

A PROPOSED CHARACTER ANIMATION WORKFLOW FOR DIGITAL
PRODUCTION ARTS WITH PREPARATION FOR CLOTH DYNAMICS

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Masters of Fine Arts
Digital Production Arts

by
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ABSTRACT

In a fast-paced production studio, procedures and standard operating practices have been created to ensure maximum use of resources, while being flexible enough to account for problems that might arise. For the animation section of the pipeline, it is imperative to produce animation in a timely manner so that the other sections of the pipeline that are dependent on animation can begin at an appropriate time. Using “Mileena Malign” and “SpaceCat” as case studies, a possible workflow for computer animation—specifically as it pertains to preparation for cloth dynamics—is developed, with highlights on the advantages and challenges encountered. This thesis presents a method for efficiently and effectively creating animation within a multi-tiered CG production pipeline.

DEDICATION

I would like to make a dedication to my wonderful wife, who I love with all my heart and my loving children, with all my soul. Mere words cannot convey the depths of love I have for them, and I thank God that I can see them everyday. I love you all!

ACKNOWLEDGMENTS

I would like to thank my family, especially my mother and father. It is through their encouragement and belief in my capabilities that has given me the will to work through and complete my education. Thanks goes out to my friends for their support, critiques, and desire to work in this wonderful and creative industry. I would also like thank to my advisor John Kundert-Gibbs for his advice and support of the various project teams during SIGGRAH and to Clemson University for providing the necessary resources to support the Digital Production Arts Program.

TABLE OF CONTENTS

	Page
TITLE PAGE.....	i
ABSTRACT	iii
DEDICATION.....	V
ACKNOWLEDGEMENTS.....	VII
LIST OF FIGURES.....	XI
CHAPTER	
1. INTRODUCTION.....	1
2. BACKGROUND.....	5
2.1 Introduction to Animation Workflow.....	5
2.2 Traditional 2D Animation Workflow.....	6
2.2.1 Reference Sheets	7
2.2.2 Dope and X-Sheets	9
2.2.3 Keyframing and In-Betweening.....	11
2.2.4 Straight-Ahead and Pose-to-Pose.....	11
2.3 Stop Motion Workflow.....	14
2.3.1 Production.....	15
2.4 Computer Generated Animation Workflow	16
2.4.1 Pipeline	17
2.4.2 Interpolation	18
2.4.3 Available Animation Curves and Tangents.....	20
2.4.4 Dope Sheet.....	24
2.4.5 Present and Future Work	26
2.5 Technical Animation in Production	27
2.5.1 Traditional Cloth Setup and Simulation	28
2.5.2 Syflex.....	28
3. ANIMATION WORKFLOW APPLICATION.....	31
3.1 Proposed Animation Workflow Overview.....	31
3.2 Initial Setup.....	36
3.2.1 Maya Screen Setup.....	36

Table of Contents (Continued)

	Page
3.2.2 Interpolation Settings.....	38
3.2.3 Storyboards	39
3.3 Step 1: Blocking out the Animation.....	42
3.3.1 Thumbnailing	42
3.3.2 Stepped Tangents.....	43
3.3.3 Blocking.....	43
3.4 Step 2: Adjusting the Timing.....	45
3.4.1 Timeline Manipulation	46
3.4.2 Review and Decisions.....	48
3.5 Step 3: Refinement of the Animation.....	50
3.5.1 Interpolation and In-betweens.....	52
3.5.2 Graph Editor Adjustments	52
3.5.3 The Role of Cloth	53
3.6 Syflex Cloth Preparation	55
3.6.1 Initial Character Setup	56
3.6.2 Initial Simulation	59
3.7 Summary.....	62
4. CASE STUDY	65
4.1 The Adventures of Space Cat	65
4.2 Mileena Malign	70
4.1.1 Preproduction	70
4.1.2 Production	72
5. CONCLUSION AND FUTURE WORK	79
BIBLIOGRAPHY	83

LIST OF FIGURES

Figure	Page
2.1 Character Sheet for Megatron from <i>The Transformers</i> cartoon series (© Sunbow Productions).....	6
2.2 Character Sheet of Kagome from the anime <i>Inuyasha</i> (© Sunrise Studios)	7
2.3 Dope Sheet(X-Sheet).....	8
2.4 Scene from <i>Wallace and Gromit: Curse of the Were-rabbit</i> (© 2005 Dreamworks S.K.G.)	13
2.5 Animator set up a shot on <i>Corpse Bride</i> (© Paramount Studios)	14
2.6 All Tangents are set to Spline	21
2.7 All Tangents are set to Linear	21
2.8 All Tangents are set to Clamped	22
2.9 All Tangents are set to Stepped.....	23
2.10 All Tangents are set to Plateau.....	23
2.11 Maya Dope Sheet	25
3.1 Proposed Animation Workflow.....	32
3.2 Viewscreen Setup	36
3.3 Animation Blending Preference Setup	37
3.4 Storyboard and Render Scene Comparison of <i>Mileena Malign</i>	40
3.5 Blocked Diagram with Animation Curves.....	43
3.6 Adjusting the timing along the Timeline	45
3.7 Blendshape Timing Adjustment through the Dope Sheet	47

List of Figures (Continued)

Figure	Page
3.8 Final Animation Refinement through the Graph Editor	50
3.9 Incorrect Cloth Setup Diagram	55
3.10 Correct Cloth Setup Diagram.....	56
4.1 Space Cat Storyboard Comparison.....	66
4.2 Mileena and the Doll interacting with each other	72
4.3 The Doll Walking	73
4.3 Doll Backpedaling	74

CHAPTER ONE

INTRODUCTION

The art of animation can be a demanding process, especially if the animator is not properly prepared for the work, and with the advent of computer animation, the production cycle of an animated film becomes even more complicated. Instead of just having animators draw the animations of the characters onto animation cells, a CG animation will have multiple departments working on various aspects of a scene. Animators, riggers, compositors, and software developers are just some of the people that contribute to the completion of a fully animated sequence. It is necessary, then, that a pipeline be implemented into the production cycle, organizing the necessary departments and feeding them into the completion of a scene. Animation and technical animation is one important section of the pipeline that we will be focusing on in this paper.

Although Maya provides all the tools for the user, animation still requires a great deal of manual labor. Even with the advent of motion capture, motion files still need to be cleaned and facial expressions still need to be hand animated. If an animator has not been shown at least a general workflow for animation, a bottleneck is created resulting in inefficient use of resources and a loss of time (and money). In certain cases, the animation will have to be completely redone, extending the original time projection, which can be especially bad given the tight deadlines of animation projects. There will be certain times where reworking an animation from scratch is necessary, but ideally any issues with an animated shot should be corrected early in the workflow process. The

purpose of this paper is not the instruction of how to animate, but rather the creation of a set of procedures to move animation through a professional-type production pipeline quickly and efficiently. The Disney 12 principles of animation (overshoot, anticipation, etc.) will not be discussed, nor is this thesis meant as a guide on how to animate characters; there are guides and books written on that subject already. This thesis is to be used as an addition to animation experience to facilitate the execution of animation in an efficient manner. The procedures discussed will include tool placement, viewing schemes, procedural techniques for animation, and a workflow for bringing animation elements together and preparing the animation for dynamic cloth simulation.

Chapter two will provide a brief examination of the history and techniques used by traditional hand-drawn animation and stop-motion artists. It is important to understand traditional animation terms and the techniques that were originally created for hand drawn and stop-motion animation, and how they apply to today's computer generated productions. Many of the technical terms that were created when Disney first started out have been used in computer generated animations as well, although often with a slight shift in meaning.

In Chapter 3, we will discuss in abstract the execution of the proposed animation system. Autodesk's Maya software offers a wide variety of tools to aid in animation, from graph curve manipulation to predefined scripts for redundant tasks. Maya's tool set and viewing scheme will be optimized for the animator so that all the necessary components are at their fingertips. From there, we will focus on a small set of tools that will help in creating an animation efficiently. Techniques such as blocking, in-

betweening, and refinement will be studied and applied in an actual workflow. The procedures created will also aid directors or animation leads in decisions regarding the path and flow their animators should take. By creating this efficient workflow, it is hoped that animation production cycles will become more streamlined and efficient in regards to other sections of the pipeline

Chapter 3 will also introduce preparation of dynamic cloth simulation using Syflex. Dynamic cloth simulation has almost become a requirement for character animation today. Properly setting up a character in the animation pipeline will help with the dynamic simulation of cloth. Significant issues include placement of said character, setup of the cloth with the character, appropriate animation for the character, and techniques for cloth simulation. It should be noted that this is not a guide on how to use Syflex. A cursory understanding of Syflex or other cloth system is required. This section mainly deals with setting up and positioning the character for simulation of cloth.

Chapter 4 is a case study in the evolution of this animation system as it was used in the creation of two computer generated animations, *Mileena Malign* and *Saitne*. *Mileena Malign* was a team project that first introduced the idea of a system that tries to accommodate time restraints, limited resources, and creative decisions; pitfalls that were initially encountered and solutions will be discussed. *Saitne* furthered refined the animation workflow system and is the latest animation to use this system.

Chapter 5 provides final thoughts on the procedures discussed in earlier chapters, as well as the future considerations for a better workflow.

CHAPTER TWO BACKGROUND

2.1 Introduction to Animation Workflow

Animation can come in a variety of forms, be it traditional hand-drawn animation, stop-motion, or computer generated animation. Even though they are completed in various forms using different techniques, they all need some form of workflow to obtain the final product in a timely, efficient manner. For hand-drawn animation, the procedure usually involves the use of dope sheets, or x sheets, to properly plan out all the needed motions, lip-synching, and dialogue. In stop-motion, due to the complex nature of shooting final shots, details are considered and finalized to the point where animation work is performed in a very rigid fashion, never straying far from the initially planned storyboards. For computer animation, actual animation is just one part of a large whole that must work smoothly together, so a pipeline is crucial to facilitate a smooth transition from various sections within a work environment.

Many of the approaches and terms used by animators in the past have also been used in computer animation as well. By looking at the performances and techniques of animators in the past, we can gain a better understanding of how past work in traditional animation forms can apply to today's computer animated films.

2.2 Traditional 2D Animation Workflow

An anonymous writer employed by Disney in the heyday of studio animation once said, “Animation is where screen direction gets down to matters of detail unheard of in live action. In animation you deal with glint in the eye, the twitch of an eyebrow, the tic of a muscle. You’re dealing with microscopic fractions if you want to” [Fiersan 1994]. This particular quote well describes in what detail an animation must be considered in the preproduction stages, which includes storyboarding, character design, and personality development. When it comes time for the animator to draw frames, the only thing that should be on their mind is getting into the character’s mindset and obtaining the animation to reflect the character’s mental processes and objectives. To that end, many tools were created for the repertoire of an animator over time. In preproduction, character reference sheets are drawn up to assist animators in the style and personalities of the characters, while dope sheets assist in the timing of the animation. Techniques such as in-betweening, straight-ahead, and pose-to-pose were created and used to make animation production go more quickly and efficiently.

A general workflow most hand-drawn animation studios follow is to use one or more lead animators to time out and provide all the key moments of action for a character. The leads will then hand these drawings to their assistants to fill in the subsequent animation drawings between each primary frame of action. Although the advent of computer graphic technologies has allowed more companies to use computer generated material with traditionally drawn animation, it is still relevant to at least have an understanding of

the animation workflow within traditional hand-drawn animation studios in order to see how the workflow also applies to a computer graphics pipeline.

2.2.1 Reference Sheets

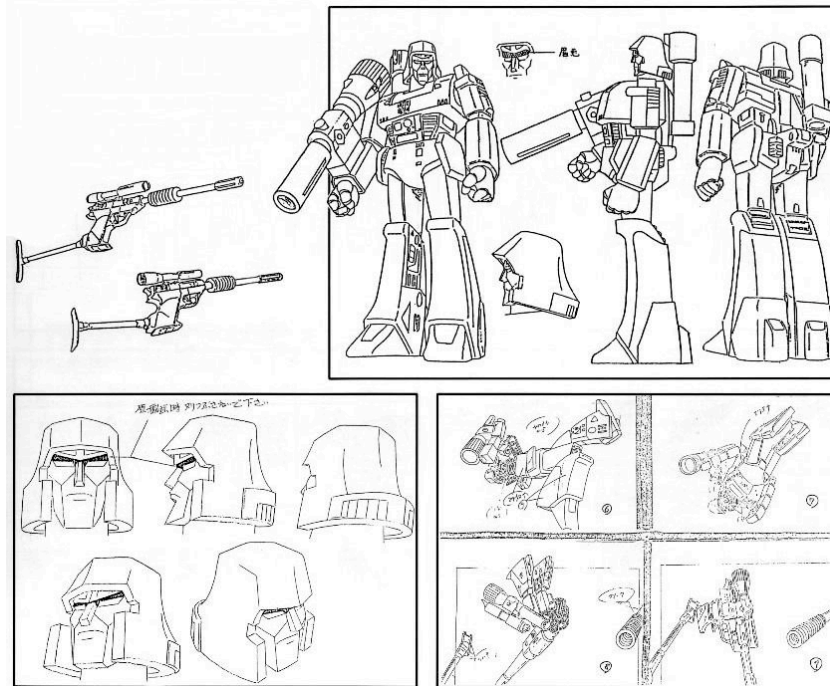


Figure 2.1: Character Sheet for Megatron from *The Transformers* cartoon series (© Sunbow Productions)

When a character is fully fleshed out in the preproduction stage of a film, a character reference sheet is created with the dominant style and orthographic drawings of the character. This reference sheet might also include initial facial expressions to help the animator draw the various facial changes required in the course of the film. Other aspects of a reference sheet can include height comparison with other characters and extra characteristics, such as the transformation of a robot to an inanimate object as seen in *The Transformers* animation series. These reference sheets assist the team of animators in

their job of keeping a consistent drawing style throughout an animation. All the character reference sheets may be combined into what an animator would usually call a ‘bible,’ as Figure 2.2 shows.



