11. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source FL3.11.
function RGBFL11_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,11);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL12. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source FL3.12.
function RGBFL12_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,12);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL13. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source FL3.13.
function RGBFL13_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,13);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL14. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source FL3.14.
function RGBFL14_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,14);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBFL15. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source FL3.15.
function RGBFL15_Callback(hObject, eventdata, handles)
SPD2();F2=SPD2;F1=F2(:,15);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBHP1. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source HP1.
function RGBHP1_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBHP2. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source HP2.
function RGBHP2_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBHP3. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source HP3.
function RGBHP3_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBHP4. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source HP4.
function RGBHP4_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBHP5. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source HP5.
function RGBHP5_Callback(hObject, eventdata, handles)
SPD3();F3=SPD3;F1=F3(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
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% --- Executes on button press in RGB3BAND. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source L.W 3-BAND LED.
function RGB3BAND_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGB4BAND. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source L.W 4-BAND LED.
function RGB4BAND_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGB5BAND. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source L.W 5-BAND LED.
function RGB5BAND_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGB7BAND. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source L.W 7-BAND LED.
function RGB7BAND_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBPM4000K. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source Philips Mixed 4000K LED.
function RGBPM4000K_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBPM4100K. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source Philips Mixed 4100K LED
function RGBPM4100K_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBPM5500K. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source Philips Mixed 5500K LED
function RGBPM5500K_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBPM6500K. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source Philips Mixed 6500K LED
function RGBPM6500K_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBWHITE. Compute the RGB values of the displayed 16 colours in Matlab by press the OK button under light source white LED.
function RGBWHITE_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,6);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in LED3BAND.Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 3-Band LED on the LEFT side of the VIS.
function LED3BAND_Callback(hObject, eventdata, handles)
open('RGBLED3BAND.txt');
% --- Executes on button press in LED4BAND. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 4-Band LED on the LEFT side of the VIS.
function LED4BAND_Callback(hObject, eventdata, handles)
```

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open('RGBLED4BAND.txt');
% --- Executes on button press in LED5BAND. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 5-Band LED on the LEFT side of the VIS.
function LED5BAND_Callback(hObject, eventdata, handles)
open('RGB5BAND.txt');
% --- Executes on button press in LED7BAND. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 7-Band LED on the LEFT side of the VIS.
function LED7BAND_Callback(hObject, eventdata, handles)
open('RGBLED7BAND.txt');
% --- Executes on button press in LEDPM4000. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under Philips Mixed 4000K LED on the LEFT side of the VIS.
function LEDPM4000_Callback(hObject, eventdata, handles)
open('RGBPM4000K.txt');
% --- Executes on button press in LEDPM4100. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under Philips Mixed 4100K LED on the LEFT side of the VIS.
open('RGBPM4100K.txt');
% --- Executes on button press in LEDPM5500. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under Philips Mixed 5500K LED on the LEFT side of the VIS.
function LEDPM5500_Callback(hObject, eventdata, handles)
open('RGBPM5500K.txt');
% --- Executes on button press in LEDPM6500. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under Philips Mixed 6500K LED on the LEFT side of the VIS.
function LEDPM6500_Callback(hObject, eventdata, handles)
open('RGBPM6500K.txt');
% --- Executes on button press in LEDWHITE. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under WHITE LED on the LEFT side of the VIS.
function LEDWHITE_Callback(hObject, eventdata, handles)
open('RGBWHITELED.txt');
% --- Executes on button press in LED3BAND_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 3-Band LED on the RIGHT side of the VIS.
open('RGBLED3BAND.txt');
% --- Executes on button press in LED4BAND_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 4-Band LED on the RIGHT side of the VIS.
function LED4BAND_RGB1_Callback(hObject, eventdata, handles)
open('RGBLED4BAND.txt');
% --- Executes on button press in LED5BAND_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 5-Band LED on the RIGHT side of the VIS.
function LED5BAND_RGB1_Callback(hObject, eventdata, handles)
open('RGB5BAND.txt');
% --- Executes on button press in LED7BAND_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the L.W 7-Band LED on the RIGHT side of the VIS.
function LED7BAND_RGB1_Callback(hObject, eventdata, handles)
open('RGBLED7BAND.txt');
% --- Executes on button press in LEDPM4000K_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the Philips Mixed 4000 K LED on the RIGHT side of the VIS.
function LEDPM4000K_RGB1_Callback(hObject, eventdata, handles)
open('RGBPM4000K.txt');
% --- Executes on button press in LEDPM6500K_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the Philips Mixed 6500 K LED on the RIGHT side of the VIS.
function LEDPM6500K_RGB1_Callback(hObject, eventdata, handles)
open('RGBPM6500K.txt');
% --- Executes on button press in LEDPM5500K_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under the Philips Mixed 5500 K LED on the RIGHT side of the VIS.
function LEDPM5500K_RGB1_Callback(hObject, eventdata, handles)
```

```
open('RGBPM5500K.txt');
% --- Executes on button press in LEDPM4100K_RGB1. Open the RGBLED3BAND.txt file to display
the RGB values of the 16 displayed colour samples under the Philips Mixed 4100 K LED on the RIGHT
side of the VIS.
function LEDPM4100K_RGB1_Callback(hObject, eventdata, handles)
open('RGBPM4100K.txt');
% --- Executes on button press in LEDWHITE_RGB1. Open the RGBLED3BAND.txt file to display the
RGB values of the 16 displayed colour samples under the WHITE LED on the RIGHT side of the VIS.
function LEDWHITE_RGB1_Callback(hObject, eventdata, handles)
open('RGBWHITELED.txt');
% --- Executes on button press in HP1_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP1 on the RIGHT side of the VIS.
function HP1_RGB2_Callback(hObject, eventdata, handles)
open('RGBHP1.txt');
% --- Executes on button press in HP2_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP2 on the RIGHT side of the VIS.
function HP2_RGB2_Callback(hObject, eventdata, handles)
open('RGBHP2.txt');
% --- Executes on button press in HP3_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP3 on the RIGHT side of the VIS.
function HP3_RGB2_Callback(hObject, eventdata, handles)
open('RGBHP3.txt');
% --- Executes on button press in HP4_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP4 on the RIGHT side of the VIS.
function HP4_RGB2_Callback(hObject, eventdata, handles)
open('RGBHP4.txt');
% --- Executes on button press in HP5_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP5 on the RIGHT side of the VIS.
function HP5_RGB2_Callback(hObject, eventdata, handles)
open('RGBHP5.txt');
% --- Executes on button press in HP1_RGB1. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP1 on the LEFT side of the VIS.
function HP1_RGB1_Callback(hObject, eventdata, handles)
open('RGBHP1.txt');
% --- Executes on button press in HP2_RGB1. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP2 on the LEFT side of the VIS.
function HP2_RGB1_Callback(hObject, eventdata, handles)
open('RGBHP2.txt');
% --- Executes on button press in HP3_RGB1. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP3 on the LEFT side of the VIS.
function HP3_RGB1_Callback(hObject, eventdata, handles)
open('RGBHP3.txt');
% --- Executes on button press in HP4_RGB1. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP4 on the LEFT side of the VIS.
function HP4_RGB1_Callback(hObject, eventdata, handles)
open('RGBHP4.txt');
% --- Executes on button press in HP5_RGB1. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under HP5 on the LEFT side of the VIS.

function HP5_RGB1_Callback(hObject, eventdata, handles)
open('RGBHP5.txt');
% --- Executes on button press in FL1_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under FL3.1 on the RIGHT side of the VIS.
function FL1_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL1.txt');
% --- Executes on button press in FL2_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under FL3.2 on the RIGHT side of the VIS.
function FL2_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.2.txt');
% --- Executes on button press in FL3_RGB2. Open the RGBLED3BAND.txt file to display the RGB
values of the 16 displayed colour samples under FL3.3 on the RIGHT side of the VIS.
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function FL3_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.3.txt');
% --- Executes on button press in FL4_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.4 on the RIGHT side of the VIS.
function FL4_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.4.txt');
% --- Executes on button press in FL5_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.5 on the RIGHT side of the VIS.
function FL5_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.5.txt');
% --- Executes on button press in FL6_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.6 on the RIGHT side of the VIS.
function FL6_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.6.txt');
% --- Executes on button press in FL7_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.7 on the RIGHT side of the VIS.
function FL7_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.7.txt');
% --- Executes on button press in FL8_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.8 on the RIGHT side of the VIS.
function FL8_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.8.txt');
% --- Executes on button press in FL9_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.9 on the RIGHT side of the VIS.
function FL9_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.9.txt');
% --- Executes on button press in FL10_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.10 on the RIGHT side of the VIS.
function FL10_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.10.txt');
% --- Executes on button press in FL11_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.11 on the RIGHT side of the VIS.
function FL11_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.11.txt');
% --- Executes on button press in FL12_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.12 on the RIGHT side of the VIS.
function FL12_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.12.txt');
% --- Executes on button press in FL13_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.13 on the RIGHT side of the VIS.
function FL13_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.13.txt');
% --- Executes on button press in FL14_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.14 on the RIGHT side of the VIS.
function FL14_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.14.txt');
% --- Executes on button press in FL15_RGB2. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.15 on the RIGHT side of the VIS.
function FL15_RGB2_Callback(hObject, eventdata, handles)
open('RGBFL3.15.txt');
% --- Executes on button press in FL1_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.1 on the LEFT side of the VIS.
function FL1_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL1.txt');
% --- Executes on button press in FL2_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.2 on the LEFT side of the VIS.
function FL2_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.2.txt');
% --- Executes on button press in FL3_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.2on the LEFT side of the VIS.
function FL3_RGB1_Callback(hObject, eventdata, handles)
```

```
open('RGBFL3.3.txt');
% --- Executes on button press in FL4_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.4 on the LEFT side of the VIS.
function FL4_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.4.txt');
% --- Executes on button press in FL5_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.5 on the LEFT side of the VIS.
function FL5_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.5.txt');
% --- Executes on button press in FL6_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.6 on the LEFT side of the VIS.
function FL6_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.6.txt');
% --- Executes on button press in FL7_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.7 on the LEFT side of the VIS.
function FL7_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.7.txt');
% --- Executes on button press in FL8_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.8 on the LEFT side of the VIS.
function FL8_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.8.txt');
% --- Executes on button press in FL9_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.9 on the LEFT side of the VIS.
function FL9_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.9.txt');
% --- Executes on button press in FL10_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.10 on the LEFT side of the VIS.
function FL10_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.10.txt');
% --- Executes on button press in FL11_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.11 on the LEFT side of the VIS.
function FL11_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.11.txt');
% --- Executes on button press in FL12_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.12 on the LEFT side of the VIS.
function FL12_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.12.txt');
% --- Executes on button press in FL13_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.13 on the LEFT side of the VIS.
function FL13_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.13.txt');
% --- Executes on button press in FL14_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.14 on the LEFT side of the VIS.
function FL14_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.14.txt');
% --- Executes on button press in FL15_RGB1. Open the RGBLED3BAND.txt file to display the RGB values of the 16 displayed colour samples under FL3.1 on the LEFT side of the VIS.
function FL15_RGB1_Callback(hObject, eventdata, handles)
open('RGBFL3.15.txt');
% --- Executes on button press in LED3_OK_Button1.It allows the user to view the displayed 16 colour s under light source of new research LED 3 on the LEFT side of the VIS.
function LED3_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,15);
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.LED3_RGB1,handles.RGBLED3];
set(sets1,'visible','on');
sets=[handles.RGB5,handles.RGBCIE_Button1,handles.RGBHP_Button1,handles.RGBFL_Button1,handles.RGBLED_Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF1,handles.RGBF2,handles.RGBF3,handles.RGBF4,handles.RGBF5,handles.RGBF6,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.RGBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,handles.F6_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,h
```

```
andles.F10_RGB1,handles.F11_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED2_RGB1,
handles.F1_RGB1];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
% --- Executes on button press in LED3_OK_Button2.
function LED3_OK_Button2_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,15);sets1=[handles.C2,handles.RGBValue2,handles.LED3_RGB2,handles.RGBF_
button2];
set(sets1,'visible','on');
sets=[handles.RGBHP_Button2,handles.RGBFL_Button2,handles.RGBLED_Button2,handles.LED1_RG
B2,handles.LED2_RGB2,handles.F2_RGB2,handles.F1_RGB2,handles.F3_RGB2,handles.F4_RGB2,ha
ndles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10
_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F1_RGB2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in LED3_RGB2.
function LED3_RGB2_Callback(hObject, eventdata, handles)
open('RGB_LED3.txt');
% --- Executes on button press in LED3_RGB1.
function LED3_RGB1_Callback(hObject, eventdata, handles)
open('RGB_LED3.txt');
% --- Executes on button press in RGBLED3.
function RGBLED3_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,15);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in Ra.
function Ra_Callback(hObject, eventdata, handles)
open('Ra.txt');
% --- Executes on button press in PM6500_OK_Button2. It allows the user to view
the displayed 16 colour s under light source of Philips Mixed 6500 K on the RIGHT side of the VIS.
function PM6500_OK_Button2_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,5);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,
handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles
.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED4BAND
,handles.LED5BAND,handles.LED6BAND,handles.LED7BAND,handles.LEDPM4000,handles.LED3B
AND,handles.LEDPM3016,handles.LEDPM5500,handles.LEDPM4100,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LEDPM6500];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in LED3Band_OK_Button1. It allows the user to view the displayed 16
colour s under light source of L.W 3-BAND on the LEFT side of the VIS.
function LED3Band_OK_Button1_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB4,handles.RGB3BAND];
set(sets1,'visible','on');
```

```
sets=[handles.RGBF_button1,handles.RGB1,handles.RGB2,handles.RGB3,handles.RGB4BAND,handles.RGB5BAND,handles.RGB6BAND,handles.RGBPM3016K,handles.RGB7BAND,handles.RGBPM4000K,handles.RGBPM4100K,handles.RGBPM5500K,handles.RGBPM6500K,handles.RGBWHITE];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBF_button1,handles.RGBHP_Button1,handles.LED4BAND_RGB1,handles.LED5BAND_RGB1,handles.LED7BAND_RGB1,handles.LEDPM4000K_RGB1,handles.LEDPM6500K_RGB1,handles.LEDPM5500K_RGB1,handles.LEDPM4100K_RGB1,handles.LEDWHITE_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button1,handles.LED3BAND_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in LED6Band_OK_Button2. It allows the user to view the displayed 16 colour s under light source of L.W 6-BAND LED on the LEFT side of the VIS.
function LED6Band_OK_Button2_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,4);
sets1=[handles.C2,handles.RGBValue2,handles.F1_RGB2,handles.RGBF_button2];
set(sets1,'visible','on');
sets=[handles.LED1_RGB2,handles.F3_RGB2,handles.F4_RGB2,handles.F5_RGB2,handles.F6_RGB2,handles.F7_RGB2,handles.F8_RGB2,handles.F9_RGB2,handles.F10_RGB2,handles.F11_RGB2,handles.F12_RGB2,handles.F2_RGB2,handles.LED2_RGB2];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.LED3BAND,handles.LED5BAND,handles.LED4BAND,handles.LED7BAND,handles.LEDPM4000,handles.LEDPM4100,handles.LEDPM5500,handles.LEDPM6500,handles.LEDWHITE];
set(sets2,'visible','off');
sets3=[handles.RGBLED_Button2,handles.LED6BAND];
set(sets3,'visible','on');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in RGB6BAND. Compute the RGB values of the 16 displayed colour samples in Matlab under L.W 6-BAND LED light source.
function RGB6BAND_Callback(hObject, eventdata, handles)
SPD4();F4=SPD4;F1=F4(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGBPM3016K. Compute the RGB values of the 16 displayed colour samples in Matlab under Philips Mixed 3016 K light source.
function RGBPM3016K_Callback(hObject, eventdata, handles)
SPD5();F5=SPD5;F1=F5(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes during object creation, after setting all properties.
function LED3Band_OK_Button1_CreateFcn(hObject, eventdata, handles)
% --- Executes on button press in LED6BAND_RGB1.
function LED6BAND_RGB1_Callback(hObject, eventdata, handles)
open('RGBLED6BAND.txt');
% --- Executes on button press in LEDPM3016K_RGB1.
function LEDPM3016K_RGB1_Callback(hObject, eventdata, handles)
open('RGBPM3016K.txt');
% --- Executes on button press in LEDPM3016.
function LEDPM3016_Callback(hObject, eventdata, handles)
open('RGBPM3016K.txt');
% --- Executes on button press in LED6BAND.
function LED6BAND_Callback(hObject, eventdata, handles)
open('RGBLED6BAND.txt');
% --- Executes on button press in CIEA_OK_Button2. It allows the user to view the displayed 16 colour s under light source of CIEA on the RIGHT side of the VIS.
function CIEA_OK_Button2_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,1);
sets1=[handles.C2,handles.RGBValue2,handles.CIEA_RGB2,handles.RGBCIE_Button2];
```

```
set(sets1,'visible','on');
sets=[handles.CIED65_RGB2,handles.CIED55_RGB2,handles.CIED50_RGB2,handles.CIEC_RGB2,handles.CIED75_RGB2,handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in CIED65_OK_Button2. It allows the user to view the displayed 16 colour s under light source of CIED65 on the RIGHT side of the VIS.
function CIED65_OK_Button2_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,2);
sets1=[handles.C2,handles.RGBValue2,handles.CIED65_RGB2,handles.RGBCIE_Button2];
set(sets1,'visible','on');
sets=[handles.CIED75_RGB2,handles.CIED55_RGB2,handles.CIED50_RGB2,handles.CIEC_RGB2,handles.CIEA_RGB2,handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in CIEC_OK_Button2. It allows the user to view the displayed 16 colour s under light source of CIEC on the RIGHT side of the VIS.
function CIEC_OK_Button2_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,3);
sets1=[handles.C2,handles.RGBValue2,handles.CIEC_RGB2,handles.RGBCIE_Button2];
set(sets1,'visible','on');
sets=[handles.CIED65_RGB2,handles.CIED55_RGB2,handles.CIED50_RGB2,handles.CIED75_RGB2,handles.CIEA_RGB2,handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in CIED50_OK_Button2. It allows the user to view the displayed 16 colour s under light source of CIED50 on the RIGHT side of the VIS.
function CIED50_OK_Button2_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,4);
sets1=[handles.C2,handles.RGBValue2,handles.CIED50_RGB2,handles.RGBCIE_Button2];
set(sets1,'visible','on');
sets=[handles.CIED65_RGB2,handles.CIED55_RGB2,handles.CIED75_RGB2,handles.CIEC_RGB2,handles.CIEA_RGB2,handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
% --- Executes on button press in CIED55_OK_Button2. It allows the user to view the displayed 16 colour s under light source of CIED55 on the RIGHT side of the VIS.
function CIED55_OK_Button2_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,5);
sets1=[handles.C2,handles.RGBValue2,handles.CIED55_RGB2,handles.RGBCIE_Button2];
set(sets1,'visible','on');
sets=[handles.CIED65_RGB2,handles.CIED75_RGB2,handles.CIED50_RGB2,handles.CIEC_RGB2,handles.CIEA_RGB2,handles.RGBFL_Button2,handles.RGBF_button2,handles.RGBHP_Button2,handles.RGBLED_Button2];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.12;
```

```
sets1=[handles.C1,handles.RGBValue1,handles.RGB5,handles.RGB_CIEA1,handles.RGBCIE_Button1,
handles.CIEA_RGB1];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGBHP_Button1,handles.RGBF_button1,handles.RGBFL_Button1,ha
ndles.RGBLED_Button1,handles.CIED65_RGB1,handles.CIED75_RGB1,handles.CIED50_RGB1,handl
es.CIEC_RGB1,handles.CIED55_RGB1,handles.RGB_CIED65_1,handles.RGB_CIED75_1,handles.RG
B_CIED50_1,handles.RGB_CIED55_1,handles.RGB_CIEC1];
set(sets,'visible','off');
% --- Executes on button press in CIED65_OK_Button1. It allows the user to view the displayed 16
colour s under light source of CIED65 on the LEFT side of the VIS.
function CIED65_OK_Button1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB5,handles.RGB_CIED65_1,handles.RGBCIE_Butto
n1,handles.CIED65_RGB1];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGBHP_Button1,handles.RGBF_button1,handles.RGBFL_Button1,ha
ndles.RGBLED_Button1,handles.CIEC_RGB1,handles.CIED75_RGB1,handles.CIED50_RGB1,handles.
CIEA_RGB1,handles.CIED55_RGB1,handles.RGB_CIEC1,handles.RGB_CIED75_1,handles.RGB_CIE
D50_1,handles.RGB_CIED55_1,handles.RGB_CIEA1];
set(sets,'visible','off');
% --- Executes on button press in CIEC_OK_Button1. It allows the user to view the displayed 16 colour s
under light source of CIEC on the LEFT side of the VIS.
function CIEC_OK_Button1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB5,handles.RGB_CIEC1,handles.RGBCIE_Button1,
handles.CIEC_RGB1];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGBHP_Button1,handles.RGBF_button1,handles.RGBFL_Button1,ha
ndles.RGBLED_Button1,handles.CIED65_RGB1,handles.CIED75_RGB1,handles.CIED50_RGB1,handl
es.CIEA_RGB1,handles.CIED55_RGB1,handles.RGB_CIED65_1,handles.RGB_CIED75_1,handles.RG
B_CIED50_1,handles.RGB_CIED55_1,handles.RGB_CIEA1];
set(sets,'visible','off');
% --- Executes on button press in CIED50_OK_Button1. It allows the user to view the displayed 16
colour s under light source of CIED50 on the LEFT side of the VIS.
function CIED50_OK_Button1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB5,handles.RGB_CIED50_1,handles.RGBCIE_Butto
n1,handles.CIED50_RGB1];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGBHP_Button1,handles.RGBF_button1,handles.RGBFL_Button1,ha
ndles.RGBLED_Button1,handles.CIED65_RGB1,handles.CIED55_RGB1,handles.CIED75_RGB1,handl
es.CIEA_RGB1,handles.CIEC_RGB1,handles.RGB_CIED65_1,handles.RGB_CIED55_1,handles.RGB_
CIED75_1,handles.RGB_CIEC1,handles.RGB_CIEA1,handles.RGB_CIED75_1];
set(sets,'visible','off');
% --- Executes on button press in CIED55_OK_Button1. It allows the user to view the displayed 16
colour s under light source of CIED55 on the LEFT side of the VIS.
function CIED55_OK_Button1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
```

