The PUPPET CONCEPT

Methods & Techniques Used to
Develop the Art of Digital Puppeteering

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Attestation of Authorship

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Sebastian Trujillo.. 8 January 2012

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Acknowledgements

Abstract

This exegesis examines the practice-based interrelation between the technical rigging aspects of a CG character and the manner in which they affect the animator's techniques and workflow. It discusses the construction and layering of essential artifacts a rig requires in order to meet the animator's needs and inhibits the relationships between the two stages of the pipeline to exemplify its findings within a short film entitled *Sam*. This short comedy demonstrates various emotional stages throughout the frustration and stress overcoming a postman who's postal truck gets stuck on some train tracks with a steam engine heading his way. Through methodological, theoretical and technical discussion, this project aims to deliver a clear understanding of the complex procedural tasks involved in creating an advanced character rig and how its flexibility, consistency and user-friendliness aids the workflow of an animator. Jason Osipa's rigging methods are examined and applied to the pipeline to further develop the performance of the character. The project studies several approaches to animating actions based on the work habits of professional animator Jason Schleifer from DreamWorks Animation Studios, and studies how the animator's workflow varies from shot to shot. It covers the progression of the critical planning, research and development of a character rig and the techniques used to produce convincing animation.
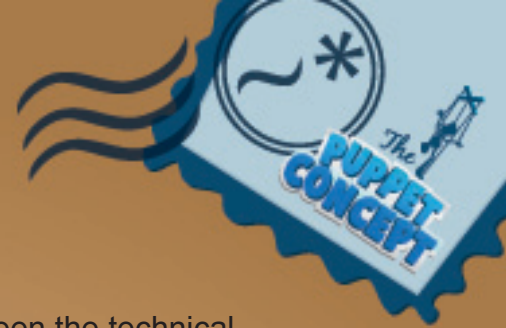
Introduction

The purpose of this exegesis is to define the connections between the technical and creative stages involved in the creation of an animated CG character. It's three chapters provide descriptive material which cover these diverse techniques and illustrate how they compliment the overall appeal of the shot.

Chapter 1: Methodology

This chapter examines the requirements necessary to produce a dynamic and compelling CG character. It explores the nature and structure of the story and what it demands from the characters performance. It depicts the challenges and methodological hurdles that are essential to overcome through planning, research and logical thinking in order to achieve what it is that the story needs.

Chapter 2: Critical Framework

This chapter outlines the stories demands and how they are met by combining animation principles, basic storytelling techniques and the technicality of the rig. It demonstrates the correlation of posing, design and composition and how it can help define the core idea of a shot. It takes a procedural pass on the planning, structure and techniques of an action, which can help determine the energy and ambience of each shot. It examines the stages taken when animating from using reference material, early blocking to final polishing, and discusses the choices made throughout the process.

Chapter 3: Technical

This chapter focuses primarily on the assembly of the rig and it's features Through experimental and independent tests it demonstrates debatable techniques in which the required rig function can be accomplished. It discusses the procedures undertaken to plug these characteristics into the rigs hierarchy and explains how the arrangement of a coherent user interface will benefit the animator's overall interaction with the character.

Defining the Story

Pre-Visualisation

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Introduction

This chapter examines the core relations between the technical and creative aspects of a CG character based on the fundamental demands of a narrative. It consists of the development of a short story and how it dictates the complexity of the characters facial and skeletal rig. Jason Osipa's (2007) methodologies are observed in order to gain an understanding of the overall setup of a facial rig. It determines the technical and procedural challenges presented by storyboard editing and justifies the importance of keeping this connection evident. The animation workflows of Jason Schleifer are examined to identify important aspects that the character rig should preserve. In comparison, two professional short films, *Coyote Falls* (2010), directed by Matthew O'Callaghan, and Pixar's *Presto* (2008), directed by Doug Sweetland, are analysed to find common animation techniques and visual elements that compliment the design and composition of a shot. It also explores different tools, setups and levels of control that are required by the animator to create an efficient and user-friendly workflow.

Defining the story

The character production pipeline in *Sam* consists of a number of stages. These stages are presented here in their most obvious order, however, throughout the process, they would often circulate in order to find balance within the overall workflow. The initial procedure order was to find the story and the character's purpose within it, consequently revealing the obstacles and challenges that the modeler, rigger and animator must dissect and solve to reach the story's maximum potential. The construction of an appealing story that captivates the audience is essential to any short film.

> "Good animation and good design never saved a bad story. Strong characters can make a weak story tolerable and a good story better, but characters develop within a story context. Each depends upon the other." (Beiman, 2007).

The complexity of a character rig strongly relies on the story that needs to be told. The story will infuse all aspects of the development and the level of which things are completed. The size of the team, available time and resources are key elements that determine the overall workload.
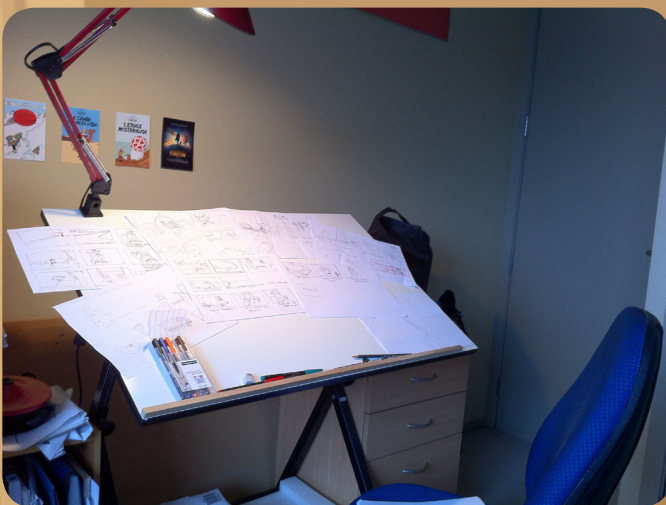
FIG 1:1 Sebastian Trujillo *Storyboarding Slides July 2011).*

FIG 1:2 Sebastian Trujillo *Storyboarding Slides July 2011).*
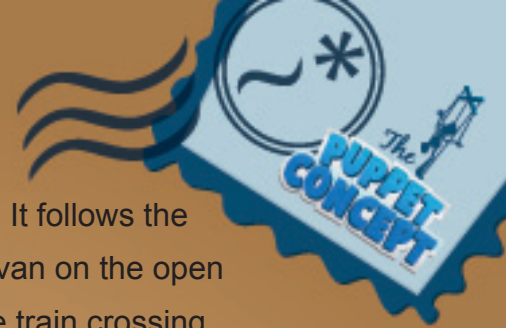
The narrative of my short film *Sam*, is fairly simple in its nature. It follows the story of the hero character, Sam, a postman who is driving his van on the open road to deliver the mail on time, when he comes upon an active train crossing. His impatient characteristics encourage him to speed up and race against the descending crossbar and clear the train tracks which would ultimately become the spot where his van gets stuck. With the sudden realisation of the situation, Sam begins to panic at the sight of the furious steam train that is heading his way.

FIG 1:3 Sebastian Trujillo *Digital Storyboarding* August 2011*).*

FIG 1:4 Sebastian Trujillo *Digital Storyboarding* August 2011*).*
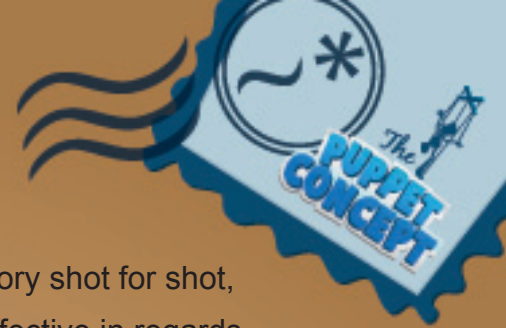
Pre-Visualisation

I created an animatic with rough audio, which plotted out the story shot for shot, with initial gag ideas, timing and direction. This exercise was effective in regards to the story structure, timing and camera angles. It illuminated many possible challenges, which required further research and development such as the facial shapes of the character, automation of the wheels of the van and simulating the steam from the train. It gave some insight into how the shots could cut together and emerged ideas on how the camera angles and lenses should be set to establish the ambience of the film. I chose to construct the animatic using some existing 3D prototype assets instead of storyboard sketches. This would enable me to test the rigs within the story itself and troubleshoot what works and what will need further development.

FIG 1:5 Sebastian Trujillo *Animatic September* 2011*).*
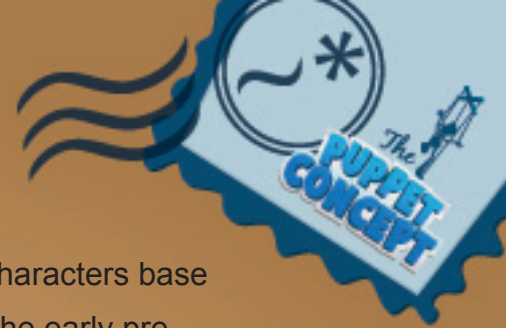
Through this process, I evaluated the overall efficiency of the characters base rig which was constructed to be used as a story telling tool for the early pre-visualisation stages of the narrative. This research emerged issues such as the global scaling of the character in relation to the assets and environment, animation controls and preferred methods, facial animation control and the value of facilitating maximum control in all areas of the rig.

The animatic revealed an interesting story, yet I wasn't satisfied with the rhythm and timing and some of the content. In the animatic, the character is patiently waiting at the crossing as a train passes. The conflict between the rapidly approaching train and Sam's track ridden van is not revealed until over a minute into the story. Sam's character was very uninteresting for the entire duration of the introduction, and the key points of the story took too long to happen, letting the audience get ahead of the narrative and risked losing the viewers interest. The audiences attention may begin to wander if the story has too much, or too little information. "The audience does not know what's going on in your story or in your character's mind until you show them." (Sullivan, et al, 2008, p. 192). At any given time in the story, the audiences understanding of the ideas is of most importance. The animation must either be timed to be slightly ahead of the viewers perception or slightly behind. However, this creates boundaries which if crossed, could either leave the audience too far behind and confused, or too far ahead and bored. (Lasseter, 1994, p. 47) This initiated the first major change in the story.
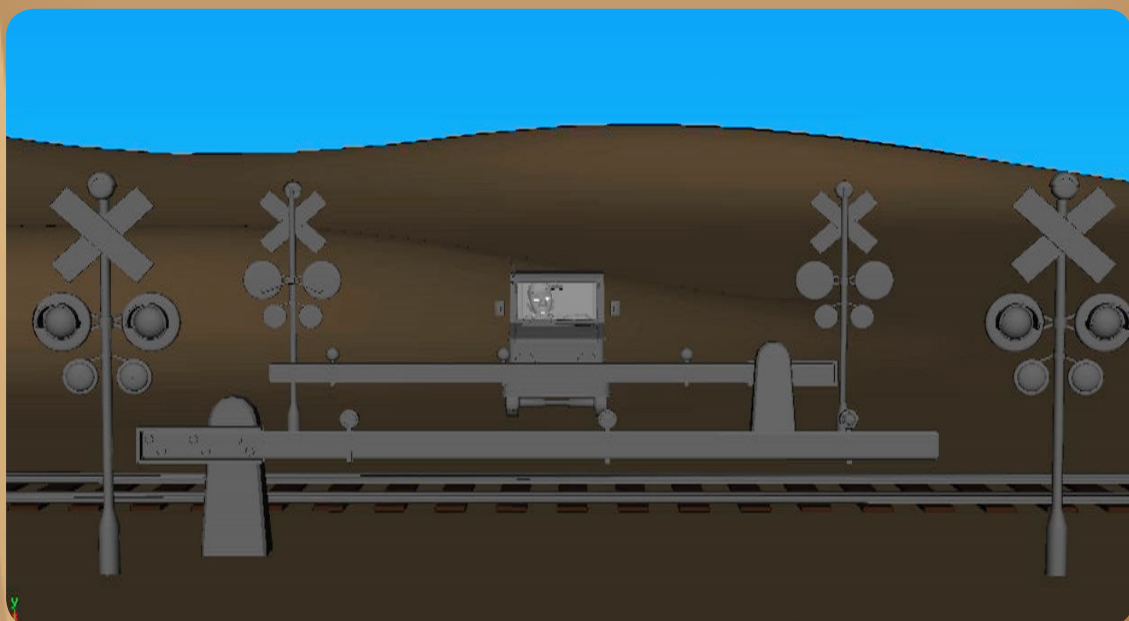
FIG 1:6 Sebastian Trujillo *Animatic Screenshot September* 2011*).*

Constructive Narrative Alterations

To create a more interesting introduction, that lead the character straight into conflict, I chose to introduce Sam as an impatient precarious driver, who races an oncoming train thinking he can beat it to the intersection. His irresponsible decision-making places him in a severe situation where he finds himself stuck on the train tracks with the furious train rapidly approaching.

This altered structure delivers a more interesting beginning and engages the audience in a non-monotonous manner by delivering the conflict within the early stages of the introduction.

In all its simplicity, this narrative presents valuable animation opportunities. Throughout the story, Sam's attitude transforms from being stubborn and impatient to terrified and regretful. These depicted emotions suggest various animation ideas and acting choices, which would in turn serve as a guideline for the rigging requirements.

FIG 1:7 Sebastian Trujillo *Animation Screenshot September* 2011*).*

Correlation of Artistry

The requirements of a shot can be delivered through the collaboration and partnership of the modeler, rigger and animator. Designing a character involves knowing who the character is and understanding the functionality of their mechanics. Defining their inclination to make distinct choices illuminates their most probable reaction to a situation. Finding the intent involves considering the belonging of the shot within the film and its purpose in the sequence. Evidently, it is what is driving the character to react and its placement and reason holds an important factor to character animation (Schleifer, 2011).

> "…how necessary it is for you to understand why your shot is in the film, and how it relates to your character's arc and the story's progression." (Schleifer, 2011)

Finding the intent of a shot requires concentrated planning and groundwork to initiate its idea and creative design. Exploring possible outcomes and various options, can help determine the demands a shot can have for its characters and assets. This research corresponds closely with the technical abilities of the rigs used and can also broaden or narrow animation solutions and opportunities. Gathering this information from valid shots as a general description of the story's requirements emphasizes the significant technical objectives that need to be addressed in the pre-production pipeline stages.

> "Every production element in a film is purposefully designed for the good of the story. The model needs to support the story in both style and function. The rig must allow the model to hit the exaggeration of a pose or action required by the story." (Sullivan, et al, 2008, p. 31)

Modeling

The translation of a 2D drawing to CG model can hold many obstacles. DreamWorks Animation Studio's character technical director Javier Solsona explains the importance of the visual material needed by a modeler and rigger before the work is commenced.

