

DESIGNING A CHARACTER SETUP FOR A PREHISTORIC ANIMAL

A Non Thesis

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ABSTRACT

Character set up is a technical procedure within the field of computer animation that is defined as the skeletal set up and controls used to animate a computer generated character. This paper explores the character setup aspect of the production pipeline as applied to a case study of a prehistoric animal. The end result places this rigged prehistoric animal into an animated sequence (scientific visualization) entitled “**Jane’s World**” seen at the Burpee Museum in Rockford, Illinois. This production is a joint collaboration between the Burpee Museum and the Advanced Computing Center for the Arts and Design at The Ohio State University. This paper is intended for an intermediate level character setup artist and the technology used is from 2005.

Dedicated to my friends and family.

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TABLE OF CONTENTS

ABSTRACT	II
ACKNOWLEDGEMENTS	IV
VITA.....	VI
TABLE OF CONTENTS	X
LIST OF FIGURES.....	XIV
INTRODUCTION	1
1.1. PROJECT OVERVIEW	2
1.2. MY ROLE ON “JANE’S WORLD” AS WELL AS ACADEMIC AND PROFESSIONAL EXPERIENCES.....	4
1.3. THE DEFINITION OF CHARACTER TECHNICAL DIRECTION	5
1.4. WHAT DOES THE CHARACTER TECHNICAL DIRECTOR (RIGGER) ANALYZE	7
1.4.1. <i>Scale</i>	7
1.4.2. <i>Motion</i>	9

1.5. CHARACTER TECHNICAL DIRECTION GUIDELINES.....	10
1.6. WHERE DOES THE CHARACTER TECHNICAL DIRECTOR LOOK FOR REFERENCE	11
1.7. CHAPTER ONE SUMMARY.....	11
GENERAL RIGGING CONCERNS.....	13
2.1. CHAPTER TWO INTRODUCTION.....	13
2.2. WHAT TYPE OF MODEL DOES A RIGGER NEED?.....	13
2.3. HOW RIGGERS WORK FOR THE ANIMATORS’ NEEDS	16
2.4. EXISTING FILMS USED FOR VIDEO REFERENCE	18
2.5. FEEDBACK FROM THE BURPEE SCIENTISTS	27
2.6. OTHER SOURCES: THE INTERNET AND ANATOMY BOOKS	28
2.7. ANATOMY AND SCALE DETERMINING THE THESCELOSAURUS MOVED LIKE AN OSTRICH.....	29
2.8. CHAPTER TWO CONCLUSION	31
APPLIED STUDY: THE THESCELOSAURUS.....	32
3.1. CHAPTER THREE INTRODUCTION.....	32
3.2. CHARACTER TECHNICAL DIRECTION GUIDELINES.....	33
3.2.1. “If it looks right it is right”.....	33
3.2.2. <i>Muscles</i>	34
3.2.3. <i>Center of Mass</i>	34
3.2.4. <i>Facial Control Setup</i>	35
3.3. RIGGING A CHARACTER FOR A SCENE VERSUS RIGGING TO SOLVE ALL NEEDS	35
3.4. ESTABLISHING THE CHARACTER WALK CYCLE TO HELP DETERMINE “RANGE OF MOTION”	36
3.6. THESCELOSAURUS REFERENCE.....	37
3.6. RIG CONSTRUCTION	47
3.6.1. <i>Skin</i>	48
3.6.2. <i>Neck</i>	49
3.6.3. <i>Eyes</i>	50

3.6.4. <i>Head</i>	51
3.6.5. <i>Hands</i>	52
3.7. BUILDING THE MODEL OF THE THESCELOSAURUS	52
3.7.1. <i>Chip Set</i>	55
3.7.2. <i>Polygon Count</i>	57
3.8. DESIGNING THE RIG (TALKS WITH THE LEAD ANIMATOR)	60
3.8.1. <i>Legs, Hips, and Spine Computer Generated Joints</i>	61
3.8.2. <i>The Foot Computer Generated Joints</i>	65
3.8.3. <i>Arms/ Hands Computer Generated Joints</i>	69
3.8.4. <i>Tail Computer Generated Joints</i>	71
3.9. MUSCLES AND BLEND SHAPES	72
3.9.1. <i>Forward and Inverse Kinematics Switch</i>	78
3.9.2. <i>Set Driven Key</i>	79
3.10. STRETCH TESTS	82
3.11. REVISIONS	82
3.12. CONTROLS	83
3.13. REFLECTIONS ON STRENGTHS AND WEAKNESSES OF THE RIG	84
3.14. CHAPTER THREE CONCLUSIONS	85
NEXT STEPS: THE MAYA EMBEDDED LANGUAGE (MEL) AND PYTHON.....	86
4.1. MEL SCRIPTING	86
4.2. MEL TOOLS ADDRESSING THE NEEDS OF DINOSAURS	86
4.3. HOW MEL COULD BE USED IN THIS CASE STUDY.....	87
4.4. THE APPLICATION OF THE MEL TOOL.....	88
4.5. THE DINOSAUR LEG TOOL.....	91
4.6. PYTHON	94
4.7. CHAPTER FOUR CONCLUSION.....	95

CONCLUSION.....	96
BIBLIOGRAPHY	98
END NOTES	101

LIST OF FIGURES

Figure 1 Size and Scale Comparison between Thescelosaurus and human.....	8
Figure 2 illustrates the thescelosaurus' scale in relation to the other prehistoric animals seen in the "Jane's World" documentary. Image is a composite of all of the animals in the animation. The Thescelosaurus is standing by the bank next to Jane.....	9
Figure 3 Image of an arm of the Thescelosaurus that is modeled with the proper number of vertices for a rig's natural deformation.	15
Figure 4 Foot with control handle.....	18
Figure 5 Image of the T-Rex in Jurassic Park (1993). The T-Rex is seen as an agile animal.....	19
Figure 6 Image of a dinosaur from the 1940 film Fantasia. This animal moves more like a movie monster, very slow and awkward.....	20

Figure 7 Image of T-Rex in full gallop in movie Jurassic Park (1993). The animal in this movie has the ability to move both head and body controls evenly in Z axis because the animal doesn't tip over. Head controls can be parented to root..... 21

Figure 8 Image of T-Rex tipped over from forward momentum with head controls unparented to root control. The head must move independently from the body. 22

Figure 9 Image from Disney's Dinosaur (2000) showing hip rotation of a bi-ped carnivore. 23

Figure 10: Images from Jurassic Park 3 showing hip rotation of a bi-ped carnivore. 24

Figure 11 Image from Discovery Channel's "Walking with Dinosaurs" showing hip rotation of a biped carnivore. These dinosaurs have the least amount of hip rotation in their gaits..... 26

Figure 12 Image from the internet, provided by the Burpee, of a biped carnivore's stride in several stages of its life. 29

Figure 13 30

Figure 14 Ostrich in neutral pose, the animal most like the thescelosaurus. (Image provided by the Burpee)..... 38

Figure 15 Image of "Jane's skull from the Burpee Museum in Rockford, Illinois which provided the jaw's pivot location..... 39

Figure 16 Images show the rotation of the Thescelosaurus arm. The left image is maximum bio-mechanical rotation, the right one is hyper extended and is not rigged for that extreme of a pose. 40

Figure 17 Actual Thescelosaurus skeleton which the joints were based. This shows a pose of the character as according to the Burpee.	41
Figure 18 Storyboard pictures showing Thescelosaurus in various poses.....	43
Figure 19 Storyboard pictures showing Thescelosaurus in various poses.....	44
Figure 20 Thescelosaurus foot pose.....	46
Figure 21 T-Rex foot pose. Image Provided by the Burpee.	46
Figure 22 Screen shots of animal in different poses utilizing multiple movements of arm rig.	47
Figure 23 This is the 2005 version (right) with forward kinematics compared to incorrect spline IK.....	50
Figure 24 Illustration of Thescelosaurus head provided by the Burpee Museum.	51
Figure 25 Image of the anatomy of a horse’s leg.....	53
Figure 26 Image showing muscles being modeled incorrectly.....	54
Figure 27 Rendered frame of the Thescelosaurus in mid stride showing the limbs of the model being bent. The wrinkles and folds in the skin are also seen right below the neck area.	55
Figure 28 Rendered image of the chip set that has been parented to the joints of the Thescelosaurus. The chip set gives basic volume of the animal and allows the animator to block out the motion.	57
Figure 29 Low Resolution Model.....	59
Figure 30 High Resolution Model.	59

Figure 31 Hypergraph of Thescelosaurus proxy showing hierarchy. Both the high and low resolution are placed under one group node.	60
Figure 32 Image of Hypergraph showing the hierarchy of the leg setup.....	62
Figure 33 Screen capture of the entire skeleton for Thescelosaurus. (2005).....	63
Figure 34 newly positioned spine (2010).....	63
Figure 35 Thescelosaurus leg strategy.....	64
Figure 36 Screen capture of the Thescelosaurus foot. The ball joint acts as a main pivot for the toes that can move independently.	65
Figure 37 Images showing feet being rolled in both extreme positions.	66
Figure 38 Image of toes being flexed independently of foot roll.	67
Figure 39 Image of Hypergraph showing hierarchy of the joints of the foot.	68
Figure 40 The 2010 version of the foot	69
Figure 41 Image showing the arm setup. In order of hierarchy: shoulder, elbow, forearm, wrist, hand, fingers.....	70
Figure 42 Image showing hierarchy of the hand and fingers.....	71
Figure 43 Image of the tail showing all twelve joints.....	72
Figure 44	73
Figure 45 Screen shots of blend shapes being used to close the eye.	74
Figure 46 Screen capture of muscles being animated while being parented to the driving joint.	75
Figure 47 Illustrations of the leg being flexed with a wrap. The wrap creates creases and moves the vertices of the mesh in addition to the rotation of the joints.	75

Figure 48 Hypergraph showing hierarchy of wrapped muscles. The muscles are the children of a group node, which is the child of the hip.....	76
Figure 49 Hypergraph setup showing joint hierarchy of base arm with FK and IK joint setup.	79
Figure 50 Fingers being spread and opened using set driven key.	80
Figure 51 Attributes of set driven hands and fingers.....	81
Figure 52 Image of Hypergraph showing hierarchy of neck.	83
Figure 53 Illustration showing controls for the character.....	84
Figure 54 Leg setup.	90
Figure 55 illustration of the schematic design of the GUI that will create the leg set.....	92
Figure 56 GUI of “foot roll setup”.....	92
Figure 57 GUI of “rotator joint” tool.....	93

CHAPTER 1

INTRODUCTION

This paper documents the rigging setup of a thescalosaurus that I created for the computer generated film, *Jane: Diary of a Dinosaur*, for the Burpee Museum of Natural History in Rockford, Illinois. In this paper I discuss the process I used to create a dinosaur's skeletal setup for the joint placement and animation controls. I also present ideas about communication between myself in the role of lead character technical director (rigger) with the lead animator on this project.

Chapter One of this paper will give an overview of the project as well as base definitions of character technical direction (rigging).

General character technical direction concerns as well as the importance of motion studies will be discussed in Chapter Two.

Chapter Three will review the case study of the thescelosaurus, itself, and the computer generated control setup involved on this biped. Three will also go over character technical direction guidelines as practiced in this industry.

Chapter Four will discuss ways to automate the character technical direction process through the use of programming languages; in this case, both MEL (the Maya Embedded Language) and PYTHON (the language used by Industrial Light and Magic).

Chapter Five of this paper will discuss other “Next Steps” conclusions and reflections on this project.

1.1. Project Overview

The project was the collaboration between The Advanced Computing Center for the Arts and Design (ACCAD) at the Ohio State University and the Burpee Museum of Natural History in Rockford, Illinois. This project for the Burpee exhibit was funded by the Institute of Museum and Library Services (IMLS) grants program. The Burpee Museum discovered the skeleton of the juvenile T.rex, “Jane”, in Hell Creek, Montana. After the discovery, the Burpee Museum

wanted to make a permanent exhibit for their visitors to see the life and death of “Jane”.

The exhibit at the Burpee Museum contains both the dinosaurs’ bones as well as interactive kiosks illustrating the story of Jane as well as the processes involved with discovering and unearthing “Jane” (dissection of dinosaur bones, etc.). The exhibit also contains an introductory linear narrative created with 3D computer animation. ACCAD created this film, *Jane’s World*, which is intended to inform visitors of the Burpee Museum about the life and death of Jane. Written by the Burpee Museum staff of museum exhibition designers, educators, and paleontologists, the story of Jane, involves a hunting scene where the juvenile T.rex (Jane) stalks its prey, the thescelosaurus, from the distance in the bushes while the thescelosaurus drinks from the water bank. An explosive moment happens in the story where the juvenile T.rex (Jane) sprints from the bushes onto the bank and pounces on the neck of the thescelosaurus, killing it instantly. This animated film is referred to as “Jane’s World.”