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sets1=[handles.C1,handles.RGBValue1,handles.RGB5,handles.RGB_CIED55_1,handles.RGBCIE_Butto
n1,handles.CIED55_RGB1];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGBHP_Button1,handles.RGBF_button1,handles.RGBFL_Button1,ha
ndles.RGBLED_Button1,handles.CIED65_RGB1,handles.CIED75_RGB1,handles.CIED50_RGB1,handl
es.CIEA_RGB1,handles.CIEC_RGB1,handles.RGB_CIED65_1,handles.RGB_CIED75_1,handles.RGB_
CIED50_1,handles.RGB_CIEC1,handles.RGB_CIEA1];
set(sets,'visible','off');
% --- Executes on button press in CIED75_OK_Button1. It allows the user to view the displayed 16
colour s under light source of CIED75 on the LEFT side of the VIS.
function CIED75_OK_Button1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,6);
sets1=[handles.C1,handles.RGBValue1,handles.RGB5,handles.RGBCIE_Button1,handles.RGB_CIED75
_1,handles.CIED75_RGB1];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGBHP_Button1,handles.RGBF_button1,handles.RGBFL_Button1,ha
ndles.RGBLED_Button1,handles.CIED65_RGB1,handles.CIED55_RGB1,handles.CIED50_RGB1,handl
es.CIEA_RGB1,handles.CIEC_RGB1,handles.RGB_CIED65_1,handles.RGB_CIED55_1,handles.RGB_
CIED50_1,handles.RGB_CIEC1,handles.RGB_CIEA1];
set(sets,'visible','off');
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
% --- Executes on selection change in Ltype10.It allows the user to select different type of light source
from lighting box on the RIGHT side of the VIS.
function Ltype10_Callback(hObject, eventdata, handles)
switch get(handles.Ltype10,'Value')
   case 1
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED_OK2,handles.CIE_OK2,handles.
CIED75_OK_Button2,handles.CIED65_OK_Button2,handles.CIED55_OK_Button2,handles.CIED50_O
K_Button2,handles.CIEC_OK_Button2,handles.CIEA_OK_Button2];
       set(sets,'visible','off');
   case 2
       set(handles.CIE_OK2,'visible','on');
       set(handles.CIEA_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED_OK2,handles.CIED75_OK_Butt
on2,handles.CIED65_OK_Button2,handles.CIED55_OK_Button2,handles.CIED50_OK_Button2,handles
.CIEC_OK_Button2];
       set(sets,'visible','off');
   case 3
       set(handles.CIE_OK2,'visible','on');
       set(handles.CIED65_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED_OK2,handles.CIED75_OK_Butt
on2,handles.CIEA_OK_Button2,handles.CIED55_OK_Button2,handles.CIED50_OK_Button2,handles.C
IEC_OK_Button2];
       set(sets,'visible','off');
   case 4
        set(handles.CIE_OK2,'visible','on');
       set(handles.CIEC_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED_OK2,handles.CIED75_OK_Butt
on2,handles.CIED65_OK_Button2,handles.CIED55_OK_Button2,handles.CIED50_OK_Button2,handles
.CIEA_OK_Button2];
       set(sets,'visible','off');
   case 5
        set(handles.CIE_OK2,'visible','on');
       set(handles.CIED50_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED_OK2,handles.CIED75_OK_Butt
on2,handles.CIED65_OK_Button2,handles.CIED55_OK_Button2,handles.CIEC_OK_Button2,handles.C
IEA_OK_Button2];
       set(sets,'visible','off');
   case 6
```