"It's great to be able to see what the character is supposed to look like and what kind of poses, expressions, et cetera it's supposed to hit. This provides ground on which to base the model and ideas on how to build the rig."
(Jones & Oliff, 2008, p. 88)

Sam's character's model was essentially quite generic. This was imposed to simplify the adjustments of these advanced rig features and help me gain understanding of how they can be implemented into a more elaborate character design. However, the importance of a well-designed character lies within the topology of the model. The polygonal faces that make up the shape of the character must be laid out appropriately to be able to deform accurately and believably. These descriptive lines that define the shapes of the model can make or break a character even if the rig is of a high standard.
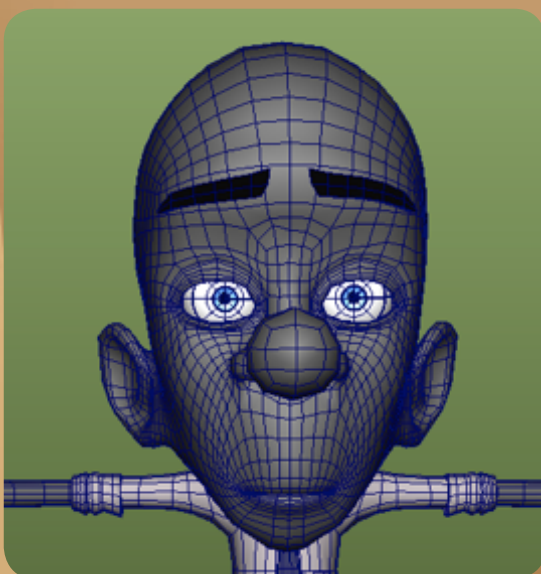
FIG 1:8 Sebastian Trujillo *Facial Topology July* 2010*).*
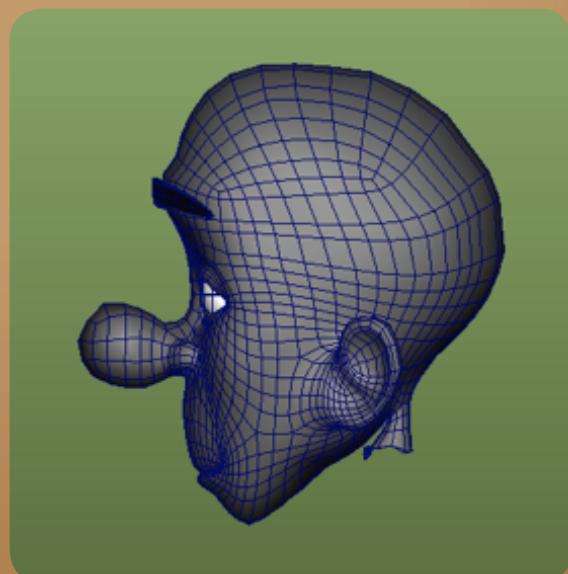
FIG 1:9 Sebastian Trujillo *Facial Topology July* 2010*).*

To create smooth movement between extreme facial shapes, the characters edge flow is prominently built around circular contours. This polygonal layout recipe allows the modeler and rigger to track the stretch and compression of the geometry and view the uniformity of the points on the mesh throughout movement. (Osipa, 2007, p. 77)
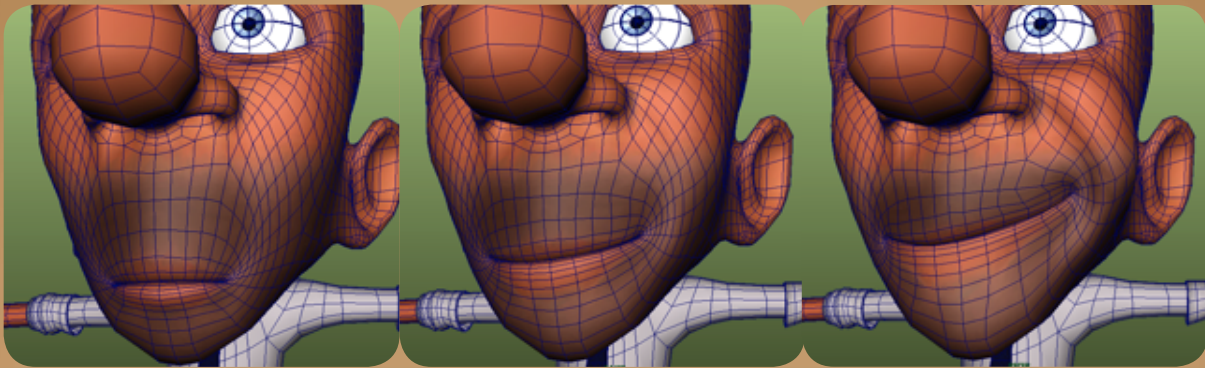
FIG 1:10 Sebastian Trujillo *Facial Topology July* 2010*).*

Turnaround drawings were created to establish the global appearance from multiple angles. This enabled me to understand the physical volume of the character and helped keep perspective on the integration of the traditional and contemporary mediums.

FIG 1:12 Sebastian Trujillo *Facial Study July* 2010*).*

FIG 1:11 Sebastian Trujillo *Facial Study July* 2010*).*

FIG 1:13 Sebastian Trujillo *Character Design July* 2010*).*

Drawings and photographs of facial posing and extreme expressions were used to dictate the topology and extremes of the facial model. This emphasized the flow of the polygonal layout and demonstrated how the face might deform.

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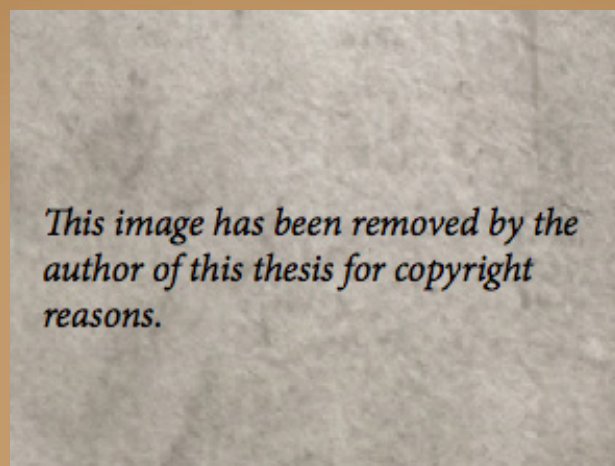
FIG 1:14 Simon, M, Facial *Studies* (2005*).*

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FIG 1:16 Blair, P, Cartoon Take (1994*).*

FIG 1:15 Blair, P, Cartoon Take (1994*).*

Planning the Rig

"Rigging is a term used to describe the process of imbuing a lifeless 3D model with the articulation necessary to fool an audience into believing it exists." (Ritchie, et al, 2007, p. 2)

Solid Drawing, one of the 12 Principles of Animation, developed by the *"Nine Old Men"* in the early 1930's, relied heavily on the craft of draftsmanship within traditional methods. The same principle applies in a computer-generated character and is demonstrated through the rig. Strong communication between the modeler, rigger and animator about the expectations of a puppet, results in a memorable and well-engineered character (Jones & Oliff, 2008, p. 92).

The criteria for each animation rig is crucial to understand before beginning the task. It is important to recognise the problems that need to be solved before determining possible solutions. The decision making while creating the rigs should be based around consistent expectable behavior, appropriately labeled control setup with correct orientation order, user-friendliness, fast interaction, minimum counter animation, and deliver the freedom to infuse any idea the animator may have for the shot (Shleifer, 2006).

By heightening the expectations of the character, movement requirements become more complex, therefore resulting in the more challenging task of creating an advanced character rig (Kerlow, 2004, p. 292).

Rig Criteria

Using the story as a guide, I created a list of features that the animator would need in the character rig to successfully complete the shots in the film.

The list consisted of qualities such as:

- Squash and Stretch in the spine, limbs and head

- Local to world attributes in the chest, limbs, head and props.

- IK to FK switching in the limbs.

- User-friendly controls and a clear global user interface for the facial animation.

- Easy animation control selection and visibility toggles.

- Bow controls in the arms to enable the bending of joints for fast movements.

- Layered facial control setup to propose a more simplistic and organized approach to facial animation.

- Automation of certain elements to reduce the workload.

- Create any necessary animation tools using MEL scripting, which would evidently complete repetitive tasks with the execution of one command.

"In 99% of situations an animator would like to be free of limitation and restriction, work with simplified controls (as few as possible), fully scalable characters in the world space and a body which can fully squash and stretch. The animator should never have to go deep inside Maya's Hypergraph or a particular hidden menu for animation, the rig must be simple to use and fast." (Ritchie, et al, 2007, p. 240)

Other assets within the film such as the postal van and the steam train play important roles within the story. During the creation of the animatic several rigging ideas emerged such as automation of the spinning wheels in relation to the forward motion of the vehicle and smoke and dust emission. Each vehicle also held its own challenges. The original story suggested that the van was a solid immobile object and its sole purpose was to remain completely still for the majority of the film. Following the changes in the narrative, the story had new demands. For the van to feel energetic and flexible, the rig needed to be configured in various ways. The following functions would ultimately bring the van to life and equip the animator with more practical animation tools.

The list of changes are as follows.

- Global squash and stretch from the center front and back of the van.

- Forward and reverse skewing to exaggerate the speed of the vehicle.

- Squash and stretch in the wheels.

- Individual controls for opening and bending doors.

- Automated noise control to add high frequency vibrations in the body of the van without having to set keys.

- Multiple pivot points from each wheel axle.

- Global banking attribute to allow the van to tip onto its side, while maintaining the contact point on the grounded wheels.

The train within the story holds a basic responsibility. It simply travels at a constant speed along the train tracks, blowing steam and looking aggressive. However, in the early tests undertaken in the creation of the animatic, the proxy rig I was using revealed an important issue. The problem was that the tracks and the train were two separate objects. This resulted in more time spent aligning the path of the train to the shape of the tracks, per shot.
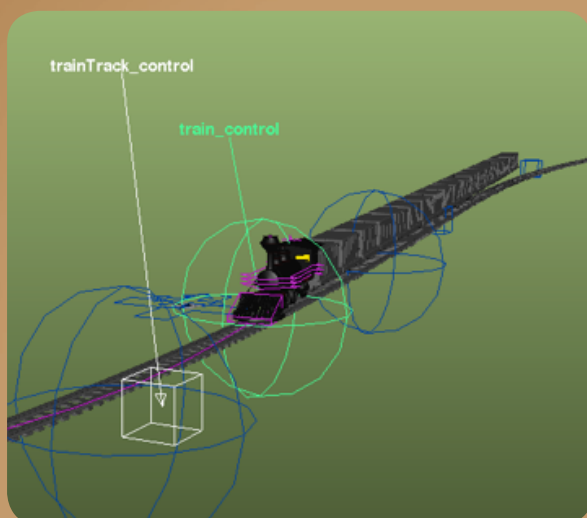
FIG 1:17 Sebastian Trujillo *Train Rig Prototype September* 2011*).*
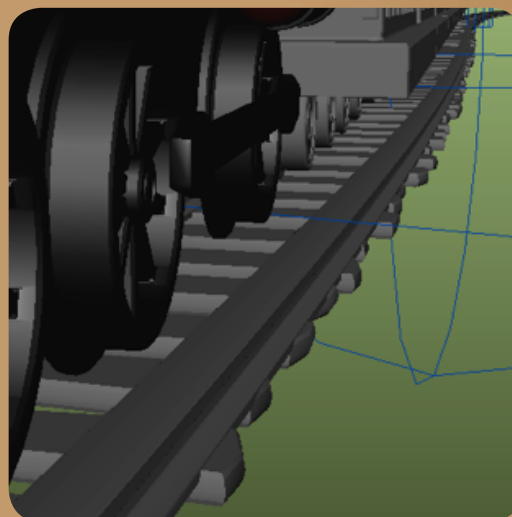
FIG 1:18 Sebastian Trujillo *Train Rig Prototype September* 2011*).*

My goal in developing the train rig was to unite the two assets and create a rig that would efficiently allow the user to shape the tracks to suit the terrain and camera angle while keeping the train and its carriages in line with the tracks. The train would also have the same automated wheel and body vibration functions as the van. Uniting the two elements would create a more robust workflow, and would allow more time for the animator to engage with the shot creatively.

An effective rig should work in an expected manner. The animation controls should be found easily, found in an expected place and be consistent in its functions. Keeping the animators needs in mind while building a rig allows them more to think about the animation rather than figuring out the rig. (Schleifer, 2006).

Animation Tools and Workflow

The research and planning that was put forward in the rigging stage was ultimately to benefit the workflow of the animator. The animation process is a time-consuming task, which requires its own preparation reference research. The job of the animator is to establish the best possible way to communicate the core idea of the shot through believable movement. The animator's toolbox can hold many instruments to help achieve tasks more efficiently. They enable them to present the current status of the shot to the director in an understandable and relatable manner within the given time frame. Some of these tools consist of shooting reference, drawing thumbnail poses and experimenting with possible patterns and rhythmic beats.

Schleifer discusses the importance of his workflow when planning a shot.

"I think that in our rush to get things on the screen and see our characters coming to life, many animators start posing out the character and working on timing. I find that I have a tendency to do this when I'm feeling pressured to get a shot out the door, or when I am certain I know exactly what I want. However, it's incredibly important to ground yourself and get into the head of the character before you start animating. Truth to the character's performance is of utmost importance if we want to sell the character to the audience. If we're not inside our character's head, thinking how they think and reacting the way they would react, the audience won't believe that the character exists" (Schleifer, 2011).

Using Reference

Some of the technical tools that address the planning stage of a shot include the ability to convert video footage into image sequences. These can then be transferred into the 3D software package Maya, and synchronised with the animation timeline. Other important tools such as selection sets can save the animator a vast amount of time. These shortcuts allow the user to select any number of animation controls with the execution of one command.

FIG 1:19 Sebastian Trujillo *Using Reference Video October* 2011*).*

FIG 1:20 Sebastian Trujillo *Using Reference Video October* 2011*).*

User Interface

As an animator, I have found that the customisation of the user interface can really affect the workflow.

"An efficient workspace shows you everything you need to see, and nothing you don't. Maya's default four panel or single panel layouts leave a lot to be desired for animating … While different tasks call for different layouts, there are several tried and true versions that many animators employ" (Luhta, 2010, p. 6).

Learning basic MEL scripting allows the animator to write customized tools and shortcuts to improve the animation progression. Tools stored in places such as Maya's marking menus, shelves and hotkeys set correctly can be used to access menus and commands faster than taking the standard procedure that the program provides. Creating different screen layouts for different approaches to animating can also be an advantage. This permits the animator to set up separate windows and panels, which can quickly be accessed, based on what is needed for the shot.
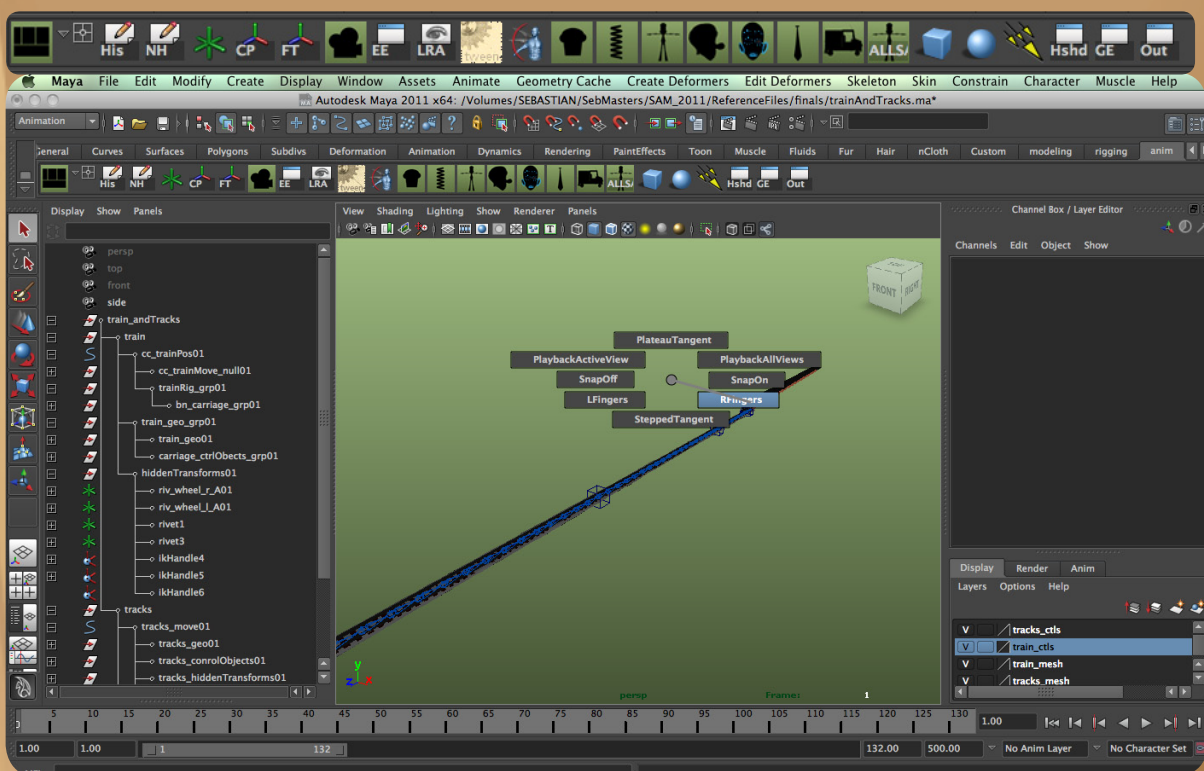
FIG 1:21 Sebastian Trujillo *Marking Menus November* 2011*)*.