This animation is a documentary style of storytelling, meaning it is not about character development. “A documentary film is a broad category of moving pictures intended to document some aspect of reality.”¹ Documentaries involving computer visualization are typically films about scientific factual information that can either be seen on television or in the theater. The dinosaurs in this piece are

not anthropomorphic. They do not speak, nor do they have personalities. Rather, this animated documentary is an informative narrative for the purposes of education to an audience visiting the museum. There is still an entertainment value to this documentary, of course, but this film was created to present possibilities about the life of Jane through animated visualization.

1.2. My role on “Jane’s World” as well as academic and professional experiences

I created the thescelosaurus model as well as the technical direction (rig) for the joint placement and controls. A rig is a series of computer generated joints bound to a computer generated mesh that are controlled by computer generated controls, to be discussed further in this chapter.

At the time of the creation of the thescelosaurus, the majority of my rigging experiences were academic. The rigs that I had created up to this point had little or no professional feedback. They were done in a student atmosphere for my amateur demo reel at the time and the feedback given was strictly from other students. The only professional character technical direction experience that I had was in creating a full grown T.rex rig that was in a documentary piece entitled “The Mystery Dinosaur”. This aired on both The Discovery Channel and the Science Channel. At the time of creating this dinosaur, I had seen a lecture on

character technical direction from Kevin Geiger, a rigging supervisor at Walt Disney Feature Animation, that brought in a rig he had done for an independent animated short entitled, “Henry’s Garden.” This was my only exposure to professional rigging up to this point.

Since “The Mystery Dinosaur” documentary aired, I have worked as a Lead Character Technical Director for several companies including Electronic Arts, Take Two Interactive, and Lucasfilm, Ltd. I have learned a great deal about character technical direction since 2005 and an alternate version of the thescelosaurus will be described in Chapter Four. The main difference between the 2005 rig and the rig I created for the same thescelosaurus in 2010 is the automation process and control accessibility. This will be discussed further in this paper.

1.3. The definition of character technical direction

My role in this process was as lead character technical director. In the profession of computer animation, character technical direction is the skeletal, technical direction, and control creation by an artist or engineer on a computer generated object. “Skeletal animation is a technique in computer animation in which a character is represented in two parts: a surface representation used to draw the

character (called the skin) and a hierarchical set of bones used for animation only (called the skeleton).

A rig is used by an animator to both block out the motion of a scene as well as finalize the animation prior to rendering for final frames. One of the most important relationships in a production setting, based on my personal professional experience, is that between the lead animator and the lead character technical director (rigger). This is a back and forth process between control creation and usability of that control. The character technical director sets up preliminary “work in progress” controls on a computer generated skeleton and the lead animator tests them. Once the animator is comfortable with the control setup (quite possibly on multiple versions of the same character) the rigger will finalize the animator’s requests on one rig. It is also possible that this rig will be altered in the future; so this relationship might be ongoing.

The bones within a rig form a hierarchy. A hierarchy is a set of parented “bones” where the parent bone controls the rotation, scale, and translation of its child bone. Moving a thigh-bone will move the lower leg too. As the character is animated, the bones change their transformation over time, under the influence of some animation controller, created by the character technical director. As these bones move, they deform the model (skin) of the thescelosaurus.

‘Each bone in the skeleton is associated with some portion of the character's visual representation. Skinning is the process of creating this association. In the most common case of a polygonal mesh character, the bone is associated with a group of vertices; for example, in a model of a human being, the 'thigh' bone would be associated with the vertices making up the polygons in the model's thigh. The movement of skin near the joints of two bones, can therefore be influenced by both bones.’² These vertices that create a skin cluster node are assigned to different bones in the hierarchy. As the thigh bone rotates, the vertices assigned to it will rotate as well.

1.4. What does the character technical director (rigger) analyze

The character technical directors, along with other members of the team, analyze factors of the creature or character being “rigged” up. These two factors are scale and motion. Scale is the general proportion of a computer generated object in relation to other computer generated objects within a scene. Motion is the translation and rotation of a computer generated object within a scene.

1.4.1. Scale

First and foremost, the character technical director analyzes proportion and scale of a computer generated object (mesh) to begin to establish the object's range of motion. (Figure 1) Range of motion will affect the rigger's decision in regards to the amount of influence a bone in a hierarchy has over the vertices of a mesh. The thescelosaurus dinosaur featured in the animated short, "Jane's World", as seen at the Burpee Museum stands at about three feet at the hip. (Figure 2)

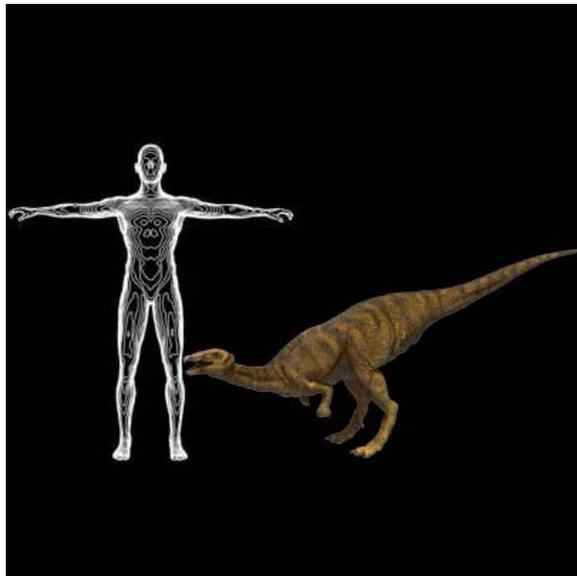


Figure 1 Size and Scale Comparison between Thescelosaurus and human.



Figure 2 illustrates the thescelosaurus' scale in relation to the other prehistoric animals seen in the "Jane's World" documentary. Image is a composite of all of the animals in the animation. The Thescelosaurus is standing by the bank next to Jane.

1.4.2. Motion

The character technical director's work will eventually be realized when the model and rig move to the animation phase of the pipeline. This is the first time the rigger sees the computer generated rig in action and will be able to make changes on the spot after feedback.

The rigger must also analyze the movement that the rig must make possible for the animation team because the rig drives the movement or motion of the animal. In order to determine how a creature will move, the character technical director

looks at reference of similar creatures as well as the character's anatomy in order to determine a benchmark to start from. The anatomy will determine physical locations of actual joints as well how these joints relate to one another.

The joints of the character's anatomy being recreated virtually will give reference to issues such as to joints penetrating each other and joint rotational freedom (range of motion), as to be discussed in Chapter Two.

Since there is no footage of movement establishing the extremities of motion for dinosaurs, scientists at the Burpee Museum suggested that our animators based the gait of this dinosaur on an existing modern animal, the ostrich. Our team viewed footage of the animal to determine the range of motion of joints. By studying an animal like the ostrich the rigger builds an understanding of the mechanics of the animal's stride.

1.5. Character technical direction Guidelines

The animation production pipeline, written by professionals in the industry, is the entire process that creates either a computer generated movie or game. In the character technical direction portion of a pipeline, certain guidelines or concerns are raised in order to guarantee that the end result meets all character technical direction criteria. First, the rule "If the computer generated object looks correct on

screen, then it is correct”, meaning what is anatomically correct joint placement is not always the best solution. Second, computer generated muscles, even the ones used in this project, might not always look like an actual muscle of the animal, however, the end result is anatomically correct. Third, the center of mass on the majority of bipedal projects that a rigger will work on will be the mean of the mathematical distance between the two hip joints. Fourth, the facial setup is determined by the face’s range of motion; the animator’s opinion is irrelevant. Fifth, and last, a rig can either be solved for a specific task in a film or game, or it can be created to solve for every possible task imaginable.

1.6. Where does the Character Technical Director look for Reference

A character technical director will look for reference from existing movies, shows, websites, and experts in their field. It is important that information pertaining to the character be established early on in the pipeline so that the character technical director does not back track and cause an excess of billable hours to the project.

1.7. Chapter One Summary

Chapter One has provided a general overview of what the reader will see in the body of this paper. In addition, the definition of character technical direction is identified. This definition will be the basis used throughout the rest of the chapters.

CHAPTER 2

GENERAL RIGGING CONCERNS

2.1. Chapter Two Introduction

This chapter will explore general rigging concerns including the types of models needed to make proper deformation. In addition, the video reference being used for this project will be discussed as well.

2.2. What Type of Model Does a Rigger Need?

There are three ways to build the model for a rig: Polygons, NURBS, and Sub-Division Surfaces. For this project, polygons were used to model the characters due to the experience of the modelers creating them. Polygons are typically weighted in animation with weighting tools, whereas NURBS and Subdivision

surfaces are typically converted to a proxy cage (to be discussed later in the paper) and weighted the same way.

The most important thing concerning models when relating to rigs are the area of folds and creases.³ For example, it is important to have a certain number of polygonal vertices around the crease to obtain the proper aesthetic look to the fold. This enhances the realism of actual folds and provides a clean mesh. The mesh is denser with more vertices added. This will give way to a better crease in the deformation. For example, the elbow's row of vertices is the crease between the forearm and the upper arm. (Figure 3) A row of vertices is needed on the actual crease line. Then extra rows of vertices should be placed above and below the crease line.⁴ This gives the rigger plenty of deformation to work with when creating the creases and folds of skin that is in the respective areas. Although these extra vertices might seem unnecessary when doing the modeling, it will be beneficial when the actual weighting takes place. Just because the model might have a great aesthetic look to it when shaded, additional vertices might be required in the construction in order to get the model to deform properly.



Figure 3 Image of an arm of the Thescelosaurus that is modeled with the proper number of vertices for a rig's natural deformation.

Ideally the rigger wants the mesh to be in quads (a polygonal face with four sides).⁵ When a mesh renders for film or exports in a game engine, the polygons on the character triangulate. If the topology of the mesh is not clearly constructed in quads, it becomes up to the computer's discretion to create the triangulation. This can lead to the artist's work becoming technically misinterpreted. It is okay to have exceptions in certain instances where there are both quads and triangles in the same geometry. More than four sided polygons can be difficult to control. In certain areas of intersection, it could be difficult to make the model in quads without having some triangular splitting, but quads should be the goal. The majority of the Thescelosaurus is in quads with a few exceptions in detailed areas where wrinkles and ridges have been modeled. This allows for cleaner topology and better creasing.

The Thescelosaurus rig and the model were created by me. However, if this were not the case, it would also be important that good communication be established between the modeling and rigging teams. This makes the process easier because the models could be designed to work directly with the rig, as opposed to having to go back to the modeler and have him add rows of vertices. But in a professional production pipeline, it is more likely that it will be in two different departments. While working at Electronic Arts as the lead rigger, one of my tasks was to approve topology on the football franchises (Madden NFL, NCAA Football). I worked closely with the modeling leads in determining the final seams on the mesh for these titles.

It is important for the rigger to understand the modeling production aspects of a project because often the riggers are required to model morph targets that could be used on the body and face of a character. Morph targets (target shapes that a bound mesh turns into) are used to create the eye blinking on the thescelosaurus. Therefore, it is advised that a rigger know a certain amount of modeling when doing a rig.

2.3. How Riggers Work for the Animators' Needs

The rigger is creating a skeletal setup and controls for the animator to use. The rigger must meet with the animator throughout the creation of the rig to go over

what controls will be necessary in order for the animator to execute motion properly. It is also important that the rigger give the animator intermediate rigs throughout the process to test out the locomotion of the character. The controls of a rig should ideally be in a clean hierarchy and easily accessible.

One of the most important aspects of creating a rig for an animator is providing accessibility to the controls. The controls need to be large enough to grab but not too large as to get in the way of other objects on the screen. (Figure 4) Some animators prefer to grab and move handles as opposed to sliding an attribute on a set driven key, which will be discussed in a later section. The controls can be placed on a layer that can be switched on and off. In addition they can be put on a non render able layer so that the body can be manipulated but the actual controls will not show up during a render.