```
        set(handles.CIE_OK2,'visible','on');
        set(handles.CIED55_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED_OK2,handles.CIED75_OK_Butt
on2,handles.CIED65_OK_Button2,handles.CIED50_OK_Button2,handles.CIEC_OK_Button2,handles.C
IEA_OK_Button2];
        set(sets,'visible','off');
    case 7
        set(handles.CIE_OK2,'visible','on');
        set(handles.CIED75_OK_Button2,'visible','on');
sets=[handles.HP_OK2,handles.F_OK2,handles.FL_OK2,handles.LED_OK2,handles.CIED50_OK_Butt
on2,handles.CIED65_OK_Button2,handles.CIED55_OK_Button2,handles.CIEC_OK_Button2,handles.C
IEA_OK_Button2];
        set(sets,'visible','off');
    otherwise
end
% --- Executes during object creation, after setting all properties. The user can select different light source
from CIE light group on the LEFT Side of the VIS
function Ltype10_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on selection change in Ltype9.
function Ltype9_Callback(hObject, eventdata, handles)
switch get(handles.Ltype9,'Value')
    case 1
sets=[handles.LED_OK1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.CIE
_OK1];
        set(sets,'visible','off');
    case 2
        set(handles.CIE_OK1,'visible','on');
        set(handles.CIEA_OK_Button1,'visible','on');
sets=[handles.RGB1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED_O
K1,handles.CIEC_OK_Button1, handles.CIED65_OK_Button1,
handles.CIED50_OK_Button1,handles.CIED55_OK_Button1,handles.CIED75_OK_Button1];
        set(sets,'visible','off');
    case 3
        set(handles.CIE_OK1,'visible','on');
        set(handles.CIED65_OK_Button1,'visible','on');
sets=[handles.RGB1,handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED_O
K1,handles.CIEC_OK_Button1, handles.CIEA_OK_Button1,
handles.CIED50_OK_Button1,handles.CIED55_OK_Button1,handles.CIED75_OK_Button1];
        set(sets,'visible','off');
    case 4
        set(handles.CIE_OK1,'visible','on');
        set(handles.CIEC_OK_Button1,'visible','on');
sets=[handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED_OK1,handles.RG
B1,handles.CIEA_OK_Button1, handles.CIED65_OK_Button1,
handles.CIED50_OK_Button1,handles.CIED55_OK_Button1,handles.CIED75_OK_Button1];
        set(sets,'visible','off');
    case 5
        set(handles.CIE_OK1,'visible','on');
        set(handles.CIED50_OK_Button1,'visible','on');
sets=[handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED_OK1,handles.RG
B1,handles.CIEC_OK_Button1, handles.CIED65_OK_Button1,
handles.CIEA_OK_Button1,handles.CIED55_OK_Button1,handles.CIED75_OK_Button1];
        set(sets,'visible','off');
    case 6
        set(handles.CIE_OK1,'visible','on');
        set(handles.CIED55_OK_Button1,'visible','on');
```

```
sets=[handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED_OK1,handles.RG
B1,handles.CIEC_OK_Button1, handles.CIED65_OK_Button1,
handles.CIED50_OK_Button1,handles.CIEA_OK_Button1,handles.CIED75_OK_Button1];
        set(sets,'visible','off');
    case 7
        set(handles.CIE_OK1,'visible','on');
        set(handles.CIED75_OK_Button1,'visible','on');
sets=[handles.HP_OK1,handles.F_OK1,handles.FL_OK1,handles.RGB1,handles.LED_OK1,handles.RG
B1,handles.CIEC_OK_Button1, handles.CIED65_OK_Button1,
handles.CIED50_OK_Button1,handles.CIED55_OK_Button1,handles.CIEA_OK_Button1];
        set(sets,'visible','off');
otherwise
end
% --- Executes during object creation, after setting all properties.
function Ltype9_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in RGB_CIEA1. Compute the RGB values of the 16 displayed colour
samples in Matlab under light source of CIE A on the LEFT side of the VIS.
function RGB_CIEA1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,1);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGB_CIED65_1. Compute the RGB values of the 16 displayed colour
samples in Matlab under light source of CIE D65 on the LEFT side of the VIS.
function RGB_CIED65_1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,2);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
 % --- Executes on button press in RGB_CIEC1. Compute the RGB values of the 16 displayed colour
samples in Matlab under light source of CIE Con the LEFT side of the VIS.
function RGB_CIEC1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,3);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGB_CIED50_1. Compute the RGB values of the 16 displayed colour
samples in Matlab under light source of CIE D50 on the LEFT side of the VIS.
function RGB_CIED50_1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,4);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGB_CIED55_1. Compute the RGB values of the 16 displayed colour
samples in Matlab under light source of CIE D55 on the LEFT side of the VIS.
function RGB_CIED55_1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in RGB_CIED75_1. Compute the RGB values of the 16 displayed colour
samples in Matlab under light source of CIE D75 on the LEFT side of the VIS.
function RGB_CIED75_1_Callback(hObject, eventdata, handles)
SPD6();F6=SPD6;F1=F6(:,6);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);disp(RGBValue);
% --- Executes on button press in CIEA_RGB1.Open the RGBCIEA.txt file to display the RGB values of
the 16 displayed colour samples under light source CIE A on the LEFT side of the VIS.
function CIEA_RGB1_Callback(hObject, eventdata, handles)
open('RGBCIEA.txt');
% --- Executes on button press in CIED65_RGB1. Open the RGBCIED65.txt file to display the RGB
values of the 16 displayed colour samples under light source CIE D65 on the LEFT side of the VIS.
function CIED65_RGB1_Callback(hObject, eventdata, handles)
```