MEL Scripts

Scripts such as tweenMachine written by Justin Barrett (2008) are powerful tools. This particular script takes the values of two keyframes, and sets a new value in between them based on the slider value of the tool. This device is useful in a way that the animator can establish the spacing and timing of a movement with one control.
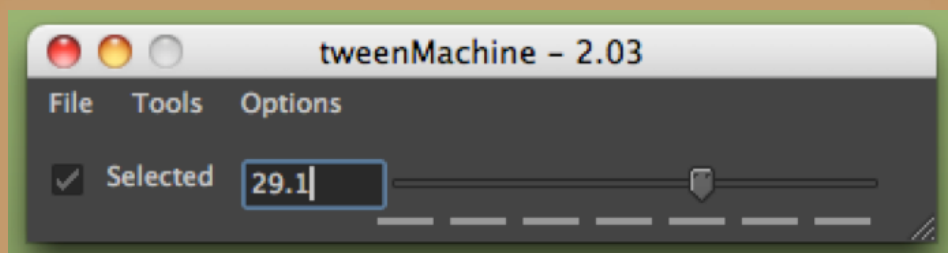
FIG 1:22 Sebastian Trujillo *TweenMachine November* 2011*).*
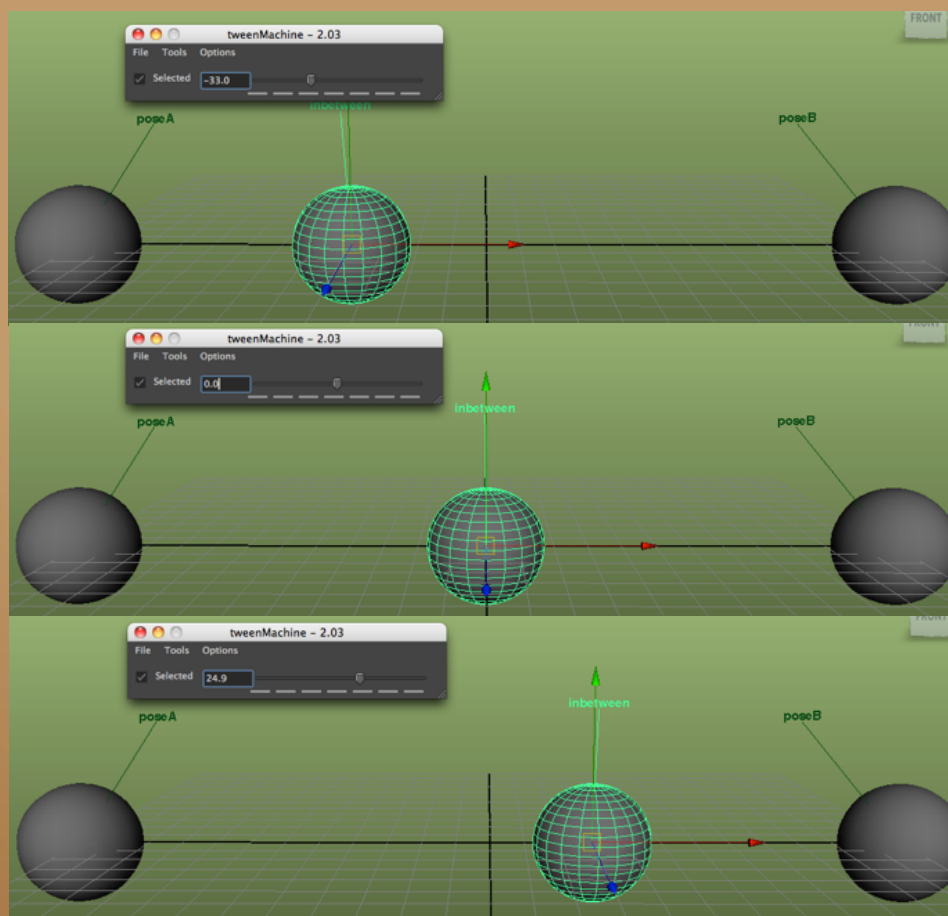
FIG 1:23 Sebastian Trujillo *TweenMachine November* 2011*).*

Conclusion

"Working with your rigger, you can create the most powerful tool a CG animator can have – a solid puppet. …When a modeler, designer, animator and rigger are all communicating about what the expectations are for the character, the most solid foundation is established." (Jones & Oliff, 2008, p. 92).

The relations between these stages of the pipeline intertwine to create the best possible solutions for the project. The versatility of a puppet is highly reliant on the understanding of the character between the designer, modeler, rigger and animator. The collaboration of these methodologies in *Sam*, produced a character and assets, which included all of the features that the story was dependent on to establish a solid foundation for the animator to work from. The congregation of these important features also helped to produce further storyline possibilities as the narrative developed.

Chapter Two

CRITICAL FRAMEWORK

Building the Scene

Camera Rig

Animation Process Case Study

Acting it Out

Blocking

Using Video Reference

Pose-to-Pose or Straight Ahead

Refining

Arcs

Line of Action

Texture

Pushing the Action

Silhouettes and Staging

Shot Continuity and Camera Movement

Introduction

This chapter examines the procedures and workflows that account for the overall demands of the story. Animation principles, utilisation of the rig, design, composition and basic storytelling techniques are administered throughout the workflow and are discussed to elaborate on their importance in the animation process. It looks at the procedural tasks and various stages that advance the shot from early conceptual planning, to final polishing and clean up. It evaluates resourceful tools used throughout the development of a shot and carries out different methods to approach diversely natured actions.

The workflow of an animator is highly dependent on the type of shot that is being animated. Establishing the nature of the action, the frame range, camera angle and complexity of the shot, can be a great advantage to the foundations stability. This means that the way the animator begins a shot, allows them to easily revert to a previous version and make any requested changes in a non-destructive manner. It provides flexibility to the workflow and offers efficient and progressive techniques for the animator to incorporate into their work creatively. This chapter discusses some of the issues that were involved through case studies of various shots.

Building the Scene

Based on the simplistic nature of the short, I created a master file, which held all the assets in the scene, including environmental props and lighting rig. Each of these assets is referenced into the file. File referencing keeps the scene organised and maintains animation functionality. By telling Maya to recall a specific file into memory instead of loading into the scene itself can keep file sizes down and can allow assets to be reused. This technique also delivers the versatile ability to make any changes to the original referenced file, and automatically have these changes appear in any scene that is using that asset (Luhta, 2010).

The assets that are not being used for the particular shot are simply removed and the scene is saved out under the appropriate shot's name. This makes more time for creative input rather than building a shot from scratch.
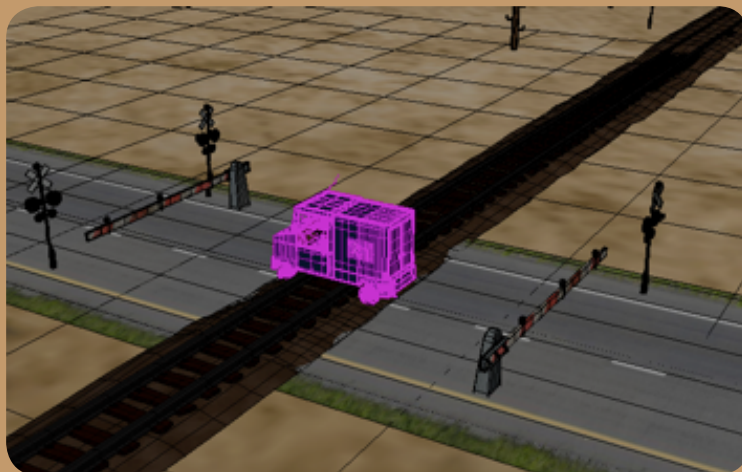
FIG 2:1 *Sebastian Trujillo, Master File November* 2011.
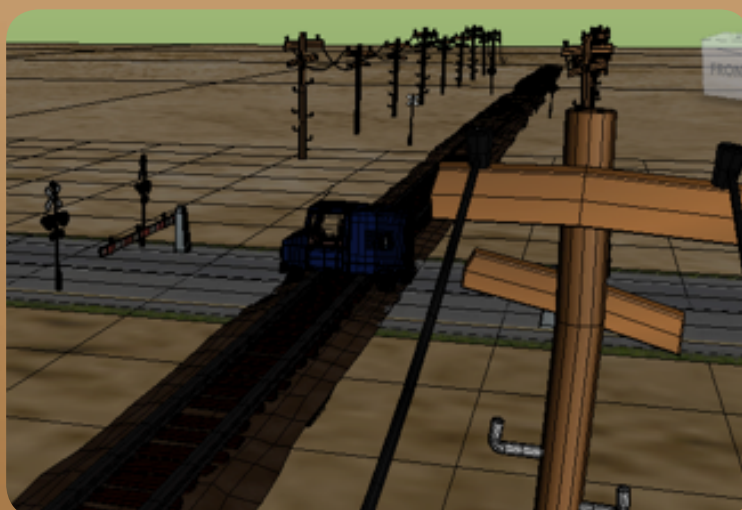
FIG 2:2 *Sebastian Trujillo, Master File November* 2011.

A camera is roughly positioned to determine the angle that the audience will view the shot from. This step helps the animation process in a way that the silhouettes are more vivid and true to the final framing.

Camera Rig

Creating camera movement with layered animation can be accomplished in many different ways. In Sam, the way that I as the animator like to work is by having the camera within a five-node hierarchy. It consists of a pyramid of four null objects and camera, with the camera as the child of the stack. The top node, labeled "renderCam_pos01", is used to place the camera at its default position depending on the shot.
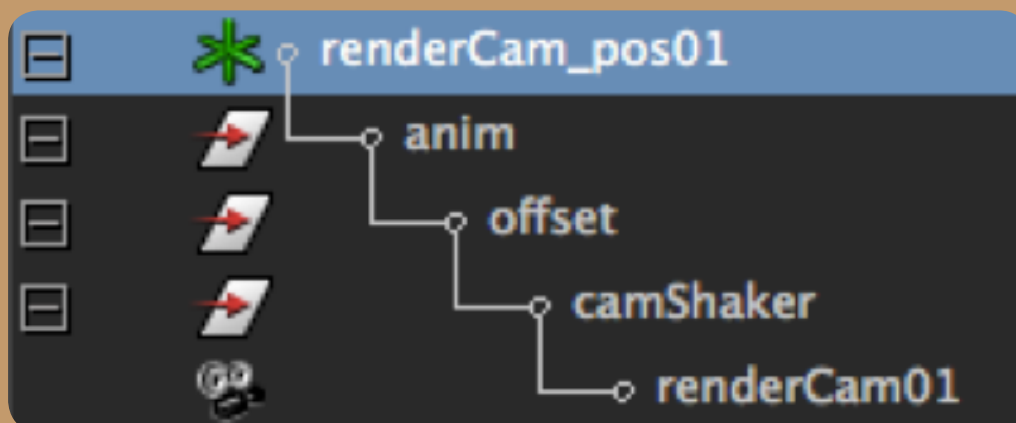
FIG 2:3 *Sebastian Trujillo, Render Camera Hierarchy November* 2011.

The second node is labeled "anim". This group holds the general animation in the camera and serves for broad movements and blocking purposes. The following node is used to create an offset. This node is important when the camera needs extra movement, such as a sudden jolt, or a subtle turn. The layering method allows the animator to experiment with the movement of the camera without interfering with the original animation on the anim node.

The final node that comes before the camera is different from the other groups. IT is labeled as the "camShaker" node. This node's rotations are connected to a series of attributes, which can be found and keyed under its channel box. These attributes control the amount of shake the camera has, the frequency in which it times its rotations and the amplitude of the motion. The last attribute controls the seed of the shakes so the animator can scrub through different combinations to suit the shot.

camShaker	
Translate X	0
Translate Y	0
Translate Z	0
Rotate X	0
Rotate Y	0
Rotate Z	0
Scale X	1
Scale Y	1
Scale Z	1
Visibility	on
Shaker	0
Amplitude	0
Frequency	0
Seed	0
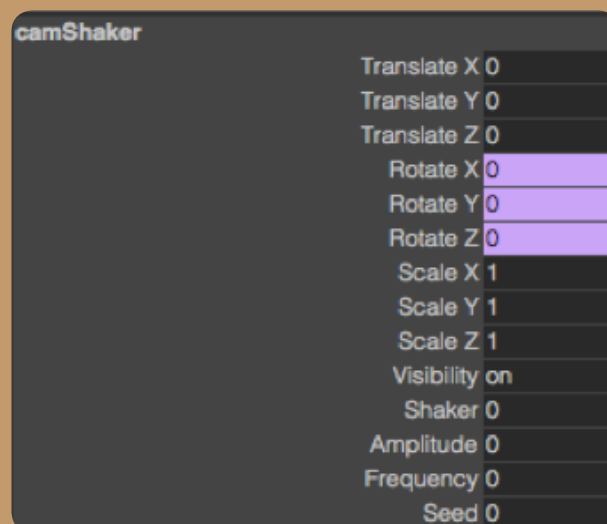
FIG 2:4 *Sebastian Trujillo, Render Camera Attributes November* 2011.

The attributes are connected to a series of variables through a customised piece of coding called an expression. These variables such as noise and amplitude can be connected to each according attribute.

This tool is very useful when adding high frequency noise to a camera and can also be used to control any keyable attributes of other objects. In *Sam* this method was used to establish a rumbling shake in the camera as it tracked alongside the moving van and train, as well as to automate the vibrations in the body of the vehicles.

The camera is parented to bottom of this hierarchy, and its purpose is solely to follow the motion of its parent group objects. Its transform attributes are locked, and the focal length is connected to a slider found under the top node for the animator to easily access while positioning the camera.

To create a similar camera rig would take some time to set up. Using MEL scripting, I created a shelf button, which automated the assembly of this rig. It labels the nodes correctly and sets up the expression for the shake node. This creates name-space consistency within each shot, which later serves for more productivity during the rendering stages of the pipeline.

Animation Process Case Study

"It's incredibly important to ground yourself and get into the head of the character before you start animating. Truth to the character's performance is of utmost importance if we want to sell the character to the audience." (Schleifer, 2011, p. 71).

Animator Carlos Baena from Pixar explains that before setting any keys and blocking out any poses, it is essential to explore the creative possibilities of the shot. Gathering inspirational material of existing work that has been done on that character, or a similar character can help enthuse an idea. This covers a wide range of mediums from concept sketches, to sculptures and animation tests. Keeping a character sheet within reach also helps to preserve the character's model. (Baena, n.d.).

In *Sam*, there were several types of shots and they each required a different method of working. In this example, Sam has just come to the realisation that his van is stuck on the tracks and that there is a powerful steam engine heading directly for him. My intent of this shot was to show an instant change of attitude and emotion, which would ultimately raise the intensity of the story and depict fear in the characters reaction.

The research that I gathered to initiate conceptual ideas involved thumbnail sketches, photographic reference and personal video footage of different acting choices.

FIG 2:5 *Sebastian Trujillo, Visual Reference October* 2011.

FIG 2:6 *Sebastian Trujillo, Visual Reference October* 2011.

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FIG 2:8 *Blair, P. Cartoon Take (*1994).