Figure 2.2: Character Sheet of Kagome from the anime *Inuyasha* (© Sunrise Studios)

In the realm of anime, Japanese animators will usually include more detailed graphic representations. These often involve extremely exaggerated facial expressions, various poses, or characters with clothing types for different situations. Typically, Japanese animation reference sheets will be more complex than traditional Western ones, spanning pages for just one character.

2.2.2 Dope and X Sheets

In order to keep track of actions, characters, and dialogue within an animated film, a dope sheet, sometimes called an x sheet, was created to assist animators with these tasks. The dope sheet helps animators by providing an ordered structure in which to time out their actions and dialogue, organize several layers of animation cells which might include multiple characters or backgrounds, and write instructions for camera movements. In addition, this dope sheet also acts as an exposure guide for film technicians when filming the various layers of animation cells together. Figure 2.3 shows a full dope sheet.

						NOTES	SHEET
PRODUCTION				SC.	FTG.		
ANIMATOR			ASST.				
SOUND	ACTION	frm	LEVELS				CAMERA

1 sec

Figure 2.3: Dope Sheet(X Sheet)

If animation is done at 24 frames per second, one dope sheet is designed to hold about 4 seconds of animation. In Figure 2.3, we see that each horizontal space is 1 frame with darker line usually representing about 7-8 frames, so for every third darker line, we have 24 frames or 1 second of animation. The various columns in the dope sheet assist the animators with the various structures of the animation. The action column provides an area for animators to plan out timing, which can be accomplished either by physically acting out the shot and timing it or through other means. The dial or sound section is used primarily for dialogue or musical cues. The levels represent various layers of animation cells, either as multiple characters or objects in the environment, with the furthest right usually labeled BG for background. The film technician will use these columns to assist in layering the various animation cells in the correct order. We finally have the camera instructions section, which outlines any type of specific camera movements in the course of the shot, which can include panning or zooms to name a few.

2.2.3 Keyframing and In-Betweening

Traditional hand-drawn, also called cel, animators have developed a workflow that most animation studios are still using today. A lead animator will provide all the key poses or key frames of a character as well as the timing; this is most commonly known as ‘key-framing’ or ‘keying’ and is a term that has transitioned to computer animation. Once all the major action poses or key frames have been drawn by the lead animator, these drawings usually will be handed off to an assistant. It is the assistant’s job to fill in the movements and actions between each key frame in what is commonly know as ‘in-betweening.’ This is a sometimes tedious task in which the assistant draws the many frames needed to reach from one key action to the next.

2.2.4 Straight-Ahead and Pose-to-Pose

There are many methods of creating animation which an animator has access to for the actual process of animating. However, the two most prevalent styles most animators have followed are the straight-ahead and pose-to-pose animation style. These styles were initially developed to assist animators in producing animation in a somewhat procedural manner [Lasseter et. el 87]. Though these methods are the most used, other styles or combinations of animation processes do exist; however, these other methods are similar enough to the two fundamental animation techniques that we will just discuss straight-ahead and pose-to-pose here.

Straight-ahead animation is a natural method of animation in which animators just begin drawing. They generally will be given the outline of what a given shot entails, but it is up to the animators themselves to create the actual action. Since each frame follows from the previous one in straight-ahead animation, most of the animation takes on a life of its own and creativity is unbound [Richards 2001]. The biggest advantage for this particular style is that the animator is unrestricted. They can animate any way they deem fit, as long as it fits the original intent of the scene. However, this method produces some serious downsides. For example, the animator might be proud of the shot, but the director might not sign off on it or consider it to be unusable because of reasons ranging from continuity or flow of the previous sequences to personal taste and vision. This would waste the animator's time and the studio's money, as the animation would have to be redone completely from the beginning. In addition, for complex shots, which can involve multiple animators working together, straight-ahead animation can be overly complex and lead to missed timing and lack of synchronization.

Pose-to-pose animation is a more deliberate and planned workflow. The animator might plan out all the major actions on thumbnails multiple times until they feel everything works, and then present this to the director for approval. Then, the major actions are considered and drawn first. By having all major actions drawn and timed first, directors can view the course of the action early on and decide whether to use it or not. The early approval process can greatly reduce production time since the animation has not been completely drawn yet, so changes are easier and quicker to make. If the director does not sign off, the process starts over, with a better idea of what needs to be

accomplished [Richards 2001]. The major downsides to this method include choppy animation from very strict action poses, loss of flow in timing, or, on a more psychological note, less creativity due to the constraints of how the animation is built. It is possible for pose-to-pose animation to become a very mechanical, robotic approach.

Most animators use some combination of the straight-ahead and pose-to-pose style. By combining the best aspects of each style, the hope is to create a process that is planned and structured enough to give directors a chance to view early animation tests, yet loose enough to allow the animator to play with character and produce quality animation.

2.3 *Stop-Motion Workflow*

Stop-motion is an animation technique in which a physical object is incrementally adjusted and then photographed. Generally, the goal of preproduction for a stop-motion film, as with other forms of animation, is to pre-visualize the finished product—in all its minute details. However, the task of minute movements on a clay figure is often more laborious than hand-drawn cel animation. Careful pre-visualization ensures that action will be animated as precisely as possible and the film shot as efficiently as possible [Fierson, 1994]. Stop-motion is often associated with clay, but is not restricted to that form. Any object can be filmed to give the perception of movement. Since animating with clay is a very laborious task, all major actions are usually decided or drawn on highly detailed storyboards before any actual production begins. Once actual animation begins, the animator follows the plan that was originally laid out by preproduction and very rarely strays from the initial intent, due to the complexity of bringing the entire animation together. The outcome can be seen in such films as *Wallace and Gromit: Curse of the Were-Rabbit* (2005) or the *Corpse Bride* (2005).



Figure 2.4: Scene from *Wallace and Gromit: Curse of the Wererabbit* (© 2005 Dreamworks S.K.G.)

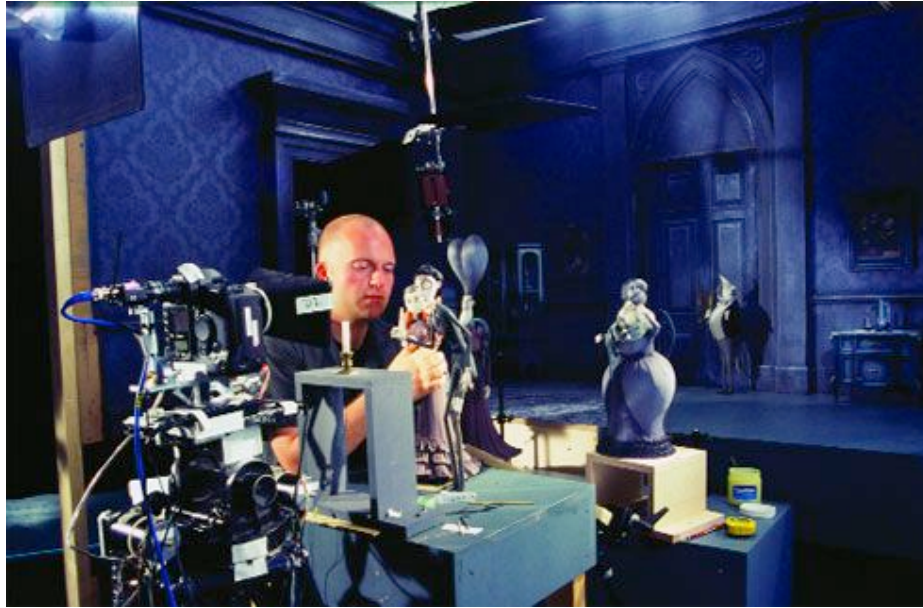


Figure 2.5: Animator sets up a shot on *Corpse Bride* (© Paramount Studios)

2.3.1 Production

As expected, stop-motion production is a very laborious process. Since each scene must be meticulously constructed and all characters animated at the same time, most production studios will obtain about 2 minutes of useable animation per week [Rowe 2005]; for a 2 hour feature length film, that would required almost 60 weeks of animation work.

A form of stop-motion animation that is commonly used is known as claymation. The only real difference between claymation and other forms of stop-motion animation is that claymation characters may not need an armature or rig. However, claymation still uses the technique of stop-motion to capture the vision of animation by single frame increments. Early claymation characters were created from clay, but present day characters are usually built from plastacine, such as *Gumby and Friends*.

2.4 Computer Generated Animation Workflow

Today, most animation studios, whether they come from a hand-drawn or claymation background, or were created as CG animation houses from the beginning, have either transitioned to or have combined their talents with computer animation. With CG, certain activities that would normally be time consuming, complex or even impossible for an animator to draw, especially minor characters, crowd movements, or background movement and camera motion, can be created and animated much more efficiently through a computer. Other advantages include the computer's ability to interpolate the in-betweens of the major poses, instead of having animation assistants draw them in. In some cases, motion capture completely removes the animator from primary animation, instead focusing more on the realistic movements of the captured actors themselves. More creative reasons to use computers in animation include the style or "look" a computer generated film portrays. These are but a few reasons as to why some studios have transitioned to or focused solely on computer generated animation.

In Disney's *The Lion King* (1994), there is a famous early example of computers being used in a hand-drawn animation: a computer generated stampede of wildebeests rampaging toward the protagonist. Present-day Japanese animation studios have started to combine computer generated characters or environments with cel animation. Major computer animation studios, such as Pixar and DreamWorks, are devoted solely to computer animation, with award-winning animations netting millions at the box office. This push towards computer graphics is an evolution of the art of animation. But like all

successful businesses, a proper plan must be designed and implemented with CG animation in order to maximize advantages and minimize problems.

Like hand-drawn and stop-motion animation, a great deal of time is spent refining the script and each storyboarded shot before any actual animation occurs. In the process of creating Pixar's *Toy Story* (1995), for example, all scenes would be completely timed out by storyboard artist and preproduction [Toy Story DVD]. When the sets are created and the characters rigged, setup artists place everything for the animator, including the time limit for each shot, the environment models and characters, and the camera. When it comes time for the animators to work, they talk to their supervisor or lead animator, obtain all the materials relevant to the shot, including the scene file, storyboards, a scene description, and dialogue. It is then up to the animator to block out the major movements for approval on a low polygon model, and then continue with refinement and final animation on a high resolution model.

2.4.1 Pipeline

As a production studio begins work on a project, an initial workflow is designed to incorporate the many jobs needed to create the multitude of shots in a film, with the storyboarded shot sequence determining what is needed in each scene. Various aspects of a shot are broken down to their base components, such as modeling, rigging, animation, special effects, and so forth. However, all these sections must work with one another to produce the final result. This interlocking type of workflow design is commonly referred to as a pipeline [Kerlow 2004].

A production pipeline takes into account everything that might be required of a shot, be it computer animation, textures, lighting, special effects or other elements. When models are created from the modeling department, a proper control rig can be created by the technical directors. Then animators will have the ability to begin animation. Modelers and riggers may still be working to produce a refined model setup even as animators are animating with a previous version of the setup. Technical personnel will assist in troubleshooting issues that arise as well as perform the necessary actions in order to import the new version of the model onto the control rig. The rough animation can be used to determine set dressing and preliminary lighting consideration. The pipeline works by feeding sections and subsections of various components simultaneously into a shot. The culmination of this pipeline is a fully textured, animated, lighted, and composited shot, ready to be edited and placed in the film reel.

2.4.2 Interpolation

One of the biggest advantages that computer animation has over hand-drawn animation and claymation is the ability to calculate or average the transitions between the key frames that the user has set. As a result, animator assistants no longer need to laboriously hand draw each in-between frame for animations and claymation animators will not have to manipulate the clay or armature for each frame. This application is known as interpolation and is generated whenever an object is keyed more than once along the timeline in a 3D animation program like Maya. The resulting graphical representation of the keys and their interpolation is a curve in a graph editor. An

understanding of how interpolation works and how to adjust animation curves will give animators the extra skill set to use the needed interpolation curves for specific results.

An animation curve that has a straight line between two keys usually exhibits constant change and is usually called linear interpolation. However, various algorithms have been developed to create more sophisticated interpolations called curved interpolation, also sometimes called interpolation ease. Curved interpolation averages the parameters in the keyframes, taking into account variations of speed over time; A graphical representation for an increase in speed is usually known as an ease-in with the curved interpolation curving up from horizontal, while a decrease in speed, known as an ease-out, is shown flattening out to horizontal [Kerlow 2004].

An object or character's position is usually defined in Maya as a transformation matrix with the following parameters: Translate X, Y, Z, Rotation X, Y, Z, and Scale X, Y, Z. These coordinates specify the position of the object in three dimensional space, although more parameters can be added if needed. Moving, rotating, or changing the size of the object will result in new parameters and new transformation matrices [O'Rourke 1998]. A graph representing curved interpolations is also called a parameter curve or a function curve [Kerlow 2004]. When an animator key frames one pose to the next, Maya will generate the necessary interpolation and a new transformation matrix for the object at each frame. Understanding the various effects of each tangent will be of great assistance when we get into the actual process of the animation workflow later on; for instance, it is important to understand which tangents the animator will use in order to

achieve a pose-to-pose format for blocking animation. Maya's interpolation algorithms will also create a tangent representation shown in the graph editor.

2.4.3 Available Animation Curves and Tangents

Whenever an animator keys one pose to the next in Maya, an animation curve is created in the graph editor. These parameter curves represent the object's movements as it transforms through 3-dimensional space along the timeline. By showing the values as they transform along the timeline, animators can refine the animation by manipulating the tangents that are created. Most animators will adjust the tangents, affecting the ease-in or ease-out of an animation curve, to obtain the desired results. The results will vary from springiness to arching motions depending on what exactly is keyed and how the curves are manipulated.

In the process of animation, Maya provides the user with animation tangents. These animation tangents assist the animator by mathematically adjusting the animation curve toward specific results, usually involving ease-ins, ease-outs, and overshooting [Steketee and Badler et al 85]. Ease-ins and outs are associated with how the curve enters and exits a given keyframe. A complex animation may contain various tangent restrictions along the peaks and valleys as shown in Figure 2.6. Depending on the tangent setting, the user can adjust the tangents, curving them either upward, downward, or smoothing them out. Maya's graph editor has provided several tangent modes for adjustment and refinement: linear, clamped, stepped, spline, and plateau.

