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2019 - School of Art and Design - Auckland University of Technology

KNITTED PAINTINGS

EXPLORING THE POTENTIAL OF COLOUR IN KNIT

"… any fool can do it
– yet it is extremely difficult, complex, involved."

Joanne Turney - The Culture of Knitting

RESEARCH QUESTION

How can a combination of automated knitting and design software inform practice-based experiments towards the development of new jacquard techniques that are both highly automatic and yet responsive to artistic notions of hue, shading and the respresentation of depth?

ABSTRACT

KNITTED PAINTINGS is a textile design project examining the significance of design and technology in knitted textile production, using practice-based investigations as a means of facilitating unique contributions to contemporary modes of knitting.

This project utilises sophisticated knitting technology to explore new techniques in digital design. It respresents an evolution of expectations of knit design processes, through the use of new programming techniques that expand potential design aesthetics of knitted materials.

This investigation aims to consider the technical and artistic challenges contemporary knitted textile designers face when accessing new knitting technologies.

Through a discussion of the unique qualities of Jacquard knit techniques and design, the contextual framework informs practice-led investigations into new modes of colour work in knitted textiles. It investigates a method of programming that can minimise technical complications in manufacturing and increase pictorial aspects while still engaging in traditional tactic design processes.

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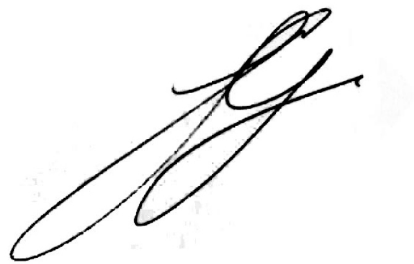
ATTESTATION OF AUTHORSHIP

November 2018

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 (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.



INTRODUCTION

Contemporary knitting practices involve digital solutions to programming and manufacturing that have largely dissolved complications in material production. However designers remain challenged by the rapidly expanding knowledge required to use such design software and machinery within this shifting technological environment. Contemporary knit designer-makers are required to have a comprehensive understanding of modern technology and production whilst engaging in design processes that rely on both traditional and innovative design experimentations (Newton, 1992). This research explores how collaboration between softwares (Photoshop and Shima Seiki Software) can expand concievable knit outcomes to achieve designs traditionally limited to woven and printed textiles.

Chapter One in this research discusses the contextual framework surrounding knitting, from cultural and historical accounts of knitted textiles in art and text, to contemporary perspectives of the craft of knitting, this sets the boundaries within which this research contributes too.

Next, observations of knitted materials introduce clearer understanding of empirical modes of creation, common in knit manufacturing processes. This section is largely concerned with understanding how various designers have previously achieved achieve colour, image and depth in knitted materials through a variety of processes'.

The second part of Chapter One discusses the technical elements of knitwear programming, manufacturing and construction. This section articulates common language and techniques used in knit design in order establish the current limitations existent in contemporary processes'.

Chapter Two introduces key research methodologies used for attaining information within the investigative process, formalising the translation of practice-based findings into a systematic action-research cycle.

In Chapter Three, practice-led experimentations respond to contextual boundaries through the development of new knitted textile programming methods that employ simplified processes, minimising complications in material production. The resulting design practice utilises a range of beginner to advanced technologies to exhibit a range of knitted textiles that encourage the material potential and communicative capacity of contemporary digital knit technology.

The intention of this research is to expand outcomes from automatic knitting software through the development of new jacquard techniques which are both highly automated and yet unlimited in terms of design potential.

CONTEXT 1.KNITTING

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Establishing the earliest examples of knitting presents a difficult task. The oldest surviving knitted items were for many years thought to be socks and small items of Coptic origin from the first centuries A. D. but were later proven to be of the knotless netting technique (Turnau, 1991).

Technology has assisted in material manufacturing processes since the first century A.D. in Egypt – where Coptic tissues were found containing a structure resembling contemporary woven tapestries (Tabard, 1978), however knitting, distinctive through its use of two needles and early use of one or two colours, can be traced as fragments of Arabian origin dating to the early middle ages, though it is impossible to date them accurately (Zilboorg, 1994).

Displays of knitting became common features in Cathedral frescos, as depicted in Madonna Knitting by Bertram of Minden (See Figure 2). Mentions of Christ's knitted robe, or references to the knitting woman Penelope are found across various biblical texts, yet surviving examples of knitwear are a rarity.

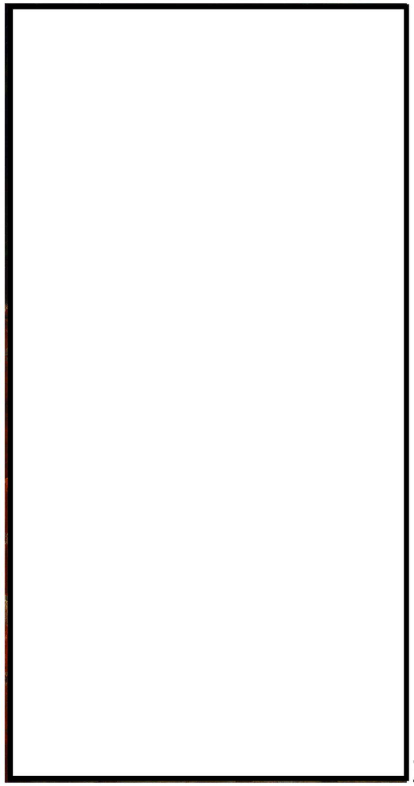
Few knitted objects survived until the establishment of knitting guilds as early as the thirteenth century (Turnau, 1991) which, by the sixteenth century, guilds had evolved to become a common custom throughout Europe.

Though knitting techniques remained relatively un-evolved during this time, knitting guilds contributed towards the wide scale embrace of simple knitted garments, such as stockings (See Figure 3), into everyday Renaissance attire (Currie, 2017).

The commonality of stockings spread throughout Europe by the 16th century, however due to the course nature of wool used in such garments were deemed uncomfortable and purely function items (Brackenbury, 1992).

The development of the knitting frame, or ‘stocking frame’ by William Lee in 1589 led to innovations in automatic knitting machinery, alleviating the intensive labour associated with hand knitting (Spencer, 1983). Continuous improvements and adaptations in technology since Lee’s invention have encouraged the development of various machines appropriate for a range of knitting tasks.

Invention of the fully-fashioned hand-knitted silk hose and William Lee’s Stocking Frame demonstrated some of the earliest forms of mechanical knitting (Black, 2002), establishing the separation between the traditional craft of hand-knitting and emerging automatic mechanical knitting processes (Brackenbury, 1992).



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Knitwear has developed within and alongside fashion movements for decades, however its complicated manufacturing processes, and functionality as a material, have often consigned it to minor roles within larger collections (Black, 2002).

Through examining unique designs and evolutions in knit, this research introduced key designer case studies across several decades of knitting practices to form an advanced understanding and historical context of the transfer of art and pictorial images into knit.

The infamous 'little black dress' (See Figure 4) designed by Gabrielle Chanel in 1926 contributed towards a significant shift in knitwear, most notably through the integration of fabric more commonly found in men's underwear into everyday womenswear (Gulvin, 1984).

Created using 'cut and sew' methods typically reserved for woven materials, these designs reflect the increased prominence of knitwear as key pieces in contemporary wardrobes (Power, 2007).

During the 1960's, John Carr Doughty's knitted garments (See Figures 5 and 6) were state-of-the-art prototypes demonstrating new structures, and therefore aesthetics, that were emerging through knitted materials of the time. A prominent figure in the development of early knitting machines and techniques, Doughty's knitted garments are distinguished examples of developments in knit that cater towards obtaining image and detail in knitted materials, despite the complexity of developing such structures.

Most notably his tromp l'oeil patterns, inspired by illusionary baroque and rococo wall frescoes, incorporated designs that made knitted materials appear more complex in structure despite using minimal colours and a relatively simple jacquard technique. The technique of Jacquard knitting, explained in further detail in Chapter 2, is the focus of this research project as it consists of multiple colour knitting which can form effective pictures or patterns in knit.

As figures 5 and 6 show, garments use jacquard structures to create the illusion of a suit. The appearance of tailored lines are not essential to the structure of the garment, but rather serve as decorative features encouraging audiences to adopt the simplicity of knitted attire over traditional woven garments.

Doughty’s career intergrated the jobs of both designer and technician into a singular role in order to seek further possibilites in knit.

I believe knowledge formed at the intersection between two paths of investigation - designer practice nd technicial expertise - is how knitwear can achieve a fuller state of potential for object outcomes. This is where this research study is postioned - between the designer and technical nexus.

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Another designer who incorporated a strong understanding of technical knowledge into a knitting practice is British designer Martin Kidman. As creative director for ‘Joseph’, Kidman influenced the successful adoption of kitsch knitwear across fashion movements in the mid 1980’s. Technology was instrumental in shaping Kidmans interest in knitting, who was once quoted saying

> “… I decided to change to fashion when I saw a friend using a knitting machine - I couldn’t believe it, the possibilities of this mechanical thing that could turn out a length of knitting.” (Lacey, 1997).

Ornate patterns, animal motifs (See Figures 7 to 9) and bight yarn choices became typical examples of Joseph’s heavy, strikingly patterned knitwear (Lacey, 1997), drawing from Kidman’s love of fine-arts. Such aesthetics, though simple in design, popularised kitsch knitwear in fashion and influenced a revival of craft movements across various design and fashion communities.

However towards the end of the 1980’s, the popularisation of sportswear and jersey apparel encouraged a sharp decline in hand-knitting, reducing the craft to a niche past-time and encouraging a general distance from knitwear altogether (Memon, 2018).

The rise of globalisation in fashion industries saw knitwear designers, particularly machine knitters, assuming more roles within larger brands. Continued advancements in technology supported automatic modes of knitting. Specialised skill-sets began to be replaced by computer aided design software, expanding access to basic knitwear technology for designers while simultaneously threatening the advancement of knitwear knowledge for technicians.

After becoming Moschino's creative director in 2014, Jeremy Scott incorporated a wide range of pop-culture symbols and images (See Figure 10) into knitted materials using relatively uncomplicated structures and automatic programming techniques (Scottsman, 2004).
Helping the global Moschino brand appeal to both high and low-end consumers, knitwear sales continue to be an essential aspect of the companies ready-to-wear range, often utilising basic jacquard and intarsia structures across various collections and garment designs.

Though the development of such designs still requires substantial knitwear knowledge, structures used within ready-to-wear ranges often utilise the same or similar intarsia and jacquard stitch structures (See Figures 11 to 13) across collections - encouraging a continued limitation in the appearance of knitted apparel and textiles, particularly within the development of pictorial or jacquard techniques.

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While weaving, print, embroidery, appliqué and other techniques have evolved to become widely embraced across fashion movements – crossing into fine art spheres (Black, 2002), knit has either been developed through hand-crafted or industrial processes, with each method requiring highly specialised knowledge.

Divides between knitting methods divulge the ways in which knitted objects are placed as both high end luxury items and functional knitted attire. As described by Sandy Black in Knitwear in Fashion, "Knitwear is universal –everyone wears it in some form, either as underwear, hosiery outerwear – but its domestic and mass market connotations have until recently consigned it to a minor role" (Black, 2002).

Outside of the industry, common attitudes towards knitting remain influenced by domestic associations (Cox et.al, 2015). Knitting evokes immediate nostalgia formed through personal relationships with knitters and the highly domesticated environments, knitting is seen to take place in.

> On the surface knitting is ostensibly an ordinary activity associated with the domestic sphere and on the surface has little connection with post modernity or the postmodern. Yet because knitting is so firmly established within popular culture through its iconology and iconography, it is an ideal genre to exploit, manipulate and challenge (Turney, 2009. pp-77).

Past attitudes towards knit, both as material and pastime, have distinct connections between cultures of class and gender that tend to limit its significance as a conveyer of social meaning. Whilst knitwear is often recognised for its contribution to homeware and fashion design practices, this investigation asserts knitted textiles can operate as both a functional material while also presenting cultural narrative through its design and mode of make.

This research hypothesises that a significant advancement in knitted materials requires the need for knit research based in aesthetic and structural developments. This needs to be void of commercial production influences that typically limit material experimentation, through which the focus on one technique in particular can advance, contributing new knowledge to fields of knitwear manufacturing and design.

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Knitted materials are defined by the forming of fabric consisting of vertical columns through the looping of a continuous yarn (Stoller, 2003).

Knitted fabric consists of loops that intermesh across, known as ‘courses’, and vertical rows known as ‘wales’ (see Figure 14).

Unlike woven materials (Figure 15), when constructing garments knitted structures boast unique properties, offering more stretch and flexibility as a fabric compared to the highly structural behaviour of woven cloth. Moreso, ‘knit-to-shape’ applications of knitted textiles can minimise waste compared to cut-and-sew construction methods popularised in industrial garment manufacturing (Willard, 2012).