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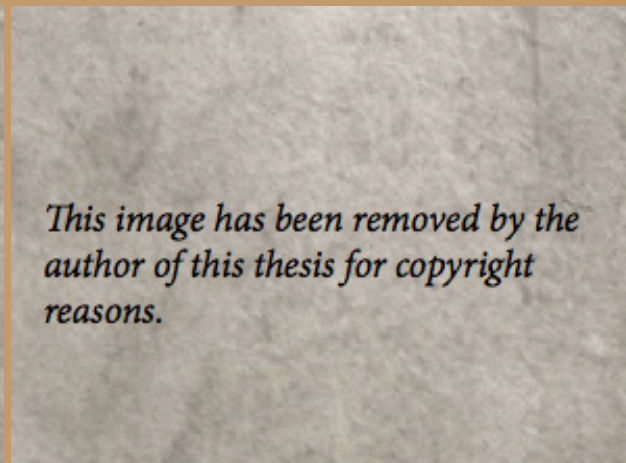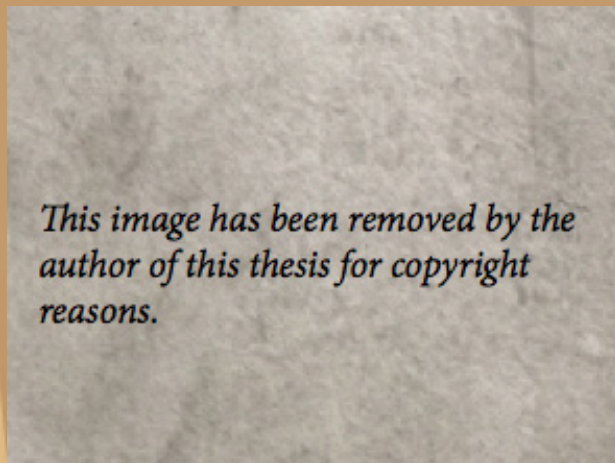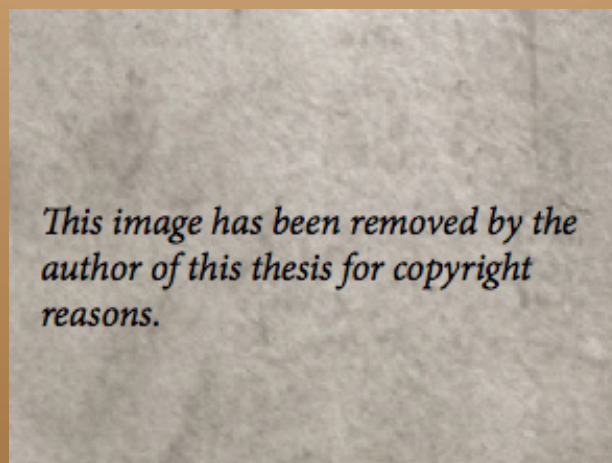
FIG 2:9 *Simon, M. Facial Extremes* (2005).

Taking this step was essential to apprehend possible pitfalls and diagnose issues before getting too involved in its entire technicality. This method also helped me understand the level of awareness the character was in over the course of the shot, and plotted out the rough timing of the beats within it. In doing so, this reference material pinpointed several subtleties that would become essential to delivering a clear perception of the characters thought process.

"The unspoken dialogue. The thoughts reflected and what we say without saying anything. In many cases, from an animator point of view, this becomes both one of the most challenging things to sell. Timing is more than a powerful tool in an animator's toolbox. You can say a lot of things by the way things are timed, both from a character animation point of view, as well as from a shot pacing or editing point of view." (Baena, n.d).

FIG 2:10 *Sebastian Trujillo, Using Reference Video October* 2011.

Acting it Out

"Every experienced artist uses reference when creating work, regardless of the medium" (Luhta, 2010, p. 68).

To gain a strong understating and gather a sense of the subtle qualities of an action, video reference acts as a vital tool. Producing ideas and sculpting the performance relies heavily on the recreation of something that is taken from its physical truth. Using a video camera to collect this information considerably upturns the characteristic and legitimacy of the work (Luhta, 2010, p. 69).

The video reference that I gathered of myself explored different acting choices, and resulted in understanding the basics of the particular action I was planning to animate. Alternating between different takes, while keeping the characters personality in mind, I decided on a clip that I wished to experiment with. It involved a subtle whimper as he gazed into the distance at the oncoming train, turned to a terrorised scream. I drew some thumbnail sketches of the main beats of the action to revise exactly what I wanted to do with the shot and once I had a good understanding of the mechanics involved in this movement I began to block out the shot.

FIG 2:11 *Sebastian Trujillo, Acting it Out October* 2011.
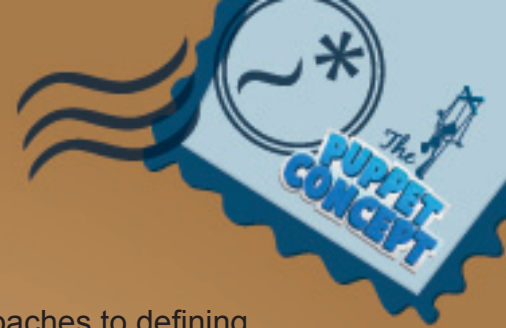
Blocking

At this stage, I was prepared to experiment with different approaches to defining the rough timing of the shot. The reference video was converted into an image sequence and plugged into Maya, synchronising the frames of the video to Maya's timeline. In doing so, Maya supplies an animation curve, which plots the start and finish of the image sequence. Initially, I was not content with the timing of the clip, as the timing of the sections that I wanted to use did not suit the beats that I had drawn out in my thumbnail sketches.

FIG 2:12 *Sebastian Trujillo, Case Study: Original Timing October* 2011.

Maya's powerful Graph Editor opens the opportunity to adjust the timing of the animation curve to speed up, slow down or hold an action or pose. I modified the curve and positioned the timing of the reference to roughly where I had previously planned.

Original Timing
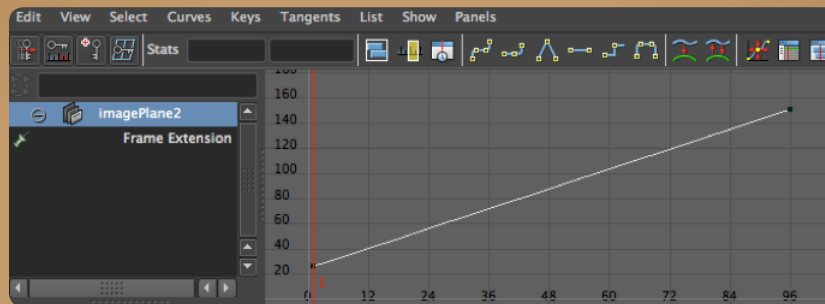
FIG 2:13 *Sebastian Trujillo, Original Timing Curve October* 2011*.*

Altered Timing
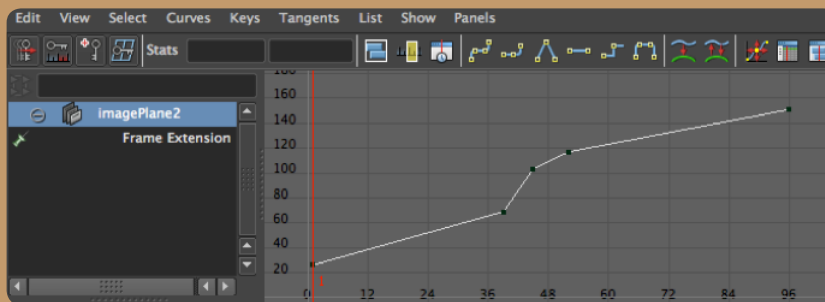
FIG 2:14 *Sebastian Trujillo, Altered Timing Curve October* 2011*.*

FIG 2:15 *Sebastian Trujillo, Altered Timing October* 2011.

Using Video Reference

"I really do enjoy using video reference and cutting it up into the best parts to get an for the timing. It all depends on what's needed to get the idea for the shot in my head. I don't leave this phase of animating until I have a clear idea of where I want to go in the shot." (Schleifer, 2011, p. 72)

Once the timing was determined, I began to break down the shot into the different beats and worked out which approach was best for that particular action. In this example, Sam stares down the length of the tracks, swallows, anticipates then screams.

FIG 2:16 *Sebastian Trujillo, Extreme Poses October* 2011.

These actions differ in energy, ambience and timing. The motion that occurs between the extreme poses holds different values and I was faced with the decision to use either the pose-to-pose or the straight-ahead animation techniques.

Pose-to-Pose or Straight Ahead

The beginning of the shot was the most important section. It communicated the inner feelings of the character through subtle expressions and described the awareness and the thought process, which lead to his hysterical reaction. I felt that by trying to animate the swallowing motion by blocking in a pose-to-pose manner, the subtle real-life qualities that were found within the video reference would look deliberate and too organized. For this reason I used the straight-ahead method. It helped to loosen up the placement of the keys and allowed for more random, indirect movements in the body and the face that would give the shot its integrity and believability. The action lasted nearly four seconds before the anticipation of the scream, which left a generous amount of time for variation and experimentation for the final move. I created a rough pose that resembled the posture and expression found in the reference footage. Then, by utilising the torso, head and shoulder controls I created a series of keys that roughly matched the timing of the reference. Taking into account the rotation of the torso and head then breaking it down into each of the three translation and rotation axis, I could witness the motion in the reference and replicate it frame for frame in the animation. At this stage, this pass was roughly laid out and used as a placeholder to validate the versatility of the action in relation to the reaction.
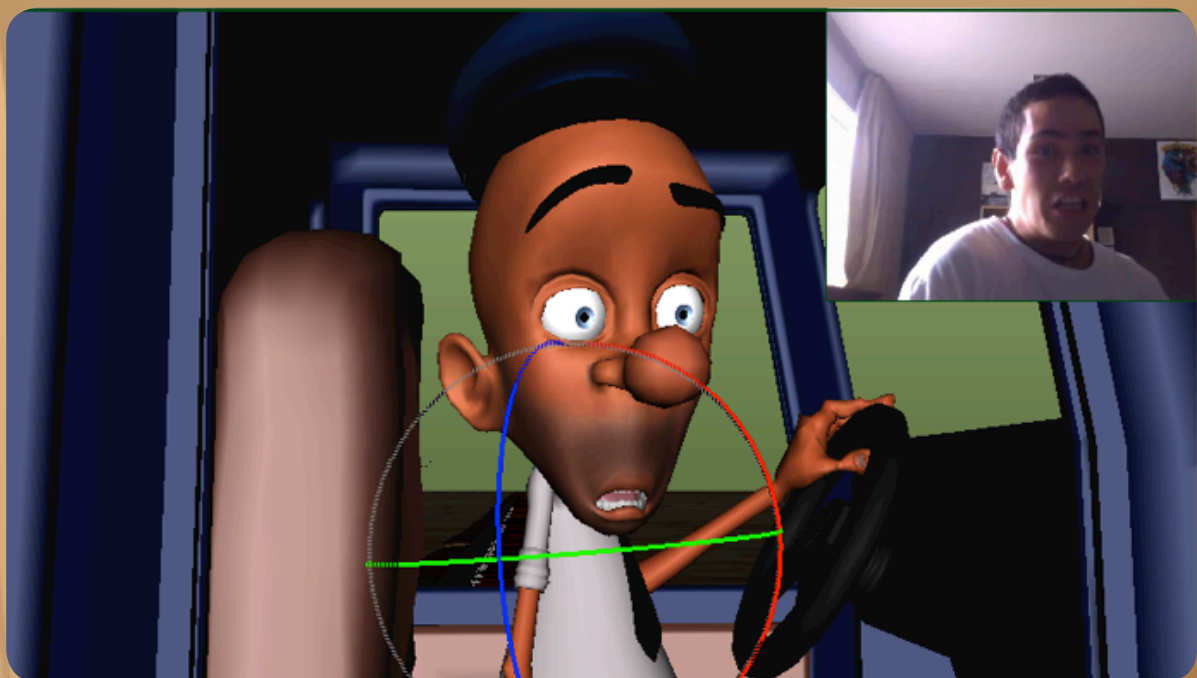
FIG 2:17 *Sebastian Trujillo, Rotation Axis October* 2011.

FIG 2:18 *Sebastian Trujillo, Case Study: First Pass October* 2011.

The second part of the shot consisted of a very sudden change of emotion. The movement required the initial astounded stance, to a sharp drop into its anticipated pose then quickly rising into the extremity of the frantic yell in the space of 25 frames. This suggested the use of pose-to-pose, as the extremes were more obvious than those of the first part of the shot. By breaking down the poses into its extremes, I was able to establish a smooth transition between them starting from the core controls and working my way out to the face, arms, fingers, hat and tie.

FIG 2:19 *Sebastian Trujillo, Case Study: First Pass October* 2011.

Defining the break down poses and facial blocking in the second pass sculpts the flow of the shot into a more understandable and clear action. The facial animation can add attitude, emotion and also act as a guide to make sure he stays in character throughout the shot process. My aim here was to keep the keys organized and match the timing of the reference. By keeping all the relevant controls keyed on the same frames to complete the action I was able to shift the poses along the timeline and experiment with different timing.

Refining

Once I had established the overall performance and positioned the keys appropriately, I began to loosen up the movement by overlapping motion, easing in and out, cleaning up arcs, defining silhouettes and the line of action. Finding the rhythm and design within the composition added appeal and was complimented by the line of action that the poses formed. Rhythm and design hold important values, which can be crucial to the charm and appeal of a shot. The line of action is the basis for this function and directs the animation (Blair, 1994, p. 92).

Arcs

Coyote Falls (2010), directed by Matthew O'Callaghan displays valid examples of rhythm, line of action and overall appeal in its animation. In this shot, Wile E. Coyote is standing on a bridge ready to bungee down and catch the Road Runner. He momentarily loses his balance, manages to regain control and then jumps. The arcs that communicate his sense of imbalance are mainly tied to his wrists and elbows. This path contrast consists of a large arc followed by a series of smaller, more controlled arcs. The timing refines rhythm within the motion and makes the action more interesting to watch.

FIG 2:20 *O'Callaghan, M. Arcs* (2010).

Another important instrument in the animator's toolbox is the ability to trace the arc of an object. This can be done either by using a dry erase marker to physically draw on the monitor and map out the 2 dimensional positions of an object through time, or using the integrated motion trail tool in Maya, which automatically creates a curve that reflects the objects movement through space.
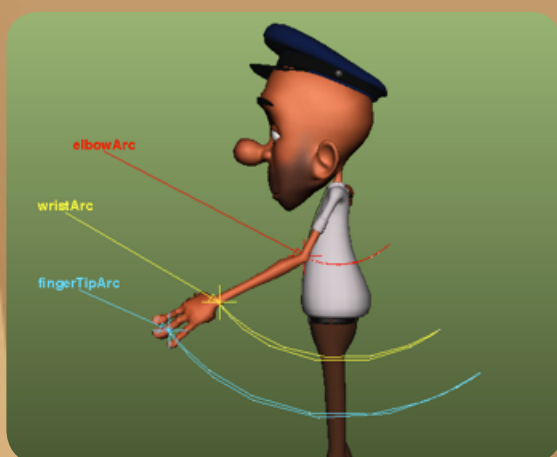
FIG 2:21 *Sebastian Trujillo, Arcs. October 2011.*
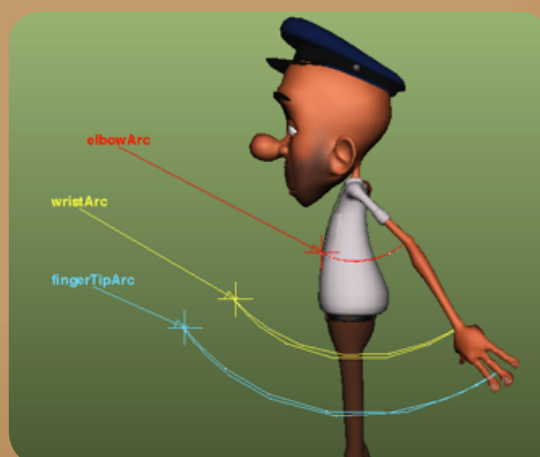
FIG 2:22 *Sebastian Trujillo, Arcs. October 2011.*
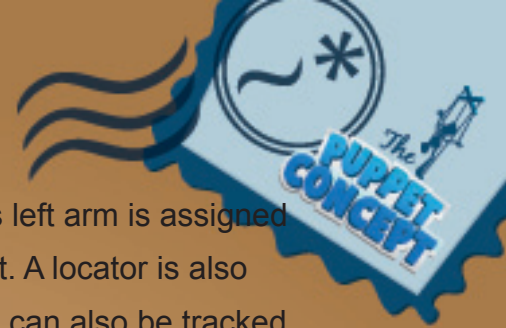
This tool can be applied to any object. In this example, Sam's left arm is assigned a motion trail to determine its motion path throughout the shot. A locator is also constrained to the tip of his nose, so that the path of his head can also be tracked.

FIG 2:23 *Sebastian Trujillo, Arcs. October* 2011.