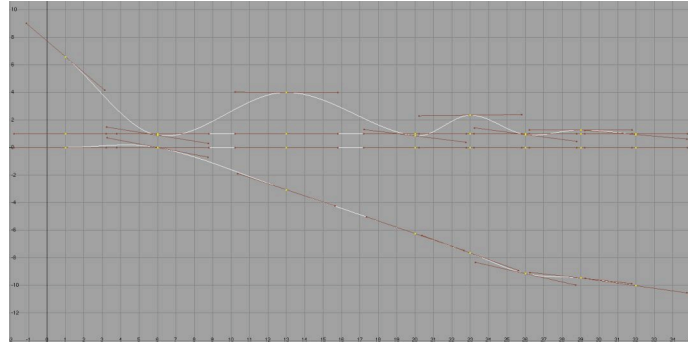


Figure 2.6: All tangents are set to spline

A spline tangent (Figure 2.6) is the most common type of tangent and is usually the default tangent setting so that whenever an object is keyed, all incoming and outgoing tangents are set to spline. The properties of a spline tangent create a smooth ease-in and out. However, this type of tangent is not limited to the hills and valleys of the curve; the values may extend past those restraints. For example, if a ball was keyed to bounce off the ground, it could actually go through the plane and then bounce back up due to the way spline tangents are calculated. While not perfect in all situations, the spline tangent can be used for most smooth animation.

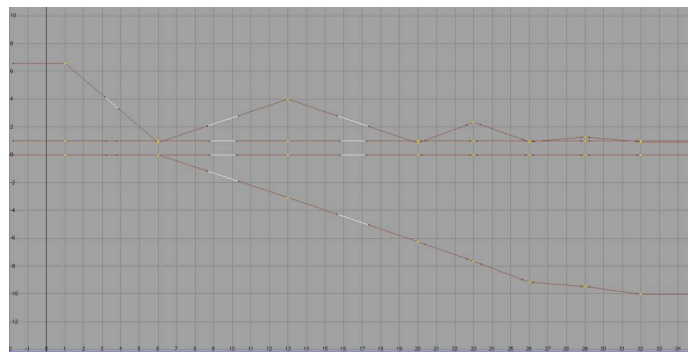


Figure 2.7: All tangents are set to linear

A linear tangent (Figure 2.7) is represented as a straight line between keys. This particular tangent can best be used to create a constant change in the attributes of the object, with very little variability. A plant or object that grows at a constant rate is a good example of this particular technique

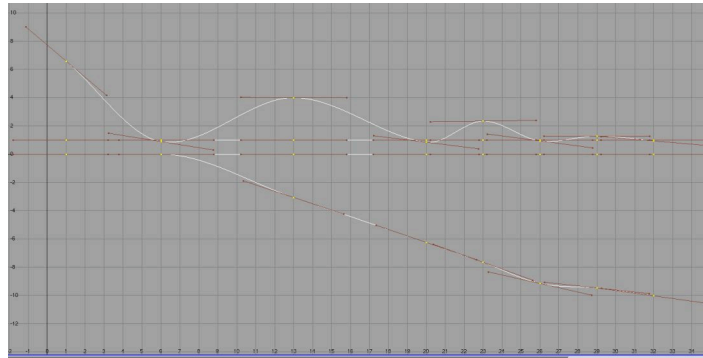


Figure 2.8: All tangents are set to clamped

A clamped tangent is a combination of spline and linear tangents and a step below a plateau tangent as shown in Figure 2.8. It smooths out the ease-in and ease-outs of an animation curve. The clamped tangent will flatten out and smooth any keys that fall between liked valued hills or valleys, converting it into a straight line or a linear curve. However, values can go past the hills and valleys that are created, allowing for greater adjustment if necessary.

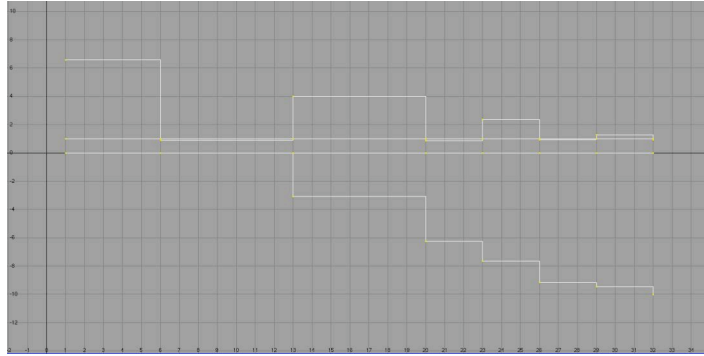


Figure 2.9: All tangents are set to stepped

A stepped tangent forces the animation curve to a 0 degree slope (Figure 2.9) [Maya Help]. This type of animation interpolation is characterized by very extreme blocky movements with no motion between poses. By using this setting, animators can block out movements and timing for each specific action without having to worry about transitions between each major action.

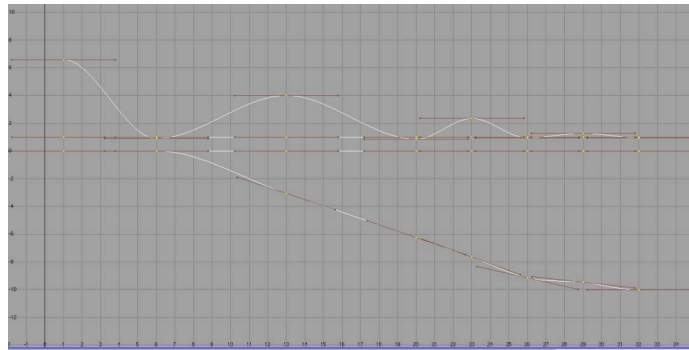


Figure 2.10: All tangents are set to plateau

A new tangent that was introduced into Maya 7 is the plateau tangent seen in Figure 2.10. This particular tangent acts as a constraint so that the values of the animation curve

do not exceed the intended, keyed values, unlike the clamped and spline tangents. This has the effect of forcing the animation to move toward a specific point but never beyond it. Three characteristics define this particular tangent. First, they flatten keyframes at the points in their curves where hills and valleys occur; second, they flatten the first and last keyframes on their curves. Finally, they also flatten points that are between like valued keys [Maya Help].

2.4.4 Dope Sheet

When the dope sheet was initially introduced, it was used as a guide for hand-drawn animators to time out actions and dialogue and give layering instructions for film technicians. Maya's dope sheet is similar to the original intent of the hard copy dope sheet in that it allows for miniscule refinement in actions. The graph representation is a timeline-like graph with colored blocks represented as actions or movements. These colored blocks are somewhat similar to the keys shown in the graph editor, but only keyframed actions are shown, not the curves between them. The left of the dope sheet houses the outliner, listing the various parameters that have been keyed. By selecting keyable parameters on the left, the associated row becomes highlighted and the animation blocks can be manipulated.

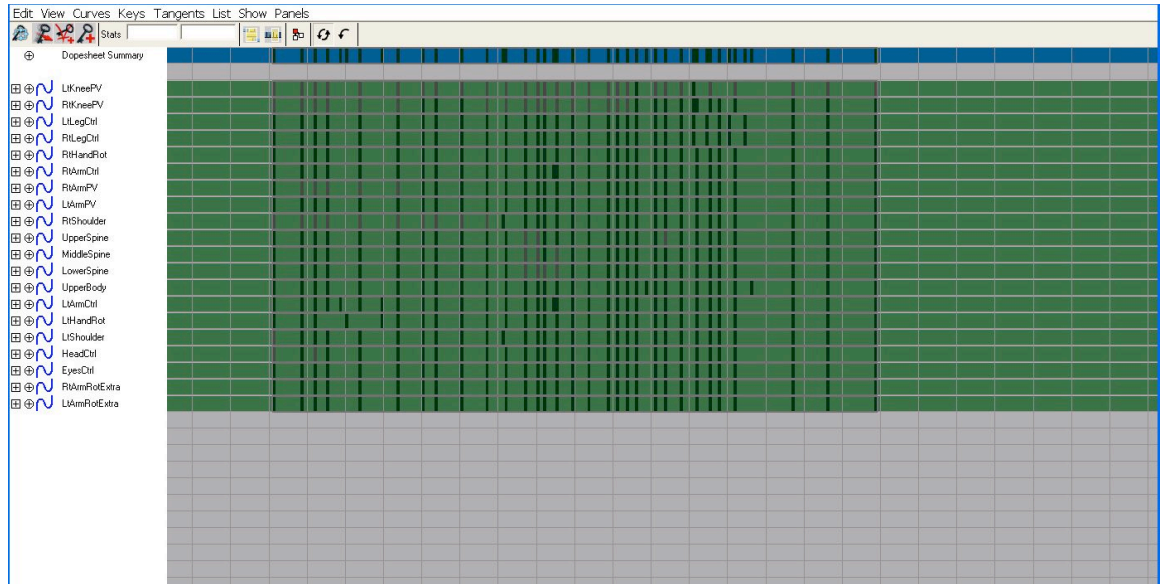


Figure 2.11: Maya Dope Sheet

The goal of the dope sheet is to refine timing. This feature is especially useful when dealing with lip-synching or sound effects. By importing a sound file, the animator can see the peaks and dips of the sound wave. Through manipulation of the colored blocks, the animator can match up the action to the sound as closely as possible. Dope sheet manipulation can also help in timing refinement for various large-scale actions, such as an arm swinging or a footstep. By clearly representing transformations as colored blocks of actions, this tool allows the user to move, scale, or cut actions according to a timeline, and even allows for blending multiple sets of actions.

2.4.5 Present and Future Work

As computer animation becomes more advanced, scientists have started to find new ways in which to assist animators. Some researchers have tried to streamline the animation process by developing algorithms that refine the interpolation process between each keyframe, making in-betweening more simplified. These refined algorithms can be seen in such experiments as spatial keyframing, in which an interactive approach is designed so that keyed animation can be manipulated in real time [Igarashi and Moscovich and Hughes et al. 2005]. Other experiments include timing adjustments based on acting out the motion using an input device, such as a mouse or tablet, to spread the keyframes into proper positions along the timeline [Terra and Metoyer et el 2004]. In addition, physically based animation, such as rigid body dynamics, has been developed to aid character animators when situations call for life-like motion. Examples include a character responding to impacts and compression in a life-like manner. Resulting motions are based on a hierarchal model of the human skeleton and the application of forces, including gravity and collision detection, to create a hyper-realistic reaction to an environment.

2.5 Technical Animation in Production

Advancements in both software and hardware capabilities in addition to the desire to get more out of digital performances has given birth to technical animators. Technical animators are responsible for the setup and simulation of the more dynamic aspects of a computer generated film. Not necessarily restricted to computer animations, technical animators also work in special effects houses that deal primarily with adding dynamics, such as explosions, lasers, etc., to live-action films. Dynamic simulation can run the gamut from particles and fluids to hair and cloth. Other responsibilities may include the development, implementation, and updating of software necessary to the completion of the project. The field of technical animation is comprised of individuals that specialize in either a single area or a combination of specialties such as hair and cloth. Here we will focus specifically on technical animators that work primarily with cloth and their responsibilities.

Most studios use either commercial software or proprietary software developed in house to create their cloth simulations. The reason for in-house development includes continuous, onsite help and fixes, and an advantage over other companies bidding on a given project. Since cloth simulation development is overseen by software engineers that have previously worked on other parts of the pipeline, the developers are already familiar with common issues and may be able to implement their tools more smoothly. However, studios have been able to implement commercial software into their production pipeline as well. The best approach depends on a variety of factors that might include cost, efficiency, and resources.

2.5.1 Traditional Cloth Setup and Simulation

The initial setup of cloth on the character usually begins with the t-pose. Almost all models that even remotely resemble a biped will be modeled, rigged, and clothed in the t-pose position. The technical animator has no access to the actual animation controls or rig itself; instead, they will have access only to the animated model, the modeled clothing, and the necessary tools to manipulate and adjust the cloth simulation. Once primary character animation has been completed, technical animators will begin manipulating and simulating the clothing into its various motions.

2.5.2 Syflex

Syflex is a powerful cloth simulation plugin developed for commercial use. Its diverse tool set and predictable behavior has made it a very popular third-party extension for 3D animation packages such as Maya and 3D Studio Max. Any polygonal object can be transformed into a cloth simulation through a spring-based system of vertex manipulation [Syflex Help]. Various tools such as forces and wrinkle mapping assist in the manipulation and formation of the cloth in various instances. For the purposes of this paper, only the setup and initial simulation will be discussed in conjunction with animation in Chapter 3.

Animation has evolved from hand-drawn and claymation style to the present form of computer generated animation. Terms such as keyframing and dope sheets that originally referred to hand-drawn animation have transitioned into digital animation while

techniques like pose-to-pose and straight-ahead have been applied to digital animation pipelines. These terms and techniques will be used and applied in the next section, which explains a workflow for computer animation pipelines using terms that were explained in this section.

CHAPTER THREE

ANIMATION WORKFLOW APPLICATION

3.1 Proposed Animation Workflow Overview

Many animation studios have developed a workflow to expedite the process of animation while taking into consideration limited human and time resources. A computer animation program in an educational environment also will benefit greatly from an animation workflow that considers available resources and that takes into account directorial decisions and pipeline issues. The animation workflow proposed in this work is targeted to help academic programs and is designed so that rough animation can be considered early on and any changes can be made at the beginning stages of blocking. By following this workflow, the animator will not waste time on animation that is either unusable or not what the director originally intended, and the production will be more efficient overall. Because of the small groups that educational environments usually create for projects, individuals may have multiple responsibilities; the proposed workflow will add the responsibility of cloth setup and preparation to the animator, as this situation is likely to occur in an academic setting.

There are several important goals this animation workflow is designed to accomplish. First, the procedure will provide a clear and concise path or system for an animator to follow. By following this path, the animator will not expend all his time and energy creating potentially unusable animation, but will work resourcefully with each section of the animation process. They will expend the minimum amount of energy in the beginning

until the blocked animation has final approval from the governing body. After the initial blocking and timing, the animator will add the final touches to refine the animation, expending most their energy at this point.