There are two basic stitch structures, knit and purl, which work together to achieve a vast range of patterns and designs (Dawson, 1984). Individual stitch structures may be noticeable or subtly presented depending on each loops relation to the surrounding stitches with variations of design being constructed through adaptations of colour, yarn and knit structure which all work together to form unique material outcomes (Spencer, 1983).

As techniques have evolved from hand-made to machine constructed, varied styles of knitted materials have become commonplace in fashion and textile markets – yet the practice of knitting between both domestic and commercial spheres has become a highly specialised method of making (Hollows, 2006. pp-106-7).

This research looks to multiple technologies, which are readily available to the machine knitter, to increase colour images through an investigation of new design processes and methods which simplify the process whilst resulting in complex colour design outputs.

The structural capacity of knitted textiles limits the number of colours available for use within final designs when produced on industrial knitted textile machinery, ultimately constricting design opportunities in knitted textiles compared to printed and woven textiles. Typically, multi-coloured designs are integrated into knitted textiles through two major established techniques - Intarsia and Jacquard.

Intarsia structures (See Figure 16) are noticeable when an area of design, usually contrasting in colour, gives the appearance of being inlaid in the fabric. Intarsia structures display sharp, clearly defined areas of knit that have no overlapping colours, with a reverse side free from floating yarn or birds eye backing, which are more characteristic of jacquard knits (Spencer, 1983).

Jacquard cloth (Figure 17) is constructed on knitting machines using jacquard mechanisms which help to achieve complicated designs through more controlled methods of needle selection and using a limited amount of colours.

Resulting jacquard structures will generally use more yarn that intarsia knits, but can produce consistent balanced structures on the reverse side of the material (Figure 18) that can simplify programming capabilities and take less production time to develop (Willard, 2012).

This project acknowledges the material limitations associated with use of colour in knitted fabrics and seeks to resolve them through new approaches to achieving multiple colour and image detail in knitted textiles.

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Colour is a fundamental quality of textile design and manufacture, especially in outputs intended for decorative purposes (Klein, 1965). The effect of colour is attained through various means, depending on material composition, from the application of surface prints commonly found in contemporary practices, to the natural and specific custom-died yarns used commonly across a history of woven and knit processes (Geijer, 1979).

Selection of colour is an integral aspect of designing knitted materials. Colours not only shape aesthetic design outcomes, they also form the structural foundation of the material itself (Newton, 1992). While colours are sourced depending on the intended final design, they often require particular tones to be dyed specifically, or alternatively utilise a mixture of yarns to achieve a desired shade (Duncan & Bull, 1978).

Colours incorporated into commercial knitwear designs are generally limited to a few in order to maximise profit and minimise structural complexities in knitwear programming and construction (Geijer, 1979).

Painting techniques formed during the emergence of impressionist art in 18th century France, specifically Pointillism, is adopted as a primary technique for translating images into knitted textiles across this research investigation. Optical illusions of colour, formed through the blending of small dots, are seen to have been incorporated into textile designs in early examples of woven cloth (Ward, 1973), with traditional techniques in tapestry making also utilising pointillist techniques to obtain richer tones and complex colour arrangements in final designs (Phillips, 1994).

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This method of image production through the use of the technique of pointillism has allowed this research to move the image production in knitted textile designs when combined with the knit technique of Jacquard, to an advance knowledge level of how to utilize a variety of colour palettes as well as increase image complexities.

While colour hues can be modified (See Figure 21) by placing them in juxtaposition with other colours (Duncan & Bull, 1978), methods of design through Photoshop used in this research process assist in predetermining the success of colour outcomes before knit programming and sampling is required.

Colour ratios, determined by the amount of colour in any one composition, further influences the appearance of colour tones. A blue and red knitted or woven next to each other can achieve purple tones, however the same blue and red printed on a fabric surface may appear duller, even brown or black (Ward, 1973).

Varying proportions of colour will affect tonal values, for example, even amounts of red and blue will form a balanced purple - but different amounts of red or blue will shift the result towards warmer or cooler tones of purple.

22.

Using processes in Adobe Photoshop, the basic principles of colour blending can be automatically translated into bitmap images (See Figures 22 and 23), where minimal selection of colours can be further adapted into pictorial images in knit with ease.

Acknowledging the additional design possibilities achievable through a mixture of Photoshop and more advanced knitwear software systems, this research has developed ways to maximise the depth achieved in knitted materials by employing previously unrelated design techniques and methods throughout practice-led investigations.

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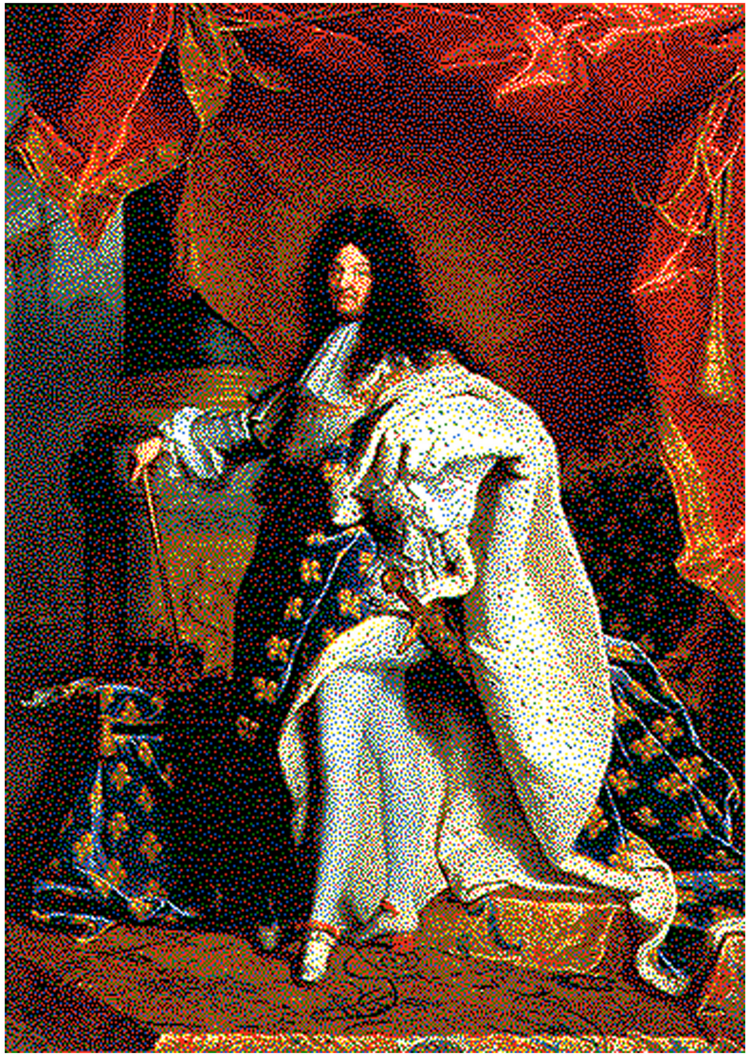

Stitch size is an apparent variable between the scale of fine, machine crafted commercial knits (See Figures 23 and 24) and chunky, large stitch knitting (See Figures 25 and 26) often associated with domestic crafted outputs.

Gauge is generally understood as the number of stitches against a standard measurement (Little, 2018). Gauge formalises the differences between tension, yarn and needle size to create consistent results among variable knitted material constructs.

Knitting gauge collates the complex variables associated with knitting, forming a design language to articulate the scale of both the individual stitch and the overall swatch scale (Newton, 1992). Gauge also dictates stitch ratios using multiple colours of yarn within a knitted fabric outcome. Understanding gauge a necessary factor of designing knitted textiles as it encourages different design outcomes depending on the size of yarn and needles being used. – and therefore the pictorial detail achievable within a knitted application.

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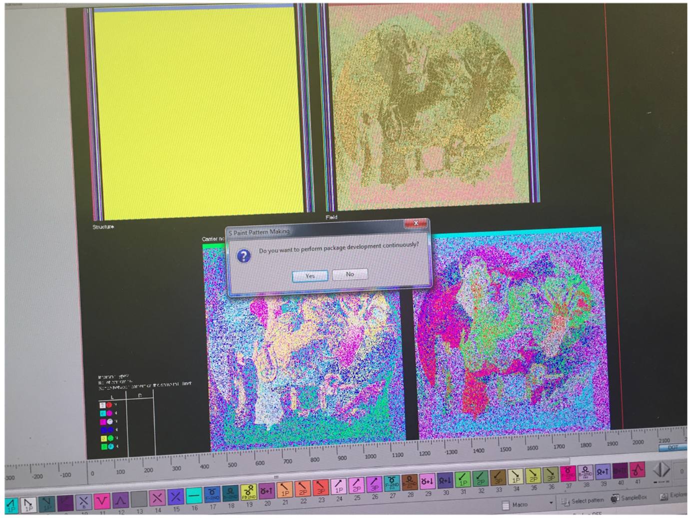
Industrial knitting practices rely heavily on the supply of fine, strong, uniformly spun yarn to ensure high quality construction, therefore yarn choice is a critical element in developing a successful knitted material (Spencer, 1983). Designers must consider the final use of the material outcome and ensure yarns chosen are structurally appropriate and aesthetically relevant to the outcome.

Like any textile fabric, there are innumerable compositions available utilising traditional organic materials through to the latest in synthetic fiber. Understanding the properties of various fibers is essential in textile design practices, where appropriate yarn selection is determined based on the final function and desired appearance of the textile.

As this research practice has a strong focus on colour work, cotton fiber has been used as the predominant material within this design experimentation process due to the wide colour ranges available in cotton yarns and the suitability for machine use and scale of image required.

28. 

Technology has had unprecedented effects on aesthetics in art and design movements, particularly though evolutions in methods and materials used in construction processes. Contemporary textile processes are more reliant on technology than ever, utilising computers, software and digitally controlled machinery to enhance textile design outcomes.

Sophisticated machinery and software programming methods utilised in contemporary processes result in virtual diagrams of knitted textiles, editable in digital form before being taken to final manufacturing. Shima Seiki software (See Figure 28) establishes production issues and advises any necessary changes before physical knitting ensues. This mode of development become an intentional knitwear production method – void of potential structural complications.

Before the Industrial Revolution, tacit knowledge was inherently integrated into textile production – where practices used entirely handmade processes to construct objects. This hand-made level of production inspired unique design outcomes developed by individual makers (See Figures 29 and 30), as explained by Barty Phillips in Tapestry:

> Medieval European tapestry images were largely pictorial and full of humour and surprises. There were touches of the weaver's own imagination in the turn of a toe or the expression on a face, and small animals and birds were included at the weaver's whim. These personal touches must have made weaving pleasurable, besides contributing to the interest and enjoyment provided by the finished piece. (Phillips, 1994. pp-9)

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Advancements in technology and manufacturing have supported a move away from individualised, traditional hand-made processes and towards automated modes of design where "artists and artists are … embracing two opposites – hand and technology." (Wada, 2002, p.145)

The wide embrace of digital processing in knitwear production has eased technical complications with knitwear development. This is particularly seen however new challenges are presented when attempting to develop unique knitted
materials that differ from results achieved via the use of automatic systems which are now commonplace in commercial production.

Practice-led research conducted through this investigation expand outcomes from multiple software processes to facilitate development of new jacquard techniques which are highly automated, yet retain various avenues for future design potentials.

The technical components of knitwear design, programming and manufacturing, encourage the separation of roles between designers and technicians. A contemporary knit-design process "…generally sees a clear distinction between the art of an object and the support structure used for that art." (Conklin, 1997), consequently the role of the technician can be overlooked as a focal element of a design process. Contrary to this, understanding technical elements of manufacturing can enhance a practice, as discussed by Jane Taylor and Katherine Townsend:

> Designer-makers have integrated a wide range of digital media and tools into their practices, many taking ownership of a specific technology or application and learning how to use it for themselves, often drawing on their experiential knowledge of established practices to do so.
> (Taylor & Townsend, 2014. pp-155-174)

Despite efforts by machine manufacturers to make complex knitting software more accessible and user friendly "… the digital interface remains a significant barrier to knitwear designer-makers." (Taylor & Townsend. 2014. pp-155-174).

While present-day modes of manufacturing have advanced the capability of production, tactic explorations within a design process are limited due to the largely automated state of modern machinery. In Ways of knowing and making, Rachel Philpott notes that

> There are both advantages and limitations to such methods. Although the utilisation of rapid prototyping as a tool for manufacture revolutionises patterns of production and distribution, … the material output of the rapid prototyping process is currently limited, narrowing both the performative possibilities of the product and the sensual experience of the users of such items. (Philpott, 2010. pp-32)

Contemporary art and design processes, particularly relating to textile products, are now heavily reliant on technical skills to achieve desired results as much as artistic direction from the designer-maker. The gap between technician and designer is a modern issue that has presented limitations over outcomes and development created in material making.