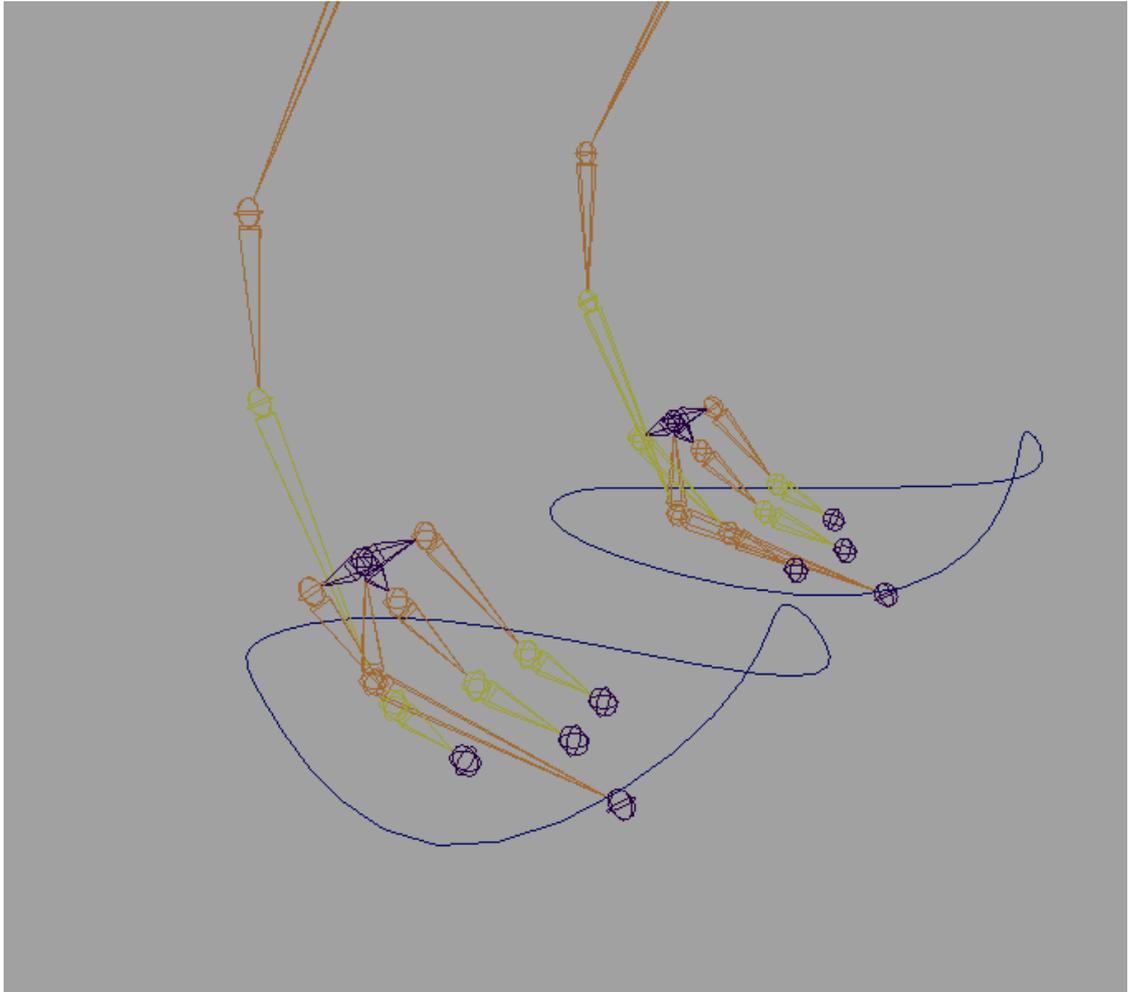


Figure 4 Foot with control handle.

2.4. Existing Films Used for Video Reference

Our team studied movement from several films that contained dinosaurs in addition to the hypothesized movement from the scientists. First and foremost, we used Industrial Light and Magic's (ILM) Jurassic Park (1993) to examine the movements of the animals.

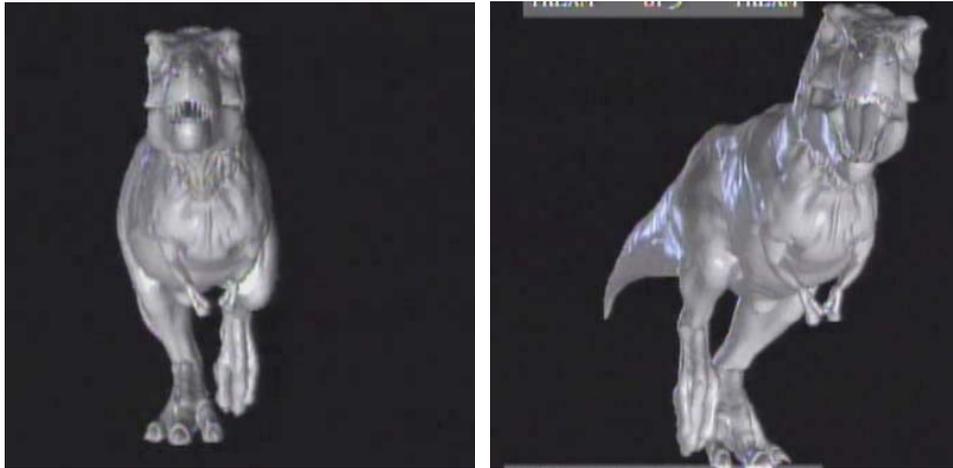


Figure 5 Image of the T-Rex in Jurassic Park (1993). The T-Rex is seen as an agile animal.

Dr. Robert Bakker, a world renowned paleontologist, had worked closely with Steven Spielberg when creating this piece. Up until the late 1980's, it was hypothesized that dinosaurs were large lumbering animals that were not agile and moved quite slow. The motion was closer a prehistoric "movie monster" like Godzilla. In fact, there is even a sequence from the Disney film "Fantasia" 1940 (Figure 6) where dinosaur movement was incredibly slow and predictable.



Figure 6 Image of a dinosaur from the 1940 film Fantasia. This animal moves more like a movie monster, very slow and awkward.

Bakker was the scientist who claimed that they moved like regular animals as opposed to large, slow, movie monsters.⁶ This is important when relating to the rigs of these animals because it directly corresponds to the range of motion that will be used when animating. The slower they are, the smaller their gait would be because large steps would throw off their balance. The smaller the gait (range of motion of stride), the closer the animals are to their bind pose (bound mesh to joint pose). This is the stance that the modeler had created for them. This would equal less joint rotation and less extreme skin deformation. The scientists at the Burpee Museum told myself and the lead animator on the project, Keith Kelley, that they have agility and could move as swiftly as modern day animals.

The difficulty with analyzing the behavior of the dinosaurs in the Jurassic Park series is that they were acting in a science fiction format. Humans were not alive

in the Jurassic period so it is difficult to understand how, for example, a full grown T. rex might move and behave towards a moving automobile. (Figure 5) In the film, Jurassic Park, the T.rex is able to be in full gallop without breaking stride and attack the jeep by lunging forward.



Figure 7 Image of T-Rex in full gallop in movie Jurassic Park (1993). The animal in this movie has the ability to move both head and body controls evenly in Z axis because the animal doesn't tip over. Head controls can be parented to root.



Figure 8 Image of T-Rex tipped over from forward momentum with head controls unparented to root control. The head must move independently from the body.

It is quite possible that in a real life situation, if T. rex is doing something similar it might actually fall forward on its face and break its own neck (Figure 8). There is no evidence of this either way. However due to the amount of mass in the front of the animal, root rotation at the hips might cause an animal of this size to be clumsy in stride. This would change the rig dramatically. If the animal were to fall forward, the head controls would be independent of the actual dinosaur's root control so it could be planted on the ground and twist independently from its body. This would simulate a "neck break". If the head control's world space is determined by the root, the animator would have to counter rotate the neck as opposed to setting the position independently of root rotation.



Figure 9 Image from Disney's Dinosaur (2000) showing hip rotation of a bi-ped carnivore.

Dinosaur (Figure 9) was created several years ago by Disney after the original Jurassic Park. Scientific theories changed slightly when comparing the movement of the dinosaurs between the two films. The better understanding of range of motion is the difference in the research between 1993 and 2000.⁷ There is less rotation of the hips in later film work.

The dinosaurs are much slower in later studies also. From an observation standpoint, there tends to be slightly less rotation of the hips and root in the Disney piece. This means that the Disney animator is rotating the root node (orientation down the spine) less than the ILM animator. The greater the rotation through the spine, the less choppy the animation would be due to greater overlapping motion. Stuart Sumida, Jack Horner, and Don Lessem were brought on board the Disney team to consult on dinosaur locomotion.



Figure 10: Images from Jurassic Park 3 showing hip rotation of a bi-ped carnivore.

The rotation of the hips and root in the Disney piece is closer to the motion in Jurassic Park 3 (2001) (Figure 10). Scientific theory based on the movement of the animals has changed. When comparing the walks of the two different movies, “Dinosaur” appears to have a more abrupt walk that involves less rotation of the hips. Scientific evidence determined that dinosaurs were much slower than were depicted in Jurassic Park.⁸

The main problem when using these two films as reference for a documentary is that the dinosaurs are actors that are performing for an audience as opposed to animals in a natural habitat reacting to an ecosystem. Therefore, it is difficult to use the footage as an absolute fact, although there are examples in both where science is lending its opinion to the movement of the characters. In other words, if

a computer generated lion was created with a walk cycle, a more accurate walk could be generated by using scientific visualization for reference, as opposed to watching a feature film. Although both provide good reference, the scientific visualization would feature the animal in its natural habitat; as opposed to a character with voice over performance that is acting in a scene. The lion in the scientific visualization piece would give a better feel for how the animal actually acts and behaves to its surroundings as opposed to an on screen acting scene. This means it makes more sense to watch The Discovery Channel over Disney's The Lion King for reference.

The Discovery Channel created a series of animated pieces titled "Walking with Dinosaurs" (1999-2005) that were designed to show dinosaurs in their natural habitat.⁹ This reference was also helpful since the dinosaurs are not depicted as characters with humanistic personalities, but rather untamed animals. Not only did these documentaries show the gaits and strides of animals, they also depict the animals' hunting, behaviors when traveling in herds, and performing territorial rituals.

Understanding behaviors of the character being rigged is beneficial to the rigger because it establishes a better communication between the rigger and the animator. It also allows the rigger to test the rig from one ideal pose to the next to see if there is any crunching taking place in the geometry.

One of the main differences in motion between this style of animation (scientific visualization) and its Hollywood counterparts is the movement in the initial gallop of the walk cycle. In “Walking With Dinosaurs” (Figure 11), it appears to be more abrupt, almost as if the animals weigh much more and the bones in their legs could not support the weight of the upper body on one limb at a time.



Figure 11 Image from Discovery Channel’s “Walking with Dinosaurs” showing hip rotation of a biped carnivore. These dinosaurs have the least amount of hip rotation in their gaits.

Although the biomechanics might have been more accurate, this causes the motion of the animals to look far choppier in stride and less smooth. It is unclear if the scientific feedback on these motions was different than that given to ILM, who worked on the Jurassic Park series. It is also possible that the animators did not have the budget to afford feedback from scientists to make the motion more accurate. However, the range of motion is approximately the same between the

gaits of The Discovery Channel and ILM. The extreme rotation of the Discovery Channel (Figure 9) piece happens over fewer frames than its ILM counterpart. The ILM piece has more follow through with its motion, therefore the motion looks smoother.

2.5. Feedback from the Burpee Scientists

One of the benefits to looking at footage from these films is that the artists and animators consulted with scientists in order to establish not only the visual look and feel of the piece, but the motion, skeletal structure, and behavior. This is essential to what the rigger needs. Once the team of animators working on the Burpee piece established a series of video reference, it was important to get feedback from the scientists about extreme joint rotations for the animals. ILM has the loosest root node (or master node controlling the spine and located equidistantly between the hips), followed by Disney and the Discovery Channel. In regards to fictional character acting, the order goes as follows: Disney (being the greatest), ILM, and then The Discovery Channel. All animation work done on Jurassic Park, Dinosaur, and The Discovery Channel is completely hypothesized with no clear cut winner, only speculation.

Before the rigging begins, the rigger will ask about range of motion for joint rotation and average gaits of the walk. During motion tests the rigger will ask if

the design of the rig is showing the proper proportion of mass and symmetry.

Meaning, are the manipulated computer generated joints accurately depicting the proper deformation of the character. After the motion test, the rigger will ask what other modifications need to be made to be put in the desired motion of the storyboard.