```
open('RGBCIED65.txt');
% --- Executes on button press in CIEC_RGB1. Open the RGBCIEC.txt file to display the RGB values of the 16 displayed colour samples under light source CIE C on the LEFT side of the VIS.
function CIEC_RGB1_Callback(hObject, eventdata, handles)
open('RGBCIEC.txt');
% --- Executes on button press in CIED50_RGB1. Open the RGBCIED50.txt file to display the RGB values of the 16 displayed colour samples under light source CIE D50 on the LEFT side of the VIS.

function CIED50_RGB1_Callback(hObject, eventdata, handles)
open('RGBCIED50.txt');
% --- Executes on button press in CIED55_RGB1. Open the RGBCIED55.txt file to display the RGB values of the 16 displayed colour samples under light source CIE D55on the RIGHT side of the VIS.
function CIED55_RGB1_Callback(hObject, eventdata, handles)
open('RGBCIED55.txt');
% --- Executes on button press in CIED75_RGB1. Open the RGBCIED75.txt file to display the RGB values of the 16 displayed colour samples under light source CIE D75 on the LEFT side of the VIS.
function CIED75_RGB1_Callback(hObject, eventdata, handles)
open('RGBCIED75.txt');
% --- Executes on button press in CIEA_RGB2. Open the RGBCIEA.txt file to display the RGB values of the 16 displayed colour samples under light source CIE A on the RIGHT side of the VIS.
function CIEA_RGB2_Callback(hObject, eventdata, handles)
open('RGBCIEA.txt');
% --- Executes on button press in CIED65_RGB2. Open the RGBCIED65.txt file to display the RGB values of the 16 displayed colour samples under light source CIED65 on the RIGHT side of the VIS.
function CIED65_RGB2_Callback(hObject, eventdata, handles)
open('RGBCIED65.txt');
% --- Executes on button press in CIEC_RGB2. Open the RGBCIEC.txt file to display the RGB values of the 16 displayed colour samples under light source CIE C on the RIGHT side of the VIS.
function CIEC_RGB2_Callback(hObject, eventdata, handles)
open('RGBCIEC.txt');
% --- Executes on button press in CIED50_RGB2. Open the RGBCIED50.txt file to display the RGB values of the 16 displayed colour samples under light source CIE D50 on the RIGHT side of the VIS.
function CIED50_RGB2_Callback(hObject, eventdata, handles)
open('RGBCIED50.txt');
% --- Executes on button press in CIED55_RGB2. Open the RGBCIED55.txt file to display the RGB values of the 16 displayed colour samples under light source CIE D55 on the RIGHT side of the VIS.
function CIED55_RGB2_Callback(hObject, eventdata, handles)
open('RGBCIED55.txt');
% --- Executes on button press in CIED75_RGB2. Open the RGBCIED75.txt file to display the RGB values of the 16 displayed colour samples under light source CIED75 on the RIGHT side of the VIS.
function CIED75_RGB2_Callback(hObject, eventdata, handles)
open('RGBCIED75.txt');
% --- Executes on button press in Plot_Re.It allows the user to plot and view the reflectances of the displayed colour samples.
function Plot_Re_Callback(hObject, eventdata, handles)
Plot_Re;
% ----------------------------------------------------------------------
function B_2G_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_2G_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
function B_10P_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_10P_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
% --- Executes on button press in FL11_OK_Button1. It allows the user to view the 16 displayed colour samples under the light source FL3.11 on the LEFT side of the VIS.
```

```
function FL11_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,7);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL11];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL2,handles.RGBFL6,handles.RGBFL5,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL7,handles.RGBFL12,handles.RGBFL13,h
andles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL1_RGB1,handles.FL6_RGB1,handles.FL5_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL7_RGB1,handles.FL12_RGB1,
handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL11_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL7_OK_Button1. It allows the user to view the 16 displayed colour
samples under the light source FL3.7 on the LEFT side of the VIS.
function FL7_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,7);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL7];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL2,handles.RGBFL6,handles.RGBFL5,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL1_RGB1,handles.FL6_RGB1,handles.FL5_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL7_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in FL5_OK_Button1. It allows the user to view the 16 displayed colour
samples under the light source FL3.5 on the LEFT side of the VIS.
function FL5_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,5);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL5];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL2,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL9,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL1_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL9_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL5_RGB1];
set(sets3,'visible','on');
```

```
% --- Executes on button press in FL9_OK_Button1. It allows the user to view the 16 displayed colour
samples under the light source FL3,9 on the LEFT side of the VIS.
function FL9_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F2=SPD2;F1=F2(:,9);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBValue1,handles.RGB2,handles.RGBFL9];
set(sets1,'visible','on');
sets=[handles.RGB1,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_Button1,handles.RG
BFL1,handles.RGBFL3,handles.RGBFL4,handles.RGBFL2,handles.RGBFL6,handles.RGBFL7,handles.
RGBFL8,handles.RGBFL5,handles.RGBFL10,handles.RGBFL11,handles.RGBFL12,handles.RGBFL13,
handles.RGBFL14,handles.RGBFL15];
set(sets,'visible','off');
sets2=[handles.RGBF_button1,handles.RGBHP_Button1,handles.RGBLED_Button1,handles.FL2_RGB
1,handles.FL3_RGB1,handles.FL4_RGB1,handles.FL1_RGB1,handles.FL6_RGB1,handles.FL7_RGB1,
handles.FL8_RGB1,handles.FL5_RGB1,handles.FL10_RGB1,handles.FL11_RGB1,handles.FL12_RGB
1,handles.FL13_RGB1,handles.FL2_RGB1,handles.FL15_RGB1];
set(sets2,'visible','off');
sets3=[handles.RGBFL_Button1,handles.FL9_RGB1];
set(sets3,'visible','on');
% --- Executes on button press in F12_OK_Button1. It allows the user to view the 16 displayed colour
samples under the light source F12 on the LEFT side of the VIS.
function F12_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,12);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F12_RGB1,handl
es.RGBF12];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF1,handles.RGBF6,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.R
GBF11,handles.RGBF7,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,hand
les.F1_RGB1,handles.F6_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11_
RGB1,handles.F7_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F8_OK_Button1. It allows the user to view the 16 displayed colour
samples under the light source F8 on the LEFT side of the VIS.
function F8_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,8);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F8_RGB1,handle
s.RGBF8];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF1,handles.RGBF6,handles.RGBF7,handles.RGBF9,handles.RGBF10,handles.R
GBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,han
dles.F1_RGB1,handles.F6_RGB1,handles.F7_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F11
_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F11_OK_Button1. It allows the user to view the 16 displayed colour
samples under the light source F11 on the LEFT side of the VIS.
```

```
function F11_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,11);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F11_RGB1,handl
es.RGBF11];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF1,handles.RGBF7,handles.RGBF8,handles.RGBF9,handles.RGBF10,handles.R
GBF6,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,hand
les.F1_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F9_RGB1,handles.F10_RGB1,handles.F6_R
GB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
% --- Executes on button press in F9_OK_Button1.It allows the user to view the 16 displayed colour
samples under the light source F9 on the LEFT side of the VIS.
function F9_OK_Button1_Callback(hObject, eventdata, handles)
SPD();F=SPD;F1=F(:,9);
r=get(handles.rvalue,'value');k1=get(handles.k1value,'value');
calculateRGB(r,k1,F1);RGBValue=calculateRGB(r,k1,F1);
Appendix V.11;
sets1=[handles.C1,handles.RGBF_button1,handles.RGBValue1,handles.RGB1,handles.F9_RGB1,handle
s.RGBF9];
set(sets1,'visible','on');
sets=[handles.RGBLED3,handles.RGB2,handles.RGB3,handles.RGB4,handles.RGB5,handles.RGBCIE_
Button1,handles.RGBLED1,handles.RGBLED2,handles.RGBF2,handles.RGBF3,handles.RGBF4,handle
s.RGBF5,handles.RGBF1,handles.RGBF7,handles.RGBF8,handles.RGBF6,handles.RGBF10,handles.R
GBF11,handles.RGBF12,handles.F2_RGB1,handles.F3_RGB1,handles.F4_RGB1,handles.F5_RGB1,han
dles.F1_RGB1,handles.F7_RGB1,handles.F8_RGB1,handles.F6_RGB1,handles.F10_RGB1,handles.F11
_RGB1,handles.F12_RGB1,handles.LED1_RGB1,handles.LED3_RGB1,handles.LED2_RGB1];
set(sets,'visible','off');
sets2=[handles.RGBFL_Button1,handles.RGBHP_Button1,handles.RGBLED_Button1];
set(sets2,'visible','off');
function B_2G_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_2G_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_10P_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_10P_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5GY_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5GY_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5GY_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5GY_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5Y_2_Callback(hObject, eventdata, handles)
```

```
% --- Executes during object creation, after setting all properties.
function B_5Y_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_5Y_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_5Y_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
% --- Executes during object creation, after setting all properties.
function B_4G_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_LG_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_LG_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_DG_2_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_DG_2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_LG_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_LG_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
function B_DG_Callback(hObject, eventdata, handles)
% --- Executes during object creation, after setting all properties.
function B_DG_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
```

Appendix V. 14- Plot_GUI.m