The introduction of machine processes has influenced an increased need for technical skills, shifting the experience of making and designing into two seperate roles; that of the technician and the designer. This research, due to the researchers tacit knowledge and previous design experience and technical knowledge, operates across this technical-design divide - extending design possibilities through a combination of multiple manufacturing processes used across practice-led experiments.

2.METHODOLOGY

As with traditional methods of attaining scientific and academic knowledge, ‘practice-led’ research seeks to gain deep knowledge and potential application through design practice experimentation (Vaughan, 2017).

Emerging paths of contemporary academia describe growing demand for the inclusion of the ‘designer-practitioner-researcher’ as a key element of design research processes. Articulated by Peter Jarvis in his publication The Practitioner-Researcher: developing theory from practice, the core of ‘design’ and ‘research’ is, in fact, practice (Jarvis, 1999). He argues that emerging practitioner-research investigations are as essential as academic and scientific discourse, and the inclusion of practice-led research is a valid and “… a recognized method of achieving authoritative research outcomes” (Vaughan, 2017. pp-10).

Practice-led design research, unlike scientific investigation, ideally doesn’t predict the outcome of research. Instead, investigations are encouraged to grow alongside the research as it progresses.

Findings, or ‘arguments’, emerge from practices (Gray, 1998), as further questions are raised and new possibilities are formed. Insight gained from such processes can typically result in the development of new, unique design outcomes being actualized, and therefore adding new knowledge to an area of research (Ehn, Ullmark. 2017).

Explicit knowledge offers translatable findings into a practical framework of research - where the knowledge is easily verbalised and discussed. Implicit knowledge differs from explicit knowledge because it requires more intuitive processes where learners are often required to learn by the action of watching or doing (Ellis, 2009).

Implicit and explicit learning styles highlight the unique aspects of design investigations, which tend to use both a mixture of propositional technical language and practical skills to achieve learning outcomes (Prawitz,1990).

The differences between explicit knowledge (formed through sentences or drawing) and implicit knowledge (perception and intuition based responses) describe the varied paths of research necessary to determine both technical and design based findings (McCoy, 2013).

Friedman (2002, p. 210) describes differences between design and technique as ‘‘doing things right,’’ which is a technical decision and ‘‘doing the right thing,’’ which is a design decision.

While Friedman was discussing industrial design, this theory can be applied to a variety of art and design practices – including textiles – because it acknowledges technical and design research as separate modes of investigation that are fused together in experiments and findings (Prawitz,1990).

Dualistic understanding of both technical and design-based knowledge is essential in organising experiments and articulating different learning outcomes achieved through a design practice and both of these knowledge bases, technical and design have been utilized within this research.

Action research is a critial aspect of this-investigation, as it encourages a preflective process of progressive problem solving (T.Stringer, 2013).

In Kurt Lewin's 1944 paper 'Action Research and Minority Problems', he proposes action research is a "a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action" (Lewin, 1944).

While practice-led research describes the overarching methodological approach to design research, an 'action-research cycle' describes the process and methods of attaining findings through a practice. Methods utilised within the action-research cycle can be the tools used to achieve a project outcome (McCoy, 2013).

Action-research cycles encourage reflective-practices that articulate the implicit and explicit knowledge gained through design investigations conducted within practice-led research, as such these form the main research methods utilized within this design practice and technologically-based research investigation.

3.PROCESS 1.INTRODUCTION

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My textile practice utilises a mixture of historical imagery with contemporary compositional elements to encourage new ways of designing and developing knitted textiles (See Figure 31). In particular, a key developmental focus has been in the increased potential for the colours and details achievable in knitted textiles.

During my honours practice I developed a unique software programme which allowed for up to six yarn colours to be successfully knitted into any one design (See Figure 32); while ensuring the reverse of the fabric remains structurally consistent and finished (See Figure 33) This method of knitting also moved a little way towards resolving some previous structural complications found in the translation of images into knitted materials.

Development of the unique jacquard structure assisted in achieving a higher level of detail and imagery into a high quality knitted textile, however as designs still had restrictions of up to six colours, opportunities for creating a sense of depth within the knitted textiles was still limited.

Following on from initial structural developments, this current research investigation has further explored the design potential of colour work in knitted textiles using and developing this technique (Figure 34), while continuing to minimise potential complications within the technical knitwear


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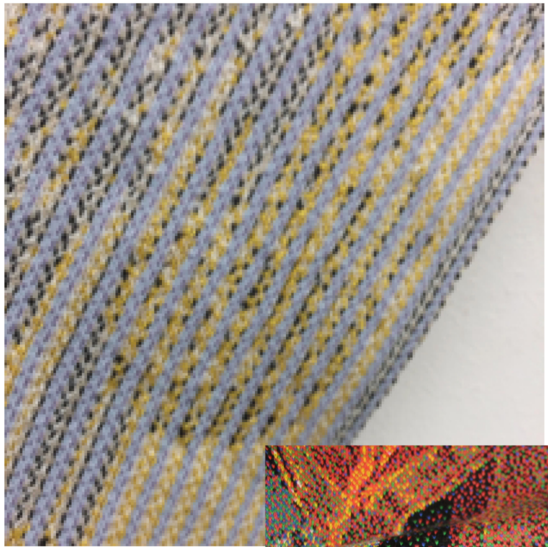
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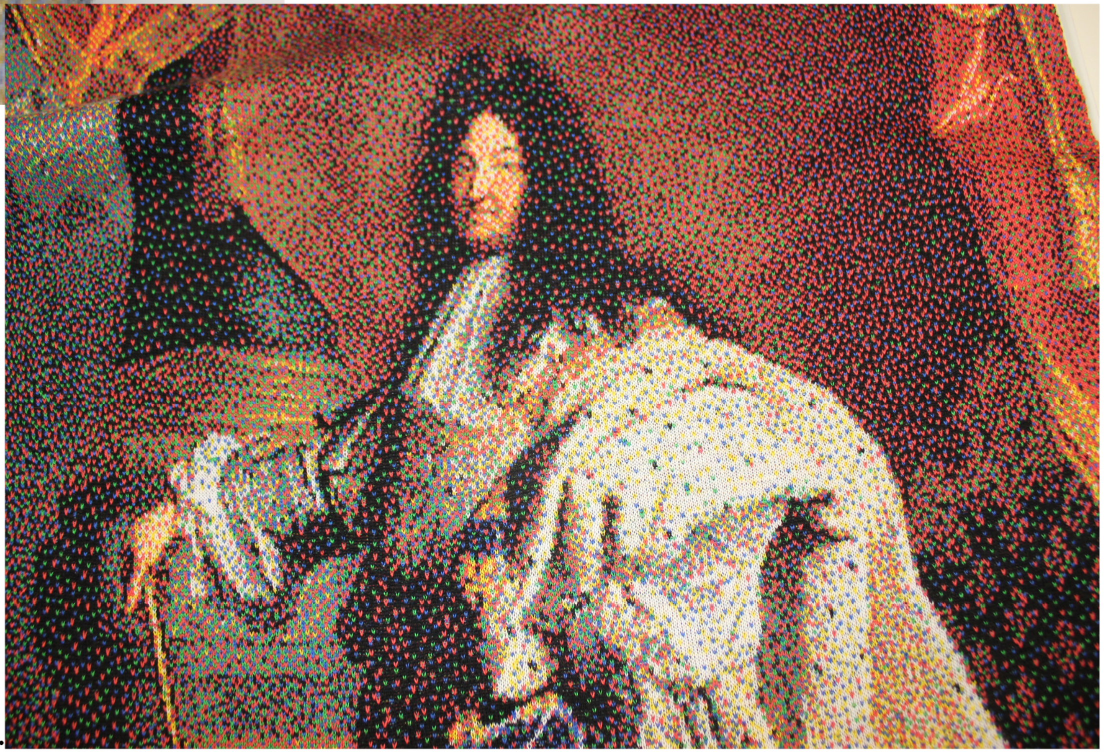

34.

As the contextual framework of knitting was established, and the methodological research approach defined, the next stage of this investigation required a range of design experiments to research further potential outcomes achievable through multiple colour work within knitted textiles.

This investigation utilised the 6-colour jacquard structure developed during my postgraduate Bachelor of Design (Honours) degree, and aimed to find new ways of further exploiting this same structure to achieve results that expanded the potential visual design outcomes when using knitted textile techniques.

As discussed in the contextual framework chapter, detail and design in knitted textiles are limited by structural capacities, materials and technology which all work together to create knitted shape and design possibilities. A common problem in knitwear programming is the use of multi-coloured designs which are difficult and often unable to be entirely translated into knitted structures (Newton, 1992).

Because of these limitations, high levels of detail, synonymous with fine-arts painting, photography and other media, are often poorly translated into pixelated versions when translated into knitted materials.

Key stages in this research persisted in developing new solutions for achieving depth, detail and colour that expanded on the aesthetic possibilities achievable in knitted outcomes.

Research, following the action research cycle, reflects upon design outcomes, evaluates use of colour, scale, gauge, detail and compositional imagery within each design experiment in order to establish new methods of understanding possibilities in knitwear processing, which could be applied during the next phase of designed iterations.

All experiments were working towards an exhibition of a final tapestry which aimed to materialise these new programming and knitting methods into one finished multiple colour knitted composition.

Knitwear designers have generally faced obstacles when using multiple colours within knitted structures – with manufacturing methods limiting the amount of yarns and colours able to be included in knitwear design in order to simplify design and programming processes (Geijer, 1979).

Unique explorations in knit can require multiple experiments before final samples are established - often absorbing expensive resources and time (Black, 2002).

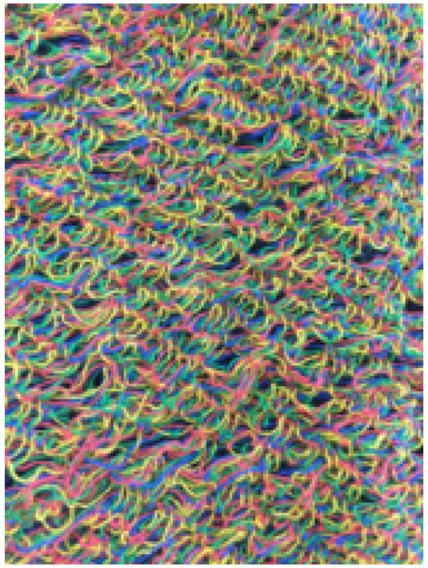
Typically knitwear technicians translate more complicated designs into knitted materials by compromising initial imagery to fit into structural limitations of the material, easing technical complications across translation processes.

Techniques introduced across the following experiments utilise the same jacquard knit structure among various designs – forming strategies for achieving a variety of colours and detailed visual compositions in knitted material outputs.

Jacquard structures, unlike Intarsia knitting, can utilise a standard programming structure across a variety of designs, despite differences in colour and composition – whereas intarsia structures tend to require more complex structural programming which are individual and pertain to each design, this is why this research has focused on just the method of construction of Jacquard.

Jacquard knitting has been adopted as the primary technique within this research to resolve the problem of too many colours creating structural complications, such as floating yarn on the reverse of the design (See Figure 35). This can weaken aesthetic and structural design outcomes on the right side of the textile (Willard, 2012).

As Jacquard techniques are already used more readily within the knitwear industry as method for achieving multiple colours in knit, research findings from this investigation are of increased value, and become a major contribution to the field of knitted structural techniques and the production of increased visual detail in the knitted textile outcome.



35.

High-level technical programming involves firsthand experience with knitted materials and a deep understanding of the software to exploit the potential of digital knit technology (Taylor & Townsend, 2014), therefore explorations such as this research assist in finding ways of simplifying the design process which is key for expanding knitwear design potentials.

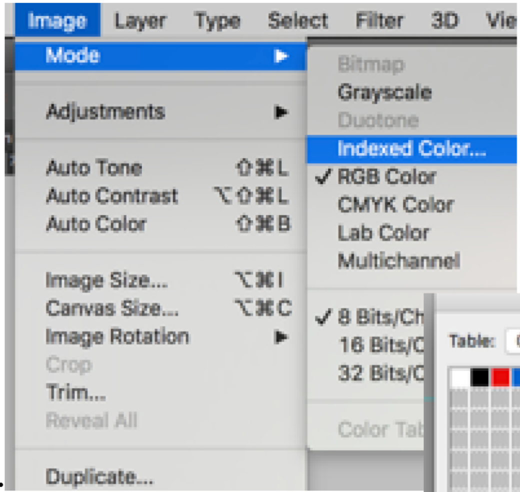
Adobe Photoshop is a standard tool in design processes, especially textiles, offering the opportunities for creating and editing images using a variety of digital tools.

Manipulation of images through software such Photoshop and the Shima Seiki Design System are key stages within this research design process, helping to reduce images into six colours which are further translated for knitting through knit design software tools.