2.6. Other Sources: The Internet and Anatomy Books

It is very helpful in this modern era to use the internet as a source to gather reference images. Several images of the Thescelosaurus were gathered as a part of the research phase of the project. These images were then presented to the team of scientists for approval. The scientists were looking for animals similar to the Thescelosaurus, like ostriches. This is where our team got video clips of ostriches were also collected during this time through use of the internet.

Additional scientific research was also added to the database that could be drawn upon when the time was right. Several images of gaits of dinosaurs were found. In addition, several illustrations of dinosaurs were given in key poses. Not only would these illustrations benefit to the look and feel of the piece, but they would also give an idea to skin deformations and proper folding of the Thescelosaurus.

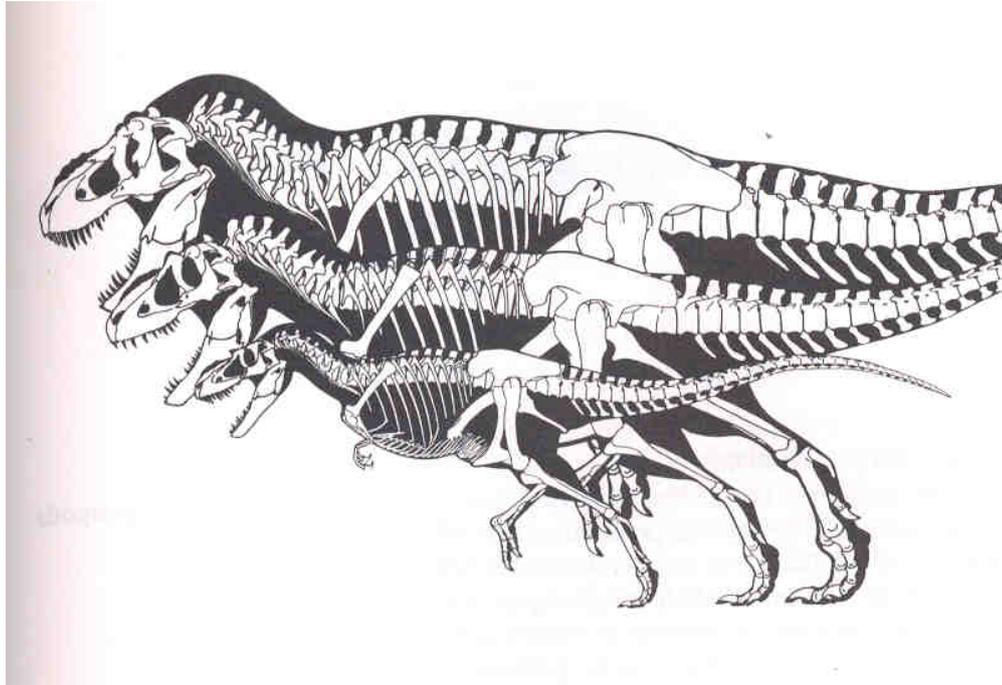


Figure 12 Image from the internet, provided by the Burpee, of a biped carnivore's stride in several stages of its life.

2.7. Anatomy and Scale determining the Thescelosaurus moved like an ostrich

The Burpee Museum gave feedback that the Thescelosaurus moved like an ostrich based off of the dinosaur's anatomy and scale. After the Burpee Museum gave the animation instruction, the lead animator and I immediately collaborated on skeletal rotation of joints, animation controls on the dinosaur, and the interaction between this dinosaur (Thescelosaurus) and the dinosaur (Jane). The scientists at

the Burpee Museum made educated guesses to establish the basic flow of movement of the Thescelosaurus.

There is no footage of movement establishing the extremities of motion for the Thescelosaurus. Our team viewed footage of the animal to determine the “range of motion” of joints. What the rigger learns by studying an animal like the ostrich is the animal’s stride, as well as how they position the root of their body between steps. Many people might think that dinosaurs walked flatfooted. That is incorrect.



Figure 13

“Dinosaurs usually walked on their toes; the scientific term for this is digitigrade. Other animals that are digitigrade include dogs, cat, and chickens. There is a pad

of tissue on the back of the feet on these animals that acts like a shock absorber. People, bears, and crocodiles walk differently; they are plantigrade (flat-footed). Dinosaurs were slightly pigeon-toed; their toes pointed inwards.

Some dinosaurs moved around on four legs (these are called quadrupeds), and some on two legs (these are called bipeds). Others may have run on two legs but walked and grazed on all four legs. Some dinosaurs were slow moving and others were speedy, depending on their anatomy. A few of the late, bird-like dinosaurs may have used their short, feathered arms to help speed up their running and perhaps glide from trees to the ground. Dinosaurs probably used their tails for balance while moving and some may have used their tails for quickly shifting their balance in quick turns.”¹⁰ The rigger takes this into account when determining the skeleton, as to be seen in Chapter Three.

2.8. Chapter Two Conclusion

This chapter has successfully shown the types of modeling topology as well as reference documentation that a character technical director looks for when completing a computer generated character. Chapter three will go on to discuss the construction of the rig itself as well as a beginning comparison and contrast to the updated and improved 2010 version.

CHAPTER 3

APPLIED STUDY: THE THESCELOSAURUS

3.1. Chapter Three Introduction

This Chapter will give a detailed overview of what general guidelines are that a character technical director will follow. It will also outline the definition for “range of motion” as used in this industry and the steps used to get it. Lastly, this chapter will give a breakdown of the 2005 rigging and modeling solution for the thescelosaurus that was given to the Burpee Museum in Rockford, Illinois, based off of feedback from DreamWorks SKG as well as my personal rigging experiences up to that point in my career in 2005. Lastly, in particular cases on

certain parts of the body where the 2005 version of the rig does not meet my current experience level (2010), an alternate version from a similar 2010 rig will be illustrated.

3.2. Character Technical Direction Guidelines

Unwritten Guidelines have been practiced throughout the years in character technical direction. What a young character technical director needs to realize is that when making either a movie or a game, what is most important is the final rendered result. The process used when constructing the rig to get to that result can either be one that is simple one or one that is complex and unorthodox. What the character technical director must never forget is that they will be evaluated on what the visual end result is, not the architecture of the rig itself. The following sections are a list of guidelines that a character technical director must follow.

3.2.1. “If it looks right it is right”

What is anatomically correct joint placement is not always the best solution. Kevin Geiger, a rigging supervisor at Disney, said in a lecture, “If it looks right, it is right”. What this means is that a joint might have to be moved in a non-anatomically correct way in order to give the correct visual look of the creature.

The rigger will have to put the joint in the proper place that will make the mesh look correct during the character's "range of motion" (the extremity of joint rotation for that character).

3.2.2. Muscles

Muscles, even the ones used in this project, might not always look like the actual muscle of the animal. Again, the final look of the skin when rendered either in game or in frame is what matters. Unless the muscles are to be seen without the flesh on them, the shape of the computer generated muscle is irrelevant. This will be discussed further in a later part of Chapter 3.

3.2.3. Center of Mass

The center of mass on the majority of projects that a rigger will work on will be the mean of the mathematical distance between the two hip joints. There might be need to place the root node in other parts of the body, depending on what the animator is trying to get the character to do. The center of mass however will begin to set the look of the character for the scene. The center of mass, typically determined by the character's root node (or highest node in the skeleton hierarchy) will determine the position of the spine and center of gravity in the

character's world space (the special relation of a character or object in reference to every other object in a computer generated scene).

3.2.4. Facial Control Setup

Facial control setup, whether it is through morph targets or through joints, can either be applied to the face directly, or on a separate GUI (Graphic User Interface) near the face. The facial setup is determined by the face's range of motion; the animator's opinion is irrelevant. The animator or animation director on the project determines the GUI or controls. This is to be discussed in further detail in Chapter Three.

3.3. Rigging a character for a scene versus rigging to solve all needs

Our team used the storyboard to determine what performances were needed for the animal and for how specific joints would have to be moving from frame to frame. For example, if the thescelosaurus does not have to look straight up in the air, then the joints of the rig would not have to be rotated in that orientation to do binding. Establishing the required range of motion early on was essential in this project. I worked extensively with the lead animator (Keith Kelley) on this. There is a difference between video game needs and film needs for a rigger. There were

several things considered when working on this project. For a video game, the rig has to be able to do everything in every situation. For a film, a rig might be created to solve for one particular shot or scene. The rig for film is limited to what it can do. For this project, Keith and I went with a video game style rig (2005) that did not solve for shot. We chose this because the length of the film on this project didn't need separate rigs for the shots. The range of motion didn't vary enough in the scenes for this methodology.

3.4. Establishing the character walk cycle to help determine “range of motion”

It is important when creating a rig for a character, animal, or creature that an established walk cycle is generated. This walk cycle is important for the project because it establishes a preliminary “look and feel” of the character. That “look and feel” sets the benchmark for that character; and can potentially cause a lot of excitement for the team working on the project. Not only is it important to understand how the character behaves, thinks, and feels, it is also helpful to establish the joint range of motion. For example, if a lion is being rigged, it is good to know how far the front legs go forward because when “weighting” (molding and sculpting the skin of the animal to look anatomically correct in extreme positions) the animal, the joint of the upper leg will be placed in the extreme position; and the weighting will take place based on that position. If the joints' range of motions are not established, then the desired movement might

cause a crunching effect will cause a very visually disturbing deformation. The character will look good in its bind pose (the default pose that the skinning takes place), but the point of rigging is to enable the animator to make the animal move and come to life. Therefore, when passed on to the animator, if the weighting does not meet the needs of the predetermined “range of motion”, the mesh vertices will look improper. The animator will then have to give the rig back to the character technical director or rigging department to fix, which will require more budgeted time. If the weighting of the skin is established earlier, this will allow more time to work on the controls for the animator.

3.6. Thescelosaurus Reference

The skeleton for the Thescelosaurus is a basic setup for a biped animal. This animal has two legs, a spine, shoulders, and arms and a neck. The joints were created and positioned based on reference from the actual skeleton of the dinosaur. Some adjustments were made accordingly to get proper rotation of the animal’s limbs.

The Burpee scientists determined that the Thescelosaurus walk gait is similar to that of an ostrich.



Figure 14 Ostrich in neutral pose, the animal most like the thescelosaurus. (Image provided by the Burpee).

The difference between the computer generated skeleton joint positioning and the actual dinosaur skeleton is the joint location of the arms. It is difficult to establish an extreme rotation position on the shoulder pivot because it is unclear what the dinosaur's arms are specifically used for.

Another debatable topic is the fingers. The question was how were they used and was the thumb opposable. The scientists determined that the fingers were non flexible nubs. The hands attached to the arms are used to bounce on the ground when the animal would be in a squatting position (as if it was to get a drink). The

accurate rotation of computer generated arm joints always needs to be established after determining arm flexibility.

The Burpee scientists gave the team the extreme rotational positions on the Thescelosaurus joints. In addition to getting feedback on a weekly basis from the scientists at the Burpee Museum, a world renowned scientist named Stuart Sumida, professor at California State University San Bernardino, visited ACCAD as a guest lecturer and gave feedback on the gaits and strides of the animals. This was not only helpful to the animators, but also helpful to me because it gave the rigging team an idea as to how the skin folded and moved. Sumida also provided details on locomotion, joint rotation, placements during the gait, and proper skin folding, including detail of joint positioning within a walk as well on T.rex stride.



Figure 15 Image of “Jane’s skull from the Burpee Museum in Rockford, Illinois which provided the jaw’s pivot location.

The rig is constructed accordingly after the scientists gave their feedback by giving the animal proper joint limits. If the animal is given more freedom in the arms, that would make rigging the shoulder far more difficult. The shoulders then rotate off of two pivot axis (forward and sideways) the majority of the time with slight rotation in a twisting movement. This gives the animator plenty of flexibility when animating the Thescelosaurus even though it does not have to reach in a predominant forward position. Figure 15 illustrates the rotation of the arm of the Thescelosaurus. In one of the sequences in the animation this animal actually squats down to take a drink from the river bed and its arms are on the ground.