"In order to get appealing, polished animation, it's a good idea for the motion to travel in pleasing arcs." (Luhta, 2010, p. 86)

Presto (2008) directed by Doug Sweetland from Pixar Animation Studios, holds many varying rig features within the character design, which assist in the power of the performance. In this example, the dependency of breaking joints and the ability to bend the bones of the rig is of important value as it provides the shot with a fast paced yet smooth transition between poses as well as the flexibility to clean up the visual arcs on which the action moves along.

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FIG 2:24 *Sweetland, D. Breaking Joints (2008).*

FIG 2:25 *Sweetland, D. Breaking Joints (2008).*

FIG 2:26 *Sweetland, D. Arcs, Breaking Joints (2008)*.

Line of Action

In this image, the focus of the shot is aimed purely at Wile E's face. His expression shows that he is confident his plan to catch the Road Runner will end in success and the animator wanted to make that clear. The graceful pose that he is in creates invisible curves that lead the eye to the expression on his face.

FIG 2:27 *O'Callaghan, M. Line of Action* (2010).

Useful reference material can often be found under a website named *Frame by Frame* (Frame by Frame, 2011), which is dedicated to the breakdown of well known animations such as Ron Clement's *Basil l'investigatopo* (1986) and Nathan Greno's *Tangled* (2010). This resource is convenient when looking for particular timing of a movement, or the definition of an arc.

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FIG 2:28 *Clements, R. Arcs and Timing (1986)*.

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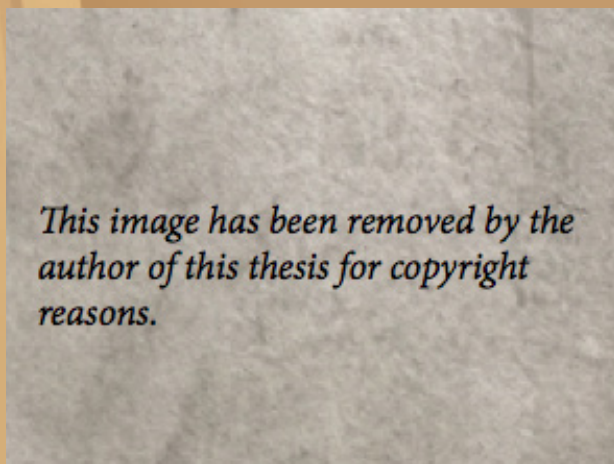
FIG 2:29 Greno, N,Howard, B. (2010)   FIG 2:30 Greno, N,Howard, B. (2010)
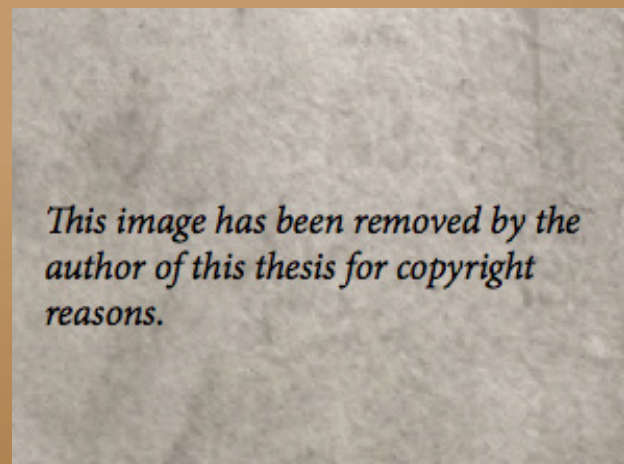
FIG 2:31 *Sebastian Trujillo, Case Study: Second Pass. October* 2011*.*

Texture

Adding texture to the motion played a very important role in this shot. It helped to heighten the intensity of the alarming turn of emotion and made the screaming hold more interesting to watch. The reference video held a lot of expressive movement and the high frequency shaking of the head shows the progression of the intensity. This worked well as a guide as to when to apply texture and when to ease out of it. I added texture to the tweaker controls of the face, mostly around the brows, lips and tongue.

FIG 2:32 *Sebastian Trujillo, Case Study: Adding Texture. October* 2011*.*

Pushing the Action

At this stage, I had matched the animation to the motion of the reference video and exaggerated the poses and breakdowns to suit the style of the animation. To push the action further and develop a more interesting silhouette, I decided to add movement to the arms and shape the already-anxious pose into something more dramatic. By lifting the arms into a more cowering pose, the idea of the situation broadens and becomes more obvious to the viewer.

FIG 2:33 *Sebastian Trujillo, Case Study: Adding Arm Poses October* 2011.

Presto (2008), exemplifies the use of staging and defining a strong silhouette. The clarity of the contrast between 2 dimensional positive and negative space clearly tells the story and produces an overall mood and attitude for the character.
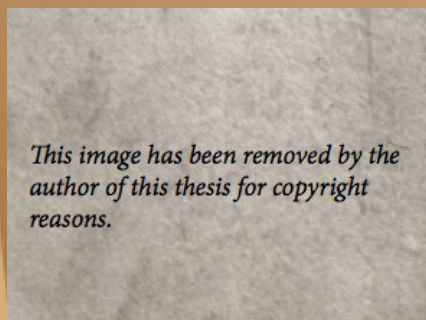
FIG 2:34 *Sweetland, D. Silhouette (2008)*.   FIG 2:35 *Sweetland, D. Silhouette (2008)*.
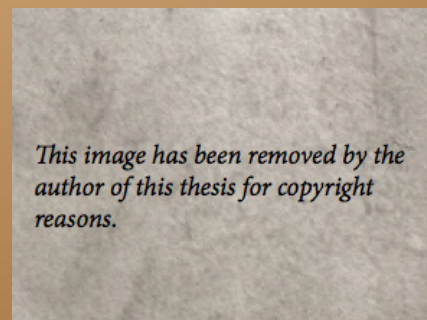
Shot Continuity, and Camera Movement

To add continuity to the flow of the sequence, an extra action needed to begin at the end of the shot and cut into the next shot. The following action was a close-up of Sam's foot stomping on the accelerator, and to create a visual connection within the movement, I turned Sam to face forward and lift his leg in anticipation. This type of cut requires experimentation in the edit to get a filmic representation of how it might cross over.

To push the intense feel of the sudden change of attitude I felt there needed to be some subtle camera move as Sam began to scream. By using the camera setup hierarchy, I was able to layer on the shake motion on top of the hand held feel and begin the panic sequence.

FIG 2:36 *Sebastian Trujillo, Case Study: Camera Work. October* 2011.

Conclusion

Throughout the process of animating, the artist may take several paths to achieve the desired look of a shot. Creating appeal and charm within a personality is accomplished purely through the understanding of who the character is and what their purpose is in their story. The ability to succeed in this field depends on how the team of artist depicts the character. An appealing character must have a reliable rig, therefore obeying the animation principle of Solid Drawing. The functionalities of the rig become practical when traditional animation techniques and tools such as arcs and line of action are applied to help refine the believability of the motion. The utilisation of reference is one of the key tools for an animator, and reveals subtle qualities that can enhance a performance considerably. Employing the use of these tools can improve the quality and workflow of an animator.

Chapter Three

TECHNICAL

Introduction

This chapter focuses predominantly on the assembly of the rig and it's features. Through experimental and independent tests, it demonstrates debatable techniques in which the required function can be accomplished. It discusses the procedures undertaken to plug these characteristics into the rig's hierarchy and explains how the arrangement of a coherent user interface will benefit the animator's overall interaction with the character.

Rigging, unlike most other 3D disciplines, is established on scientific and mathematical logic. The construction of a rig can be compared to programming, however using Maya's kinematics and deformation tools can benefit the construction of a system that supports the motion of a character. (Ritchie, et al, 2007, p. 8).

A User Friendly Rig

To compile an efficient, user-friendly character rig, a variety of factors must be considered. Keeping the connection between the narrative and the character's action requirements in perspective assists with the rigs feature criteria and its priorities. Parallel to this, the rigger must also associate the animator's workflow to the way the particular control will be constructed.

The foundation of the rig lies upon the carefully constructed skeletal joint chain, which determines the pivot points and orientation of each major bone. This plays a crucial part to the initial setup as it will later regulate the deformations and flexibility of the character. The skeleton will ultimately influence the deformation of the mesh.
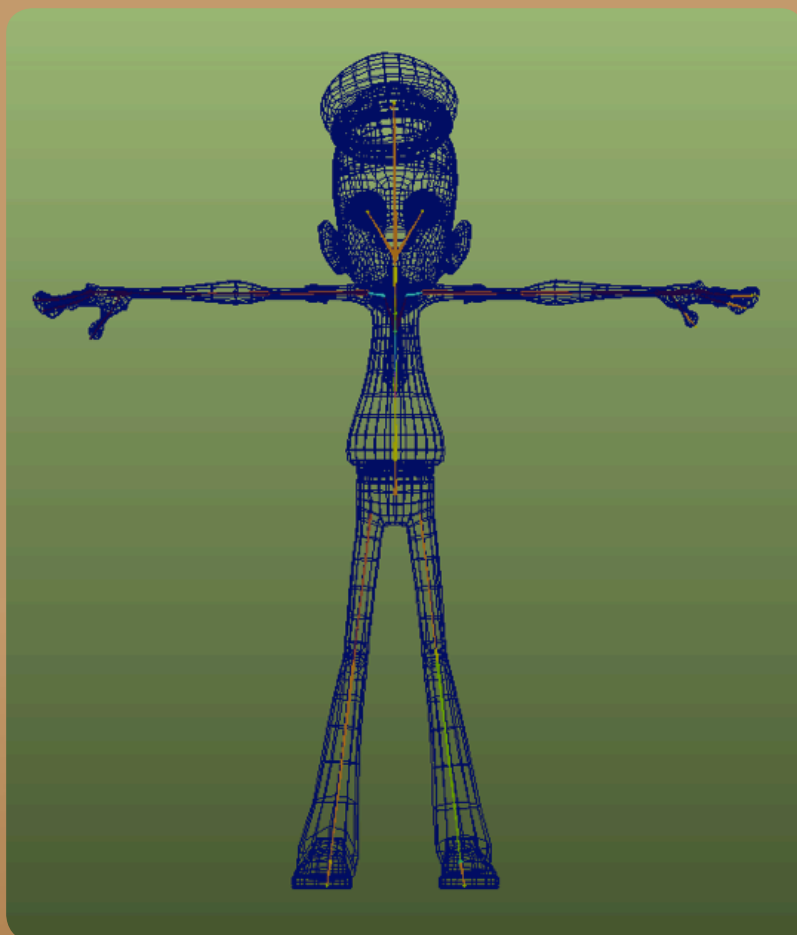
FIG 3:1 *Sebastian Trujillo, Skeletal Layout. May* 2010.

While each part of a rig holds its own challenges, there were particular changes that I intended to make, to redefine the way that I was going to approach animating.
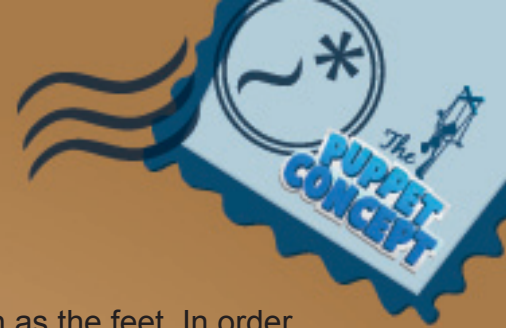
Reverse Foot Rig

Particular areas that required custimisation were sections such as the feet. In order to achieve believable movement that is easily adjusted by the animator, the rigger must first decide on the logic that will be used to build this setup, then connect these functionalities to an animation control. The setup in this example is called a Reverse Foot Rig. It consists of a secondary group of joints that run opposite to the original joints. They drive the original foot joints through constraints from an offset pivot point. This gives it the credibility that is gained from locking the heel, ball, toe and side of the foot to the appropriate contact point on the ground as the character moves about. The rotations of the Reverse Foot joints are driven with keyable sliders assigned under the foot control. These attributes can be configured to drive individual motions of the foot such as raising the heel, banking on one side or the other and pivoting the rotation from the tip of the toe.
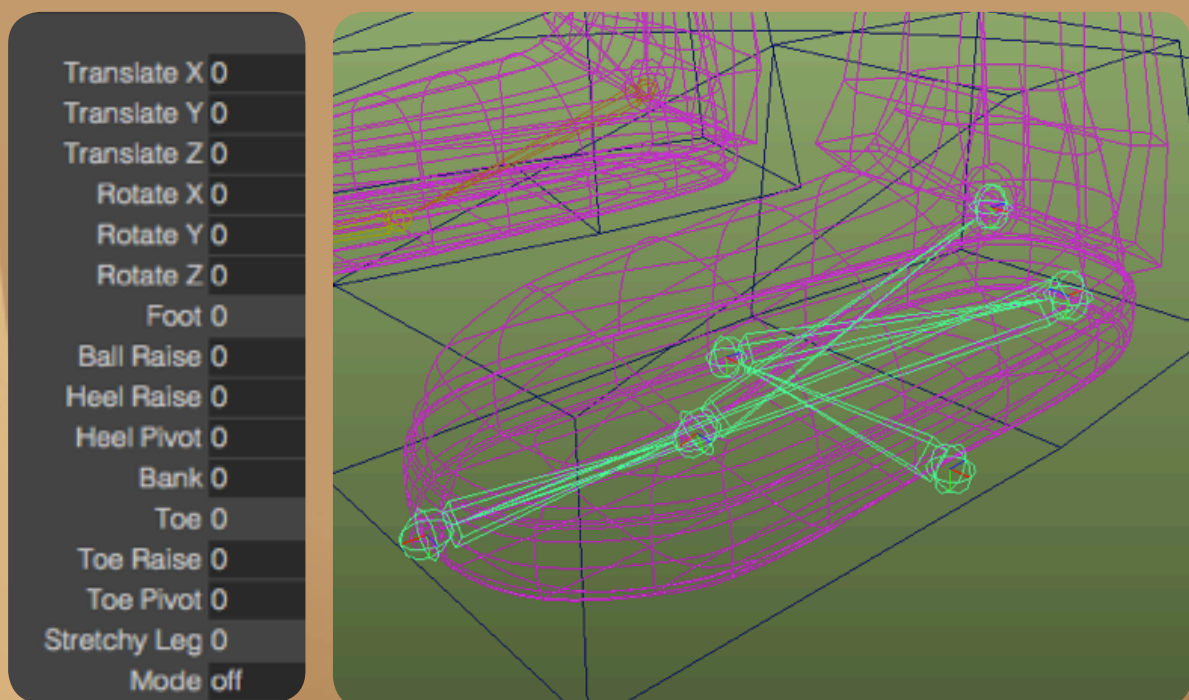
FIG 3:2 *Sebastian Trujillo, Reverse Foot Rig. May* 2010.

FIG 3:3 *Sebastian Trujillo, Reverse Foot Rig. May* 2010.

IK FK Setup

Animation workflows vary in many different ways. A shot can lead an animator to experiment with several approaches before they discover the most convenient and efficient manner to decipher the action they are trying to convey. The limbs of a character by default are usually controlled with an IK chain, or Inverse Kinematics. This is a technique used to animate a hierarchy or chain of joints so that each related object automatically rotates as the end of the chain is placed into position. (Jones & Oliff, 2008). This gives the limbs a marionette-like quality and is efficient when the character is performing an action where the hands are required to lock to an object or in space, such as a character opening a door, or doing push-ups. "If your character is going to plant his hand on something to support his weight or push or pull it, you will have no choice but to use IK arms if you want acceptable results." (Luhta, 2010, p. 88)

FK, or Forward Kinematics is an orientation-based rig where each joint in the chain is rotated manually. (Jones & Oliff, 2008, p. 308). This setup can be used to achieve arm overlap in a walk-cycle, or to smooth out broad arcs.
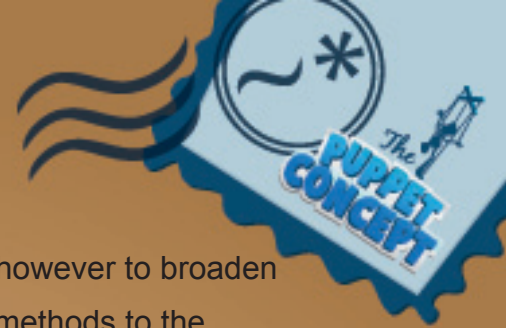
Each of these setups is efficient and profitable in its own way, however to broaden the range of animation possibilities by providing both of these methods to the animator, the rig must be taken a further step. "Almost any rig that is intended for character animation will have the arms and legs available in two modes, IK (inverse kinematics) and FK (forward kinematics)." (Luhta, 2010, p. 88)

Both of these setups cannot be applied to the same joint chain, it would simply break the rig. This would require an IK/FK switch, which would allow the animator to choose from either method at any given frame. The technicality of creating an IK FK switch would add more time to the rigging, but the function itself would save the animator a generous amount of time.