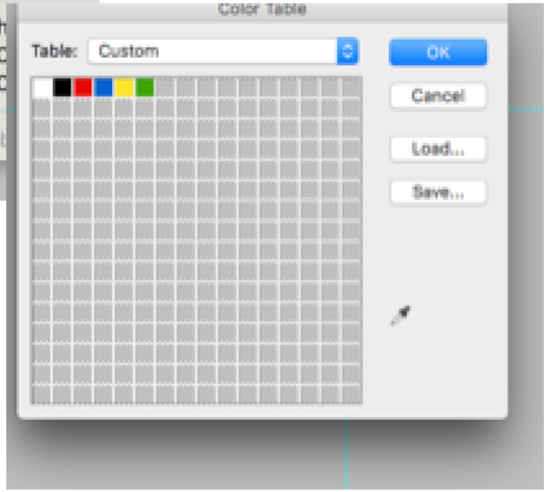
Adobe Photoshop is a standard tool in design processes, especially textiles, offering the opportunities for creating and editing images using a variety of digital tools

Using the ‘Index Colour’ function (See Figure 36 and 37), images are able to be converted into any range of specified colours. As a limitation of six colours has been established as the maximum amount of yarns that can be used due to structural capacities during manufacturing. The six colours used across this project reflect the most effective selection of coloured hues needed for recreating full colour images in knit. In addition, a limitation of six colours has been established as the maximum amount of yarns that can be used due to structural capacities during manufacturing.

Before processing through specific knitwear design systems, design through photoshop assists in eliminating expected complications when translating colour and detail into Shima Seiki software available to this researcher, challenging present limitations in knitted textile design processes’.



36.

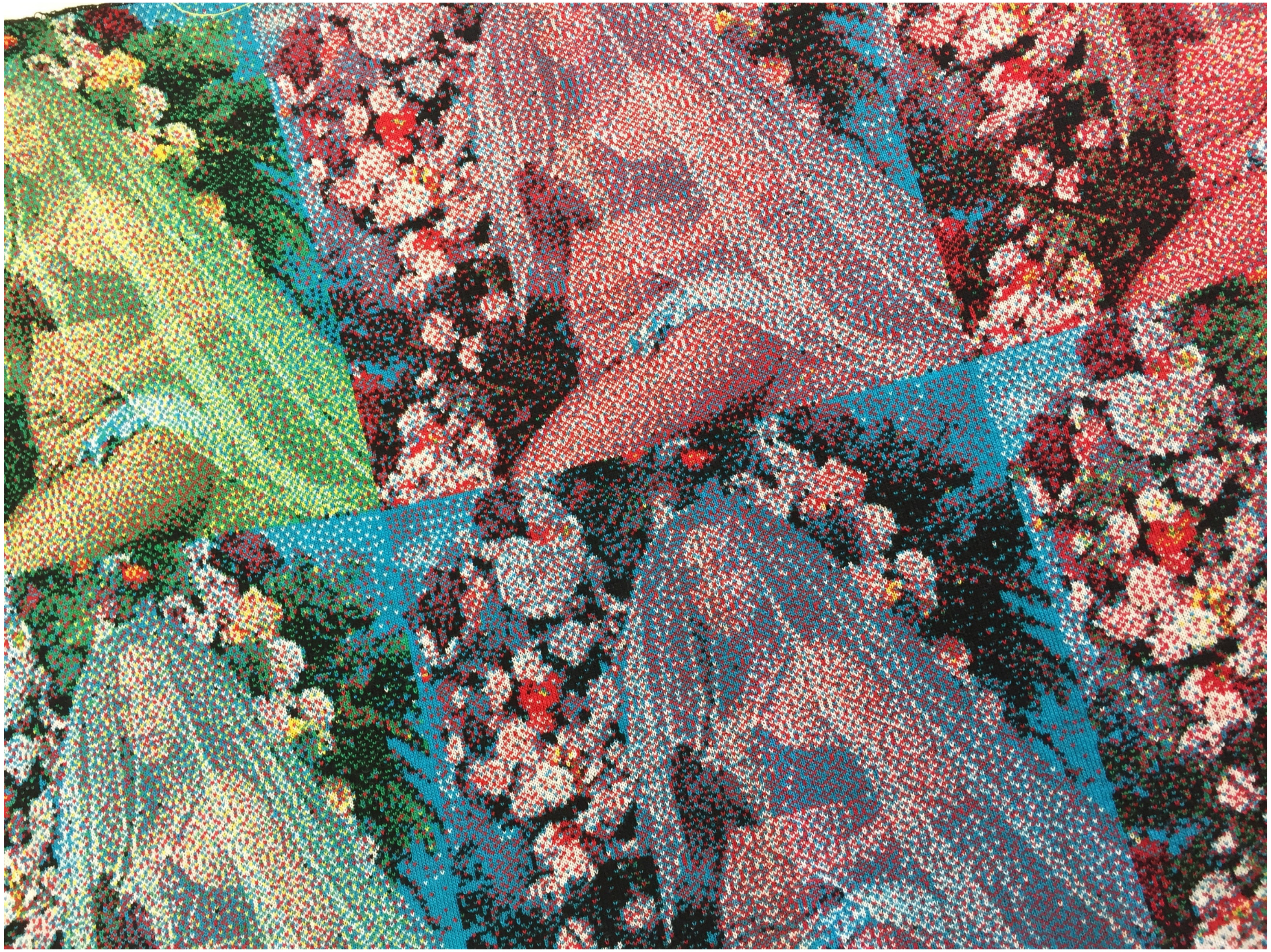


37.

Once images have been digitally manipulated in Photoshop, the Shima Seiki design software can be used to translate the final design into dense structural and technical knit instructions and information appropriate for knitwear programming, eventually able to translate the image into a knitted sample. Despite differences between designs, the same structure can then be used across a variety of samples, ensuring consistency among various and multiple knitted outputs while expanding the potential use of automatic programming systems in this knitwear design process.

The research investigated through this project has established that the above contemporary design programming processes can utilise aspects of automatic software – such as index colour in Photoshop – to resolve aesthetic design issues such as colour, line and scale of application; before any knit technician input is required.

Technical possibilities, which would otherwise be time-consuming or impossible to achieve by hand or directly inputted into knitted computer software, are made more accessible through the use of the two forms of software applications of Photoshop and the Shima Design Systems working together as a fluid process for design development.



Colour is a significant aspect of this textile project which seeks to exploit the basic principles of colour management to develop more complex knit design and image possibilities.

Insights into study of colour reveal a complex relationship between the human eye and light, where our brains interpret objects as reflections of different hues of the light spectrum (Duncan & Bull, 1978). The nature of colour is a dense study in itself that involves aspects of scientific observation and art theory outside of the scope or time frame of this project – however this project does utilise basic technical understanding of colour to create and examine new image possibilities in knit.

This research investigated aspects of colour theory to create more detailed imagery and depth perception across colour work created within knitted Jacquard structures.

Because opportunities to achieve colour in knitted materials are heavily reliant on developing knitted structures that have enough capacity for the chosen colours, when manipulating images into bitmaps, colours juxtaposed next to each other on a small scale can achieve new tonal values when designs are viewed from a distance (Duncan & Bull, 1978).

One of the aims of this research project was to seek to further understand aspects of colour in order to expand the material potential of knitwear and knitted textiles using techniques previously found in art and design movements.

The recognition of a similarity between the results of traditional pointillism and modern digital bitmaps heavily influenced this practice-led research towards challenging the visual capacity for detail to be increased in knitted material outputs.

Typical surface printing processes blend Cyan, Magenta, Yellow and Key (C, M, Y, K) to achieve correct colour outputs. Due to structural capacities within knitted textiles, the blending of colours is more illusionary than that found on surface prints, which rely on the blending of these colours when using inks.

Adobe Photoshop's 'Index Colour Mode' helped to determine the most appropriate colour selection for this unique Jacquard knit technique. Digital visualisations within this research experimented with a range colour and tonal combinations (See Figure 38) in order to determine the six most effective colours to use to gain the best colour results – Red, Blue, Yellow, Green, White & Black.

40.

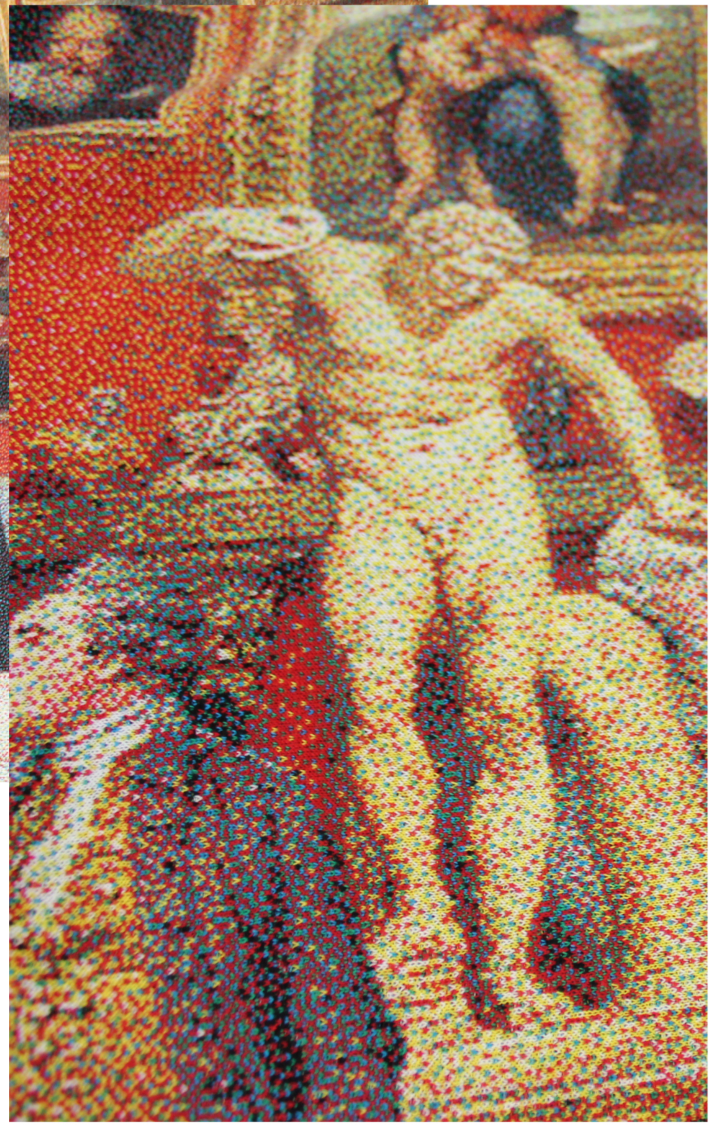
39

41.

Design experimentations shown across figures 39 to 42 show design processing between the original image (Figure 39), a bitmap of the original image broken down to six colours (Fig 40) and the final large-scale knitted outcome (Fig 41).

As shown in Figure 42, the digital file, once translated into a knitted structure, can successfully blend colours at a distance – creating photographic quality images within knitted jacquard structures (Figure 43) while also maintaining detail and depth of colour previously unachievable in knitted textile materials.

42.



43.

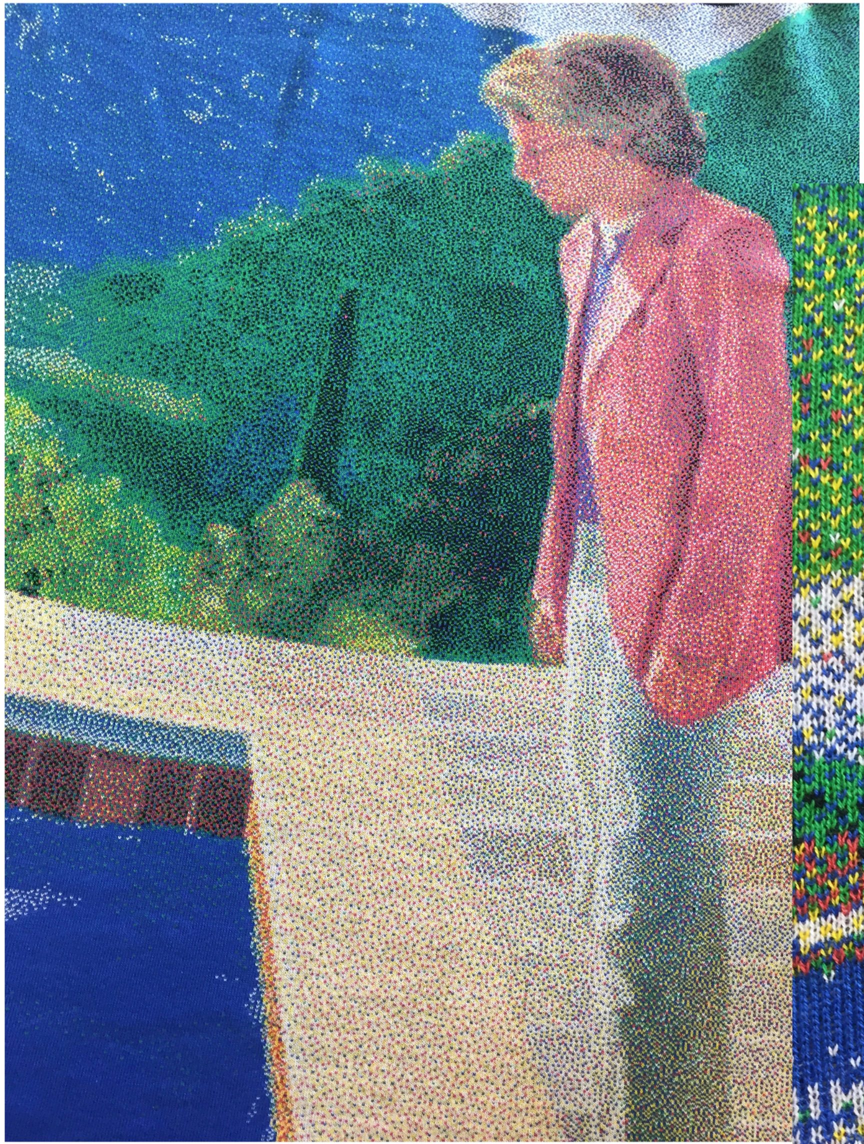
The appearance of textiles is largely formed through the manipulation of scale and gauge in stitch structures (Newton, 1992). Experimentations within this design practice utilise two aspects of scale to gain effective aesthetic design outcomes.