```
%The Plot _GUI file implements the Plot SPDs System, one of the most important performance in the file is allows the user to plot and view the SPDs of the compared light sources.
function varargout = Plot_GUI(varargin)
% PLOT_GUI M-file for Plot_GUI.fig
%      PLOT_GUI, by itself, creates a new PLOT_GUI or raises the existing
%      singleton*.
%      H = PLOT_GUI returns the handle to a new PLOT_GUI or the handle to
%      the existing singleton*.
%      PLOT_GUI('CALLBACK',hObject,eventData,handles,...) calls the local
%      function named CALLBACK in PLOT_GUI.M with the given input arguments.
%      PLOT_GUI('Property','Value',...) creates a new PLOT_GUI or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before Plot_GUI_OpeningFunction gets called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to Plot_GUI_OpeningFcn via varargin.
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
% See also: GUIDE, GUIDATA, GUIHANDLES
% Edit the above text to modify the response to help Plot_GUI
% Last Modified by GUIDE v2.5 06-Oct-2008 12:38:26
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @Plot_GUI_OpeningFcn, ...
                   'gui_OutputFcn',  @Plot_GUI_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end
if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
function Plot_GUI_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);
function varargout = Plot_GUI_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;
function Plot_Button_Callback(hObject, eventdata, handles)
global F F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 LED1 LED2 LED3
global FL1 FL2 FL3 FL4 FL5 FL6 FL7 FL8 FL9 FL10 FL11 FL12 FL13 FL14 FL15
global L1 L2
global HP1 HP2 HP3 HP4 HP5
global LED3Band LED4Band LED5Band LED6Band LED7Band LED3000K LED2950K
global PM3016K PM4000K PM4100K PM5500K PM6500K White A D65 C D50 D55 D75 High_efficacy_source
```

F=[F means is the SPDs of all the selected 54 light sources, in this research project. The SPDs of the 54 ligth sources are displayed in Appendix V-5,6,7,8,9.];

```
F1=F(:,1);F2=F(:,2);F3=F(:,3);F4=F(:,4);F5=F(:,5);F6=F(:,6);F7=F(:,7);F8=F(:,8);F9=F(:,9);F10=F(:,10);F11=F(:,11);F12=F(:,12);LED1=F(:,13);LED2=F(:,14);LED3=F(:,15);FL1=F(:,16);FL2=F(:,17);FL3=F(:,18);FL4=F(:,19);FL5=F(:,20);FL6=F(:,21);FL7=F(:,22);FL8=F(:,23);FL9=F(:,24);FL10=F(:,25);FL11=F(:,26);FL12=F(:,27);FL13=F(:,28);FL14=F(:,29);FL15=F(:,30);HP1=F(:,31);HP2=F(:,32);HP3=F(:,33);HP4=F(:,34);HP5=F(:,35);LED3Band=F(:,36);LED4Band=F(:,37);LED5Band=F(:,38);LED6Band=F(:,39);LED7Band=F(:,40);PM3016K=F(:,41);PM4000K=F(:,42);PM4100K=F(:,43);PM5500K=F(:,44);PM6500K=F(:,45);White=F(:,46);A=F(:,47);D65=F(:,48);C=F(:,49);D50=F(:,50);D55=F(:,51);D75=F(:,52);LED3000K=F(:,53);LED2950K=F(:,54);
x=380:5:780;
L1=get(handles.Lsources1
,'value');
switch L1
    case 1
        L1=F1;
    case 2
        L1=F2;
    case 3
        L1=F3;
    case 4
        L1=F4;
    case 5
        L1=F5;
    case 6
        L1=F6;
    case 7
        L1=F7;
    case 8
        L1=F8;
    case 9
        L1=F9;
    case 10
        L1=F10;
    case 11
        L1=F11;
    case 12
        L1=F12;
    case 13
        L1=LED1;
     case 14
        L1=LED2;
    case 15
        L1=LED3;
    case 16
        L1=FL1;
    case 17
        L1=FL2;
    case 18
        L1=FL3;
    case 19
        L1=FL4;
    case 20
        L1=FL5;
    case 21
        L1=FL6;
    case 22
        L1=FL7;
    case 23
        L1=FL8;
    case 24
        L1=FL9;
    case 25
        L1=FL10;
    case 26
        L1=FL11;
    case 27
        L1=FL12;
    case 28
        L1=FL13;
    case 29
        L1=FL14;
    case 30
        L1=FL15;
    case 31
        L1=HP1;
    case 32
        L1=HP2;
    case 33
         L1=HP3;
    case 34
         L1=HP4;
    case 35
         L1=HP5;
    case 36
         L1=LED3Band;
    case 37
        L1=LED4Band;
    case 38
        L1=LED5Band;
    case 39
        L1=LED6Band;
    case 40
        L1=LED7Band;
    case 41
        L1=PM3016K;
    case 42
        L1=PM4000K;
    case 43
        L1=PM4100K;
    case 44
        L1=PM5500K;
    case 45
        L1=PM6500K;
    case 46
        L1=White;
    case 47
        L1=A;
    case 48
        L1=D65;
    case 49
        L1=C;
    case 50
        L1=D50;
    case 51
        L1=D55;
    case 52
        L1=D75;
    case 53
        L1=LED3000K;
    case 54
        L1=LED2950K;
    case 55

L1=High_efficacy_source
;
 otherwise
end
L2=get(handles.Lsources2
,'value');
switch L2
    case 1
        L2=F1;
    case 2
        L2=F2;
    case 3
        L2=F3;
    case 4
        L2=F4;
    case 5
        L2=F5;
    case 6
        L2=F6;
    case 7
        L2=F7;
    case 8
        L2=F8;
    case 9
        L2=F9;
```

```
    case 10
      L2=F10;
    case 11
      L2=F11;
    case 12
      L2=F12;
     case 13
      L2=LED1;
     case 14
      L2=LED2;
    case 15
      L2=LED3;
    case 16
      L2=FL1;
    case 17
      L2=FL2;
    case 18
      L2=FL3;
    case 19
      L2=FL4;
    case 20
      L2=FL5;
    case 21
      L2=FL6;
    case 22
      L2=FL7;
    case 23
      L2=FL8;
    case 24
      L2=FL9;
    case 25
      L2=FL10;
    case 26
      L2=FL11;
    case 27
      L2=FL12;
    case 28
      L2=FL13;
    case 29
      L2=FL14;
    case 30
      L2=FL15;
    case 31
      L2=HP1;
    case 32
      L2=HP2;
    case 33
       L2=HP3;
    case 34
       L2=HP4;
    case 35
       L2=HP5;
    case 36
       L2=LED3Band;
    case 37
      L2=LED4Band;
    case 38
      L2=LED5Band;
    case 39
      L2=LED6Band;
    case 40
      L2=LED7Band;
    case 41
      L2=PM3016K;
    case 42
      L2=PM4000K;
    case 43
      L2=PM4100K;
    case 44
      L2=PM5500K;
    case 45
      L2=PM6500K;
    case 46
      L2=White;
    case 47
      L2=A;
    case 48
      L2=D65;
    case 49
      L2=C;
    case 50
      L2=D50;
    case 51
      L2=D55;
    case 52
      L2=D75;
    case 53
      L2=LED3000K;
    case 54
      L2=LED2950K;
    case 55

L2=High_efficacy_source
;
    otherwise
end
plot(x,L1,'r',x,L2,'b');
set(handles.Plot_gui,'visible','on');
set(handles.Value,'visible','on');
axes(handles.Plot_gui);
function Fvalue_Callback(hObject, eventdata, handles)
open('Fvalue.txt');
function Close_button_Callback(hObject, eventdata, handles)
close Plot_GUI;
%It is allows the user to select any one of 52 light sources in ligh group 1.
function Lsources1_Callback(hObject, eventdata, handles)
global F F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 LED1 LED2 LED3
global FL1 FL2 FL3 FL4 FL5 FL6 FL7 FL8 FL9 FL10 FL11 FL12 FL13 FL14 FL15
global L1
global HP1 HP2 HP3 HP4 HP5
global LED3Band LED4Band LED5Band LED6Band LED7Band LED3000K LED2950K
global PM3016K PM4000K PM4100K PM5500K PM6500K  White A D65 C D50 D55 D75
High_efficacy_source
```

F=[F means is the SPDs of all the selected 54 light sources, in this research project. The SPDs of the 54 ligth sources are displayed in Appendix V-5,6,7,8,9.];

```
F1=F(:,1);F2=F(:,2);F3=F(:,3);F4=F(:,4);F5=F(:,5);F6=F(:,6);F7=F(:,7);F8=F(:,8);F9=F(:,9);F1
0=F(:,10);F11=F(:,11);F12=F(:,12);LED1=F(:,13);LED2=F(:,14);LED3=F(:,15);FL1=F(:,16);F
L2=F(:,17);FL3=F(:,18);FL4=F(:,19);FL5=F(:,20);FL6=F(:,21);FL7=F(:,22);FL8=F(:,23);FL9=
F(:,24);FL10=F(:,25);FL11=F(:,26);FL12=F(:,27);FL13=F(:,28);FL14=F(:,29);FL15=F(:,30);H
P1=F(:,31);HP2=F(:,32);HP3=F(:,33);HP4=F(:,34);HP5=F(:,35);LED3Band=F(:,36);LED4Ban
```