The setup consists of three identical joint chains. For the arm rig, this would ideally be the upper arm, the elbow, the forearm twist, and the wrist joints. The primary bound joint chain drives the mesh through a skin cluster deformer. The second and third chains correspond to the IK and FK setups.
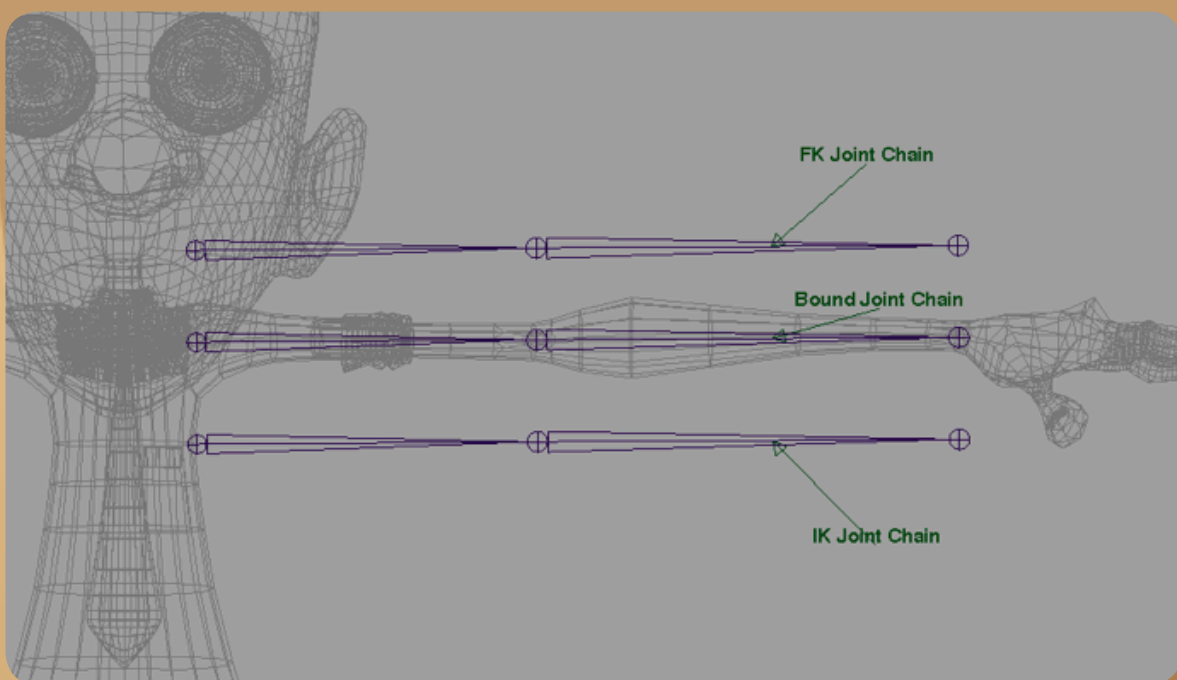
FIG 3:4 *Sebastian Trujillo, IK FK Setup. May* 2010.

The IK setup is straightforward and requires two controllers. The first translates the IK handle and also rotates the wrist. The second controller becomes a guide for the elbow joint to follow using a pole vector constraint. With these two controllers, the animator is now able to maneuver the wrist and get a natural bend in the arm.
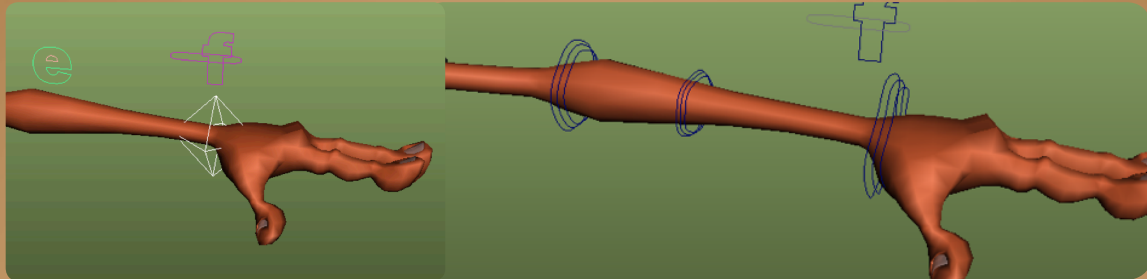
FIG 3:5 *Sebastian Trujillo, IK FK Controls. May* 2010.

Setting up an FK joint chain is more simplistic in its logic. The rigger simply creates a hierarchy of controls, in this case, the upper arm, elbow, forearm and wrist control, which would rotate each joint through an orient constraint.

The procedure taken to connect these external rigs so that they drive the initial skin bound joint chain involves setting up constraints between the corresponding joints and switching between them with an IK/FK attribute. Each bound joint is orient constrained to the related IK and FK joints. This leaves the bound joint with a fifty percent influence from each chain. An attribute was created and used to direct the constraint to favour one of the external chains by toggling the constraint influences on and off. The bound joint chain is influenced by one of the two rigs at all times. To execute this function, driven keys are used. The switch attribute becomes the driver of the constraint's value and is used to toggle between them.

FIG 3:6 *Sebastian Trujillo, IK FK Blend. May* 2010.

FIG 3:7 *Sebastian Trujillo, IK FK Attributes. May*
2010*.*
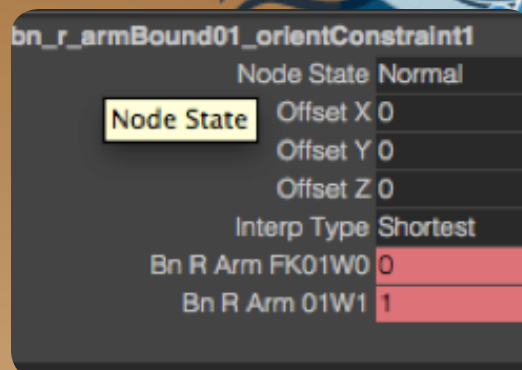
FIG 3:8 *Sebastian Trujillo, IK FK Parent*
Switch. May 2010*.*

Integrating stretch into the IK/FK switch setup creates another challenge. The external IK chain is configured to stretch when the joints reach their maximum extension relative to the distance that the controller is translated. The scaling of these joints is not inherited by the bound chain, in which case the same processes of setting up driven keys must be applied to a new scale constraint. The influence values are also connected to the IK/FK switch and enable the bound joints to scale accordingly. A similar technique can be applied to the FK joints and connected by setting up scale attributes under its corresponding controller. This function allows the animator to scale the joints while maintaining a bend in the elbow. In Sam, I didn't consider the FK scaling to be an important feature to the main characters rig and was not included.

Local to World Switching

An important asset to an animator's toolbox is the functionality of local to world controls. Using this particular setup, the animator as able to choose whether the control object is driven locally or locked in world space and still allow its transform attributes to be keyed. The idea behind this concept can be used for many tasks within rigging and animation. In this instance, the feature is applied to the arms, legs, chest, elbows, knees, hat and eye controls. These manipulators become more practical when animation presents a challenge where for example, the character is falling from the sky, then lands on the ground. This action would require the root of the character to be driving its limbs in local space as he is falling, but as he hits the ground, the limbs must break away from the initial body and define their own path of motion as the mass of the body settles. This setup reserves the ability to refine the timing in the animation on individual objects, without affecting others through the more complex part of the shot.
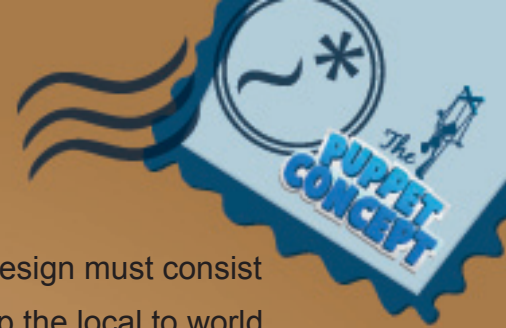
To build this setup using the wrist control as an example, the design must consist of a control object parented under a null group object. To set up the local to world constraints, the null object must be parent constrained to a local control, and a world null object that is not connected to anything in the scene. The appropriate parent driver for the wrist is ideally the chest control. The wrist null control is parent constrained to the chest control and also to a world null object. Utilising the constraint switching method found in the IK/FK setup, the wrist control can alternate between the two influences. The important factor here is, while the null object's transform attributes are occupied by the parent constraints, the wrist control is grouped under the null and has it's attributes free to animate. This function would not be available if the constraint was applied straight to the wrist control.
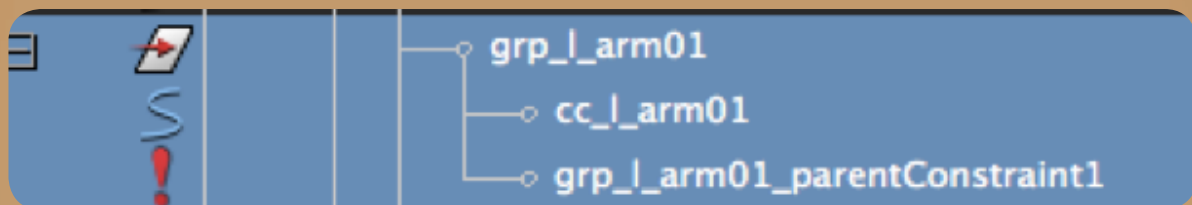
FIG 3:9 *Sebastian Trujillo, Null and Control Object Hierarchy. May* 2010.

FIG 3:10 *Sebastian Trujillo, Null and Control Object Parent Switch. May* 2010.

The flexibility of this design also allows the influenced object to be driven by more than two other objects. The hat control has an attribute that toggles between being influenced by the head, left and right hands and world constraints. Each of these can influence the control object at one time. It is also an effective method to animate characters interacting with other objects. In *Sam*, the character's hands are constrained to the steering wheel and the animator is still able to layer any additional animation on top. This particular connection was not included in the rig, but constructed within the shot itself for these specific animation details.

Joint Bows

To create fluid movement using the breaking of joints as shown in *Presto* (2008),
I compiled an external rig that would ultimately drive the deformations of the arm
joints through the use of a blendShape. The mesh of the body was duplicated and
connected to the original mesh as a blendShape with its value permanently set to 1.
Along the length of the arm of the duplicate mesh, I placed a joint chain, which was
driven by a spline IK. The curve provided when utilising a spline IK is manipulated
to get the bend in the joints. These deformations are automatically transferred to
the original mesh. Controls were set up to maneuver these curves and its visibility
was made optional to the animator as they are secondary controls.

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FIG 3:12 *Sebastian Trujillo, Arm Bow Setup. May* 2010.

FIG 3:11 *Sweetland, D. Broken Joints (2008)*.
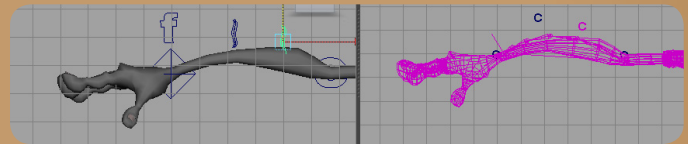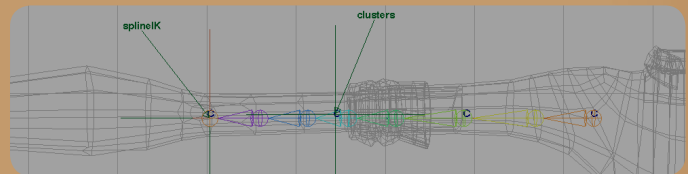
FIG 3:13 *Sebastian Trujillo, Arm Bow Setup. May* 2010.

FIG 3:14 *Sebastian Trujillo, Arm Bow in Sam. Jan* 2011.

Facial Setup

The primary focus that this rig was based around was the articulation of a facial deformations that would convincingly provide smooth facial expression blending built into a user-friendly control setup. The benefits of this rig give the animator different levels of control and create an efficient workflow.

"There are thousands of factors that can contribute to the success or failure of an animated face" (Ritchie, et al, 2007, p. 91).

The idea behind this setup involves creating external local rigs, which are ultimately driving the original head mesh. This allows for the entire rig to be broken up into individual sections and modified coherently without breaking or adding any additional connections. The global rig is divided into three sections, each responsible for a particular feature of the rig.

Squash and Stretch Rig

The first section of the rig presented the issue of squash and stretch. This feature can be implemented using various methods, however Jason Osipa's technique was relevant to the goal I was trying to achieve. The method consisted of two, three-joint chains positioned in the middle of the head and aligned relatively to the upper head and the jaw. Once the mesh was bound to the joints, the translating, rotating and scaling of the chain would influence the way the face deformed (Osipa, 2007, p. 290).
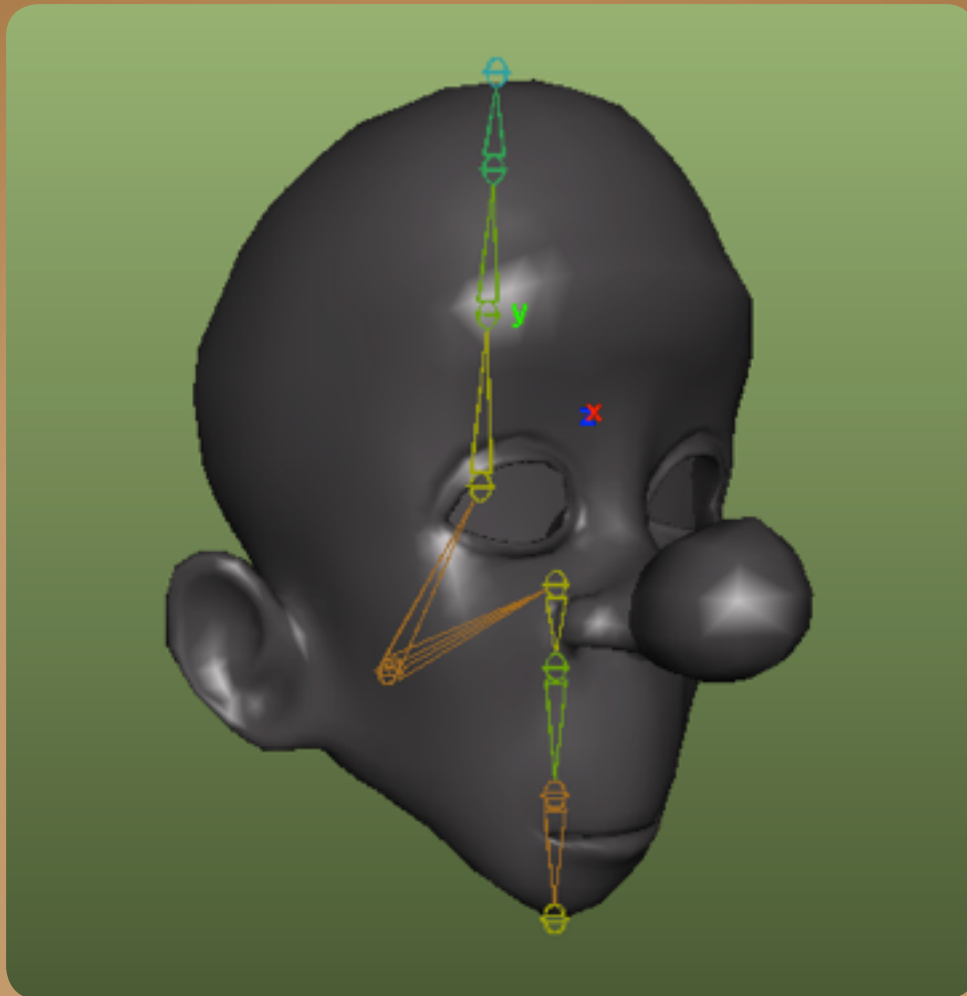
FIG 3:15 *Sebastian Trujillo, Squash and Stretch Facial Setup May* 2010.