A smaller stitch size produces finer details and more accurate blending of colours; the Shima Seiki N.SES.WG knitting machine has a fine 14 needle gauge, which utilises fourteen stitches to the inch. When the fourteen gauge machine was used for producing knitted textiles using the techniques developed in this research, it effectively blends tones between each individual stitch, resulting in more detail of the produced visual image and truer colour representations compared to larger stitch size or gauge of knitting machine outcomes.

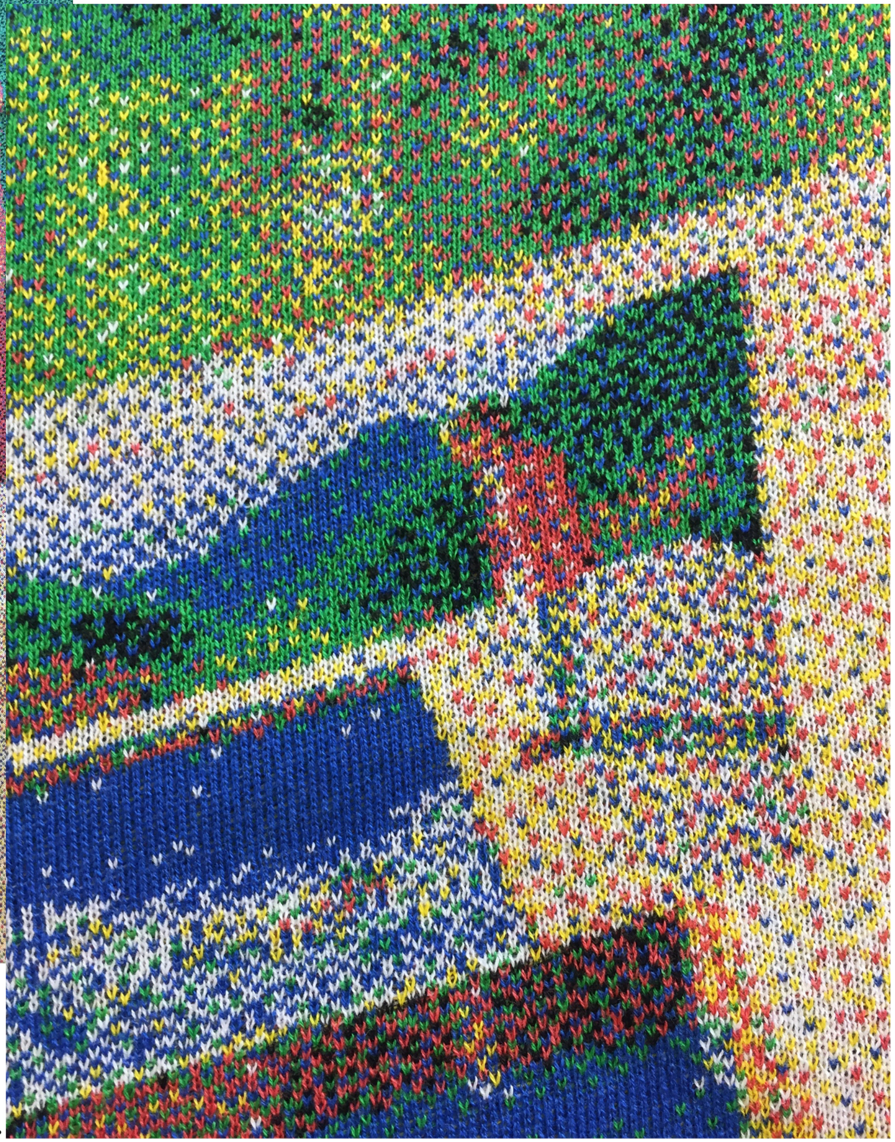
This as well as the automation capabilities of the knitting technology means the scale of samples which were previously unattainable or difficult to achieve by hand, are now able to be created by machine within a reasonable timeframe. This process was used to develop and transfer images into large material outputs, which started to become reminiscent of historical tapestry art through the relativity of stylistic features.

Experimentation showed that the same image can be reduced to six colours in a variety of sizes, achieving a range of effectiveness in results depending on scale and gauge of machine used and the initial image selection as can be seen in Figures 44 and 45.

44.



45.



47.

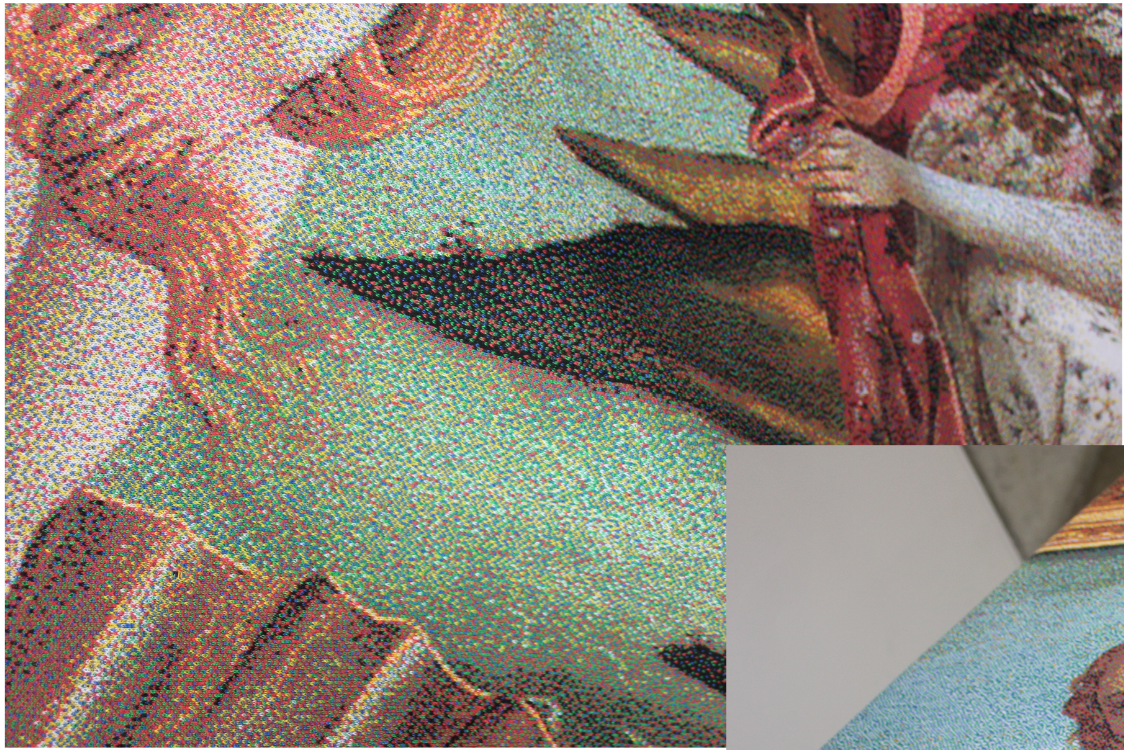
46.

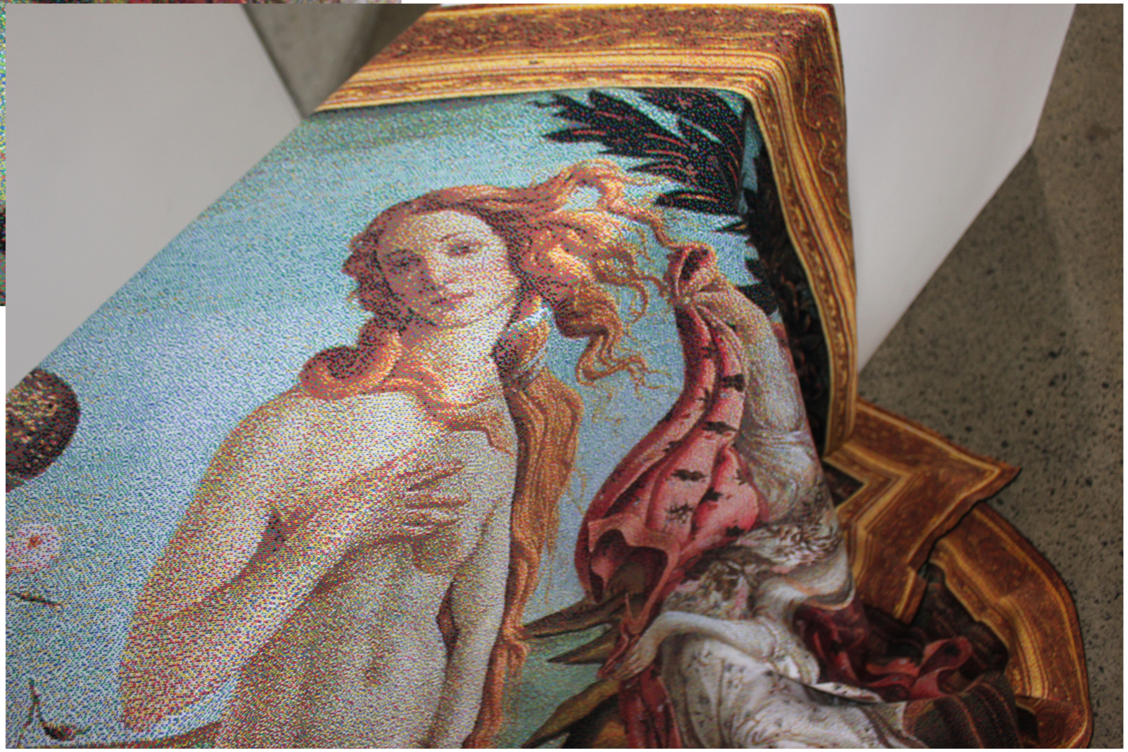
Painterly nuances, tonal shifts and colours previously unimaginable in knitted materials have the potential to be realised through this technique, expanding the capability of knit design outcomes, processes and the technological capacity of programming and machine functions.

Practice-based experimentations oversaw the creation of a variety of historical paintings (Figure 46) and contemporary images (Figure 47) in knit, investigating the compositional potential of this technique.

Investigations (Figures 48 to 56) translated a spectrum of works to specifically analyse aspects of scale, colour and the potential range of aesthetics achievable when translated into the same knitted jacquard structures.

48.