```
d=F(:,37);LED5Band=F(:,38);LED6Band=F(:,39);LED7Band=F(:,40);PM3016K=F(:,41);PM4
000K=F(:,42);PM4100K=F(:,43);PM5500K=F(:,44);PM6500K=F(:,45);White=F(:,46);A=F(:,4
7);D65=F(:,48);C=F(:,49);D50=F(:,50);D55=F(:,51);D75=F(:,52);LED3000K=F(:,53);LED295
0K=F(:,54);High_efficacy_source=F(:,55);
L1 = get(handles.Lsources1,'value');
function Lsources1_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
function Yo_button_Callback(hObject, eventdata, handles)
open('YoValue.txt');
%It is allows the user to select one of 52 light sources in ligh group 2.
function Lsources2_Callback(hObject, eventdata, handles)
global F F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 LED1 LED2 LED3
global FL1 FL2 FL3 FL4 FL5 FL6 FL7 FL8 FL9 FL10 FL11 FL12 FL13 FL14 FL15
global L2
global HP1 HP2 HP3 HP4 HP5
global LED3Band LED4Band LED5Band LED6Band LED7Band LED3000K LED2950K
global PM3016K PM4000K PM4100K PM5500K PM6500K  White A D65 C D50 D55 D75
High_efficacy_source
```
F=[F means is the SPDs of all the selected 54 light sources, in this research project. The SPDs of the 54 ligth sources are displayed in Appendix V-5,6,7,8,9.];
```
F1=F(:,1);F2=F(:,2);F3=F(:,3);F4=F(:,4);F5=F(:,5);F6=F(:,6);F7=F(:,7);F8=F(:,8);F9=F(:,9);F1
0=F(:,10);F11=F(:,11);F12=F(:,12);LED1=F(:,13);LED2=F(:,14);LED3=F(:,15);FL1=F(:,16);F
L2=F(:,17);FL3=F(:,18);FL4=F(:,19);FL5=F(:,20);FL6=F(:,21);FL7=F(:,22);FL8=F(:,23);FL9=
F(:,24);FL10=F(:,25);FL11=F(:,26);FL12=F(:,27);FL13=F(:,28);FL14=F(:,29);FL15=F(:,30);H
P1=F(:,31);HP2=F(:,32);HP3=F(:,33);HP4=F(:,34);HP5=F(:,35);LED3Band=F(:,36);LED4Ban
d=F(:,37);LED5Band=F(:,38);LED6Band=F(:,39);LED7Band=F(:,40);PM3016K=F(:,41);PM4
000K=F(:,42);PM4100K=F(:,43);PM5500K=F(:,44);PM6500K=F(:,45);White=F(:,46);A=F(:,4
7);D65=F(:,48);C=F(:,49);D50=F(:,50);D55=F(:,51);D75=F(:,52);LED3000K=F(:,53);LED295
0K=F(:,54);High_efficacy_source=F(:,55);
L2 = get(handles.Lsources2,'value');
function Lsource2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
function pushbutton6_Callback(hObject, eventdata, handles)
open('FLValue.txt');
function HP_Callback(hObject, eventdata, handles)
open('HPValues.txt');
function LEDs_Callback(hObject, eventdata, handles)
open('LEDValues.txt');
function Ra_Callback(hObject, eventdata, handles)
open('Ra.txt');
function CIE_Button_Callback(hObject, eventdata, handles)
open('CIEValues.txt');
function Lsources2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
   set(hObject,'BackgroundColor','white');
end
function pushbutton11_Callback(hObject, eventdata, handles)
open('High-efficacy-light source.txt');
```

Appendix V. 15 - Plot_Re.m