An important issue that this technique presented was the fact that neither of the eyes, teeth or tongue were deforming with the head. Osipa demonstrates a method where by applying a lattice to each object and then connecting the head mesh to the lattice with a wrap deformer, the objects become not only attached to the mesh, but also deform in a similar fashion.

"In the spirit of putting joints in odd places to get a new look, this is something that will keep the top of the head fluid enough to be able to bend slightly to accent any pose on the face, or the body in general" (Osipa, 2008, p. 290).
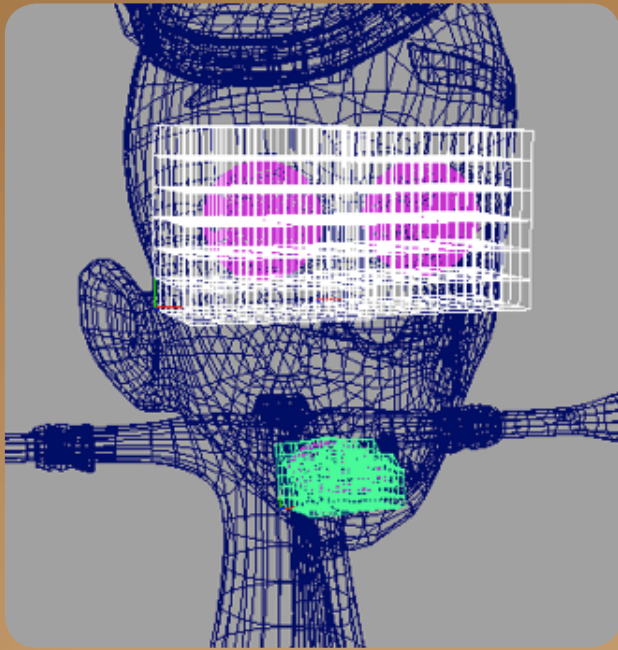
FIG 3:16 *Sebastian Trujillo, Lattices May* 2010.
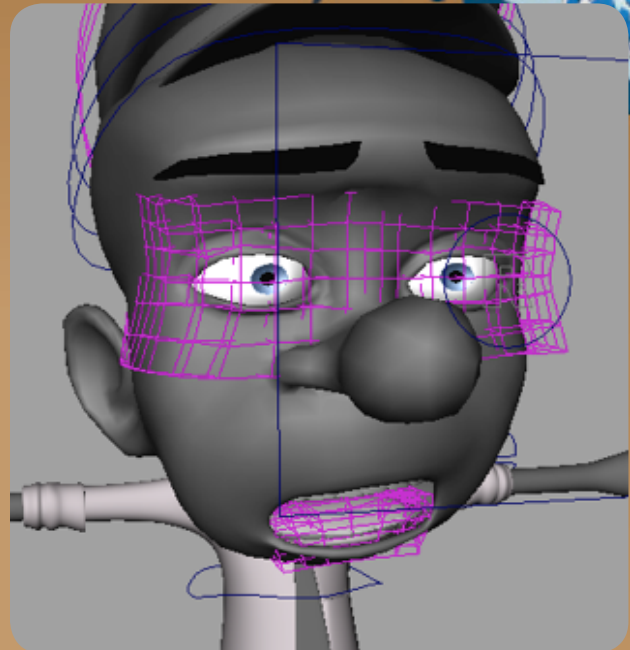
FIG 3:17 *Sebastian Trujillo, Lattices May* 2010.
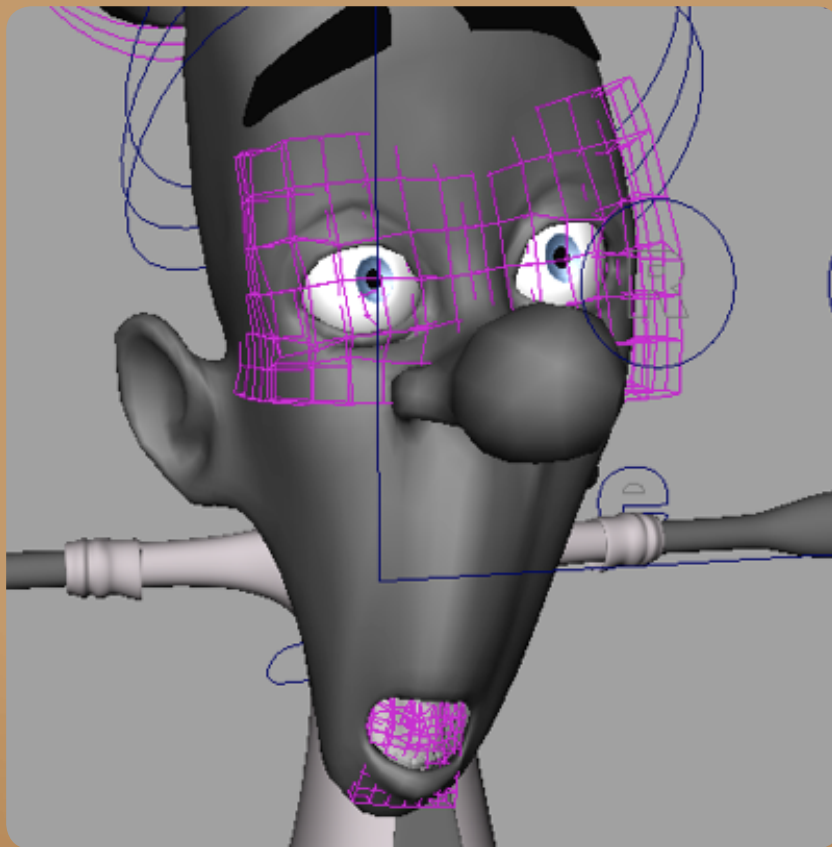
FIG 3:18 *Sebastian Trujillo, Lattices May* 2010.

This method manipulates the position of each vertice rather than the local pivot point of the object. It results in a visual rotation of the object when the head is moved leaving the pivot of the extra objects remaining in their original positions.

Rigging the eyes to rotate appropriately inside the eye socket became an issue, as the likeliness of the eye rotating and intersecting the mesh when the head was in its squashed state was very high.

FIG 3:19 *Sebastian Trujillo, Eye Intersections May* 2010.

Osipa's workaround to this involves setting up driven keys to direct the orientation of the eye based on the position of a control object. This solution was enough to get the minimal control that an animator needed to move the eye. However, to get realistic believable eye movement, the rotation of the eye must have the ability to stay locked to its target instead of rotating with the head. This gives the illusion that the character is focusing on something, and retains the illusion of life, and leaves room for experimentation when animating. With the default solution presented by Osipa's concept, the animator would have to leave the crucial importance of the eyes until the very end, or risk having to redo all the eye work just because the head, torso or root needed adjusting. This method is not suitable for animation.

An ideal technique to animate the eyes involves the use of an aim constraint. This connects the rotation of the eye to point in the direction of the proposed control object. Not having this feature adds more time to the animators workflow, as they have to counter-animate each movement of the control to lock the eyes to their target. Inevitably, any further changes made to the head and upper body would offset the eye lines entirely.

FIG 3:20 *Sebastian Trujillo, Eye Control Setup May* 2010.

The above video demonstrates two versions of the character rig, each set up with different eye rigs. The grey model on the left shows Osipa's standard eye control setup which limits the animator to only animate the eyes locally. To have the eyes lock onto a target can become a frustrating task as any changes made to the head can alter the direction in the eyes are looking.

The coloured model on the right exemplifies my workaround to this issue. The animator is able to take the eye control and simply aim it at a target and either lock their rotations to the head, or to the target in world space - regardless of what the rest of the body is doing.

Applying the aim constraints to the eye's of Osipa's example would not solve the problem as it would result in double deformations caused by the rotations inherited from the head and the constraint. This means that the aim constraint would function well until the head turned, offsetting them from their original state.

For this setup to function properly, the setup needed to be altered in an entirely different manner. In order for the rotations to drive the eye correctly while staying within the eye socket, even in its squash and stretch state, an influential object had to be placed within the hierarchy to intercept the rotations of the original eye. A secondary eye object was parented under the head joint and drove the original eye. The secondary eye was not affected by the squash and stretch but only by the parent/child relationship of the head joint. The original eye was orient constrained to the secondary eye, which overrode the rotational influence of the head. Once the secondary eye was aim constrained to the target eye control object, the original eye followed the correct orientation and gave the extra amount of control the animator needed.

If the animator however, did want the eyes to lock to the head, the use of the local to world rig principle can be applied. By using the switch discussed earlier to control the parent influence of the eye's null object, the animator can choose which method would best suit the particular action required for the shot.

If this function were to be applied to the original eyes in Osipa's method, not only would it result in double transformations, but the head's squash and stretch functions would also cause the eyes to intersect with the eye socket as they rotated to follow the target.

The squash and stretch function is important in this rig as it delivers more organic and fluid motion. Its functionality is used mostly to strengthen breakdown poses and add overlap during fast actions. Being able to lock the eyes to a target would be of greater importance, and this is why this issue was interrogated.

BlendShape Rig

The second section of the rig was created as the single housing for the collection of blendShapes. These shapes were modeled and tailored to affect general expressive features of the face and create solid ground from which the animator can build the facial animation for a shot. The basic facial blocking needs can be captivated through broad shapes such as the opening and closing of the mouth, eyebrow raising and lowering, smile to frown and blinking to name a few.
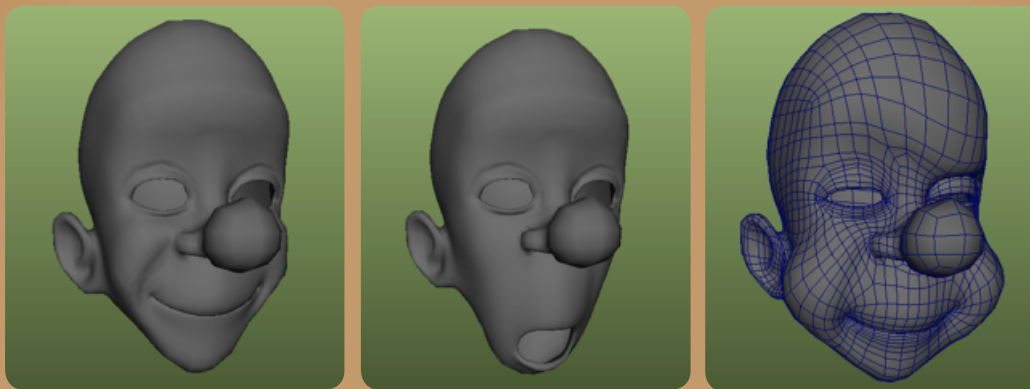
FIG 3:21 *Sebastian Trujillo, BlendShapes May* 2010.

One feature that I wanted to achieve was the automated movement that an eyelid inherits when the eye moves. I wanted this subtle movement to be something the animator wouldn't have to worry about as it was generated by the initial movement of the eye control.

To dictate a smooth arc from which the eyelids would slide across, I pinpointed the center of the eye in its default position and created a joint. I then created two more joints and positioned them roughly on the middle edge of each of the upper and lower lids. I then parented the two lid joints under the main eye joint. This resulted in a global rotation of all joints when the main joint was moved. The next step was to take the main eye joint and orient constrain it to the secondary eye object only in its X and Y axis. This ensured that the lids would never roll in the Z axis. I created an extra dummy joint as a decoy for the areas of the head that would not be influenced by the eye, then bound the mesh to the eye joints. Each of the upper and lower eye joints had their influences mapped onto the mesh accordingly to get a believable deformation as the eye moved around in its socket.

FIG 3:22 *Sebastian Trujillo, Eyelid Automation May* 2010.

BlendShapes work in a linear fashion. Each vertice takes a direct path from its original pose to its blendShape pose. Using the non-linear functionality of a joint can add more realism to the movement of a blink, giving the illusion that the lid is pressing up against the eye as it slides to close and open. Furthermore, interpreting this rotational information through a blendShape creates a stable workflow.

FIG 3:23 *Sebastian Trujillo, Animation Screenshot October* 2011.
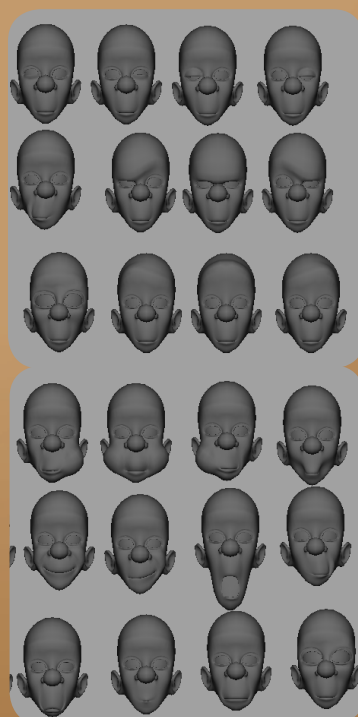
FIG 3:24 *Sebastian Trujillo, BlendShape Library May* 2010.

FIG 3:25 *BBC Worldwide. Eyelid Reference* (2010)

Websites such as BBC Motion Gallery (BBC Worldwide, 2010) house a major range of video reference. For this instance, I needed to see how an eyelid behaves when the eye rotates inside the socket. The complexity of the realistic deisgn was simplified to suit the style of the animation.

FIG 3:26 *BBC Worldwide. Eyelid Reference* (2010)
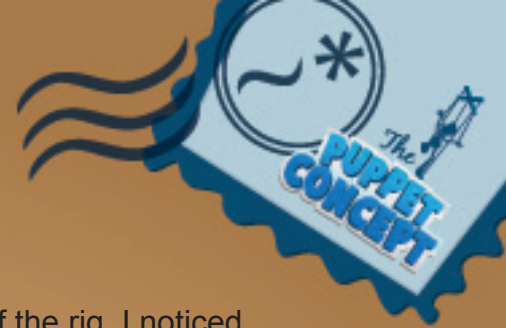
The Tweaker Rig

After working on the animatic and utilising the earlier version of the rig, I noticed that there was a level of control that the facial rig was lacking. I realised the face shapes were very plain and inexpressive. They blocked out the basic shapes that were necessary to portray the emotion, however it lacked character and personality. I soon discovered that to communicate the characters true emotion I needed to have more control over the specifics.

With this in mind, I created another local rig and positioned a series of joints along the areas of the face that may need further modifications. The area that required the most control was the mouth. The shapes that were in effect from the blendShape rig were a good starting point, yet if the animator had the ability to alter the shape of the mouth and create more asymmetry, the character would become more appealing and entertaining to watch.

These joints were placed along the eyebrows, eyelids, along the nose, nostrils, lips and ears. This part of the rig would ideally be for tweaking purposes during the final polishing stages of the animation.
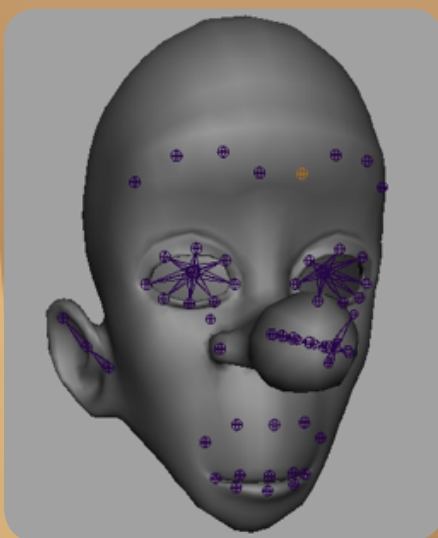
FIG 3:27 *Sebastian Trujillo, Joint Driven Face Rig. November* 2011.
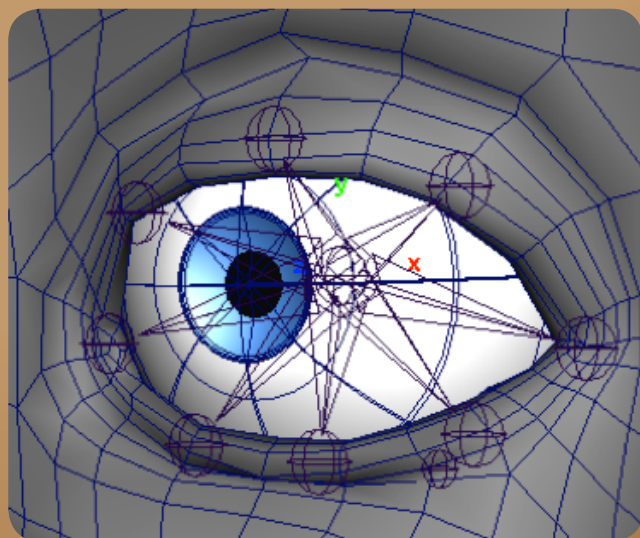
FIG 3:28 *Sebastian Trujillo, Joint Driven Eye Rig. November* 2011.