Second, the workflow allows for the director to view rough animation in a semi-complete form for critique and approval. Without this workflow, critiques often only come when the animation has been almost completed, and camera angles might only be decided after or during animation. In such circumstances, scenes might have to be restarted from scratch because they fulfill neither the original ‘vision’ nor ‘intent’ of the director. Through the proposed workflow, all animation should be constantly reviewed and critiqued up to a point; the director can decide or experiment with various camera angles until making a final approval without wasting the time and energy of the animator, which equates to money in professional studios.

Third, because of the relatively small size of student projects or smaller companies, many members will have multiple responsibilities in one production workflow. This system will combine what is usually the setup artist’s job in professional studios—laying out the characters and backgrounds and timing considerations for the animator—with that of the animator. By having the animator aware of what needs to be done for cloth simulation, they can properly setup and key the character in their proper t-poses and positions before animating, hopefully reducing cloth issues for the simulation department.

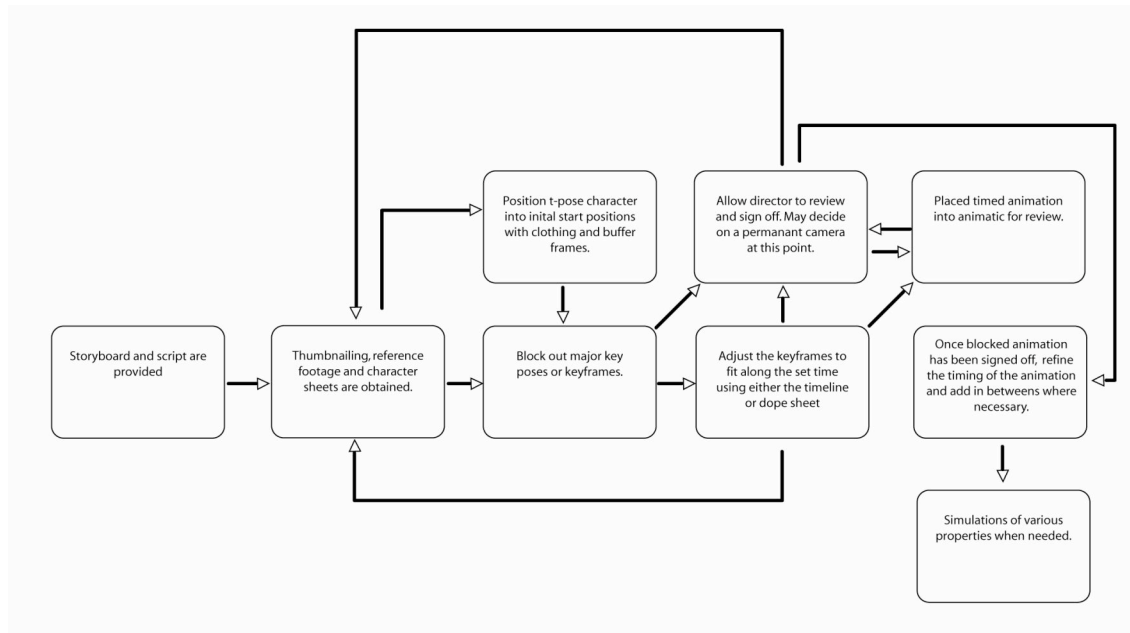


Figure 3.1: Proposed animation workflow

Ideally, all major creative decisions, camera placement, and motions will have been intensely considered and made during preproduction. Part of the reason for storyboards is to define an initial camera placement. The placement of the camera as it relates to the character will sometimes also determine how much of the character should be animated. For example, if the camera's viewpoint is mostly around the face, most of the animation can be limited to the face and some of the upper body. However, if the shot does not flow with the rest of the film or the composition is slightly off, a new camera position might be decided later; this decision can adversely affect the animation, possibly producing the need for animation in the lower half of the character that was originally out of view. The flow has been disrupted and the animation will have to be redone to suit the needs of the adjusted shot angle.

Figure 3.1 is a diagram of the proposed animation workflow. Beginning with storyboards and an initial script, the animator will obtain a general idea of what the shot or sequence will entail, usually while talking with a supervisor or director on the needs of the scene. Once an understanding of the shot is obtained, the animator will research and obtain references for the needed actions and may sketch out some poses for the actions. As the animator feels comfortable with where the animation will begin and end, they may begin to block out the primary poses of the animation. Once the major poses are finished, the animator will move and adjust the keys for timing. At any point during these two sections of the workflow, the animator can call upon the director or supervisor to review the current state of progress.

What is different about this animation workflow is that the blocking and timing are separate. Whereas most studios would have the animator block out the major movements and timing in one pass, this workflow allows the animator to first focus on the poses of the character. Then, timing can be adjusted by moving those keyposes until the action is timed correctly. Timing can be a difficult element of animation for a first time animator, but by separating animation into two distinct phases, the animator can focus on each section independently before pulling everything together.

At any point during the blocking and timing phase, the animator can scrap the current animation and start from scratch if needed; reasons can range from personal dislike, to change in story path, to a new idea for the shot. The first two phases of blocking and timing are designed so that animators do not expend massive amounts of effort to create the basic animation, and that if changes are introduced, there will not be a large loss of

time and money. Once the shots are blocked and timed, the director can view the scene with other shots and place it in an animatic if needed. It is also critical at this point for the director to make a final decision on camera placement. Professional productions will have everyone follow what the storyboards used as the camera placement, but smaller productions allow a more flexible decision process regarding the placement of cameras.

Each section of the proposed animation workflow (Figure 3.1) is designed so that animation is done in incremental steps, with reviews after each stage. Since the steps are broken into manageable chunks, the animator has a clear path of what to do in each step; this setup also gives the director a good sense of how the animation is progressing and at what point it can be completely signed off.

The major advantages of the proposed workflow are to allow directors, producers, and the group to view and evaluate the animation in a partially completed and timed state, and to give the animator a systematic path in the animation process that never fully expends their energy on a single shot before having the final sign off by either the group, director, or artistic lead. By maximizing the time and energy of the animator and giving some leeway for decisions involving the current state of the animated shot—especially at the start of the animation—a more efficient workflow is created that does not waste resources.

3.2 Initial Setup

Before any type of animation can be done, certain aspects of Maya must be configured to allow for optimal performance. These configurations are intended to let the animator have easy access to commonly used tools. By making the interface as accessible as it can be to animators, they can work more efficiently and consistently across days and different computers.

Another thing to consider is the creation of a script that selects all the controls on the control rig. By creating this script, the animator can simply click the script to select all the controls and set the keyframes by hitting the 's' key, as opposed to selecting each control separately. This will assist the animator by allowing them to key the entire body for each key movement, focusing on the specific action pose rather than wasting time selecting controls to keyframe. Setting up a simple selection script can either be performed by the animator or a technical director at the beginning.

3.2.1 Maya Screen Setup

The Maya user screen should be set up to accommodate the animator as much as possible. Figure 3.2 shows one screen configuration that might work for animators. It is designed for a moveable perspective view and a set camera view if the camera has already been decided. Below the two screen perspectives lies the graph editor. Through the graph editor, the animator can switch between the various tangents to use in whatever ways that are needed at a given time. The graph editor can also be replaced with the dope sheet when performing lip-synching, or if the animator prefers the dope sheet, it can be

used as the initial setting instead of the graph editor. With the perspective window and set camera window side by side, the animator can animate in one window free of restrictions while noticing how the action will be viewed in the actual camera window. By pressing ‘spacebar’ over each window, the animator can switch effortlessly between the viewing screens when required.

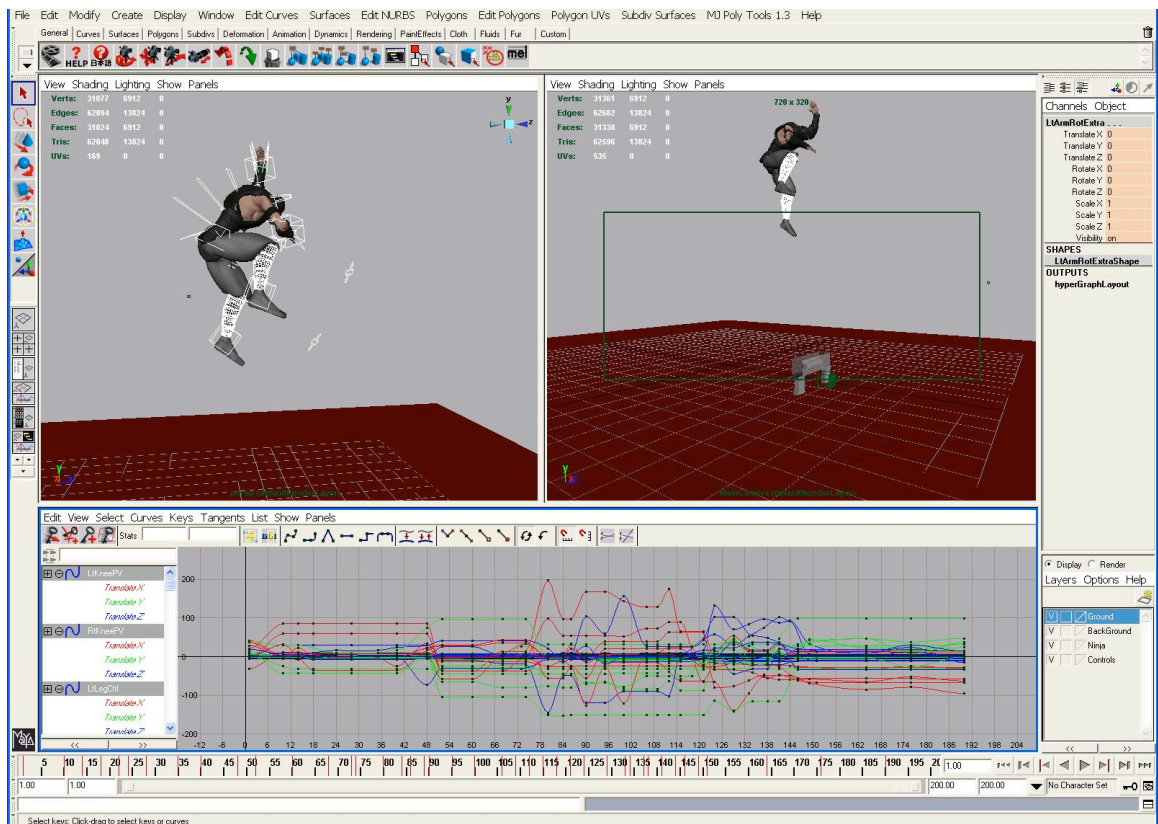


Figure 3.2: Viewscreen Setup

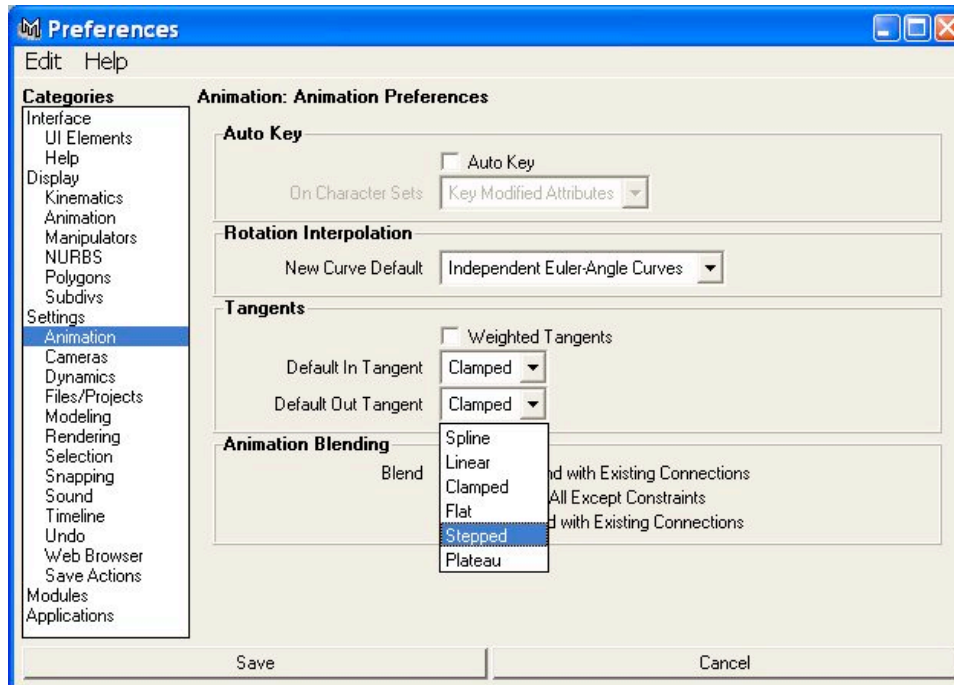


Figure 3.3: Animation Blending Preference Setup

3.2.2 Interpolation Settings

As discussed in Chapter 2, Maya has various interpolation settings to assist in transformation of various objects within Maya. Once the blocked animation meets the approval of the director and gets signed off, final animation and refinement can begin. However, the initial setting that is used in the animation preferences will determine what interpolation algorithm will be applied to each subsequent key. As seen in Figure 3.3, when the animator first begins the blocking process, the animation settings should be set to stepped tangents to make timing the animation easier. Once the animator begins final animation and refinement, the setting should be switched to spline to allow for smooth

transitions for in-betweening. This setup will again be noted in the sections on the initial blocking phase and final refinement pass.

3.2.3 Storyboards

At Clemson University, during the Digital Production Arts program's production of *Spacecat*, a 6-minute animated short created in 2005, many of the storyboards weren't actually followed, somewhat defeating the purpose of storyboards. The initial composition of the characters and environment as provided by the storyboards was not used or even considered, much less the camera placement. Issues such as camera position and how much to animate were directly affected by not following what was laid out. Following storyboards is very important, as they provide key moments of actions that give the animator ideas as to how to properly produce the necessary movements.