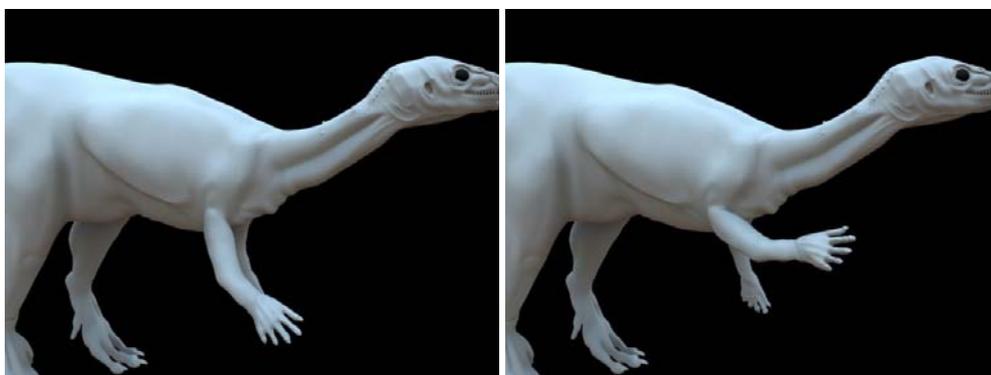


Figure 16 Images show the rotation of the Thescelosaurus arm. The left image is maximum bio-mechanical rotation, the right one is hyper extended and is not rigged for that extreme of a pose.

This is important to have the arms flexible enough to give the animator the desired output but not flexible enough to break the anatomical limitations. In this particular example the rig is given limits in its axis to prohibit the animator from doing what science has said to be impossible. This is not always recommended because some animators like to hyperextend joints to give an extreme pose. However, in this particular case the scientists felt it would be best to place limits on the joints. When I spoke to the lead animator (Keith Kelley) after this sequence was completed, he felt that the rig's joint rotation limits did not impede his ability to create animation. Keith was able to create the approved scientific motion with no problems.



Figure 17 Actual Thescelosaurus skeleton which the joints were based. This shows a pose of the character as according to the Burpee.

References provided by the Burpee Museum are used to help determine the rigging and modeling of the animal. (Figure 17) It is important to look at the illustrations to determine how it actually stands in different poses as well as how it moves. This plays to the importance of the rig because several shots within the piece relied on strong poses and silhouettes based on the dinosaur proportion. The team knew that the *Thescelosaurus* would rotate at the hips in order to get a drink of water based on the Burpee storyboards. What the Burpee scientists told us was that the arms would not rotate forward past the neck while drinking (this will be discussed further in the paper). The storyboard also did not require the *Thescelosaurus* to sprint in an open field. That meant that the rig did not have to support a wide gait. Additional helper joints would not be necessary to compensate any potential mesh tearing that could occur from a long stride. At the end of the animation, the *Thescelosaurus* scampered away from Jane before getting caught by Jane's jaw. The core skeleton (base skeleton without helper, or "leaf", joints to assist in deformation) was sufficient to fulfill the requirements of the storyboard.

A character technical director can look at a skeleton and determine proper computer generated joint location based on hypothesized rotation. For example, the spine of the skeleton is closer to the upper portion of the animal as opposed to be centered within the torso. A character technical director might want to put

skeletal joints in the absolute center of a mesh. This would equally distribute the mesh deformation at all angles. In the case of the Thescelosaurus, however, it is clear from the actual skeleton that the spine is closer to the roof of body as opposed to be centered. The 2005 version of the Thescelosaurus addresses this issue by placing the joints closer to the top of the mesh. The 2010 version created by myself after more professional experience even locates the computer generated joints even closer to the roof of the mesh, causing an even more accurate deformation.

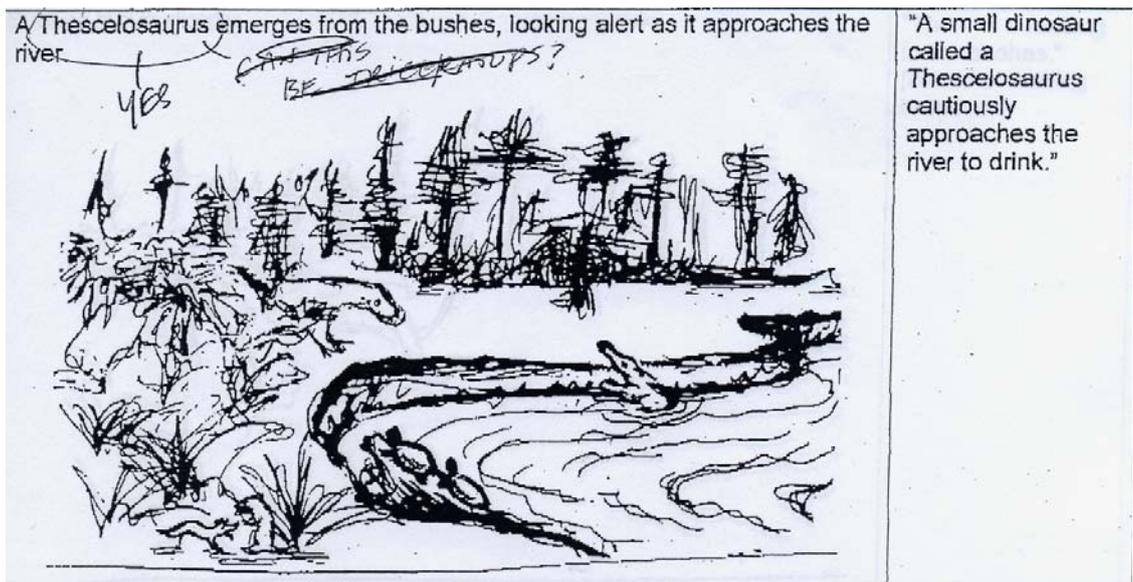


Figure 18 Storyboard pictures showing Thescelosaurus in various poses.

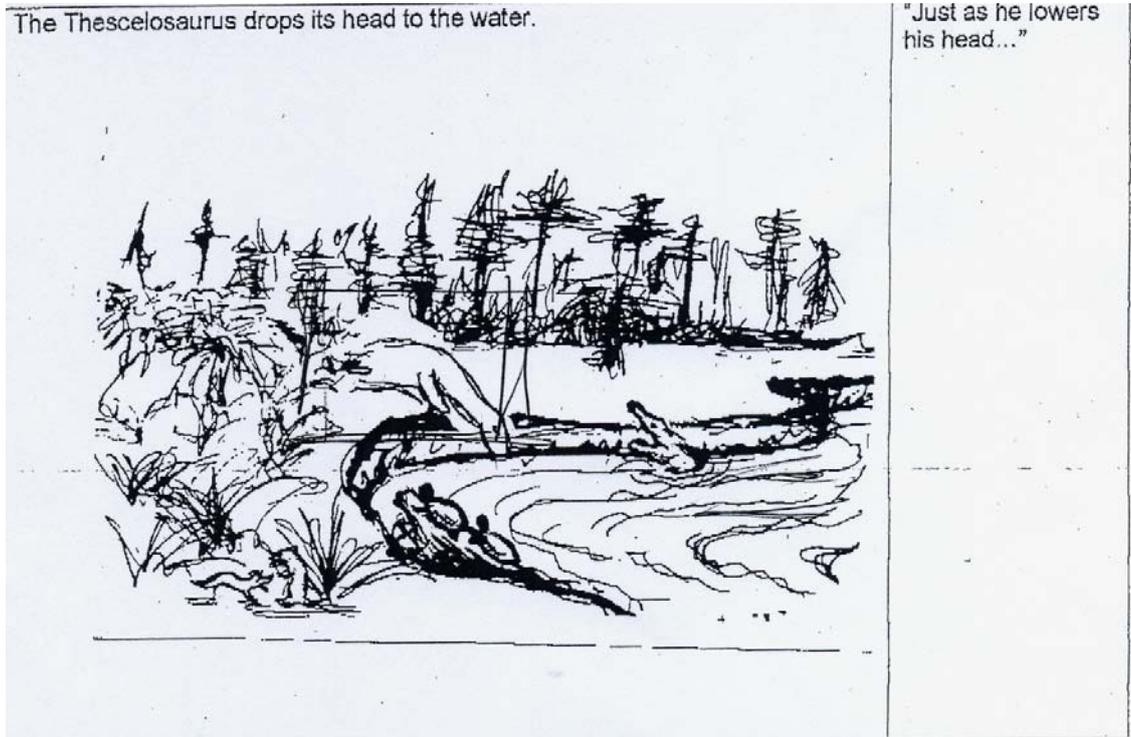


Figure 19 Storyboard pictures showing Thescelosaurus in various poses.

Several discussions with the Burpee Museum ended up influencing the final rig output. In addition, the storyboards (Figure 18 and 19) are used to assist in blocking out the main motion of the dinosaur.

I (the lead rigger) worked with the Burpee scientists to determine what the mesh of the Thescelosaurus would look like after the joints were rotated at fifty percent of the total range of motion. The storyboard did not call for the Thescelosaurus to be in full gallop, so fifty percent of the total range of motion was all that the mesh required to be visually correct.

The first major difference between the feedback from Burpee and the provided illustrations were the size of the Thescelosaurus toes and their base position. The stance of the animal, according to the illustrations, seems to be a little flat footed. However, after discussing this with the Burpee scientists, I discovered that the animal actually stands up on its tip toes (Figure 20). This information plays a key role in the development of the rig. The animal's bind pose would be unorthodox in comparison to other dinosaurs, even the T. rex, which stands more flat footed (Figure 21).

The model of the Thescelosaurus was designed so the feet would be on their tip toes in neutral pose (as to be shown in later sections of this paper). The range of motion is biased towards a foot flex, meaning if the animator wants to rotate the toes towards the body, the mesh could potentially crunch unless extra attention is paid toward the binding. A foot setup like this affects the modeler more than the character technical director. The modeler (in this case me) had to create the polygonal mesh to look like Figure 20. The toes rest position is actually flexed.



Figure 20 Thescelosaurus foot pose.

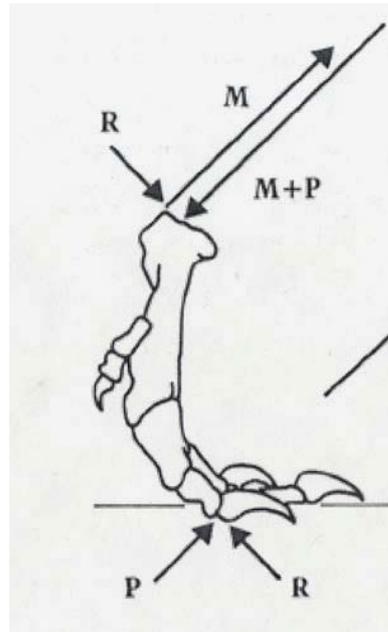


Figure 21 T-Rex foot pose. Image Provided by the Burpee.

For this project, the “preferred angle” (or neutral angle of the joint) has a slight rotation on the joint orient. Although the joint could be set to zero, it is possible that the rotational coordinates on the toes would have non zero values. This could potentially complicate rigging toes for the 2005 version of this rig. The toe keyframing is achieved by sliding set driven keyframe attributes and not by

rotating forward kinematic controls. The rigger has to deal with non zero values when setting up the set driven keyframe which leaves greater chance of creating an error (more decimals to deal with).

The storyboard provided by the Burpee helped in determining the locomotion of the animal. The animal moves in a series of dramatic poses by the water (crouching, fleeing, etc.) Due to the physique of the animal, it must be easily animate able from one pose to the next.



Figure 22 Screen shots of animal in different poses utilizing multiple movements of arm rig.

3.6. Rig construction

This portion of the paper will describe particular construction areas of the 2005 version of the thescelosaurus. Areas of the 2005 version that do not meet the

standards of my experiences up to 2010 will be compared to a later version (2010) of a cleaner rig.

3.6.1. Skin

The character technical director must determine whether or not skin folds are going to be put into the model geometry of the animal or if they are or going to be left out by the modeler and applied by the shader artist. An advantage to modeling in skin wrinkles is that the character technical director can see how the wrinkles deform in real time playback using the software. If the wrinkles are texture maps, it is difficult to see how they will behave with deformations because the character has to be rendered in frames in order to see how the wrinkles look. This takes more time. If the wrinkles are small and insignificant, then it might not be necessary to model them in the character. However, if they play a key role in the design, then they might need to be modeled. In addition, the character technical director must determine what method will be used to create these wrinkles. They can be added with a bone driven displacement shader (a shader that contains a texture map that creates a bump or displacement on a polygonal mesh), or they can be added as a bone driven blend shape (morph target). The advantage to a bone driven blend shape is that in real time playback the modeler and rigger can see the end result quickly. The problem is that if the shapes, or original model, are too dense, playback in the software might be too slow, which might make

animating in real time a problem for the animator. The frame rate of the playback could potentially be blocky and the animator will not be able to get a true feel on the motion being created instantly. The real time playback of a bone driven displacement wrinkle would not be blocky at all, however, the rigging and modeling team would not see the wrinkle until rendered. This might add hours to the rendering production phase of the project. Both would be triggered based on the rotation of the shin or thigh. The Thescelosaurus (2005) wrinkles were modeled in. After working with Lisa Connors (texture lead at PDI DreamWorks), we decided that a bone driven displacement shader was not necessary due to the density of the mesh.