FIG 3:29 *Sebastian Trujillo, Joint Driven Facial Rig. November* 2011*.*

Each joint was connected to a animation curve control, under a group which could be made visible through the facial control panel.

Rigging the Brows

I intended to keep the eyebrows of the rig separate from the original mesh. The reason for this was because at some stage of the production, the animator may want to really exaggerate the poses of these facial features and push them past the limits of the blendShape. The tweakers are convenient tools for small adjustments and subtle micro expressions, so to use these to push the shape of the brows would result in a strange unreadable expression and possibly break the rig.

The eyebrows preserve the same local rig concept. An external blendShape rig affects the original brows. This rig is simply driven by a joint chain, which can be altered with a spline IK, behaving similarly to the arm bows of the character. This gives the animator more control to force the expression into what is needed to tell the story and sell the reaction. To minimalise the work for the animator I used a wrap deformer to connect the eyebrows to the mesh of the face so that when the skin area of the eyebrow would shift, it would take the eyebrow itself with it. The animator still retained the ability to layer on any additional animation with the eyebrow controls.

Global User Interface

The last crucial step that needed to be taken in order to complete the rig, was to build and connect the Global User Interface that the animator will use to animate. The controls are labeled and simply laid out for the animator to pick up and start to animate.

These controls were arranged in categories, which separated the different functions of the face. The controls were given maximum and minimum values and were limited to stay within its perimeter inside the GUI. They are connected to the relevant attribute of the applicable rig. The limits of the controls are mapped to the limits of the blend shapes and the rotation and scaling of the joints in the instance of the squash and stretch rig. The values of the controls are within the -1 to 1 range for purpose of simplicity when it comes to adjusting the animation curves within the graph editor.

Individual controls are assigned to the tweaker joints and are given no limits. The tweakers empower an independent level of animating and should be treated separately. The animator may prefer to have these control objects hidden, so I included a visibility toggle within the user interface which switches the tweakers on and off at the animators request.
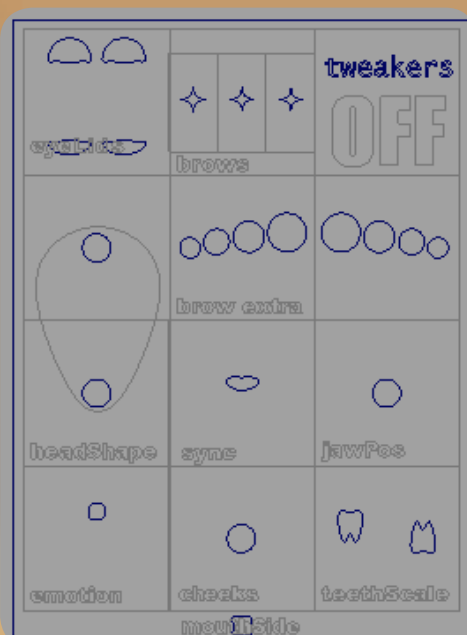
FIG 3:30 *Sebastian Trujillo, Facial GUI. November* 2011.
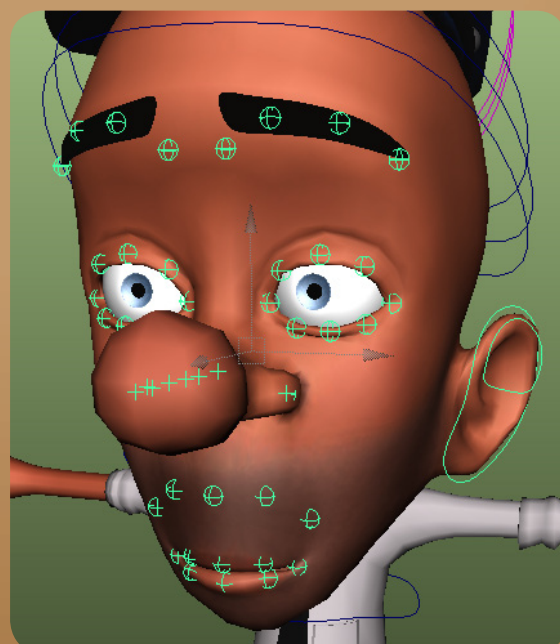
FIG 3:31 *Sebastian Trujillo, Facial Tweaker Controls. November* 2011.

FIG 3:32 *Sebastian Trujillo, Character Rig Demo. December* 2011.

Vehicles

Rigging the Van

The vehicles played important roles within the story. The alternate beginning to the narrative suggested further research into the construction of the Van rig in order to achieve the desired style with user-friendly controls. Primarily, the features necessary to animate the van were the automation of the wheels and the ability to rotate the van globally from either axel's pivot point. The change in the story demanded a more flexible rig.

Getting a natural automated rotation in the wheels required the use of driven keys and basic mathematics. To determine the amount of distance needed to be covered to complete a full 360 degree turn, the following formula was applied.

(pi x 2) + radius of wheel = distance travelled
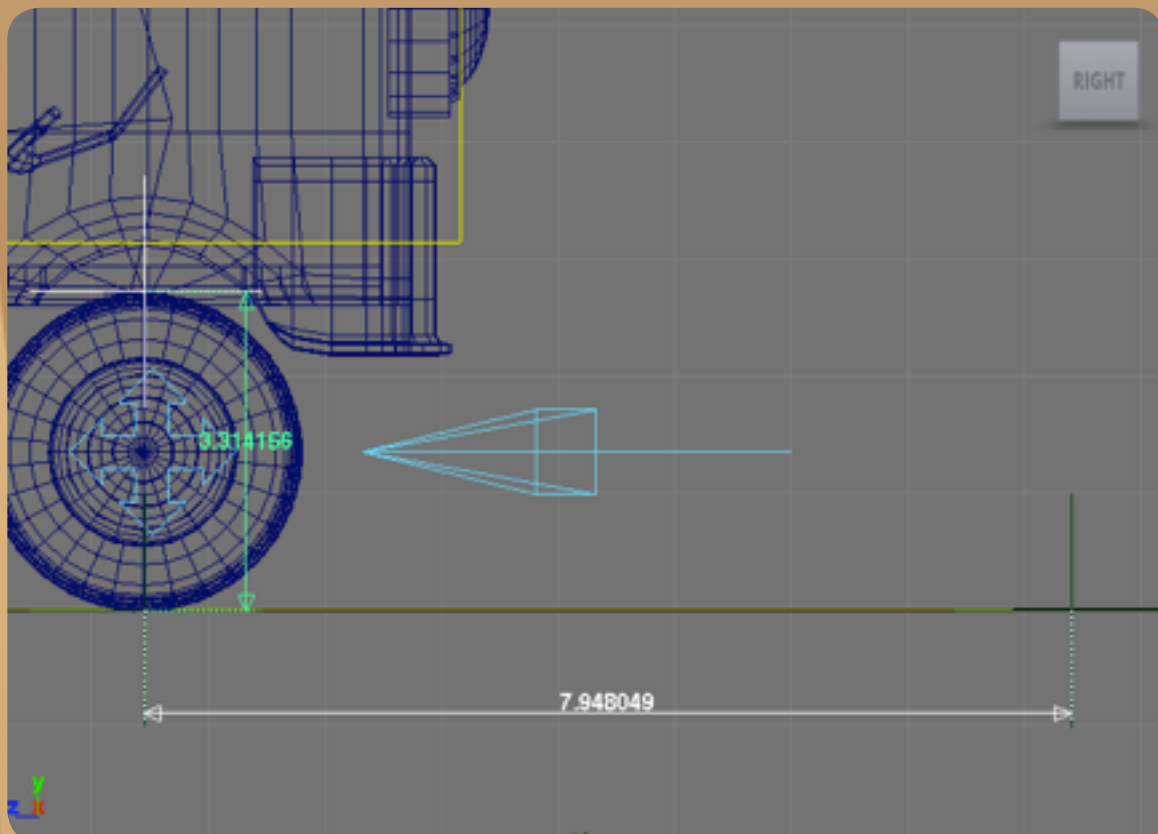
FIG 3:33 *Sebastian Trujillo, Wheel Autoimation Measurements. November* 2011.

The circumference of the wheel equals the amount of forward distance the van needed to cover in its Z axis. In this case, the formula looked like this.

(pi x 2) + 1.66 = 7.94

 Once this was figured out, I used Maya's set driven key tool and created a key at 0 and 7.94 in the Van's Z translation (forward). This corresponded to the wheels 0 to 360 degree spin. The driven keys curve was then cycled with an offset, which kept the rotation of the wheel constant instead of simply snapping back to zero degrees and beginning the cycle again.This would ultimatelly create motion blur glitches in the final renders.

Using Maya's built in non-linear deformers, I was able to plug in a series of functions which gave the animator the ability to squash and stretch the van, globally and partially and skew it forwards and backwards. Bending attributes were added to all doors, as well as the overall model. Using a similar joint setup that is found in a Reverse Foot Rig, I was also able to apply a banking attribute, delivering a more direct animation method when the need to tip the van onto two wheels was necessary.

FIG 3:34 *Sebastian Trujillo, Van Rig Demo. November* 2011.

FIG 3:35 *Sebastian Trujillo, Van Doors Bend. November* 2011.

FIG 3:36 *Sebastian Trujillo, Van Bank Demo. November* 2011.

Rigging the Train

During the creation of the animatic, an issue arose concerning the vast amount of time it was taking to compose any shot that had the train in it. This was due to the fact that the train and the tracks were rigged as separate objects, therefore would need to be positioned individually, then made to match so the train doesn't come off the tracks. In each train shot, I would take the time to adjust the tracks first to create an interesting composition within the cameras framing. Since the train and the tracks were different lengths, their identical rigs would behave differently, creating further problems and consuming more time.
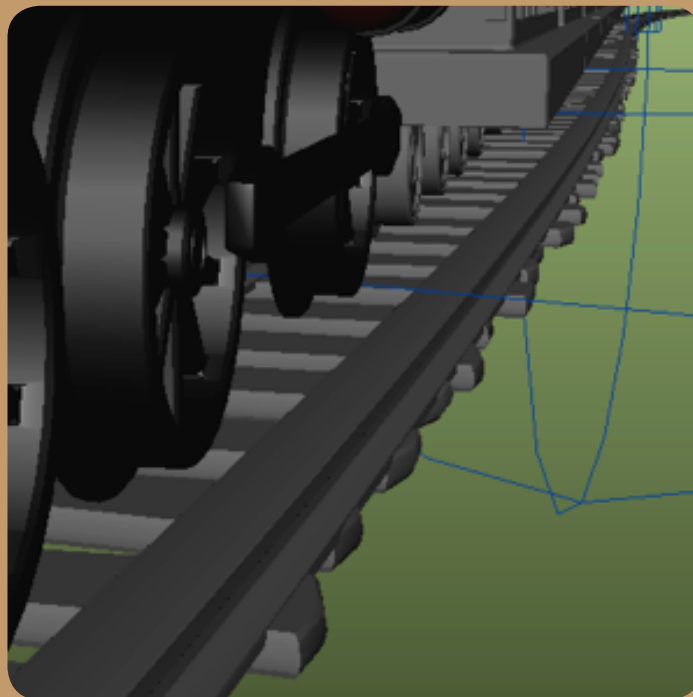
FIG 3:37 *Sebastian Trujillo, Train Derailed. November* 2011.

For this reason I decided to re-rig the entire setup, and combine the two assets to be driven by only one set of controls.

I created a joint chain that ran down the entire length of the tracks then bound the mesh of the tracks to them. To get a smooth deformation in the tracks I applied a spline IK to the joint chain which automatically creates a curve object, used to manipulate the shape of the joints. Controls were assigned to the points on the curve, and when translated would result in a natural bend in the tracks.

FIG 3:39 *Sebastian Trujillo, Tracks Turn. November* 2011.
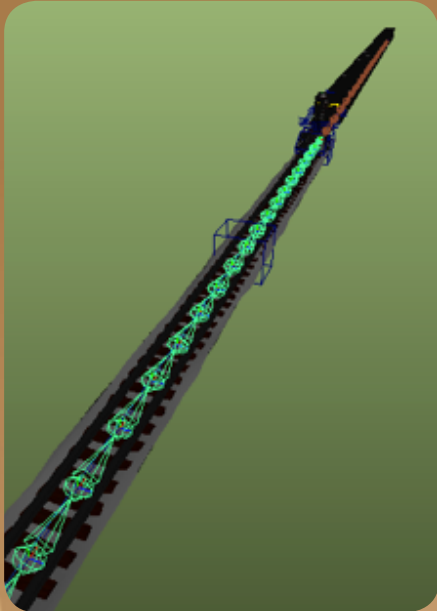
FIG 3:38 *Sebastian Trujillo, Tracks Joint Chain. November* 2011.

At this point, the train was not attached to any form of control. My initial plan to lock the train to the tracks involved taking the train and each carriage and applying it to the spline IK's curve as a motion path. This would constrain the objects to the curve and supply an attribute from which the animator can control the movement along the line. This method raised issues as it used a lot of memory and would ultimately crash Maya. Secondly, the way each object rotated around the curve broke the linking between them and spoiled the illusion that they are all connected in a chain.

The way that this rig was finally constructed involved a similar setup to that of the tracks. Once again, I created a chain of joints that ran down the length of the train, each corresponding to the pivot of the carriage. This chain became the driver of the train. The next step involved creating a spline IK, but instead of accepting the curve that Maya supplied, I chose the existing curve that was already driving the shape of the tracks. This step was crucial in connecting the two joint chains to the same deformation curve. As a result, the train's joint chain and the track's joint chains were driven by the same controls. The forward movement of the train was animated using the offset attribute found under it's spline IK, which was also the driver of the rotation of the wheels using the same automation formula found in the wheels of the van.

FIG 3:40 *Sebastian Trujillo, Train Wheel Automation. November* 2011.

FIG 3:41 *Sebastian Trujillo, Train and Tracks Rig Demo. November* 2011.

Conclusion

The understanding of the requirements necessary to produce an efficient rig depends on the collaboration between the designer, rigger and animator. When the story is established, and the characters duty is determined, the artists can begin to plot out the most effective way to construct the character. The technicality of this rig brought together the fundamental animation necessities with different levels of control and sophisticated functionality. The animation tests that were undertaken during the creation of the animatic were key elements in diagnosing issues within the rig from an animation point of view. They illuminated areas that needed attention as well as suggesting various methods to achieve certain tasks. The overall awareness that a rigger must have of the preferred animation workflows is important to comprehend, as it bridges the two forms of artistry and defines the meaning of digital puppetry.

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Appendices

Appendix One: *Sam* Animation Tests

Trujillo, S. *Sam Animation Tests*. Auckland: Private Collection of Sebastian Trujillo

Trujillo, S. *Sam Animation Tests*. Auckland: Private Collection of Sebastian Trujillo

Appendices

Appendix Two: *Sam* Animation Process

Trujillo, S. *Sam Animation Process*. Auckland: Private Collection of Sebastian Trujillo

Trujillo, S. *Sam Animation Process*. Auckland: Private Collection of Sebastian Trujillo