```
%This file implements the Plot Reflectances of the displayed colour samples system,it is allows the user to view the reflectances of the 16 dsiplayed colour samples in this research project.
function varargout = Plot_Re(varargin)
% PLOT_RE M-file for Plot_Re.fig
%      PLOT_RE, by itself, creates a new PLOT_RE or raises the existing
%      singleton*.
%      H = PLOT_RE returns the handle to a new PLOT_RE or the handle to
%      the existing singleton*.
%      PLOT_RE('CALLBACK',hObject,eventData,handles,...) calls the local
%      function named CALLBACK in PLOT_RE.M with the given input arguments.
%      PLOT_RE('Property','Value',...) creates a new PLOT_RE or raises the
%      existing singleton*.  Starting from the left, property value pairs are
%      applied to the GUI before Plot_Re_OpeningFcn gets called.  An
%      unrecognized property name or invalid value makes property application
%      stop.  All inputs are passed to Plot_Re_OpeningFcn via varargin.
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
% See also: GUIDE, GUIDATA, GUIHANDLES
% Edit the above text to modify the response to help Plot_Re
% Last Modified by GUIDE v2.5 04-Jun-2008 10:03:50
% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @Plot_Re_OpeningFcn, ...
                   'gui_OutputFcn',  @Plot_Re_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end
if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT
% --- Executes just before Plot_Re is made visible.
function Plot_Re_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
% Update handles structure
guidata(hObject, handles);
% --- Outputs from this function are returned to the command line.
function varargout = Plot_Re_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;
% --- Executes on button press in Re.
function Re_Callback(hObject, eventdata, handles)
set(handles.Reflection,'Visible','on');
axes(handles.Reflection);
imshow('Samples.bmp');
% --- Executes on button press in pushbutton2.
function pushbutton2_Callback(hObject, eventdata, handles)
close Plot_Re;
```

APPENDIX VI-SUBJECTUVE TEST RESULTS

Appendix VI.1-Test results from Group I

		Test 1		**Test 2**		**Test 3**		**Test 4**		**Test 5**		**Test 6**		**Test 7**		**Test 8**		**Test 9**		**Test 10**	
Reference	Test	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M
A	**4-BAND**	25	25	22	24	18	18	16	16	20	20	22	22	22	22	16	16	22	24	16	20
A	**5-BAND**	12	12	10	12	15	15	4	4	14	14	12	14	16	18	8	8	14	16	14	16
A	**6-BAND**	12	12	10	12	15	15	4	4	14	14	12	14	7	9	1	15	15	17	16	14
A	**7-BAND**	2	8	4	10	17	18	2	12	7	13	12	20	7	9	5	9	4	14	-2	27
A	**HP3**	3	7	3	5	1	1	2	6	3	3	1	7	5	7	-3	11	4	8	-6	15
A	**FL3.2**	5	7	4	8	8	8	3	5	3	5	8	14	6	14	6	8	10	14	8	20
A	**FL3.7**	4	9	-10	10	1	3	1	7	-1	9	-7	13	-6	10	-1	11	-3	7	-3	19
A	**FL3.12**	3	38	0	2	1	1	2	6	3	3	0	0	0	0	1	1	0	0	1	5
A	**FL3.13**	12	12	15	17	10	10	11	11	13	13	21	21	20	20	22	22	14	16	27	29
A	**F12**	0	0	-4	6	0	2	3	7	2	2	3	7	0	6	-6	14	-5	14	-6	14
A	**PM3016**	4	4	7	7	8	8	5	7	8	8	5	7	8	12	14	14	14	14	-4	4
D50	**LED3**	0	0	-3	3	-3	3	-1	7	3	11	6	8	-1	1	-3	7	-3	3	-2	6
D50	**F8**	-2	2	-2	2	0	0	-4	8	-6	6	-6	8	0	0	-5	9	-2	2	4	14
D50	**F9**	-16	16	-14	14	-7	7	-14	16	-9	9	-18	20	-16	16	-23	23	-13	13	-16	16
D50	**FL3.10**	-4	4	-1	3	-2	6	-8	12	-2	4	-3	7	0	0	-10	14	-10	10	2	10
D50	**FL3.14**	-3	3	0	0	0	0	-4	8	0	0	0	0	0	0	1	1	1	1	0	8
D65	**F1**	0	0	-9	11	3	7	-5	15	-2	10	-7	11	-6	10	-12	16	-11	11	-12	16
D65	**F5**	-4	4	-12	14	3	7	-10	12	-4	8	-7	11	-4	14	-8	4	-14	14	-3	15
D65	**F7**	-3	3	-3	3	0	0	-11	13	-4	11	-6	6	-1	5	-4	17	-3	3	-4	4
D65	**FL3.15**	-1	1	0	0	0	0	-7	11	-2	12	-2	4	0	0	-15	14	0	0	-19	19

Appendix VI.2-Test results from Group II

		Test 1		Test 2		Test 3		Test 4		Test 5		Test 6		Average	
Reference	**Test**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**AT**	**AM**
D50	**F8**	-3	7	-5	9	1	3	-8	16	-1	3	-2	2	**-3.0**	**6.7**
D50	**FL3.10**	-4	4	-6	8	-2	8	-14	18	-3	8	-3	3	**-5.3**	**8.2**
D50	**F10**	-6	10	-17	17	-6	10	-15	25	-6	10	-13	13	**-10.5**	**14.2**
D55	**PM5500**	-38	38	-24	24	-48	48	-25	27	-27	48	-7	13	**-28.2**	**33.0**
D65	**FL3.15**	0	0	0	0	0	6	-5	11	-2	6	0	4	**-1.2**	**4.5**
D65	**F7**	-3	3	-6	6	-2	2	0	13	-3	2	-1	5	**-2.5**	**5.2**
F9	**F7**	36	38	25	25	16	16	21	25	11	16	12	14	**20.2**	**22.3**
F12	**F11**	11	13	13	13	16	16	-6	24	17	10	4	4	**9.2**	**13.3**
F12	**PM3016**	9	11	10	16	8	10	4	26	5	16	6	8	**7.0**	**14.5**
F12	**HP3**	2	4	-2	4	-2	3	4	14	-1	3	0	0	**0.2**	**4.7**
F12	**FL3.12**	2	2	2	2	3	2	0	18	-5	2	2	2	**0.7**	**4.7**
F12	**HP2**	-6	8	-2	2	-3	3	8	20	-12	3	-5	5	**-3.3**	**6.8**
PM4000	**F11**	-16	16	-15	21	-10	10	13	25	-7	10	-12	14	**-7.8**	**16.0**
PM4000	**HP4**	-18	18	-20	20	-13	13	0	28	-6	13	-13	15	**-11.7**	**17.8**
F8	**FL3.10**	-2	2	-4	4	-2	2	-3	13	-1	2	-1	-1	**-2.2**	**3.7**

Appendix VI.3-Test results from Group III

		Test 1		Test 2		Test 3		Test 4		Test 5		Test 6		Average	
Reference	**Test**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**T**	**M**	**AT**	**AM**
D50	**F8**	-3	7	-5	9	1	3	-8	16	-1	3	-2	2	**-3.0**	**6.7**
D50	**FL3.10**	-4	4	-6	8	-2	8	-14	18	-3	8	-3	3	**-5.3**	**8.2**
D50	**F10**	-6	10	-17	17	-6	10	-15	25	-6	10	-13	13	**-10.5**	**14.2**
D55	**PM5500**	-38	38	-24	24	-48	48	-25	27	-27	48	-7	13	**-28.2**	**33.0**
D65	**FL3.15**	0	0	0	0	0	6	-5	11	-2	6	0	4	**-1.2**	**4.5**
D65	**F7**	-3	3	-6	6	-2	2	0	13	-3	2	-1	5	**-2.5**	**5.2**
F9	**F7**	36	38	25	25	16	16	21	25	11	16	12	14	**20.2**	**22.3**