While in the process of animating for the project *Mileena Malign*, a 3 minute animated short created in 2006, the placement of the camera and composition of the shot was already decided in preproduction. Figure 3.4 shows a shot by shot comparison of various rendered animated scenes and the original storyboarded shots. By setting the composition and camera at an early stage and never deviating far from it, the group was not faced with issues that involve too little or incorrect animation due to changed camera angles. Even if some of the characters' poses do not match exactly the intended storyboards, the composition of each shot and their relation to other shots were still useable, allowing for shot continuity throughout the final animation. The preproduction stage should not be overlooked as it so important to efficient and timely animation. That said, it should be recognized that as animation proceeds and sets are modeled, camera

placement might need to change. In addition, the story might continue to evolve, necessitating a change in camera direction, costumes, hair, lighting, and other considerations. This workflow will take these necessary changes into account at an early stage by allowing the director to preview the rough animation, making decisions off of those shots, rather than the final, fully animated shots.

Original Storyboards

Rendered Scenes

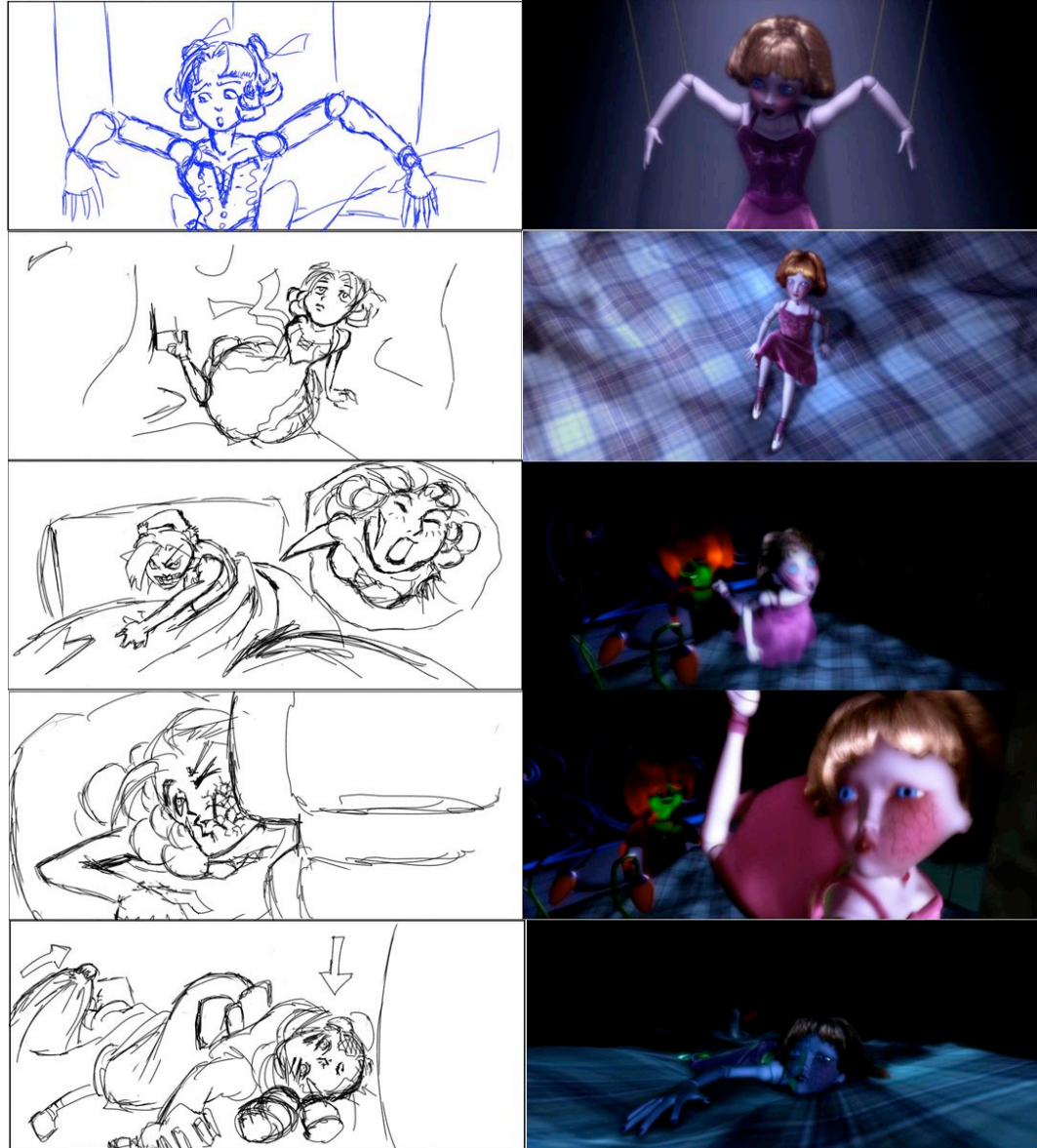


Figure 3.4: Storyboard and Render Scene Comparison of *Mileena Malign*

3.3 Step 1: Blocking out the Animation

Blocking animation is the beginning of the proposed animation workflow. It is at this point where the animator starts to block out the major poses. The purpose of blocking out a shot is to obtain a quick and rough animation of all the key poses. A good analogy would be manipulating an action figure to create the major poses of an action. Once the camera angle has been configured, the actual animation can begin. We begin with a rough setup of the animation, detailing the major steps that the character will go through. The animator can either draw actions on thumbnails to get the initial idea of how the shot is to be performed or follow the storyboards.

3.3.1 Thumbnailing

There should at least be a general idea of what actions are taking place and how the camera placement and composition will be affected. Hopefully the storyboards will provide most of the information, but if something is not available, the animator can roughly sketch out some poses that the character will go through. A very quick and easy way to create rough motions is through thumbnail sketches. Even veteran animators from Disney will generally draw some quick, small sketches to assist in the actual process of the animation [Cordingley 2006].

3.3.2 Stepped Tangent

When beginning using the pose-to-pose approach, it is best to set initial tangents as stepped. Refer back to Figure 3.3 for the animation preference settings. Alternatively, the animator can select all keyframes in the graph editor and convert them to step tangents at a later point. There will be no smooth linear translations, but a quick, if somewhat stiff, transition from one pose to the next, allowing the animator and lead(s) to see the timing of the animation more clearly.

3.3.3 Blocking

After setting up stepped tangents where needed, the animator can begin the actual process of blocking. Blocking animation is the process of working on the key or major poses of the character and only those key poses. By focusing attention on each individual pose, the animator can take into account the full body motion and movements, as well as how each pose interacts with the camera position. Bear in mind that the blocking in this animation workflow should be done with full-body animation as opposed to localized animation. In major studios, the camera placement of a scene as well as character setups will have been done for the animator by the setup artist. If the camera has already been set in preproduction, the animator knows that there will be very little change in the camera's position, so if the camera is pointed mostly at the face and upper body, the animator will not have to worry about animating the lower body. However, since student run projects have much more leeway in terms of camera positioning, changes in a camera placement may adversely affect the animation, such as the decision to pull the camera

back to reveal the whole body as opposed to just the upper half. Using full-body animation during the initial animation stages, the animator can block the character with the entire body at little extra cost in time, and if there is a change in the camera, the animation can still be used.

While blocking out the initial poses, many animators set keyframes on every fifth frame; for example, set a key on frames 5, 10, 15, etc. At this stage, the animator should not be focused on the timing, merely on posing the character(s). Blocking out the poses on every fifth frame keeps all the keys organized, making corrections easier at this stage. With organized keys, the animator can more easily read and redirect the keys in the next step of the process, which is timing.

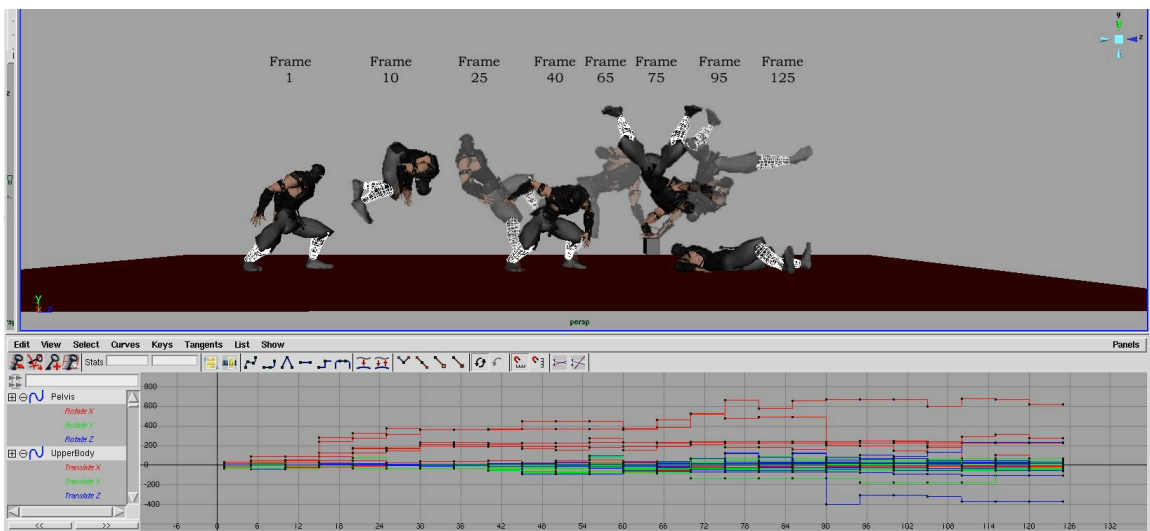


Figure 3.5: Blocked diagram with animation curves

3.4 *Step 2: Adjusting the Timing*

The next pass involves adjusting the timing of the keyframes, which is where some animation systems differ. Whereas most animators might work the timing and blocking into one pass, the system makes it into two different passes. Timing has always been an issue, especially creating character animation that fits into a limited amount of time during an academic project cycle. By separating the rough blocking and timing, the animator can play with the timing until it suits the director or it matches with the audio if sound has already been added into the animatic.

Since the animator keyed only on every fifth frame during the blocking phase, there is an ordered structure to the keyframes, making them easier to read, but there is no sense of proper timing from this stage. As seen in Figure 3.5, all keys are in a very symmetrical order for manipulation. This allows the animator to know exactly what to move in order to obtain a more refined, and most importantly, a timed animation. During the course of adjusting the keys, it is best to select all keys on that frame and move them as a whole. By doing this, all controls (hip, arms, clavicles, etc.) of that key pose will still be on a single frame. The animator will eventually break the ordered structure, but at this point, the ordered key structure will serve the purpose of making the graph readable, understandable, and ordered for the animator.

It is important to note that there must be a general idea of the timing involved before proceeding to this stage. This can be accomplished either through viewing filmed reference footage used for timing, or by the animator timing out actions themselves. In

some cases, pre-production has already performed the work of timing all shots so that everything fits. Even if the timing is still in its initial stages, some time requirements might help the animator fit the animation into a timed environment; for instance, preproduction may have already spliced the audio files together. With the combined voice files, the animator begins to time out the blocked animation in tune with the voice acting.

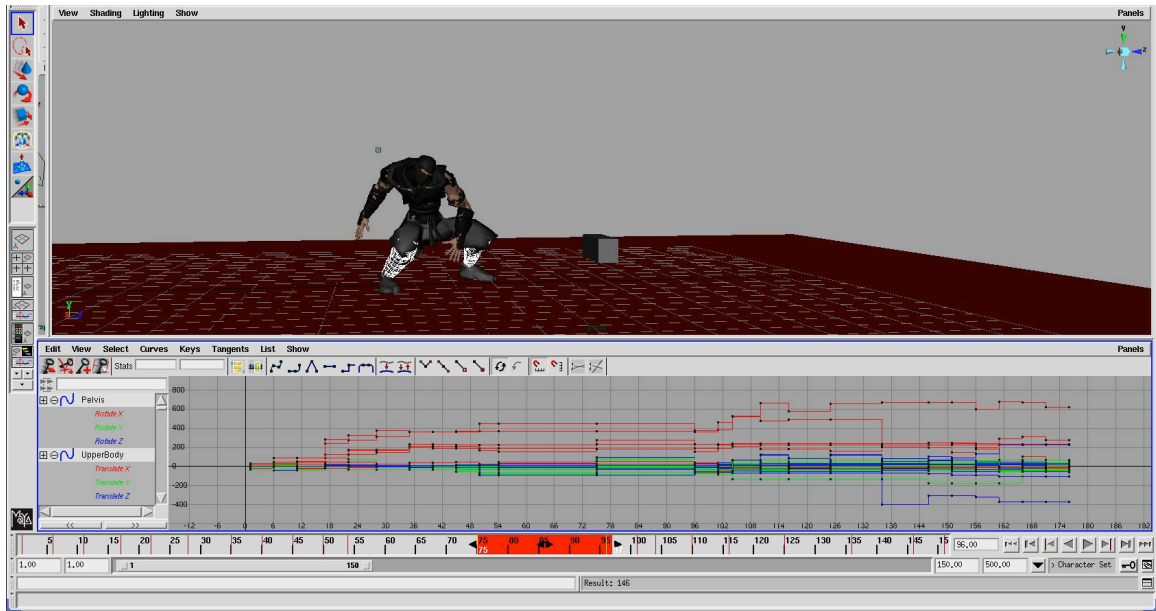


Figure 3.6: Adjusting the Timing along the Timeline

3.4.1 Timeline Manipulation

There are at least two ways to move the keys along the timeline in Maya. In the first method, the animator can move the red key ticks along the timeline at the bottom of the viewer. The second method is to adjust the blocks of keyframes along the dope sheet

or grab the animation points available in the graph editor. Both techniques perform the same function, so which is used will depend on the animator's preference.

The most direct way of adjusting the timing is through the timeline along the bottom of the screen. By selecting the red tick marks along the timeline, the animator can cut and paste or move keyframes to the positions needed for the execution of the animation. By holding shift and middle-mouse dragging along the timeline, a red bar extends, allowing multiple keyframes to be moved at once. Whatever the red bar encompasses is within its field of manipulation.