3.6.2. Neck

The neck, which according to Burpee is too short in Figure 22, is approached in several different ways. The neck needs to be keyable, according to the storyboard. In order for the Thescelosaurus to drink from the water bank as shown in the storyboard, both the root and the neck joints need to be rotated. The neck also needs to be opposable, like an arm, as well as follow the root node. Multiple joint constraints are used on the neck to achieve all of the desired positions. In the 2005 version of the rig, separate joint chains constrained to one another have both an Inverse Kinematics (IK) Spline as well as forward kinematic controls. In the version created in 2010, only forward kinematic controls are created. After

looking at the final animation and the rig used (2005), I determined that the setup of the IK Spline caused an improper bowing of the neck. The IK solver, when positioned, causes an undesirable arch towards the base of the neck. The control was made for Keith to work with and signed off on, but the end result is anatomically inaccurate. Forward kinematics and a proper deformation would have occurred in the animation had the opposable IK control not been created.

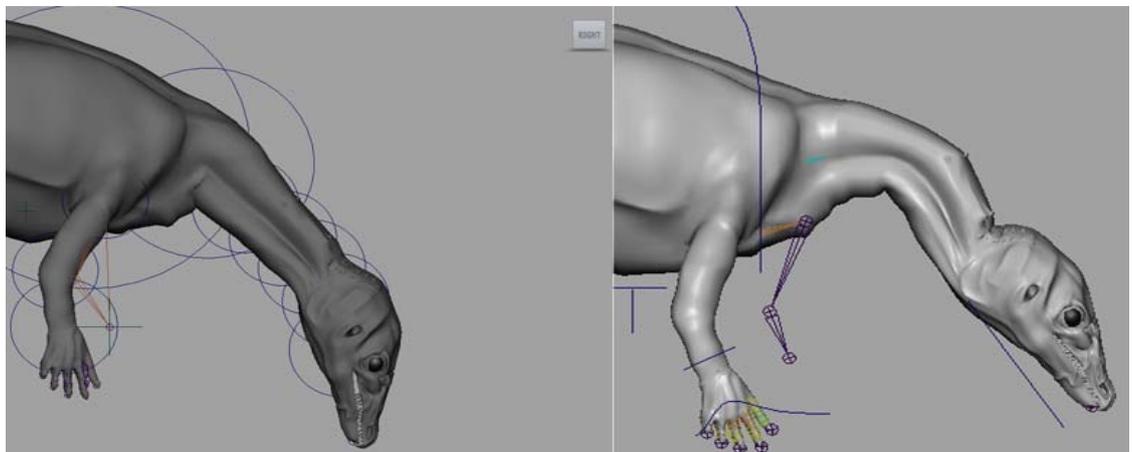


Figure 23 This is the 2005 version (right) with forward kinematics compared to incorrect spline IK

3.6.3. Eyes

The eye sockets play a role in character setup. Eye sockets determine whether or not the eyelids' "blink" is based on a rotation of joints, or whether they are a morph target (blend shape). In this case, blend shapes are used. If the eye is not circular in shape, it might be easier to do a blend shape, although that is not

always the circumstance. (Figure 24) The eyelids are not driven by skeletal rotation, although some riggers prefer to set up eyes this way.

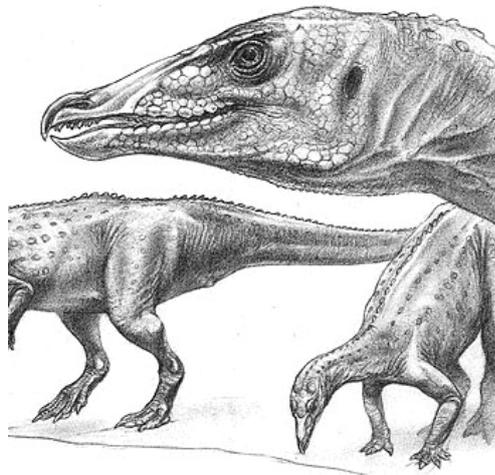


Figure 24 Illustration of Thescelosaurus head provided by the Burpee Museum.

3.6.4. Head

The head of the illustration remains accurate; however, the body illustration needs some adjustments. The neck is elongated and has far more pivot control than the illustration would have lead to believe. This would make the animal easier to rig

because the neck would have more degrees of freedom (aim constraints could be used as opposed to just having a set driven neck setup).

3.6.5. Hands

It is determined by the scientists that although the fingers could move, they would not be able to grip anything with an opposable thumb. This is an important aspect concerning the rigging because the joint structure of the hands and fingers is determined for its skeleton. If the hands are not to have opposable fingers, joints could simply be set driven as a whole and all could move at once. If the fingers are opposable, they need to be set driven individually.

3.7. Building the Model of the Thescelosaurus

When modeling for a rig, crease points are an important element.¹¹ Rows of vertices need to be inserted into the mesh to create the proper creases. Muscles and wrinkles were modeled into the mesh itself as opposed to using a displacement shader or a bump map (as mentioned in the previous section). The muscles that were modeled into the leg topology are based on the basic anatomy of a horse (Figure 25).

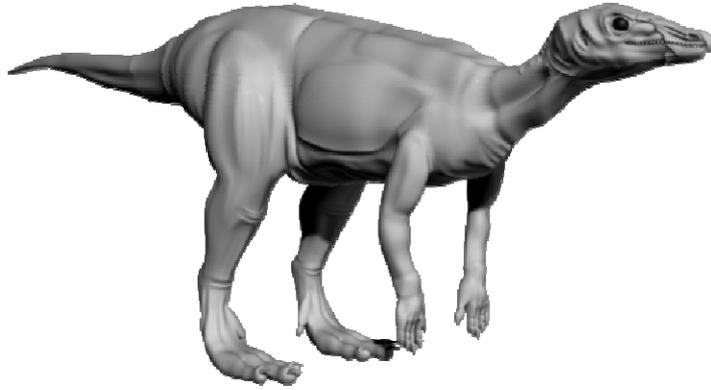


Figure 26 Image showing muscles being modeled incorrectly.

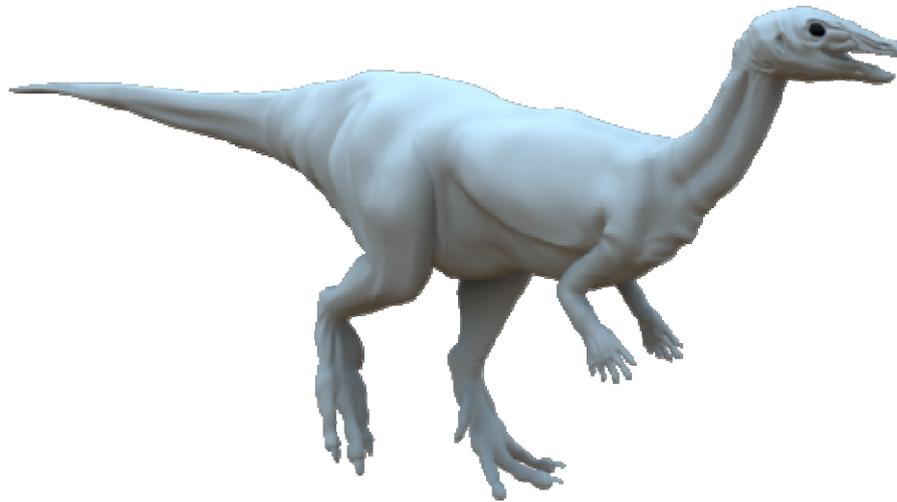


Figure 27 Rendered frame of the Thecoscelosaurus in mid stride showing the limbs of the model being bent. The wrinkles and folds in the skin are also seen right below the neck area.

3.7.1. Chip Set

A lower resolution rig is often included for the animator to use during playback. When animating, it is important that the animator playback animation in real time. If the mesh of the character is too dense, or “heavy”, the playback will be staggered in real time and the animation will appear choppy. The smoother the

playback, the easier it will be to determine the final motion being animated. One way to avoid less than real time playback is to create lower resolution geometry. The character rigger can simply take the final resolution model and extract pieces of the geometry from it, then combine the pieces into their own individual smaller meshes. These pieces can then be parented to the joints and then they will rotate and move according to the key framing that the animator does. Ultimately, the animator can playback the animation in real time, viewing the joints rotate the chip set geometry, to establish scale, timing, and volume.

Both the chip set and the final geometry are attached to the skeleton. The dinosaur mesh is bound to it and the chip set is parented to the individual joints. The skeleton can then be animated and rotated to achieve the desired positioning. The difference between parenting for a chip set and binding for a final piece of geometry is that the pieces of a chip set will not be deforming with joint rotation. The individual pieces will be moving as a whole piece with the joint. It is not necessary to have deforming geometry with the actual joint rotation of a chip set. A chip set (Figure 28) is merely used to block out general motion and give the animator an idea of how the total volume is moving.



Figure 28 Rendered image of the chip set that has been parented to the joints of the Thecosaurus. The chip set gives basic volume of the animal and allows the animator to block out the motion.

3.7.2. Polygon Count

The polygon count of the Thecosaurus is 7864. This is a relatively low polygon count for a main character. On the video game, **Superman Returns**, the main characters are at an approximate polygon count of around ten thousand. The game is a setting with real time playback as opposed to rendered images. The

The scelosaurus was well below a video game poly count limit. This polygon count is very manageable. This lower resolution mesh is used to lay out the UV coordinates for texturing. For final animation, a poly proxy (a lower polygonal mesh, lattice, influencing a higher polygonal mesh) is used on the character to create an even higher resolution. (Figure 30) This can make the final resolution of the image appear smoother. The higher the polygon count, the higher the level of detail. This lattice mesh controls the vertices of the higher resolution mesh. The higher resolution mesh increased the polygonal count three times. The lattice is what is weighted, and that will drive the higher resolution mesh that is bound to it. Due to the fact that this model is for render and not for game, the topology is not as essential to be perfectly clean. Although in an ideal case quads are preferred, having both quads and tris does not matter. What matters is the model's ability to deform properly. This was achieved.

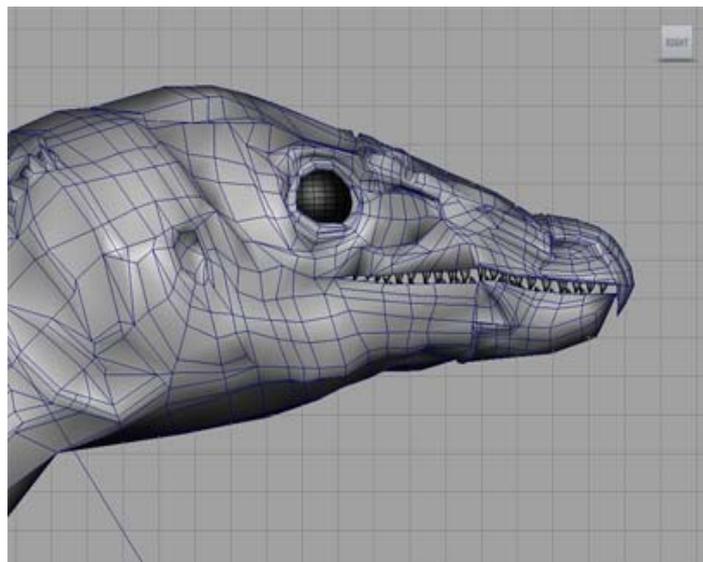


Figure 29 Low Resolution Model.

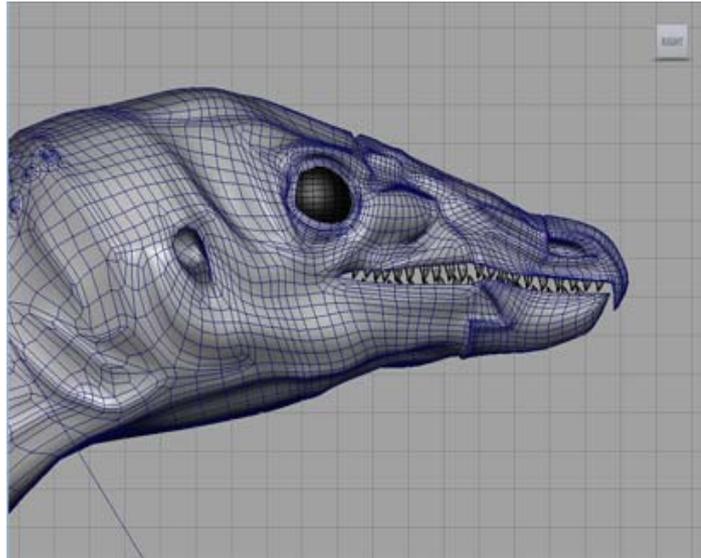


Figure 30 High Resolution Model.