49.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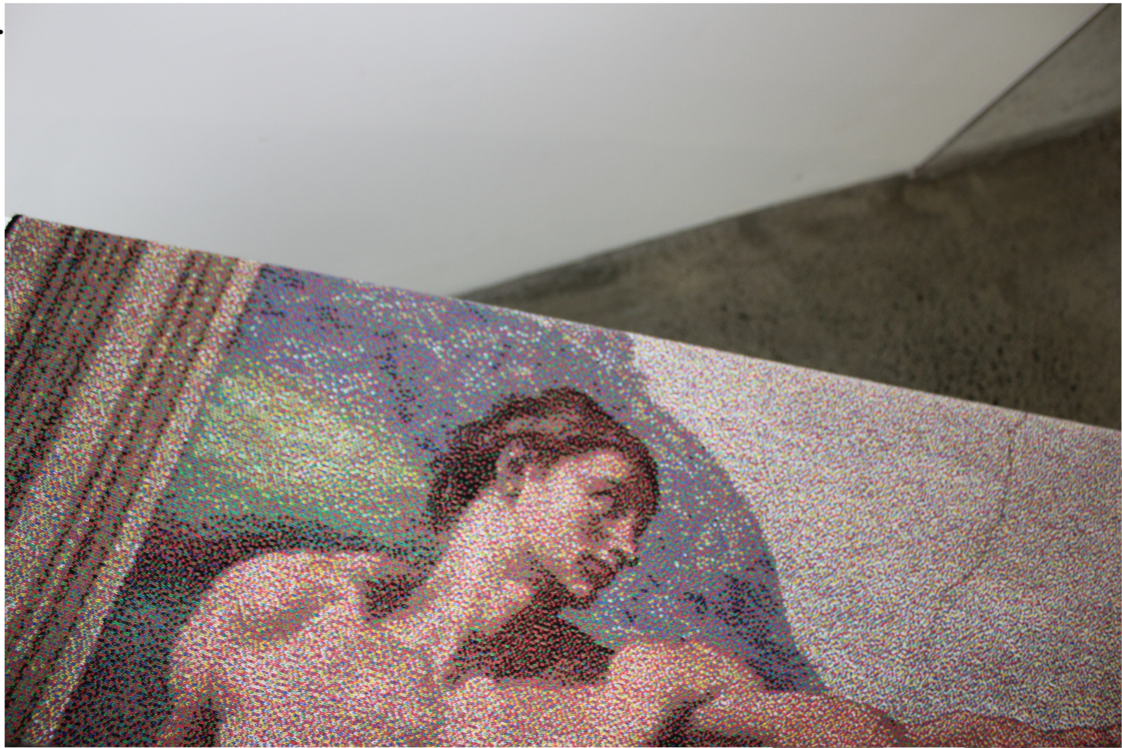
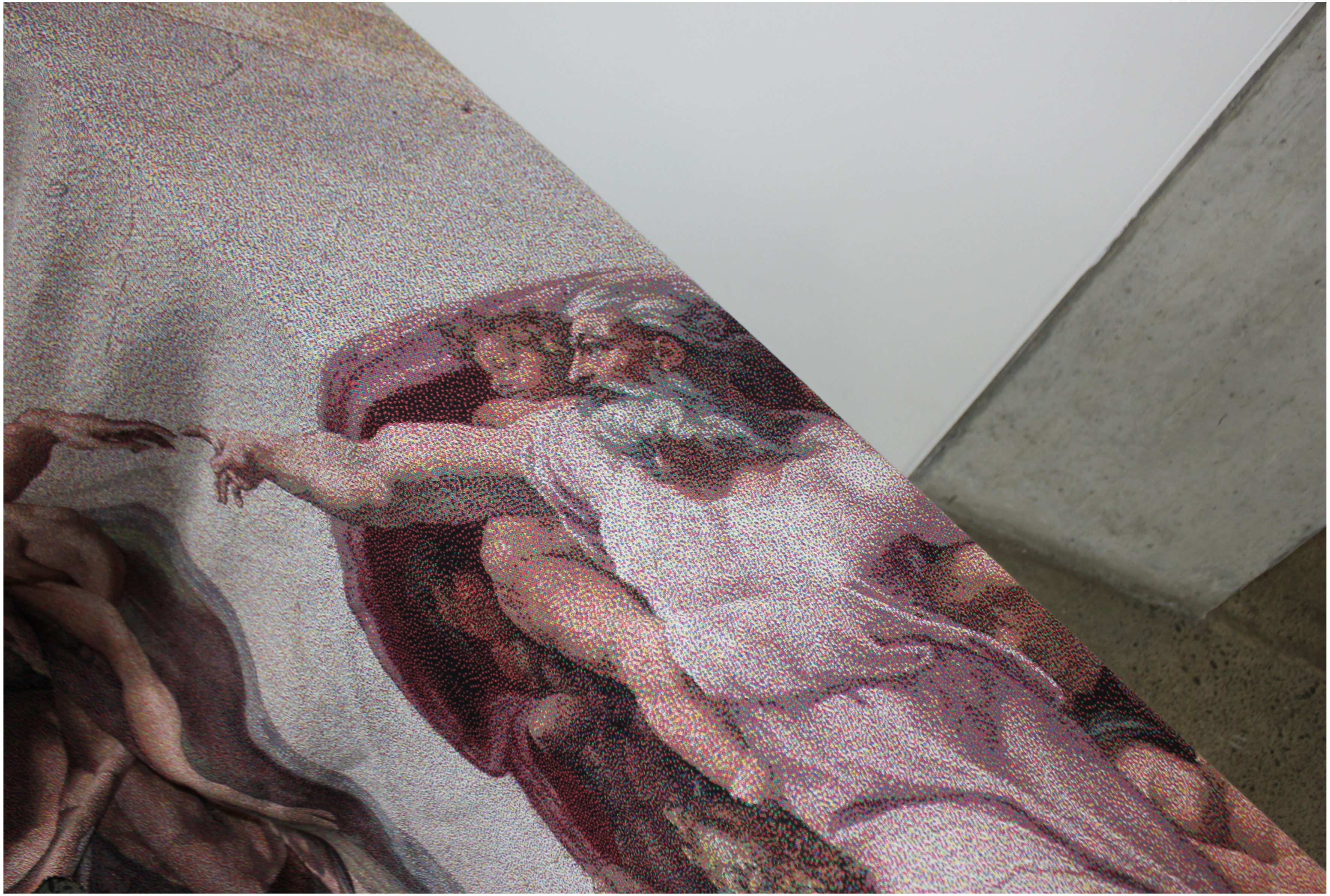


52.

53.



54.

55.

56.

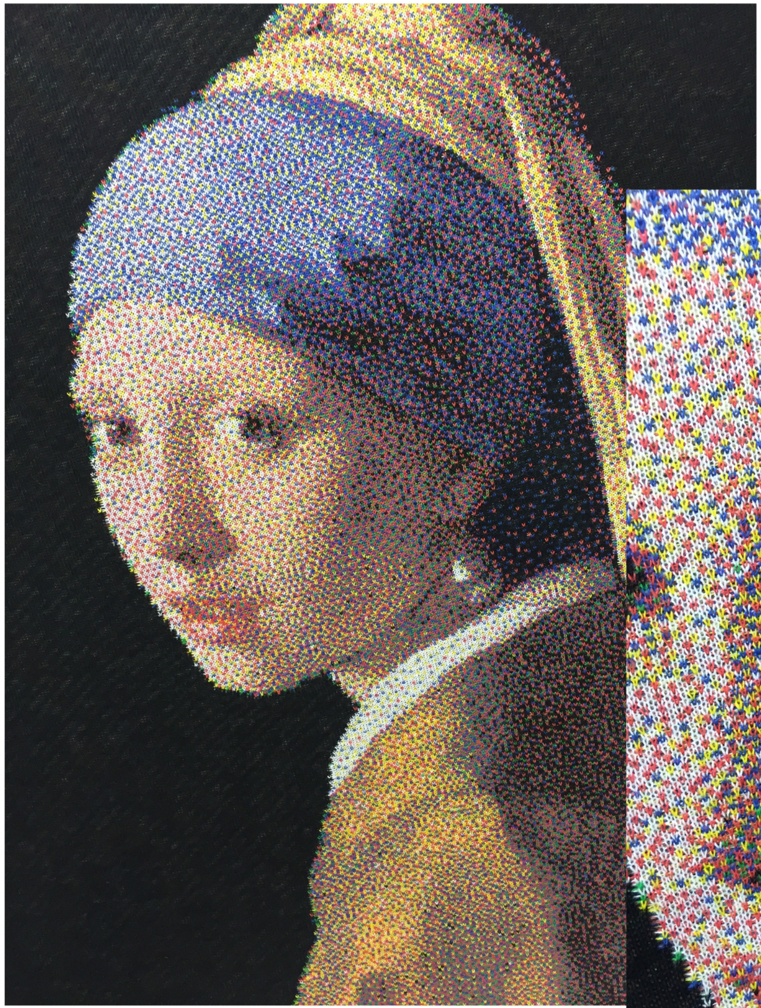
New methods for simplifying image-into-knit using multi-disciplinary software technologies assisted in the translation and processing of detailed colour and images into knitted textile outcomes. This research describes the expansion of visual effects in knit, despite technical machine limitations, and how to incorporate six colours within a complex visual fabric structure.

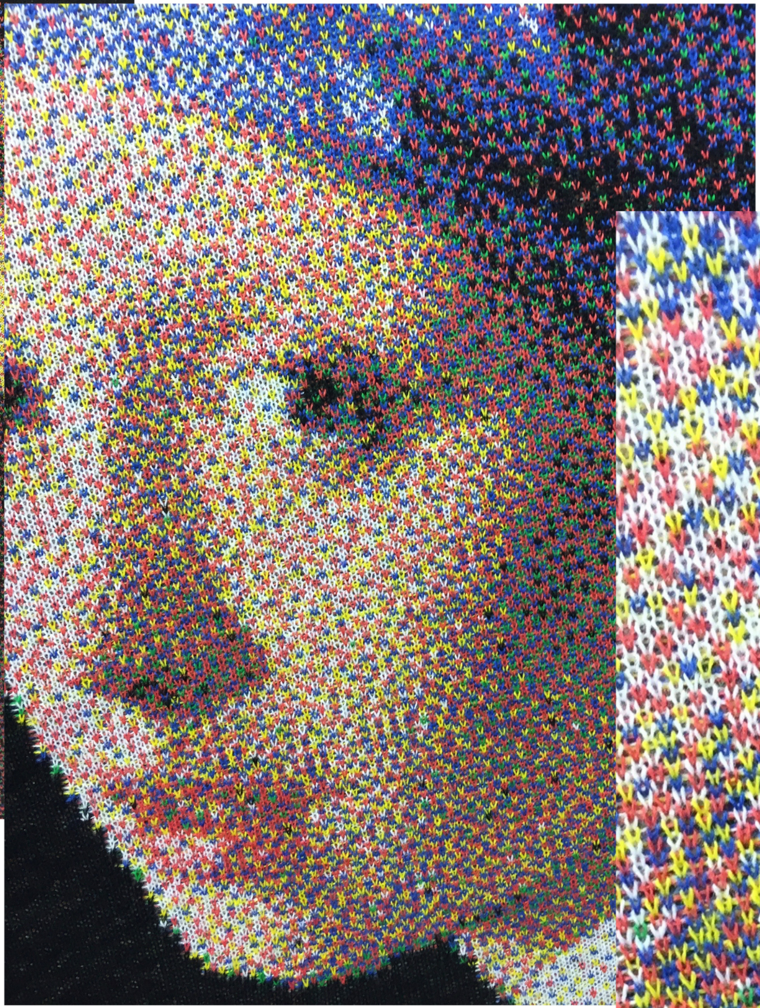
Relying on the optical blending of six base colours, instead of physically requiring each colour tone, translates photographic and painterly techniques into knitted materials with ease, offering more automatic processes for developing complex coloured images in a knitted textile or form.

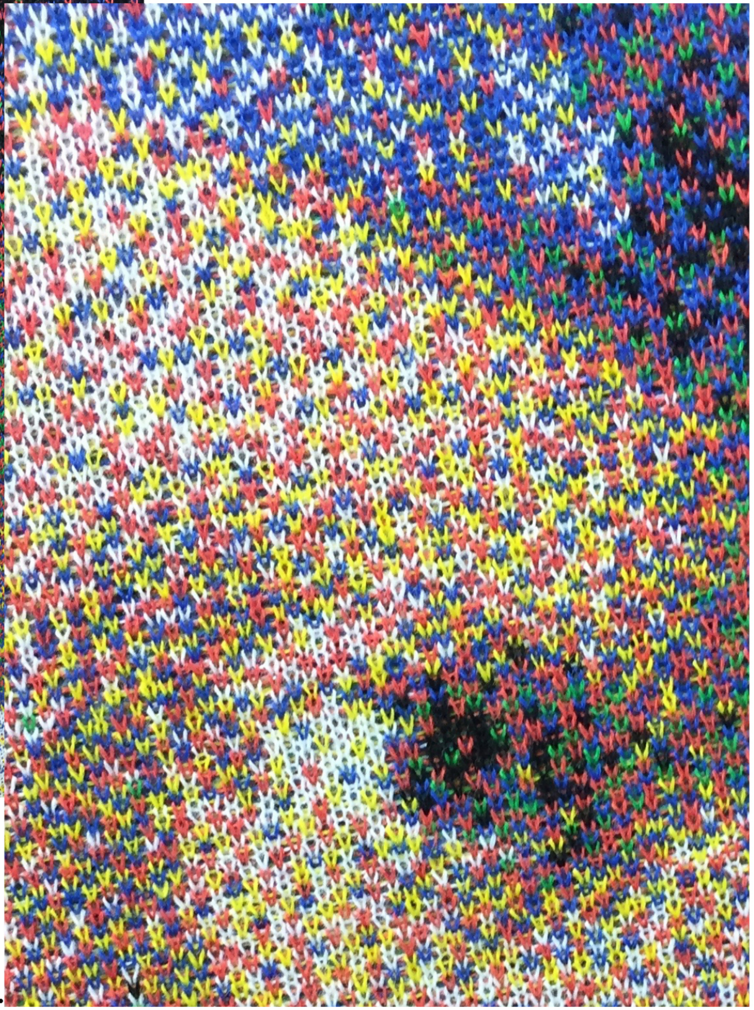
When viewed at an appropriate distance, the eye can perceive a sense of tonal depth and a vast variety of colours (See Figures 57 to 59), despite only having used a standard selection of six limited colours.