In Figure 3.6, the red bar located at the timeline is one way to time the keys as described in the previous section. Another way would be to use the graph editor position under the character view screen to move and adjust timing. Alternatively, the animator can use the dope sheet to adjust timing as seen in Figure 3.7. The dope sheet is particularly useful when trying to match facial blendshapes to prerecorded audio files, also known as lip-synching. As opposed to the tick marks that are created along the timeline, the dope sheet allows the animator to use audio files as a reference and provides a better visual representation of each keyframe on each channel for matching lip movements.

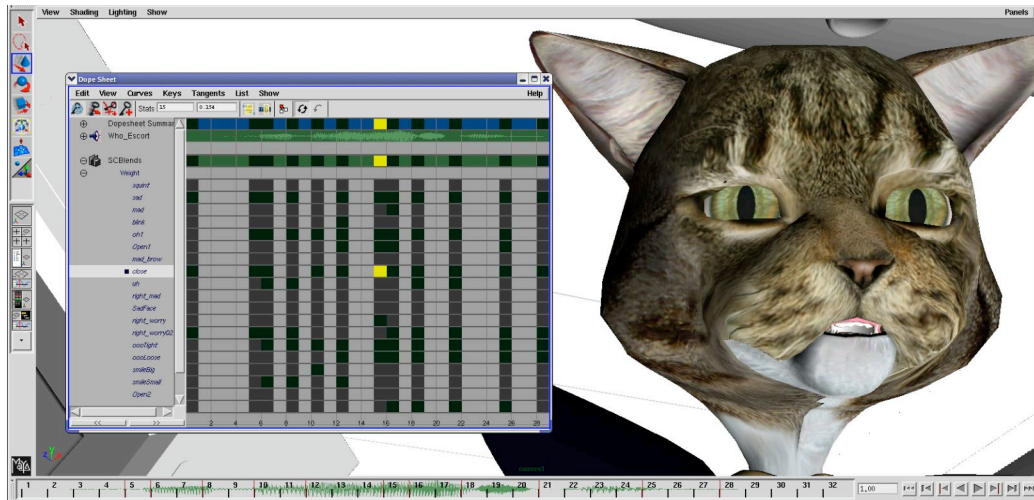


Figure 3.7: Blendshape Timing Adjustment through the Dope Sheet

3.4.2 Review and Decisions

Once the rough, blocked animation has been completed, it is time to decide on the camera placement or animation changes that might be required by the creative directors. At this point, the animation is timed to the point where it can be placed into an animatic for review as well. Final camera placement is needed to determine whether or not the animation needs to be changed. Since the animator has performed full body animation as opposed to localized animation, the position of the camera is not restricted to a specific area of the character; this will give more freedom for the director to decide between various camera angles to capture the action or emotion of the scene. By making decisions at this early stage, the director has a say on the current animation and the animator has not wasted a large amount of work. If the animation needs to change, whether due to some problem with the action or simply because it does not work with other shots, it can be changed or even completely redone with relatively little extra effort on everyone's

part. This gives the animator the freedom to create a timed and animated shot without expending all their resources if the director decides it does not work.

3.5 Step 3: Refinement of the Animation

Once the animation has been keyed to the point where the timing is set and the camera angle has been decided upon by the director or group, refined animation can be created. The animator should set animation blending preferences back to spline before proceeding (refer to Figure 3.3). As the director has signed off on the shot at this point, there should not be any more changes to the camera placement or general blocking and timing of the animation. If further changes need to be made, they should be decided before the animator reaches the final refinement stage. If drastic changes are made after the shot is fully animated, the animation most likely will have to be completely redone, therefore invalidating the work and the workflow. Thus those in the production must agree to live with the choices made up to this point.

Refining the animation is the most laborious process of this workflow, which is why having director (or lead) sign off on the shot before this point is so crucial. It is at this point where each action is refined to the fullest extent. Follow through, overlapping motions, anticipation, and arcing are added and must be scrutinized and adjusted to where they meet the requirements of the director. This is the time where the animator must expend all their energy to create high quality animation that meets the standards of the production. Of course critiques from the director or lead(s) are to be expected at this point, but they should relate to details of the animation, not to general blocking and timing, nor of camera angles.

The animator can begin work by deleting or offsetting keys using either the timeline or graph editor. As mentioned earlier the symmetrical nature of the keys are broken at

this point in the workflow, and the animation tangents may start to look chaotic (Figure 3.8). It is because of the far more complex and chaotic animation graph that any major decisions should be done back in the first two passes: obviously major changes at this late stage are complex and often require more time to fix than starting over again from scratch. To refine animation, one can start by simply offsetting the arm controls several frames behind the legs to give the character a sense of looseness, and progress to more and more complex and subtle adjustments to the blocked out animation, in the end producing the desired character action.

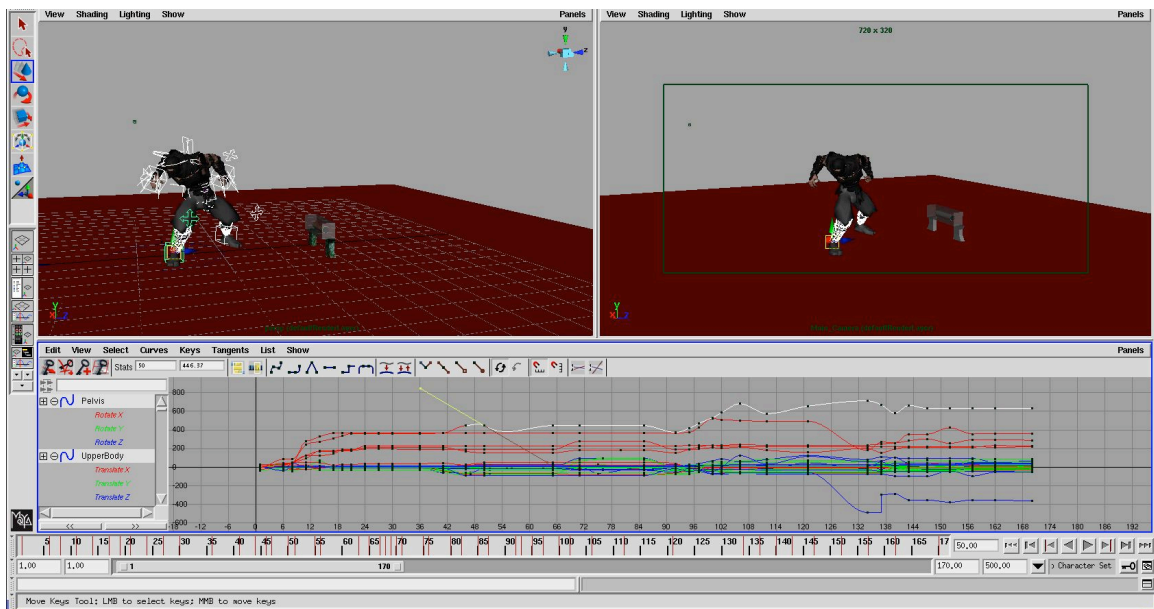


Figure 3.8: Final Animation Refinement through the Graph Editor

3.5.1 Interpolation and In-betweens

Because Maya automatically interpolates between each keyframe, the animator can use the interpolated keys to assist in the manipulation and keying of in-between frames. If we look back at Figure 3.1 as an example, we see the key poses for the ninja character in the start position on frame 1 and the midair twist on frame 10. By allowing the computer to interpolate between those frames, the animator has a rough place to work from. Default interpolation, however, will rarely give the animator the perfect in-between pose: it is up to the animator to use the set of interpolated poses as a basis from which to create the correct timing and position and then allow the animation to flow along a coherent line of action.

3.5.2 Graph Editor Adjustment

The graph editor is a valuable tool at this point for the animator. By using the available tangents to the animator's advantage, the animator can manipulate the various animation curves and in-betweens to create complex animation without having to overload the scene with too many keyframes. For instance, if a certain motion does not feel like it has enough follow through, one can adjust the tangents until the arcing gains more visual appeal rather than having to place keys on every in-between frame. In Figure 3.8, the graph editor and timeline shows a very complicated and sometimes confusing set of adjustments. This complexity is common to most fully animated shot sequences, with

keyframes all over the timeline. To stop at this point and redo the entire scene again would be a tremendous waste of time and resources, which reinforces the importance of having director signoff early in the animation process.

3.5.3 The Role of Cloth

Special effects and animation studios have started to include various dynamic simulations into greater and greater numbers of their productions. Many animated features, such as Pixar's *Incredibles* (2005) and DreamWorks' *Shrek 2* (2004), include complex cloth systems to enhance the visual appeal and realism of the characters. Dynamic simulation has become so ingrained into the production pipeline that some studios have created a separate department solely for dynamic simulation. Many recent projects within Clemson's Digital Production Arts program have also used dynamic cloth systems in various projects. As seen in the projects *Mileena Malign* and *Tartan Troubles*, dynamic cloth simulation can add secondary animation to the characters or the surrounding environment. By adding cloth preparation to the animation workflow, the animator can assist in partial setup of the character or even combine the abilities of both an animator and technical animator, thereby expediting the workflow process. However, there are pitfalls that need to be avoided for technical animators to properly simulate a particular animated sequence.

Most studios will begin cloth simulation once the animation for a scene is fully completed and signed off. Simulating anything before a fully animated scene would not be in the interest of the technical director, as changes in the animation would almost

surely adversely affect the cloth simulation; however, the technical director can test settings on the cloth during the rough animation stage to obtain an initial set of values to work from for final simulation.

3.6 *Syflex Cloth Preperation*

Syflex is both the name of a company that specializes in cloth simulation and the software that produces cloth simulations through a plugin for high-end animation packages. Films such as *Pirates of the Caribbean*, *X-Men 3*, and *Superman Returns* have used the software to simulate their cloth requirements. The software's ease of use and stable simulations have made it a favorite for many studios looking to implement cloth into their production pipelines. This thesis describes how to properly set up and key the character in preparation for cloth simulation with Syflex as a model. While an overview of the simulation itself will be presented, the paper will focus on setup rather the simulation itself.

To begin with, as the animator prepares the animation, several keyframes, or buffer frames, need to be set in order assist in the cloth simulation. In addition, the character must be situated in the correct beginning position and pose for the simulation to run as smoothly as possible. By having the animator perform these preparatory steps, the simulation department will obtain a better lead up into the actual simulations, resulting in faster, more efficient and better simulations. These buffer frames and starting positions will assist the technical animator when they set the initial simulation, helping maintain coherency throughout the simulation.

3.6.1 Initial Character Setup

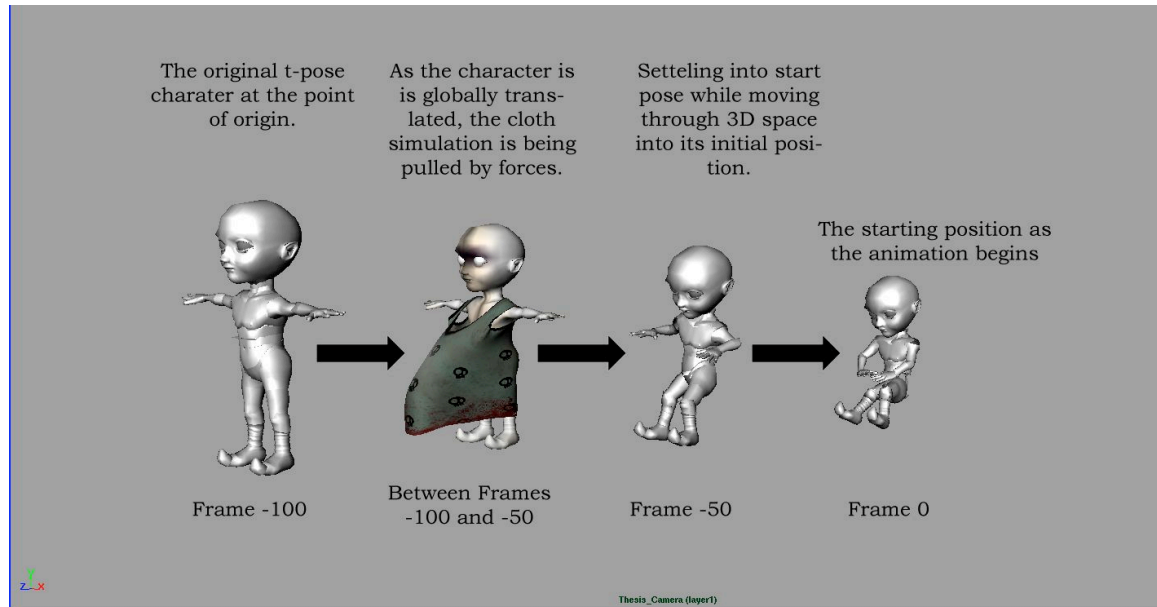


Figure 3.9: Incorrect Cloth Setup Diagram

Two issues arise if the animator has not set and positioned the character correctly or if not enough buffer frames have been provided. If cloth simulation begins when the character is not in the default t-pose or is transitioning through 3D space into the starting pose of the first frame, the cloth simulation can become very unstable from the start. Since the character is moving to the starting frame, all forces are already active and will affect the cloth by pulling it through the preset gravity or other forces. Once the model has moved into the start frame, the sudden change of motion on the model can cause the cloth to penetrate the model, causing difficulties later on.

The second issue that arises concerns buffer frames. If not enough buffer frames are allowed, the simulation may not be given enough time to properly settle into its starting

position before the actual animation begins. When a simulation begins, the forces acting upon it may cause extreme behavior in the cloth; eventually, the cloth will stabilize to the forces applied to it. However, if the character or object begins primary animation before the cloth stabilizes, the cloth can be in an unusual state, and the collision detection may disrupt the simulation, causing an unstable, unsightly simulation.