F12	**F11**	11	13	13	13	16	16	-6	24	17	10	4	4	**9.2**	**13.3**
F12	**PM3016**	9	11	10	16	8	10	4	26	5	16	6	8	**7.0**	**14.5**
F12	**HP3**	2	4	-2	4	-2	3	4	14	-1	3	0	0	**0.2**	**4.7**
F12	**FL3.12**	2	2	2	2	3	2	0	18	-5	2	2	2	**0.7**	**4.7**
F12	**HP2**	-6	8	-2	2	-3	3	8	20	-12	3	-5	5	**-3.3**	**6.8**
PM4000	**F11**	-16	16	-15	21	-10	10	13	25	-7	10	-12	14	**-7.8**	**16.0**
PM4000	**HP4**	-18	18	-20	20	-13	13	0	28	-6	13	-13	15	**-11.7**	**17.8**
F8	**FL3.10**	-2	2	-4	4	-2	2	-3	13	-1	2	-1	-1	**-2.2**	**3.7**

APPENDIX VII-USERS' MANUAL

Introduction

Users' Manual button has been added in this system to help users to run the application. When clicked, the document manual of VIS will come up automatically and information about which is detailed in following section.

The virtual image for colour rendering system is used to display the colour rendering properties of different lighting sources. Colour rendering index, SPDs of each light source, Reflectance of colour samples are contained in the computer interface application system.

This manual will guide you step by step though the following tasks:

1. Run Main GUI via Matlab.
2. Run the Plot SPD GUI
3. Run the Plot reflectance GUI
4. Calculate the colour rendering index of light sources
5. Calculate the RGB values of each colour sample under different light sources
6. Calculate the spectral power distribution of each lighting source.
7. Compare the difference of the same colour samples under difference light sources.

Menu Graphic User Interface (Menu GUI)

To run the system, users must have a MATLAB version installed in the computer (version 2006 or later) and this program is authored using MATLAB version R2007b.

In **Current Directory** box, switch to the: **MATLAB_GUI** (See Figure VII.1).

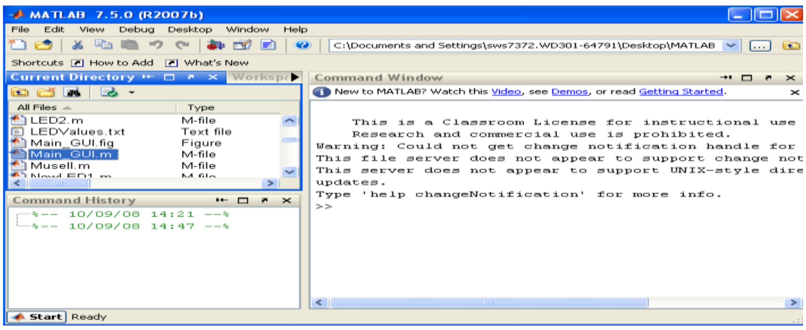


Figure VII.1-Running MATLAB

To **RUN** the **Matlab_GUI**, right click on **Matlab_GUI.m** file and select run, or double click **Matlab_GUI.fig**. The Matlab_GUI will appear on screen.

To **START** the Main application: Press the **Main GUI** button, otherwise, choose **Plot to SPD or Plot Reflectance** by clicking the relevant button. This manual can be viewed by pressing **Manual button.**

Main Program Graphic User Interface (Main GUI)

After pressing Main GUI button, two buttons; a **Gamma button** and a **K1 button** will appear**.** To begin, the user must enter a computer gamma value and a K1 value then press the OK button. At this point, two light source boxes will appear (See Figure VII.2).

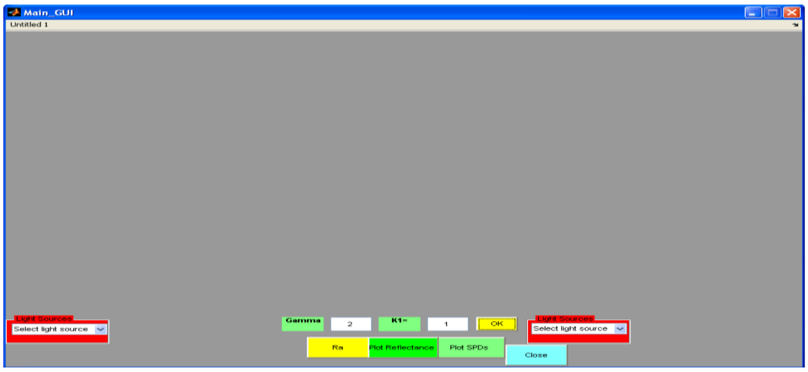


Figure VII.2-Main GUI

To **OPEN test images under different light sources**, select CIE D65 from the left Light sources box (as the reference light source) and select Multi-Band Fluorescent FL3.14 from right light sources box (as the compared light source). Figure VII.3 shows the example of compared the displaying images.

Figure VII.3-More active buttons to use

To calculate RGB values of each colour samples under different light sources, press **Calculate RGB** button. The results will appear in a MATLAB command window. (See Figure VII.4).

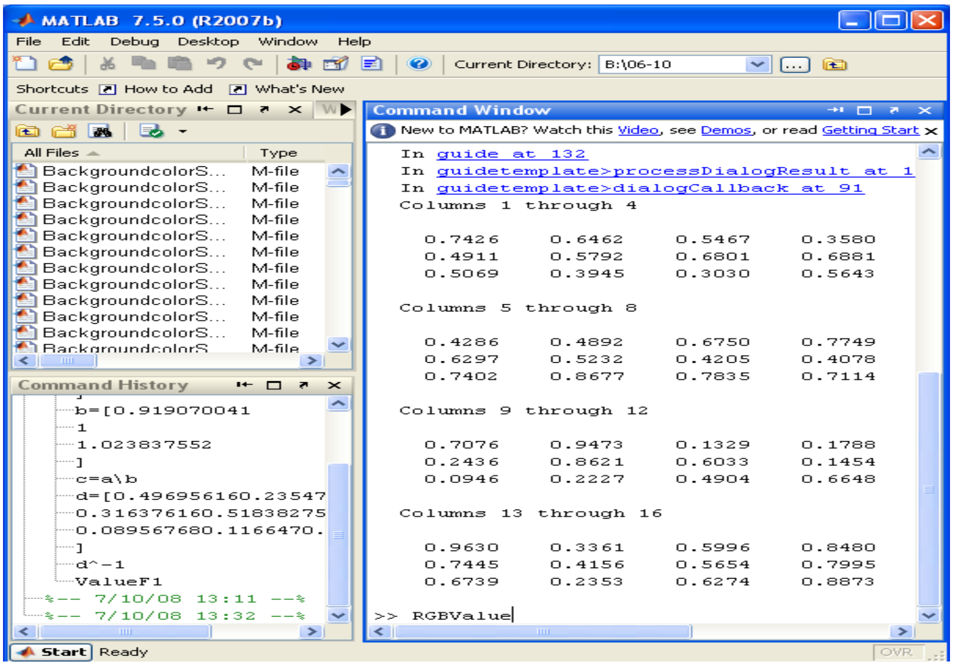


Figure VII.4-Calculate RGB values of displaying colours

To calculate RGB values of each colour samples under different light sources with computer monitor gamma value=2 and K1=1, press **OK** button next to **RGB Value Under r=2, k1=1** button in both sides of this image (See Figure VII.5).

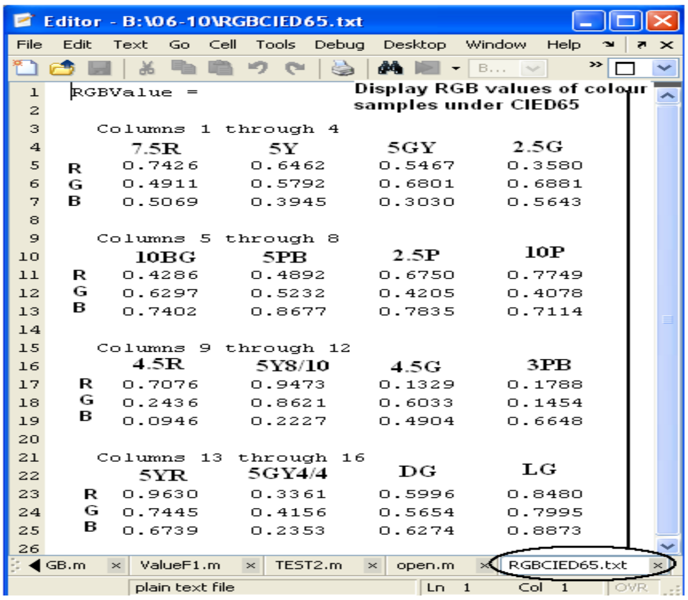
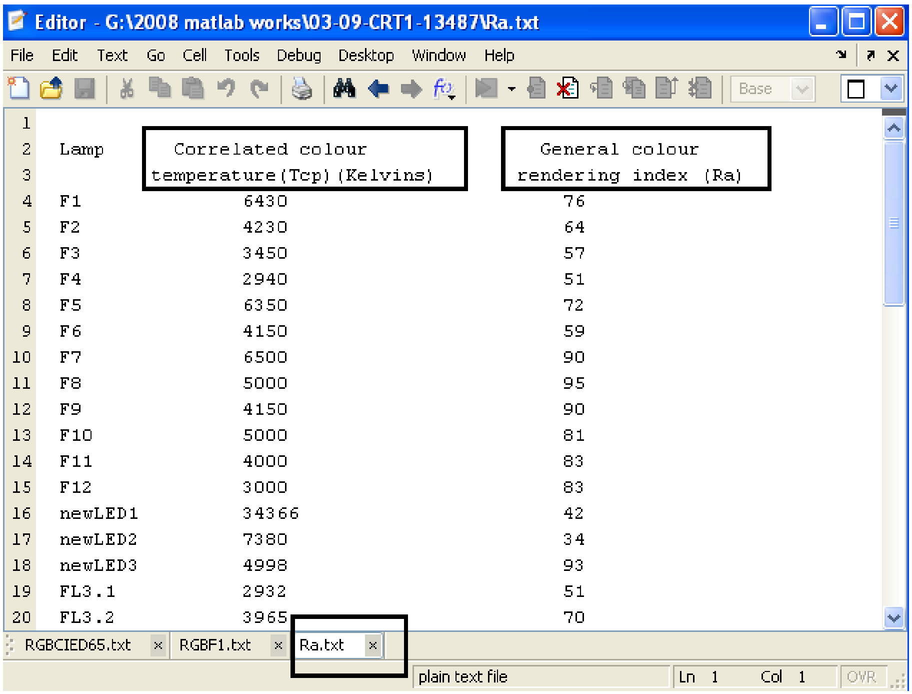


Figure VII.5-Calculate RGB values of displaying colours with gamma r=2, k1=1

To calculate colour rendering index of light sources, press **Ra** button. This also displays the colour temperature of each lighting source (See Figure VII.6).



Editor - G:\2008 matlab works\03-09-CRT1-13487\Ra.txt

Lamp	Correlated colour temperature(Tcp)(Kelvins)	General colour rendering index (Ra)
F1	6430	76
F2	4230	64
F3	3450	57
F4	2940	51
F5	6350	72
F6	4150	59
F7	6500	90
F8	5000	95
F9	4150	90
F10	5000	81
F11	4000	83
F12	3000	83
newLED1	34366	42
newLED2	7380	34
newLED3	4998	93
FL3.1	2932	51
FL3.2	3965	70

Figure VII.6-Calculate colour rendering index Ra and colour temperature values of light sources

To plot spectral power distribution of the selected light sources, press the Plot SPD button. Figure VII.7 shows a screenshot of Plot SPD GUI interface.

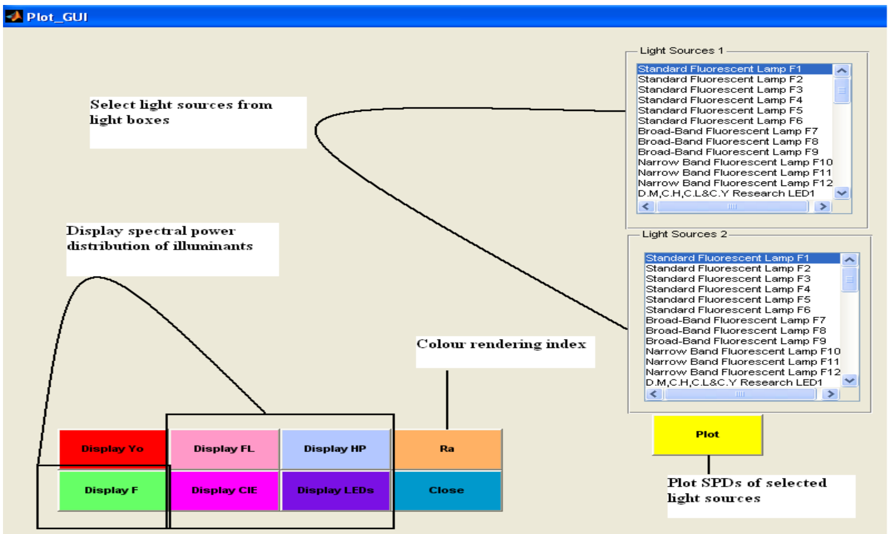


Figure VII.7-Plot PSD GUI

Two light sources boxes are displayed on the screen which the user can choose from to compare their SPDs. Figure VII.8 displays a reference light source of CIED65 (red line) compared with a Multi-Band Fluorescent FL3.14 light source (blue line). To view SPDs of selected light sources, press the Display F, Display FL, Display HP, Display LEDs, Display CIE buttons which located at the bottom of the screen

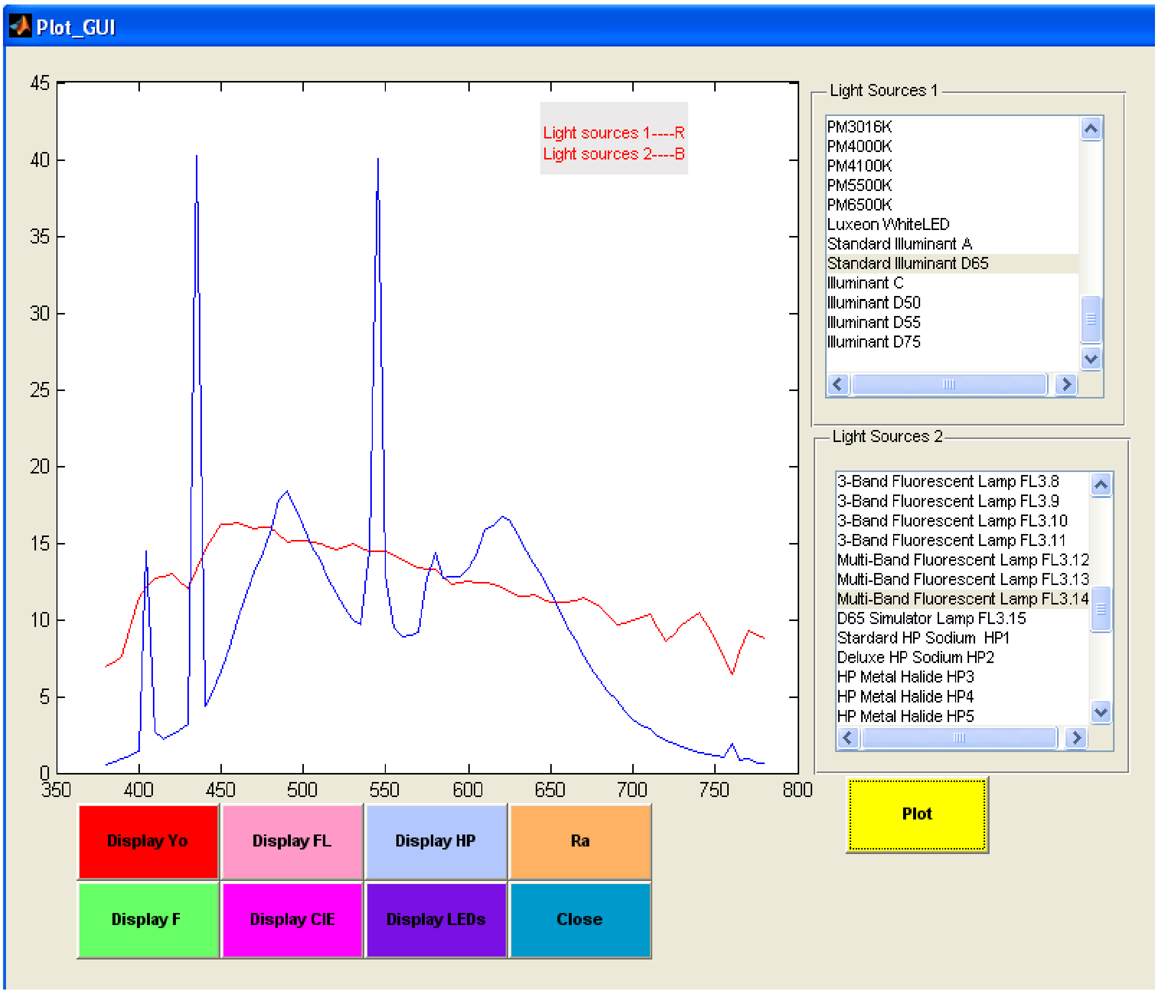


Figure VII.8-SPDs of CIED65 and FL3.14

Plot Reflectance GUI

The Plot Reflectance button on TEST 2 GUI or Main GUI will allow the user to view a the interface of the plot reflectance of test colour samples. To plot reflectance of colour samples, press Plot Reflectance button and the graph will be displayed (See Figure VII.9).

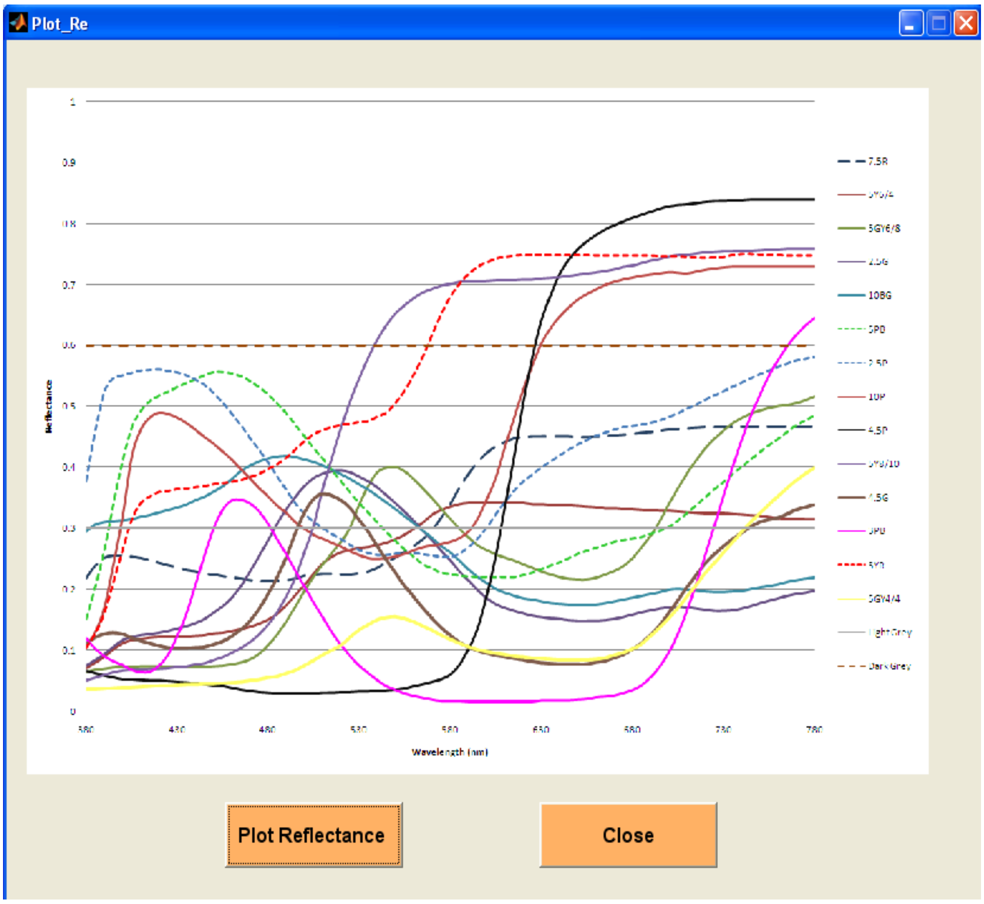


Figure VII.9-Plot Reflectance GUI

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