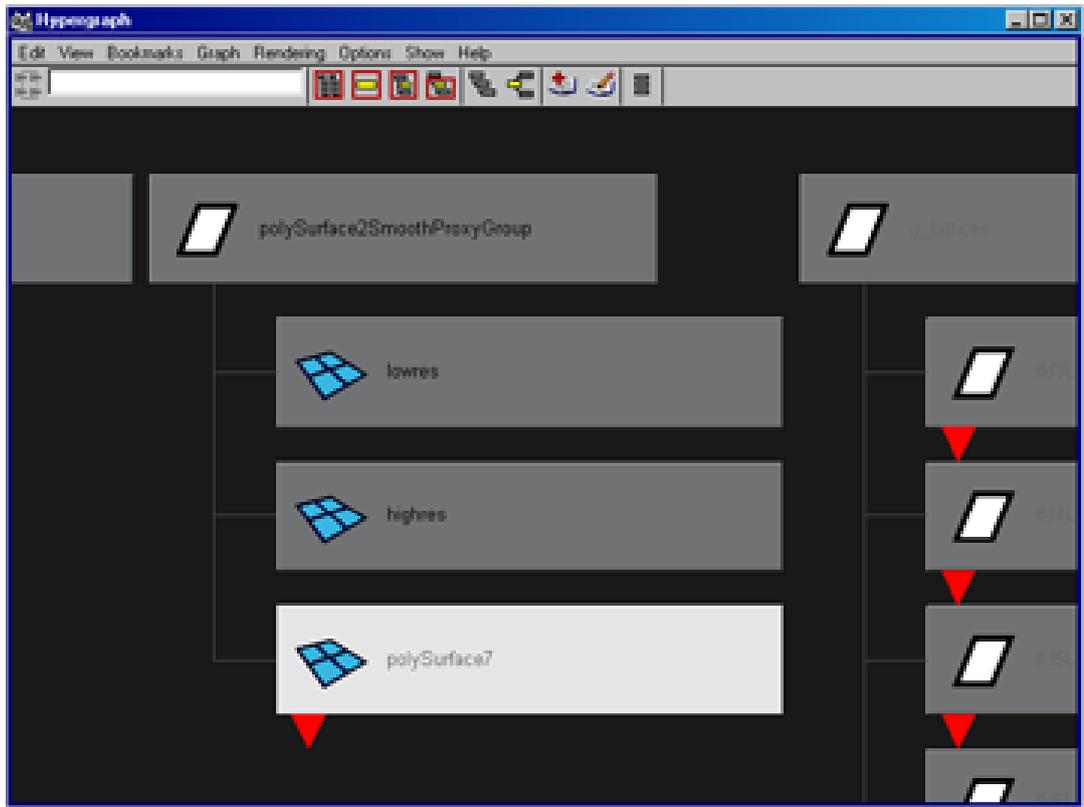


Figure 31 Hypergraph of Thescelosaurus proxy showing hierarchy. Both the high and low resolution are placed under one group node.

3.8. Designing the Rig (Talks with the Lead Animator)

When discussing the aspect of rigging with one of the lead animators on the project, he had several comments to say. The rig should feel invisible and should not impede the animator doing his or her performance. The animator should not have to struggle nor should they have to think about the rig that they are using. That could affect the performance of the animation that is being created.

Therefore, if the rig is cumbersome or awkward to work with, then the animator will be focusing on the controls of the rig as opposed to the performance. This could drastically affect the final performance of the characters being animated. In regards to the amount of controls, it should be streamlined enough not to impede the animators performance. There is no set amount of controls to have, however, when talking to the animator on our project, he would have preferred having the ability to grab handles and slide them as opposed to sliding attributes in a set driven key format.

3.8.1. Legs, Hips, and Spine Computer Generated Joints

The hip joints are actually placed a little higher in the Y axis than the actual bones in order obtain more movement from the mesh's upper backside. The upper hip area and upper back have greater influence from the rotation of the hip because its pivot point of the joint is higher. The knee area is located in the approximate location as the knee on the actual skeleton. The storyboard requires the animal to tilt forward to drink water. The way that this is handled is by connecting the legs to IK handles that were parented to controls separate from the root control. This is a typical setup. (Figure 32)

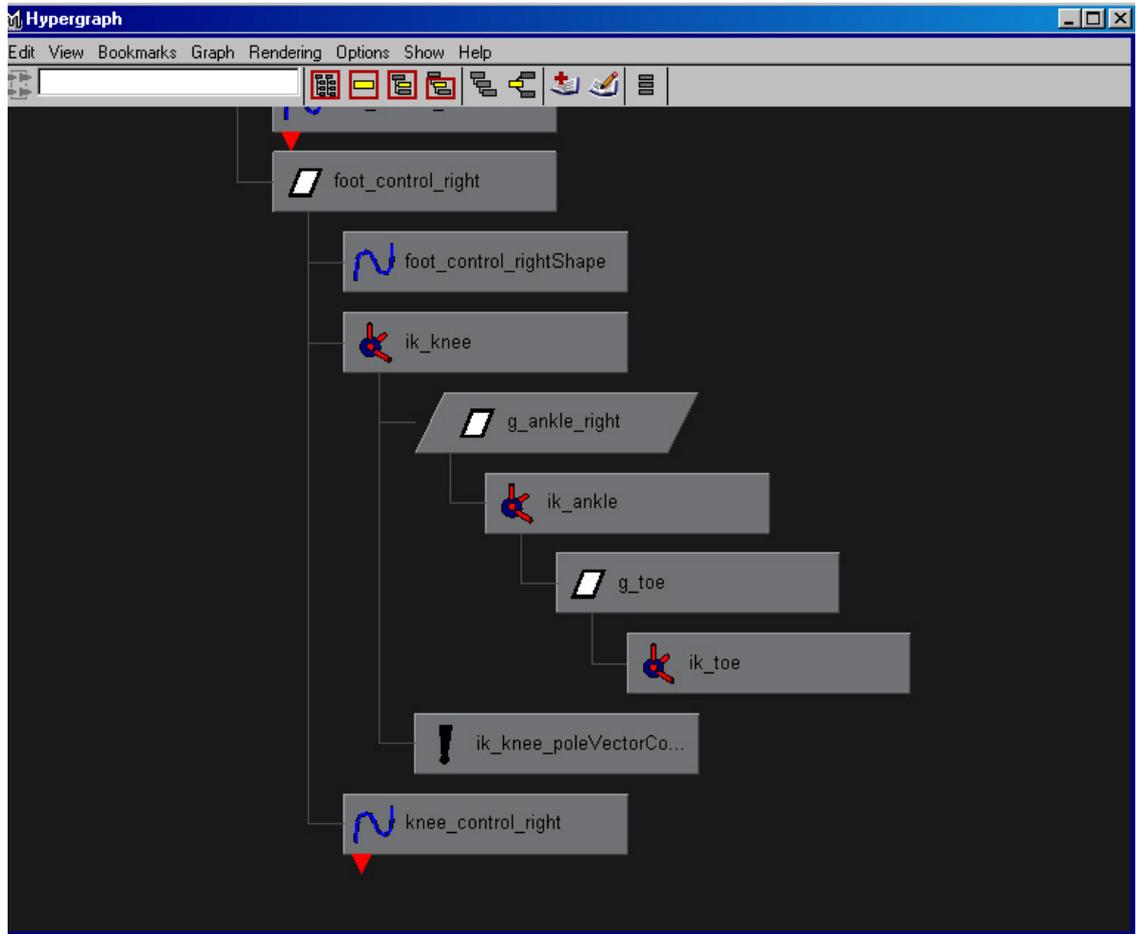


Figure 32 Image of Hypergraph showing the hierarchy of the leg setup.

The animal could then rotate at the hips downward in order to get a drink. (Figure 33) The joints will actually pull the flesh slightly and deform with the actual movement.



Figure 33 Screen capture of the entire skeleton for *Thescelosaurus*. (2005)

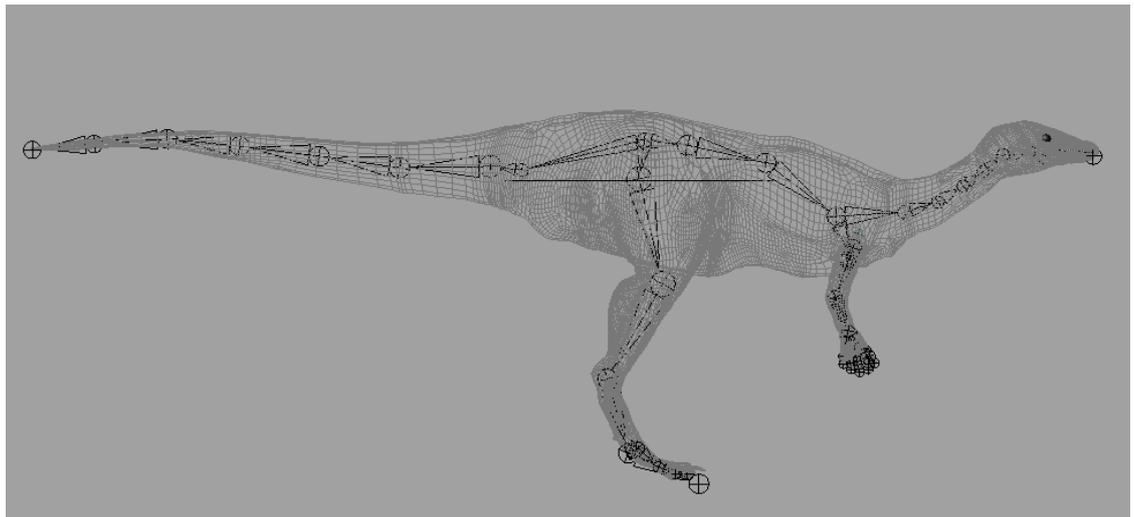
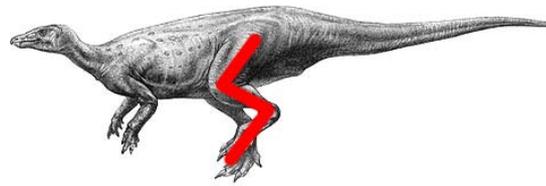


Figure 34 newly positioned spine (2010)

This enables the animal to have a more realistic skin deformation throughout its upper hip area even though the joint would not be in the proper anatomical location. In retrospect, although the 2005 skeletal spine doesn't bother me all that

much, the 2010 version provides a much more accurate deformation. The spine of the Thescelosaurus is visually identifiable at the roof of the model. The 2005 version of the dinosaur has the origin of the spine dropped closer to the center of the mesh, as opposed to the 2010 version where the spine is more closely positioned to the roof of the mesh. The 2010 version is more correct based on the anatomy of the designed model. The 2010 version has a greater optimized joint count in the spine as well. There is minimal movement in the joint chain past the thorax of a character. The majority of motion on visual effects style of animation (which is what this is) takes place in the waist and in the thorax. I removed the extra joints in the spine for this reason and the result is still correct.



Possible joint setup for the leg.

Figure 35 Thescelosaurus leg strategy.

3.8.2. The Foot Computer Generated Joints

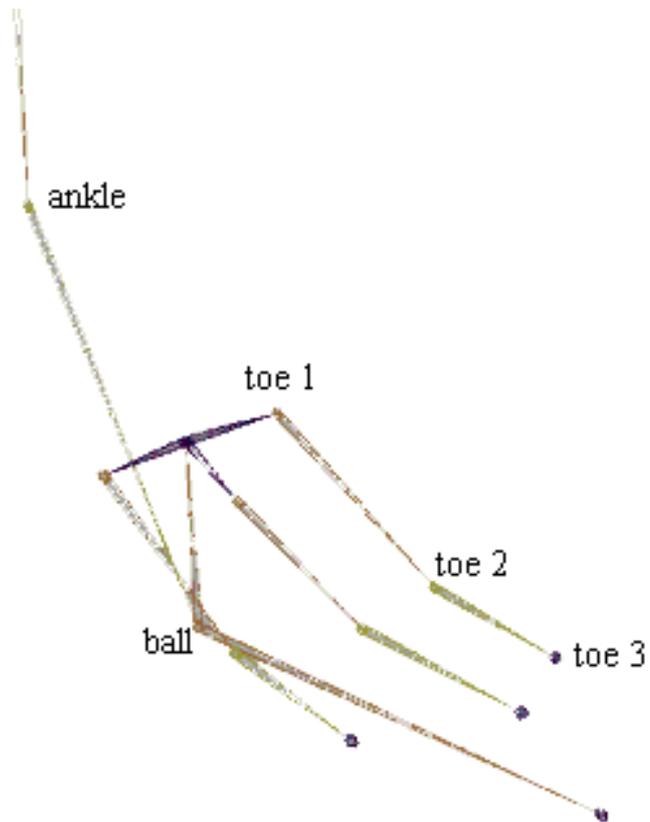


Figure 36 Screen capture of the *Thescelosaurus* foot. The ball joint acts as a main pivot for the toes that can move independently.