This technique in itself is a leap forward within the field of knitting, where various coloured areas of a knit design would usually require unique yarn selections for specific areas of a design – typically adding to design and programming and knitting complications (Geijer, 1979).

Aspects of this technique refer to basic colour theories formed during 18th century impressionistic-pointillism (Foster & Tudor-Craig, 1987). However, this process reflects contemporary technology and skills though the use of automatic digital technologies used to further inspire new possibilities in knitted design outcomes.


57.


58.


59.

Practice-led experiments aimed at fully maximizing an understanding of potential tonal variations and manipulations achievable whilst working within this new mode of production. A variety of images were developed into knits across experimentation cycles towards a clearer understanding of colour hues and tones created using a limited range of only six colours.

A variety of contemporary and historical aesthetics generally excluded from the graphic nature of knit design (See Figure 60) were processed into a range of textiles that effectively produce the same image in knitted form, un-compromised by the material structure.

Complex nuances found in a painters handwork or rich detail in photographic images were able to be translated into knitted textiles using this basic six colour technique, confirming the wide range of design aesthetics achievable in knit when utilising this technique.

This technique simultaneously over comes many of the typical issues associated with colour in knit, by showing that all of these designs were made possible using the same six colour yarns.

Further practice-led research aims so consolidate the potential commercial and industrial applications for such manufacturing, particularly because of the very limited range of yarn or colours needed to produce multiple imagery which reduces production costs.

60.

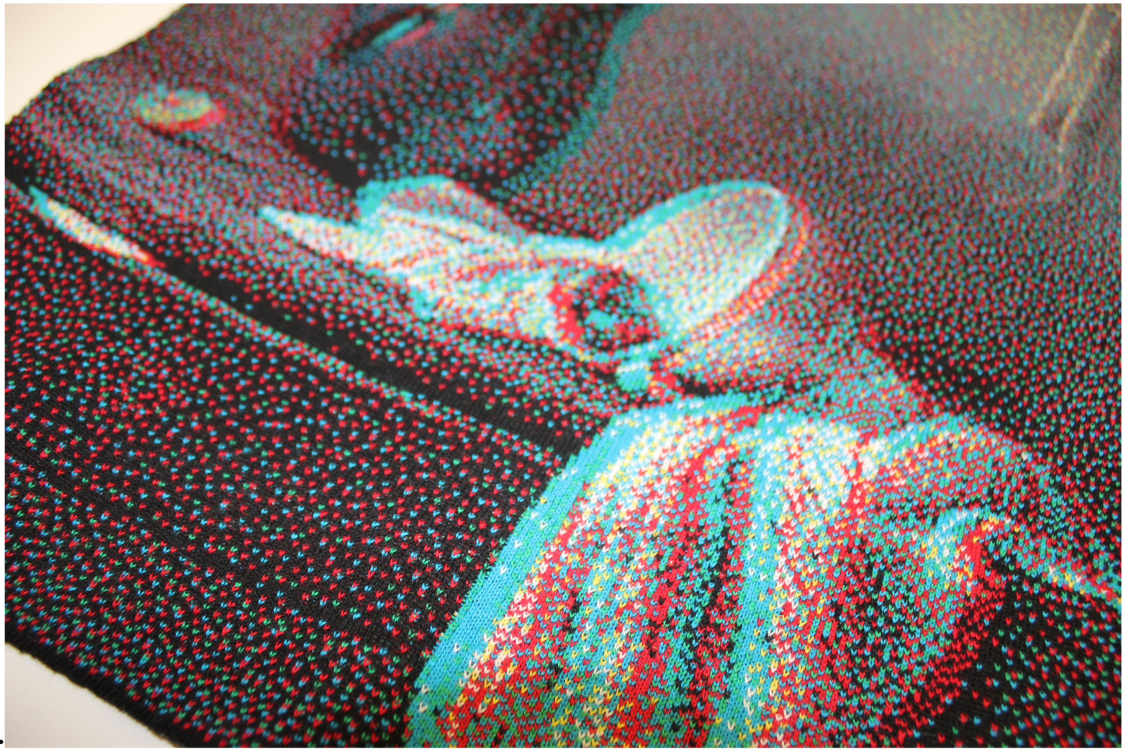
One of the findings from this research and practice-based experimentation was the potential for 3-D illusions to be translated into knit using this technique.

Through digital manipulations of the placement of colour within an image, a three-dimensional aspect to the imagery could be created.

In order to develop textiles that had this further contemporary aesthetic quality increased, practice-based experimentation was undertaken where the manipulation of images into three-dimensional files that could be further translated into knitted outcomes.

While such three-dimensional outcomes are usually reliant on a high level of detail to achieve tones and colour variations into dimensional images, the conversions into six colour Jacquards allowed for a rich level of tonal detail and colour transference into knitted outputs which expanded opportunities for dimensional iterations of imagery and designs to be developed.

61.



62.

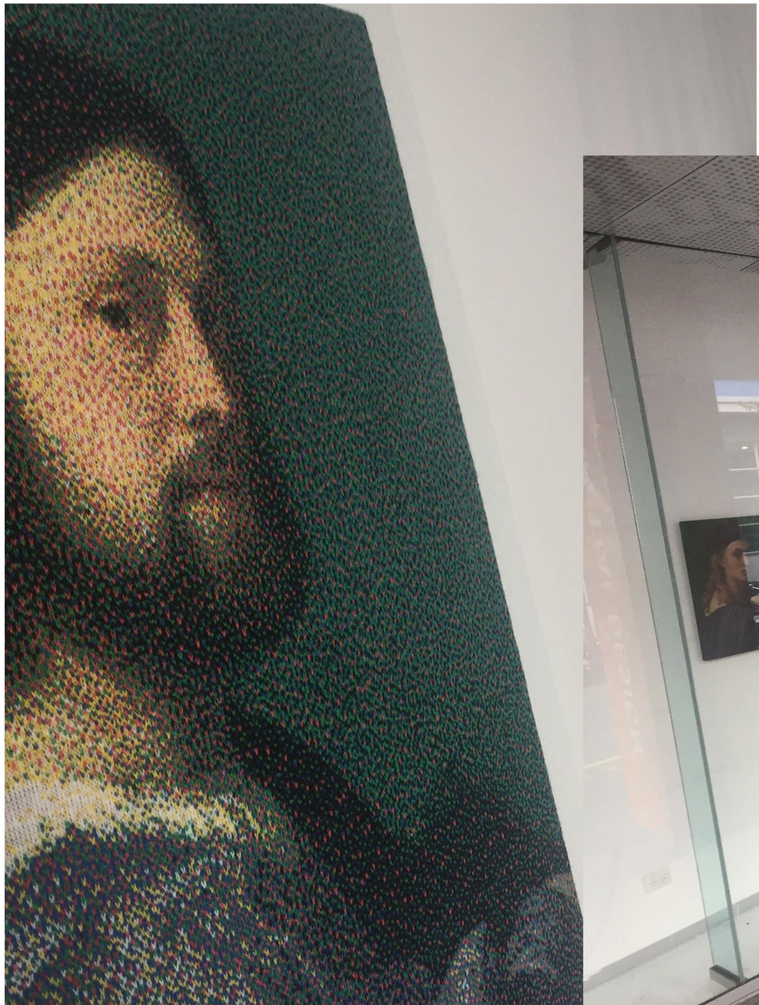
Widening the interactive capability of knitted fabrics through this additional dimensional process creates further opportunities for designed outcomes which have never been explored, and have been previously excluded, from knitted material outputs.
Because it is considered to be outside of the current research parameters, the dimensional aspect of these knitted images discovered during this research experimentation process has not been fully explored within this project. It does however provide a potential area of investigation for further research.

Adobe Photoshop remained as a key component for image design processing in the development of ideas for a final exhibition to demonstrate the findings within this research.

Typically, careful consideration is built into knitwear processing where limitations of structure predetermine the capacity of colours in a final knitted textile design output. Encouraging knit design processes to manipulate images through software, such as Adobe Photoshop, assisted in eliminating previous complications for achieving colour in designs; expanding and experimenting with the design potential before any technical processing input was required.

A series of seven portrait-style tapestries (See Figures 66 to 72) were produced to explore how various colours and tones can be achieved through the standard six colour range used within this knitted jacquard technique.

Each portrait was manipulated through photoshops colour editing techniques to obtain an overall colour profile, displaying how digital manipulation can further enhance colours and tones producible in knit, using this technique.


63.


64.

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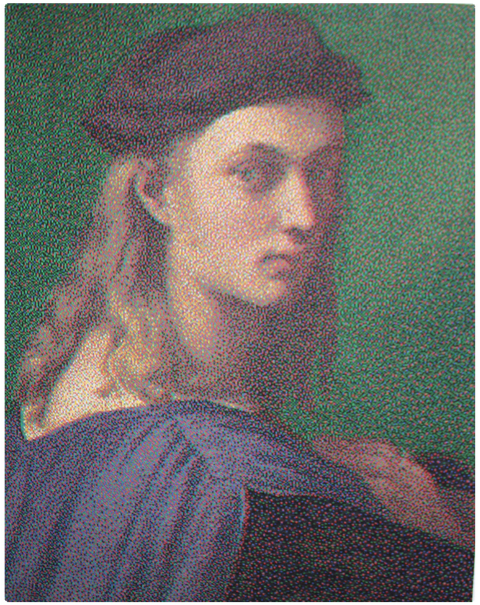
66.



67.

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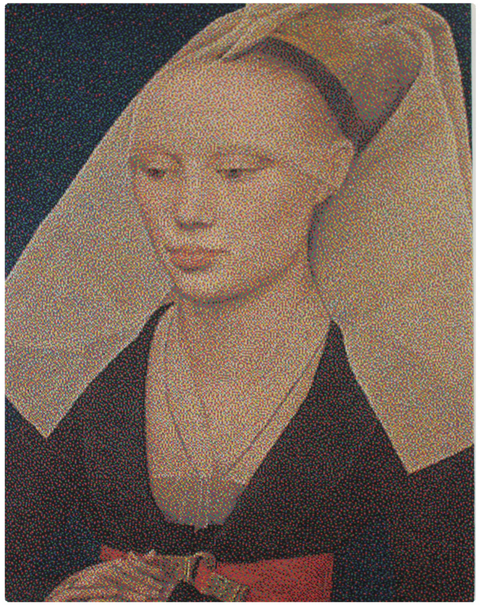

72.

For the final knitted textile work it was decided to develop a large-scale knitted tapestry design which aimed at demonstrating and consolidating the techniques and knowledge formed across this practice-based research project into one final work. It was also used to demonstrate and inform audiences of the commercial and artistic potential of this new knitted textile technique.

Influenced by the wide range of historical painting and classical tapestry designs explored throughout this research, the final design references the ‘Garden of Eden’. This is a common scene found across a varied history of tapestries and art movements, and interpreted through a variety of mediums – but rarely found in knit.

Adaptations of the biblical scene allowed for the use of a wide variety of imagery across one composition as means of displaying diverse examples of scale, detail and colour achievable through this contemporary knit process.

Motifs typically associated with traditional tapestry and fine-arts mediums were then translated into this contemporary knitted textile medium using these new jacquard processes developed and understood more fully through this research.

73.


74.


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76.

The final series of designs explored concepts of modernising traditional compositions in tapestry and art. Adobe Photoshop was employed as the key method of producing the final knit, where designs could be arranged with ease by utilising these basic tools within the software. Digital collages adapted a range of historical and contemporary copyright free source imagery – which were further edited and manipulated into new compositions (See Figures 73 to 75).

Within this process, colours, scale and compositional arrangement could be adapted though a series of reflective design phases which analysed design effectiveness prior to physically knitting the swatches.

Processes for design have been drastically simplified by the incorporation of photoshop editing before technical programming ensues, while the six colour Jacquard technique enhanced opportunities for image consistency when translating high levels of detail across to knitted structures – without compromising final knitted textile designed visual outputs.

The final design (Figure 76) can be translated into a largescale tapestry design to be exhibited within AUT's St Paul St Gallery Space. Figures 77 and 78 display images from this final exhibition display.

77.

78.

FINDINGS AND SUMMARY

This research expanded outcomes from automatic knitting software through the development of new jacquard techniques. These techniques indicate expansive knitwear potential can be realised through the collaboration of existing softwares (Photoshop and Shima). Techniques developed should support the future potential avenues of software development in this field, particularly towards the inclusion of colour blending theories into future software applications.