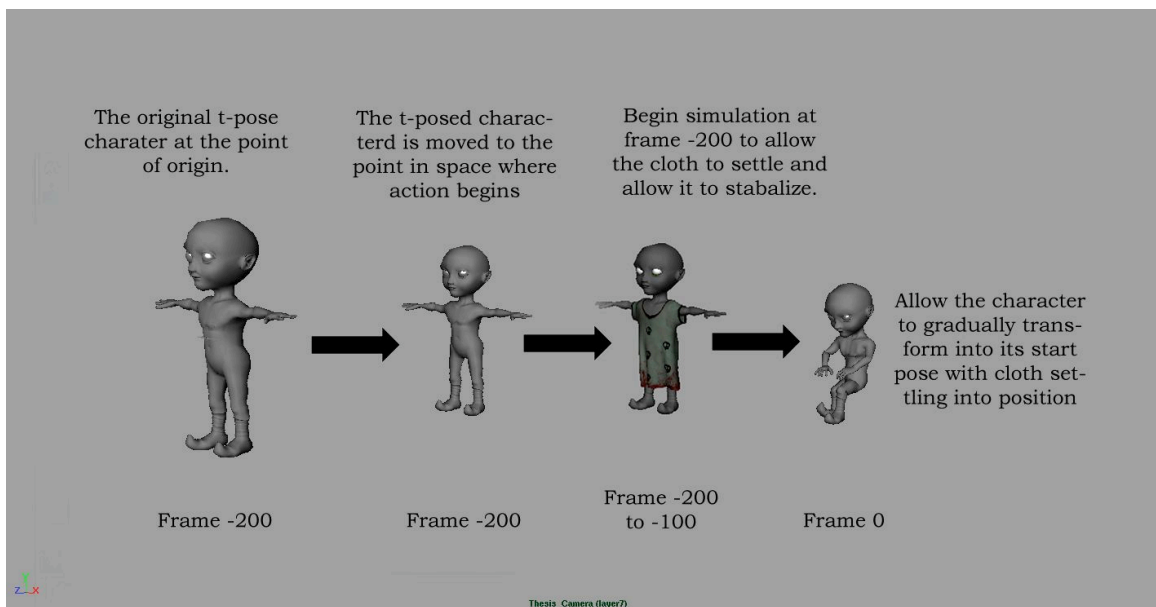


Figure 3.10: Correct Cloth Setup Diagram

To correct this situation, the animator or setup artist places the character, still in its t-pose, in 3D space where action will begin if the action does not start at the origin. This way, the cloth can be positioned where the character action begins without the cloth having to follow the geometry as the simulation begins. In addition, setup animators need to allow enough buffer frames from the t-pose into the first pose (where the primary

action starts), and for the cloth to come to rest in the initial pose before primary animation begins. A setting of 100 frames should give the cloth enough time to settle onto the t-pose, thereby stabilizing and allowing the technical animator to see if initial settings are useable. If the settings are ideal, then the simulation can settle into the start pose.

Once the character model has been positioned where it needs to be to begin the action for the shot, another 100 frames must be allocated for the stable cloth simulation to adjust and come to rest as the character transforms to the start pose. In Figure 3.10, the Mileena character is globally placed into the position in which the action will begin. At frame -200 to -100, the cloth will initially settle and stabilize to the t-pose of Mileena with current forces applied to it. At frames -100 to 0, Mileena will position itself into the starting pose of the animation, allowing the cloth to simulate and settle properly in that position. By following this method, inaccuracies or problems with the simulation will be reduced.

3.6.2 Initial Simulation

Syflex provides a variety of tools from physical forces such as gravity and wind to keyable attributes of the actual cloth itself to simulate a variety of materials such as silk and leather. While obviously a leather jacket in a vacuum will move differently than a cape blowing in a strong wind, refining the actual cloth simulation is outside the scope of this paper. Instead, the thesis will describe a small set of tools used to obtain an initial stable simulation that can later be modified by the technical animator to produce the exact result desired.

Even though in our setup, the cloth has been given a buffer of 100 frames, heavy scenes or extreme start poses may require more time for the cloth simulation to stabilize. Syflex has a feature which allows the simulation to continue running along the timeline without having the animation begin. By selecting Syflex Live Mode, cloth can continue to simulate without any type of animation driving it, thus allowing the cloth to come to rest using the model's current position before animation occurs. This tool works incredibly well when the buffer frames provided are not enough to allow the cloth to settle properly into its starting pose. Live Mode also allows for real time adjustment of the simulation. By changing settings on the cloth, forces, or collision objects, the changes to the cloth interaction will occur as the Live Mode is on, providing an excellent way to refine a simulation if needed without having the animation drive it.

However, live mode should be used only if the simulation has already been settled to a point where the current parameters are acceptable. What this means is that the current settings placed on the cloth, collision objects, and other forces work and that only minor

refinement is needed. This option should be used at the start of frame 1. Once live mode has been initiated, the technical animator will not have the chance to go back and re-simulate from the t-pose. Instead, the cloth will fall into the form and position of when Live Mode was initially switched on.

At certain times, the initial simulation may reach a point where everything works except for small areas of the garment where the cloth penetrates itself; this problem will likely occur around the armpits where the arm may contact the character's side. Resolving this issue can be done in several ways, but we provide two tested solutions. The first is to cache the simulation by giving it a name in the attribute editor of the Syflex cloth node. Once the simulation is cached, the technical animator can go into the areas of inter-penetration and either manually pull the vertices out from one another or use the sculpt-polygon tool to push, pull, and smooth the areas of penetration.

The second way to remedy the situation occurs before enacting the simulation by painting influences on the cloth. Syflex allows the technical director to paint a variety of maps based on the forces and nodes connected to the actual cloth itself. By right-clicking on the cloth object, and going to the paint section, any nodes applied to the cloth will appear. From here, the technical director can select the appropriate syCloth node and paint on the polygonal object's areas of influence. If too much influence in a certain area disrupts the simulation, the technical director can remove some influence around that area. These are but two ways to smooth out minor issues in cloth adjustment and refinement.

By having the animator properly prepare a character for cloth simulation during the animation section of the pipeline, technical directors receive a character optimized for initial cloth simulation. In some cases, the animator can even setup cloth with all the initial settings, reducing some of the setup work for the technical director so that they can focus on simulating the rest of the sequence. Given how small some school productions are, an animator that can also simulate will be a great advantage to the team.

3.7 *Summary*

Above we presented a workflow designed for a small studio or academic production environment. Numerous elements are discussed that can help increase the efficiency of these productions. First and foremost, it is ideal that all camera angles and composition of characters and objects be decided in the preproduction stages. In hand-drawn animation and claymation, almost all aspects of the characters and their actions are decided beforehand. However, this workflow takes into account the fluidity of animation production, and gives the director and animator some leeway to decide on proper camera angle and composition at a later point in production.

The first pass is where the animator begins to block out the shots. Using some of the storyboards or thumbnails as a point of reference will allow the animator to have an idea of where to center and focus most of the action at this stage. By setting the animation curve settings under the preferences to stepped tangents, the animator has the ability to focus on each key pose and the full body action rather than worry about timing at this stage. At each key action pose, the animator keys all controls to the specific pose that is desired. By blocking every fifth frame, all the keys are in an orderly fashion for manipulation later on. Using full-body animation as opposed to localized animation, greater leeway is allowed for camera placement. The animator is not focused on timing at this point but rather on all the major actions that will be taking place.

The second pass involves movement of the keys to fit in the timeframe and action needs for each shot. If the timing for the shot has already been planned out through video referencing or an animatic, the animator can start to move the keys to match the reference

footage. By either selecting all the keymarks on the timeline or through the dopesheet, the animator can still keep an orderly construct of keys when doing gross adjustments on the timeline. Once all actions have been set to the proper timing of the shot, the animator can convert keys to a spline tangent to view interpolated actions. As all tangents are smoothed out, the animator and lead(s) now have a rough idea of how the animation will work with the camera angle and amongst other shots. It is at this point that the director, animator, or group will come together and observe the shot either by itself or in the context of an animatic.

The third pass involves refinement of the animation into its final state. At this point, we can use the interpolation capabilities of Maya to assist in the in-between frames of our action. The animator will key in any necessary in-between frames or extra action frames and adjust the animation through either the graph editor or dope sheet. By using the available animation tangents, the animator can further refine the animation. By this point the timed and blocked animation should have been signed off on, with the camera position already set by the director, group, or animation lead. Therefore there should not be any major changes at this point, other than the quality of the animation itself, which allows the animator to focus on excellent animation performance rather than worry about whether the shot will work for the director. Going in different directions or completely redoing the animation after this point would be a waste of all the time before that; there would have to be a very good reason why the current animation does not work to justify completely redoing a shot at this point.

The goal of the proposed workflow shown on Figure 3.1 is to produce animation in an efficient manner while considering the needs of the animator, the director and the overall direction of the film. Through blocking and time adjustment in the beginning, the director has the ability to look at the animation in its rough, yet useable, state, and make decisions on the viability of the shot without any major wear on the animator. At any time during the first two passes, the director has the ability to preview where the animation is heading and can provide critiques or suggestions for the shot as a whole. These partially completed shots can be placed in the animatic to see the flow of the film and give more information to the director as well. If the shot needs to be redone, the animator has not spent an enormous amount of time and can go back and redo the shot if necessary. Once the shot has been signed off, the animator can move onto the final pass of this workflow with confidence, focusing all their capabilities in producing and refining the animation to its fullest quality.

CHAPTER FOUR

CASE STUDY

The previous chapter discussed details of our proposed workflow and its potential advantages. In this chapter we will discuss the evolution and implementation of the workflow referencing two Clemson University Digital Production Arts productions. The first project, “The Adventures of Space Cat,” was what originally provided the inspiration to develop a computer animation workflow. Here we will describe the issues that were encountered in that project that lead to the workflow contained herein. The weaknesses encountered in Space Cat were corrected in the second project, “Mileena Malign.” However, different issues were encountered during the production of “Mileena Malign,” leading to a more refined workflow in the later shots of “Mileena Malign.”

4.1 The Adventures of Space Cat

“The Adventures of Space Cat” is a 5 minute animation project produced in 2005 and the first animation project that the author worked on. During the course of the production, we encountered the enormous logistical complexity involved in creating a digital short film. In particular, the limited human resources and time became a contributing factor to how much energy we could put into each shot. With no idea of what we were getting into, the animators proceeded by animating the characters in the only way they know: straight-ahead.

The animation system that was used in “Space Cat” can be considered a straight-ahead approach, but there was no formal system that was implemented to help the animators work in the production pipeline. The animators were given the script, storyboards, and general contact with the lead directors at that time. Because of the straight-ahead approach, animators worked straight through a shot, implementing in-betweens, overshoots, etc., in one pass, in essence, working up a fully animated shot in one effort based on the materials that were given them and expending all their time and energy on that shot. As mid-course critiques and reviews had not been provided for each shot, issues were encountered once the shot was given to the directors for approval, not only wasting time when major elements had to be redone, but causing morale issues with the overtaxed animation team.

The first and most obvious issue was creative decisions. With three directors overseeing the production of the film, people had different ideas on what the animation in each shot should look like. Because the shots were shown only in the near completed or finished form, changes would necessitate an entire reworking of the animation. Had some formal animation workflow been implemented, one in which early drafts of animation could be shown first, diverging creative decisions could have been made without too much more effort on the part of the animator if the animation needed to go in a different direction. Instead, entire shots had to be scrapped and reworked from the ground up, often at the last minute.

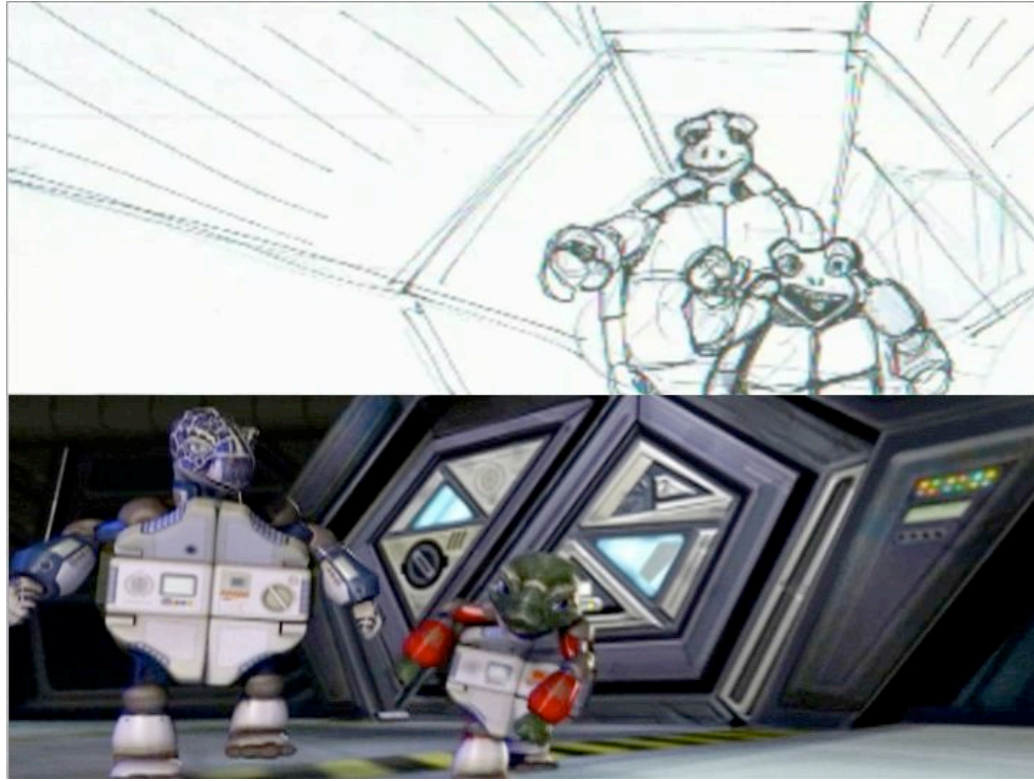


Figure 4.1: Space Cat Storyboard Comparison

From an animation standpoint, a little turtle child running up to a Space Cat can be done in different manners under various conditions, as seen in the comparison between storyboarded and realized shots shown in Figure 4.1. The turtle child could have been skipping, hopping, sliding across the floor toward Space Cat's feet, flying into Space Cat's arms, ramming him like a baseball, and so forth. The possibilities for animation scenarios are countless. However, since the animators had no way, or system, of presenting rough animation for directorial approval, the animation was created in one pass. Inevitable changes necessitated starting from scratch.

The second issue to be encountered was the camera placement and character and environment setup. In large studio productions, the job of setting up the scene and importing of characters with rough timing is the responsibility of the layout (setup) artist. However, for the Clemson animation projects, animators were also doubling as setup artists, obtaining the necessary scene files and objects and placing them into the scene themselves. In either case, the setup artist or animator must visually know how to layout the environment and place the characters in the proper position in regards to the camera, something that is usually shown through storyboards.

The storyboard shown in Figure 4.1 has the turtle child running up to Space Cat, with the inside of the spaceport terminal in the background. Two problems were encountered while setting up and animating this scene, the first being the scale of the set. Due to an error in communication and improper setup, the space station's scale was much larger than the characters that inhabit them. Because the characters relation to their environment was incorrect, and problems were encountered with trying to match backgrounds with character animation. Unfortunately this was not noticed until after animation was already created for several of these shots.

Because animation was produced using the layout of this incorrectly scaled set, the animation had to be scrapped after it was finished. The second problem was the placement of the characters in relation to their location inside the space station. According to the original storyboards, it appears the turtle family is walking and meets Space Cat inside one of the hallways protruding out of the space station. Having fully animated the scene inside the hallway, it was then decided that the characters should be

meeting inside the main room of the space station, and not in the hallway. Because the characters were already animated in the hallway, taking them out necessitated a complete reworking of the animation.

As expected, multiple reworks of the animation can be trying on the animator and costly to the production timeline. Because there was no path or system to work through, the animators had animated in a straight-ahead approach, which was not necessarily the best way to animate for the “Adventures of Space Cat” production given the time constraints. With no formal workflow implemented that a director could see and understand, animators were not fully aware at what point animation should be shown for critiquing, expending more resources and time than needed.

For the next project, we wanted to create a system that could solve the issues encountered in “Adventures of Space Cat.” A clearly implemented system that animators could follow, with each section necessitating minimal amount of energy expenditure until the final refinement of animation. A system that directors could follow and know at what points they were to critique and when they had to give final approval for animation, composition and camera placement. A system that allowed more time in preproduction compositing the elements of a shot, including the camera view.

4.2 “Mileena Malign”

After working through “The Adventures of Space Cat” and encountering many animation issues, it was obvious that the next project’s animation needed to be more structured. With the 2006 two-and-half minute animation project “Mileena Malign,” we implemented an animation workflow system that would help reduce some of issues encountered in “The Adventures of Space Cat,” primarily codifying the timeline for director’s decisions and creating a structured system for animators to follow. However, with the introduction of Syflex cloth simulation into the pipeline, unexpected new issues developed that necessitated some reworking of the animation workflow.

4.1.1 Preproduction

First and foremost, storyboards were essential to the efficiency of the animation workflow. As shown in Figure 3.4, whatever the team decided upon in the preproduction phase of the project was adhered to in later production stages. Because we kept to the storyboards, the environments were already set up properly and the camera’s position was already decided upon. For instance, any shot that involved the evil girl, Mileena, was only animated from the waist up, since her feet were never seen from the initial storyboards. For the Doll character, since the audience would view her entirely, we decided to do full body animation, even if the camera angle would not show the entire body. During production, some scenes did necessitate minor changes in the camera, but nothing so drastic that it required a reworking of the entire scene. One example of this is

when the Doll character is backpedaling from lifting the knocker on the door. The camera angle on this shot needed adjustment due to the Doll's motion across the screen, but because we had performed full body animation, changes to the camera did not need a complete reworking of the animation.

Before animation, scenes were worked out, such as visibility of characters, environments, and lighting, in preproduction through storyboards. Once storyboards were completed, and we had a good idea of what the entire story entailed, we started to obtain reference material. From models walking on a catwalk in fashion shows to various movies that provided good action sequences, we created an online set of resources available to the entire production team. Then we started acting out all the necessary movements for each shot; from a doll walking in high heels to an evil girl waking up from sleep, we acted out every single shot.

While an animator acted out the characters, one of the directors would watch and make comments about the actions and timing. Because of this early "live action" work, we were able to refine the timing and movement before we even did any animation. Creative decisions, such as framing and visibility of the characters, were carefully considered during this process. In the end, there was at least one individual who knew all the motions needed for the characters in all the scenes, a suitable position to lead animation for that character.

4.1.2 Production

During the actual production phase, the initial version of the animation workflow system was implemented. The core concepts were already in place: animators would first setup and block out major poses, and were only to continue once the blocked animation was good enough to be signed off by the directors; this process provided a systematic approach for animators and directors, while leaving some room for critiques by directors.

As for the issue of cloth simulation, originally animators and setup artists keyed the characters in the original t-pose positions first to allow for cloth simulation later in the pipeline. This method was, unfortunately, not robust enough for the production, and thus was modified during production of “Mileena Malign.”

The beginning of the animation process included blocking of characters into their primary poses. Using the storyboards as a guide, characters were placed into the scene and animators would begin blocking out major poses. Luckily, most of the beginning shots were only of a single character, the doll. In the beginning, we used linear tangents as a way to minimize movement between each pose. At any point, the animator could get a critique from the directors on the state of the blocked characters, usually pertaining to whether the poses were reading correctly or how the composition looked with the current camera setup. This continuous critiquing of the animation at this early stage allowed for better refinement of the poses with maximum efficiency.



Figure 4.2: Mileena and the Doll interacting with each other

Things became complicated in later shots, which required the doll and Mileena to interact with one another, as seen in Figure 4.2. If blocking out one character using linear tangents was difficult, blocking two characters interacting with one another was jarring. At this point, the linear tangent just was not working. The purpose of the tangents was to eliminate any in-betweens so the animator could focus only on the pose. While the linear tangents proved sufficient for a single character, even though there were still in-betweens, two characters animated in this fashion were difficult to comprehend and critique . At this point, we switched from linear to stepped tangents based on trial and error. Using this tangent, we completely eliminated all in-betweens, giving the animation at this point a very blocky feel. This worked out much better for the animator as they could focus only on the poses and motion of each character. It worked out so well, in fact, that it would have been better to start out with stepped tangents at the beginning, even for shots with just one character.



Figure 4.3: The Doll Walking

Once all the characters were blocked and approved, timing was the next issue animators had to tackle. By separating blocking from timing, the animators could focus first on the motion, and then on creating appropriate timing. At this point, reference footage was used to obtain the proper sense of timing. Even though we knew the necessary number of frames for each sequence, the animators still had to fit the necessary motions within the time limit. Unfortunately, this element of the pipeline ended up being rather flexible. For example, Figure 4.3 shows a shot of the doll walking slowly up to the gateway. Originally the shot was intended to be a quick walk, but when cut into the animatic, the shot did not convey the sense of foreboding needed. Fortunately since the animators focused only on blocking first, timing could be adjusted fairly easily by selecting the keys and spreading them further apart.

When adjusting the timing, animators continued using stepped tangents, which turned out not to be a good idea. At this point in the pipeline, it was necessary to get an idea of motion and weight that the character was going through, so once animation reached the timing stage, animators would change the initial tangent settings from stepped to spline, giving the smooth in-betweens necessary for animators and directors to view the animated sequence and make better critiques.



Figure 4.4: Doll Backpedaling

Once the directors looked at the roughly blocked and timed shot, they would sign off on the shot and final animation refinement would begin. Needing major changes in the animation caused the shot to not be signed, allowing the animator to correct the shot before undertaking refinement of the animation. The usefulness of this system was evident during the sequence shown in Figure 4.4, where the doll character was

backpedaling after the knocking on the door. Although the poses were solid, the actual timing became an issue, so it was not signed off on initially. Since all the poses were reading correctly, adjustment was a matter of manipulating the keys to a suitable timing. Once proper timing was obtained, the shot was signed off and the animator finished the animation by adding all the necessary tweaks such as overshoot, weight, anticipation, etc., knowing they would not have to start from scratch again.

At this point Syflex cloth simulation became a major factor. The initial idea was to key all characters in their t-pose position at the beginning of each scene file. This would allow technical animators to place the cloth on the character in their default position and then run the simulation. This would have worked if the characters had started moving at that exact position the t-pose started from, usually at the origin. However, the characters were not necessarily at the origin when animation began, and in the case of two characters facing and interacting with one another, at least one character had to be turned around. This caused problems for the initial Syflex simulation. Once this issue was detected, it was decided for all preceding shots to move the characters, still in a t-pose, to the position in 3D space where the start of the animation would begin. This way, the simulation would always be in one position at the beginning of the animation.

During the course of animating and simulating the cloth for the characters of “Mileena Malign,” the process of preparation of cloth simulation for the characters changed. From the beginning, the animators were to allow at least 100 frames for the simulation to first stabilize. However, the sudden change from t-pose to the first pose of the animation initially was only several frames, which caused the cloth to jump

erratically. The plan was altered to first give 100 frames for the cloth to stabilize into the t-pose and then a buffer of 100 to 200 frames to allow the character to slowly move into their starting position with the cloth following it. Later shots that were animated using this setup process of moving the character into starting position, allowing 100 frames before the t-pose, and 100 to 200 frames from the t-pose to starting pose, were much more orderly and saw fewer simulation problems than earlier shots.

By the end of production of “Mileena Malign,” we had created an animation workflow system that took into account the limitations of the character animators, directors, and technical animators, and gave them a system to work through. Because there was a system in place, the directors knew at what stages they could critique the animation, and at what point they needed to give final approval. In addition, the animator and technical director had a stable and useable method for setting up a character for cloth simulation. A setup process was developed through trial and error for initial cloth simulation and preparation that will help future Digital Production Art’s animation projects should they choose to use dynamic cloth simulation.

CHAPTER FIVE CONCLUSION AND FUTURE WORK

By applying the outlined workflow to the Clemson DPA project, “Mileena Malign,” the team was able to produce better-than-average animation given the time constraints and limited resources available. By first blocking out the animation and then adjusting the timing, all the while garnering directorial input, animators were able to work through numerous shots relatively quickly. In addition, the group was able to view several sequences together and was able to see if the action of each shot flowed with the others surrounding it. If not, the shot could either be adjusted, redone, or thrown out completely without having the animator expend all their energy finalizing animation that would not end up being used.

Still, the outlined workflow is not perfect. Most importantly, more work needs to be performed during the preproduction phase to improve the process. Major studios such as Pixar and Dreamworks spend almost a year in preproduction, working on the composition of each scene and the flow of the story while concurrently models and rigs are created during the later preproduction period. Storyboard artists, writers, and producers work in this period to refine the story and character personalities and the composition of each shot. Once completed, a working animatic with all the storyboards provides a much clearer path for animators to work from.

What the workflow described above tries to address is the lack of a path for animators to follow in a smaller production environment. Without a path, not even a director knows

when to critique and when to sign off. This system assists animators and directors alike by providing an ordered sequence of tasks necessary to animating characters in a timely manner. While presently DPA teams follow the process of storyboarding and story rewrites, there are currently few if any formalized critiquing sessions in the preproduction phase. Once some rough animation is available and then placed into an animatic, it is then that critiques and judgments begin in earnest. Issues such as camera placement and composition are discussed when they should have already been cleared during the storyboarding phase. Pixar’s story team works out all of these issues during preproduction so that the animators and setup artist can perform to their fullest extent without concerning themselves with issues that should have been taken care of already. Given that students in DPA are still learning the visual language of animation and building their confidence in critiquing given shots, however, the proposed workflow allows for more evaluation and changes at a later point than would be available in a fully professional pipeline.

The “Mileena Malign” workflow was designed so that everyone can view partially completed animation in varying stages—such as poses and timing—rather than simply still drawings, thereby giving everyone a solid idea of what the animation will look like when finished. Issues that get resolved at this point include not having a set camera placement, changes to large-scale animation blocking, or even alterations to the background of the shot. The critiques given are helpful and can make the animation better, but ideally they would be given earlier in the pipeline. Although our workflow addresses the issue of visually showing the animation in a rough state, future

considerations and changes could do away with camera placement and composition calls in the production phase, pushing them up into the preproduction phase. In such a case, cameras will be set and the storyboards will have all the character and object composition completed in the preproduction phase, and then this near final set of storyboards and script will be followed as closely as possible by animators, setup artists, technical directors, and compositors.

Because technical animation has started to play a more important role in current and future animation projects, the preparation work proposed in this paper takes into account issues that were encountered in the project “Mileena Malign,” such as allotment of buffer frames and the position of the character as they begin to move in 3D space. Normally the most crucial moment for simulation stability is the beginning, as forces start to act on the cloth. If not enough time is allowed for the simulation to stabilize, simulating the rest of the scene can become difficult. By having the character animator prepare these steps early in the animation phase, the technical animator will have enough leeway to first test the parameters and view which settings work. This preparation is not restricted to cloth but extends to other dynamic work including fur and hair systems.

Another issue to consider in future work is procedural or dynamic character animation simulations introduced in the animation workflow. There are commercial programs that assist in the animation of characters using rigid-body dynamics, involving physical forces making the character act in a realistic fashion. The programs that are currently out in the market can aid with certain actions such as dropping a body into a crumpled heap or falling down stairs and may benefit an animation that requires a hyper-

realistic animation. Setting initial animation key poses and then applying the algorithms based on these software enhancements can help reduce animation of highly complicated actions that are more suited for dynamic forces.

In conclusion, this system was developed to assist animators and directors in a small production setting by providing a workflow for them to follow, and to allow for appropriate technical animation. Using this pipeline, animators have a path and format to follow. Because there is a system in place, directors can view the animation in its varying stages and know when the final sign off must be made. Because future projects will incorporate more technical elements into their animations, a proper setup for simulations has to be adhered to and extended by the animator or setup artist. This workflow is a solid path for animators to follow to assist in the completion of an animated digital film. As computer graphics continues to evolve, so must this animation system change and adapt as well.

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