The action-research methods employed throughout the investigation produced a series of knitted objects to serve as expressions of possible aaplication, rather critiques in isolated as works of visual art.

Converting digital imagery through digital knit design processes is a practice investigation that yields a series of unique outcomes. This investigation began as a pursuit to achieve richer levels of detail into knitted textiles, which are traditionally known for low-resolution translation of images once applied to knitted structures.

Exploitations of basic colour theories in combination with knitted structures have greatly expanded the visual and aesthetic capacity of knitted material outcomes. With structural restrictions usually limiting opportunities for colour in knit, this method of design utilised automatic software through a series of digital technologies, specifically Photoshop and Shima Seiki Design Software, to expand designer interaction.

This supported creative opportunities when using highly specialised Jacquard processes for knit design, with designs typically limited to woven or printed textiles made capable in knit through this technique.

Digital processes' used across this research informed this designers understanding of colour, scale and composition all utilised in the final designs. Opportunities to manipulate material outcomes before engaging with the more technical programming processes highlight the potential of applying technical training and design thinking together.

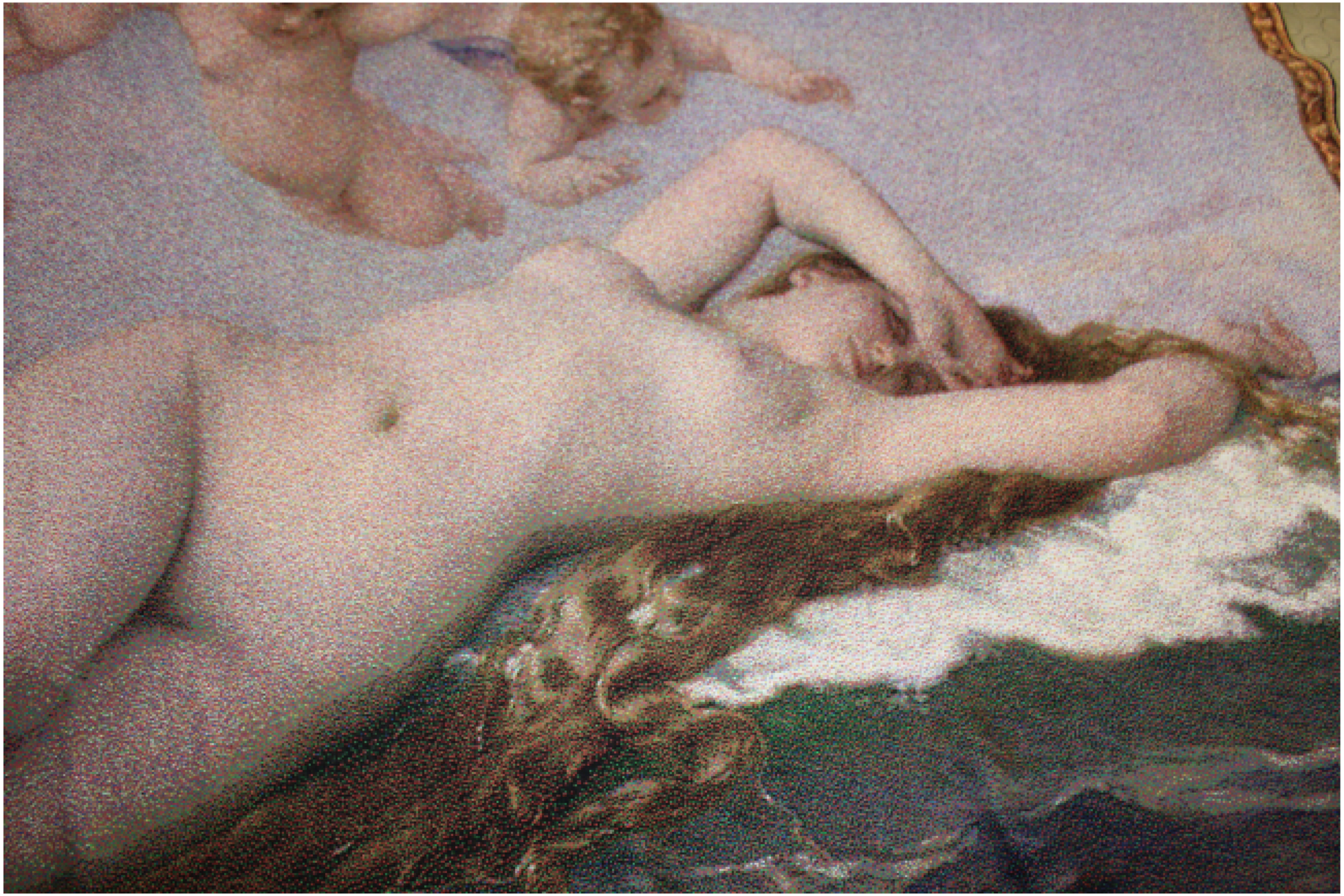
This research demonstrates that the pursuit of developing knits using digital techniques becomes uninhibited by previous colour restrictions which limited options for design potential, thus this expands the designers access of technical knowledge and enhances an understanding of knitted textile manufacturing processes and future possibilities for knitted material outcomes.

Across this practice-based research, the translation of images into knit encouraged new methods for achieving colour levels, image details and visualises new methods for approaching knitted images and scale; with a sense of accuracy previously unassociated with knitted textiles.

Experimentation across this investigation has resulted in several further avenues of research, including the manufacturing of objects and garments using such materials, which have not as yet been explored using this technique, and the continued exploring of three-dimensional potentials in knit using this Jacquard technique, which offers richer opportunities for human interaction with knit.

Emerging paths of research stemming from this investigative design project highlight additional potential unexplored traditional techniques in knitwear processing that may also be under-developed in contemporary industry. This research therefore, demonstrates that further investigations into the utilisation of digital imagery, software and technology during knitted textile design pre-manufacturing processes, can assist in exceeding material expectations of knitted textiles. This is just one traditional technique that has been explored that of Jacquard and this research shows that it offers increased manufacturing options for knitted textile design outcomes that have great potential for increased visual imagery use within industrial and commercial applications.

79.



Black, Sandy. (2002). Knitwear in Fashion. Thames and Hudson, United Kingdom.

Brackenbury, T. (1992). *Knitted Clothing Technology.* Blackwell Science, UK.

Bye, Elizabeth. (2010). A Direction for Clothing and Textile Design Research. *Clothing & Textiles Research Journal* 28(3) 205-217 2012 International Textile & Apparel Association.

Conklin, William J. (1997). Chungara: Revista de Antropologia Chilena, Vol. 29, No. 1, pp. 109-131. Retrieved from https://www.jstor.org/stable/27802053?seq=1#page_scan_tab_contents

Cox, J. J., & Minihan, S. S. (2015). Where Pop meets Purl in Knitting in *The Curation of Craft, and the Folk/Mass Culture Divide.*

Currie, Elizabeth. (2017). *Fashion and Masculinity in Renaissance Florence*. London. Bloomsbury Academix.

Dawson, Pam. (1984). *The Encyclopaedia of Knitting*. Orbis, London.

Design world at their feet. (2004, April 29). The Scotsman. Retrieved from https://www.scotsman.com/lifestyle/design-world-at-their-feet-1-1010234
A.H. & A.W. Reed LTD. Wellington.

Ellis, Rod. (2009). Implicit and explicit knowledge in *Second Language Learning, Testing and Teaching*. Buffalo : Multilingual matters.

Ehn, Pelle & Ullmark, Peter. (2017). Educating the Reflective Design Researcher in *Practice-based Design Research* edited by Laurene Vaughan, (p. 77). Bloomsbury Academic.

Farago, J. (2014, August 12). *The 10 most beautiful tapestries*. BBC Culture. Re trieved from: hhttp://www.bbc.com/cul ture/story/20140812-the-10-most-beauti ful-tapestries

Foster, Robert., & Tudor-Craig, Pamela. (1987). *The Secret Life of Paintings*. New York: St.

Friedman, K. (2002). Conclusion: Toward an integrative design discipline. In S. Squire & B. Byrne (eds.), *The Collaboration of Anthropologists and Designers in the Product Development Industry*.

Geijer, Agnes. (1979). *A History of Textile Art*. Philip Wilson Publishers Ltd, London.

Gottschall, Jonathan. (2013). *The Storytelling Animal How Stories Make Us Human*. Boston: Mariner Books., 2013.

Gulvin, C. (1984) *The Scottish Hosiery and Knitwear Industry*. John Donald Publishers Ltd, Scotland.

Hollows, Joanne. (2006). ‘Can I Go Home Yet?’, in Joanne Hollows and Rachel Mosley (eds.), *Feminism in Popular Culture*, pp. 106 - 107. Berg.

Jarvis, Peter. (1992). Learning Practical Knowledge in *New Directions for Adult and Continuing Education*, no 55. Wiley Periodicals, Inc.

Klein, Bernat. (1965). *Eve for Colour*. Pillans and Wilson Limited. Edinburgh, Scotland.

Lacey, Hester. (1997, November 16). *Thats the Wonder of Woolies*, in The Independent. Retrieved from https://www.independent.co.uk/life-style/thats-the-wonder-of-woollies-1294370.html

Little, Ashley. (2018, August 12). *How to Measure Your Gauge in Knitting*. [Blog Post]. Retrieved from https://www.mybluprint.com/article/how-to-measure-your-gauge-in-knitting

Matkovic, Vesna Marija Potocic. (2010). The Power of Fashion in *The Influence of Knitting in Design on the Development of Knitting Technology*. Textile. Volume 8, Issue 2, pp. 122-147

McCoy, Richard. (2013). *Composite: the future of patterned textiles*. Auckland University of Technology.

Memon, Noor Ahmed. (2018). Pakistan's knitwear industry faces many challenges in *Pakistan Textile Journal*, vol. 67, no. 1, 2018, p. 58. Academic OneFile, Accessed 2 Oct. 2018.

Newton, Deborah. (1992). *Designing Knitwear*. The Taunton Press, United States of America.

Philpott R., (2010). Ways of knowing and making: searching for an optimal integration of hand and machine in the textile design process in Proceeding of the Textile Institute Centenary Conference: *Textiles: a Global Vision*, Manchester, 2010, 12pp.

Prawitz, Dag. (1990). Tacit Knowledge - An Impediment for AI? by Goranzon B., Florin M. (eds) in Artificial Intelligence, Culture and Language On Education and Work. *The Springer Series on Artificial Intelligence and Society*. Springer London.

Phillips, Barty. (1994). *Tapestry*. London: Phaidon Press.

Philpott, Rachel. (2010). Ways of knowing and making: searching for an optimal intergration of hand and machine in the textile design process in *Proceeding of the Textile Institute Centenary Conference*: Textiles: a Global Vision. Manchester, pp. 12.

Power, J. (2007). Functional to Fashionable: Knit wear's Evolution throughout the Last Century and into the Millennium in *Journal of Textile Apparel*, Technology and Management Vol. 5, Issue 4, Fall 2007. Retrieved from https://textiles.ncsu.edu/tatm/wp-content/uploads/sites/4/2017/11/Power_full_184_06.pdf

Reichman, Charles. (1966). *Knitting Dictionary*. National Knitted Outerwear Association. New York, N. Y. United States of America.

Schutt, R. K. (2006). *Investigating the Social World The Process and Practice of Research.* London. SAGE Publications

Spencer, David. J. (1983). *Knitting Technology: A Comprehensive Handbook and Practical Guide. Third Edition*. Woodhead Publishing Ltd. Cambringe, England.

Stoller, Debbie. (2003). *Stitch 'n' Bitch Handbook: Instructions, Patterns and Advice For a New Generation of Knitters.* Workman Publishing.

Tabard, Francois. (1978). *The Book of Tapestry: History and Technique*. Vendome Press.

Taylor, Jane & Townsend, Katherine. (2014). Re-*programming the hand: Bridging the craft skills gap in 3D/ Digital fashion knitwear design*. Craft Research, Volume 5, Number 2, 1 October 2014, pp. 155-174 (20).

T., Stringer, Ernest. (2013). Action research (Fourth ed.). Thousand Oaks, California.

Turnau, Irena. (1991). *History of Knitting before Mass Production.* Retrieved from http://www.marariley.net/patterns/I.%20Turnau%20-%20History%20of%20Knitting%20Before%20Mass-Production.pdf

Turney, Joanne. (2009). *The Culture of Knitting*. Oxford; New York: Berg.

Vaughn, Laurene. (2017). *Practice-Based Design Research*. Bloomsbury Academic, Bloomsbury Publishing Plc.

Wada, Y.I., (2002). *Memory of Cloth: Shibari Now*. Kodansha America, Inc, New York.

Ward, Machael. (1973). *Art and Design in Textiles*. Van Nostrand Reinhold Company Inc, London.

Willard, Dana. (2012). *Fabrics A-to-Z: The Essential Guide to Choosing and Using Fabric for Sewing*. New York: Stewart, Tabori & Chang.