The foot is created to enable a rigged foot roll (Figure 36). The joints of the foot are designed to have a tradition roll that might be present in a biped's typical foot

setup. On the ball joint, additional joints are parented to weight the toes. The toes rotate with the ball to simulate a roll while the toes rotate independently. (Figure 36) The foot setup is different than the actual anatomy of the animal. The ball joint has a separate joint that is its child containing the toes which rotate independently. The foot can then have a roll to it while still being able to move its individual toes. (Figures 37 and 38)



Figure 37 Images showing feet being rolled in both extreme positions.



Figure 38 Image of toes being flexed independently of foot roll.

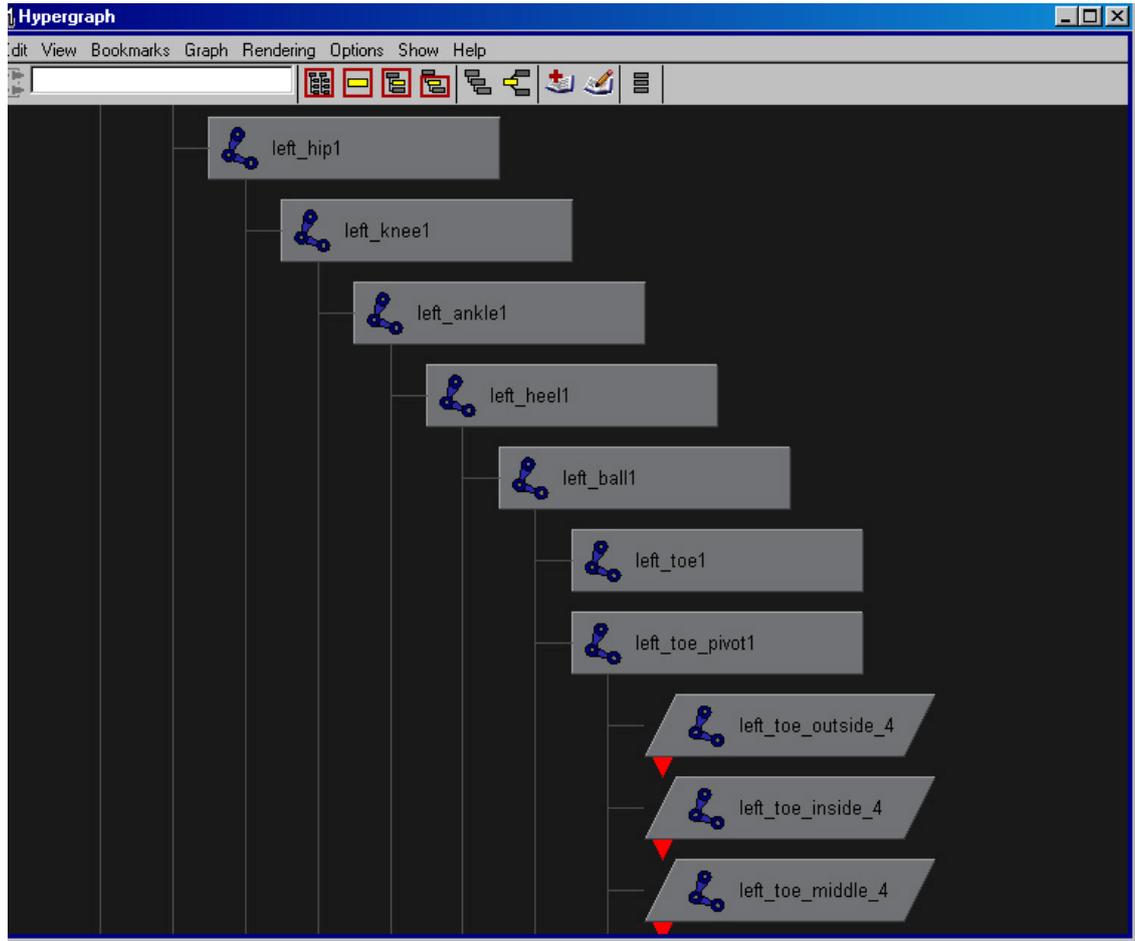


Figure 39 Image of Hypergraph showing hierarchy of the joints of the foot.

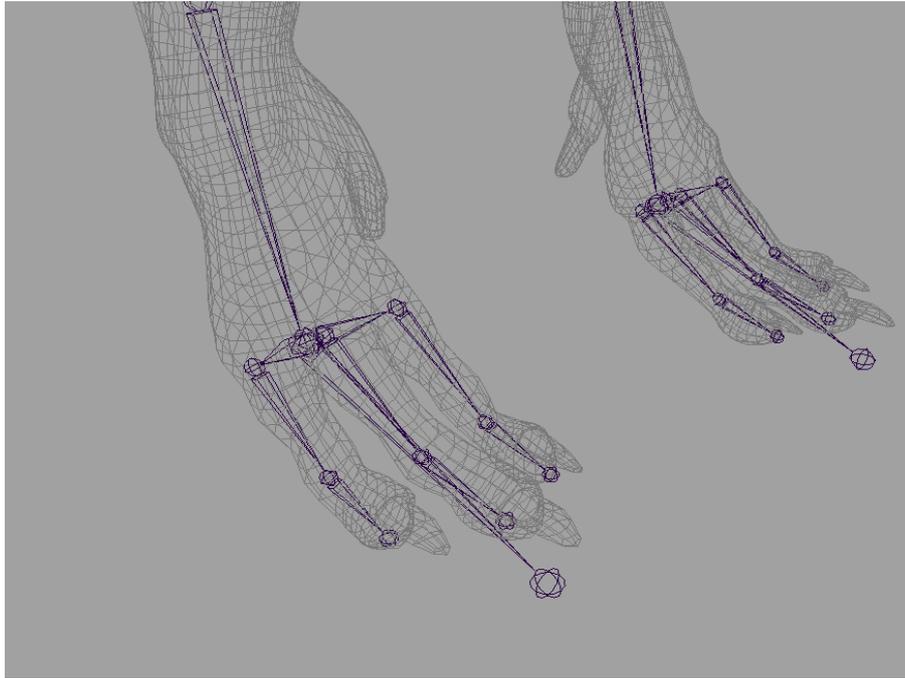


Figure 40 The 2010 version of the foot

The 2010 version of the foot (Figure 40) not only has an optimized joint count from its 2005 predecessor; but the pivot point of the two is repositioned. The 2005 version of the dinosaur has a toe pivot point that is too high above the mesh. This means that in a foot roll, the toes crease line is in the improper position. The 2010 version of the skeleton has the main toe pivot at the base of the individual toes. Deformation is far more accurate.

3.8.3. Arms/ Hands Computer Generated Joints

The bound skeleton has the basic setup for an arm (Figure 41). A shoulder joint is there, as well as an elbow and a forearm. The fingers are created to have rotation

at the base of the first knuckle, and rotate throughout. The forearm rotates the skin and the wrist causing a double rotation. This is good because the skin of the forearm must rotate with the actual wrist movement to a certain degree. By practicing proper wrist movement and rotation, the rigger will become accustomed to making rigs that are complete. This type of practice will make the rigger more qualified for jobs requiring realistic motion.



Figure 41 Image showing the arm setup. In order of hierarchy: shoulder, elbow, forearm, wrist, hand, fingers.

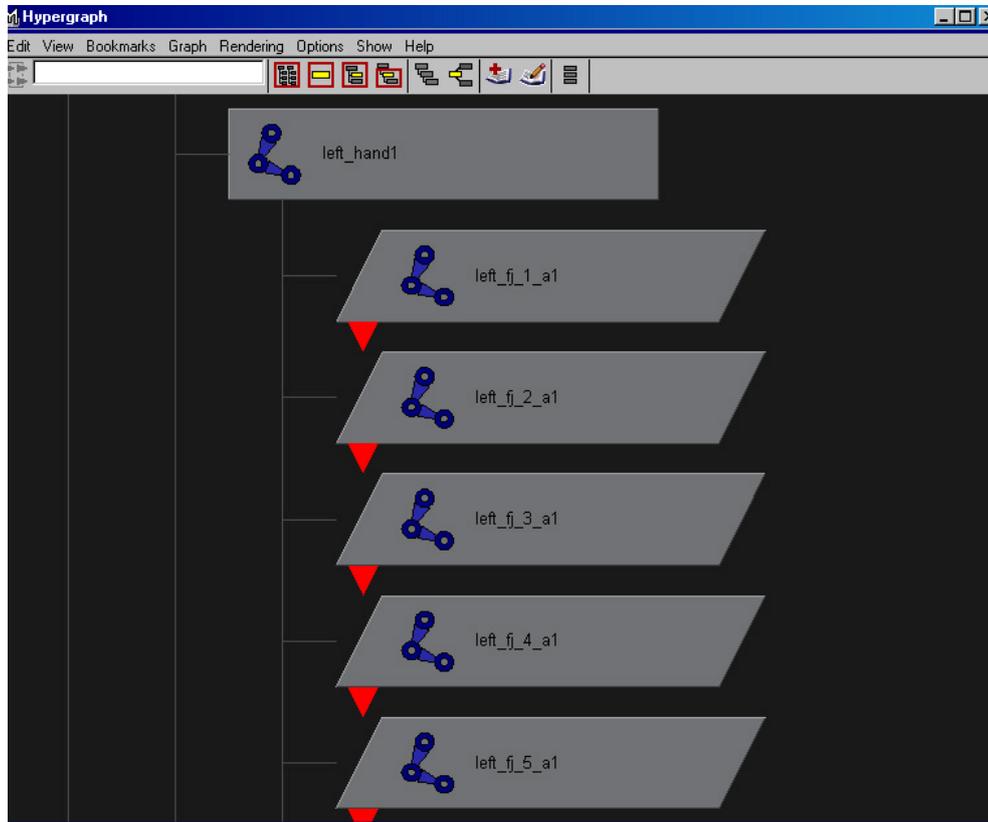


Figure 42 Image showing hierarchy of the hand and fingers.

3.8.4. Tail Computer Generated Joints

The same strategy that is used for the spine is used for the bound portion of the tail (Figure 43). The rigger thinks about how the animator is going to be keying this portion of the character. The rigger wants to make the life of the animator as easy as possible. Several joints are placed in the tail to achieve proper rotation in

all axis: bend, curl, and twist. The tail is a key part to the character because it provides the balance of weight distribution when the character is in extreme positions. There are twelve joints in the tail. This will give the tail enough curvature when moving and rotating in several of the degrees.

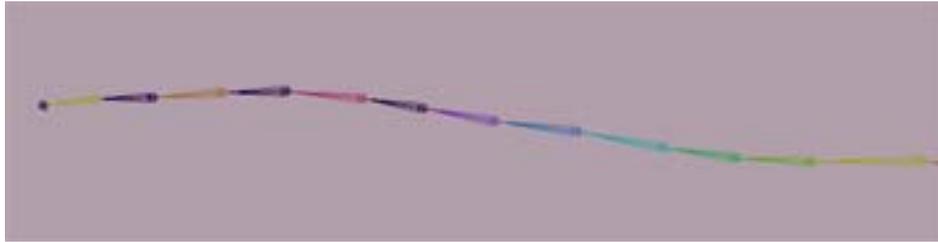


Figure 43 Image of the tail showing all twelve joints.

3.9. Muscles and Blend Shapes

There are different ways to create muscle deformation in the rig of a character. One of those ways is to use blend shapes (Figure 44) that will actually sculpt out the muscles to whatever form is desired. This can be an easy way to create muscle bulge. The problem is that in order to create blend shapes the character must be in a bind pose. If you try to create blend shapes in a pose that is not the one that it was bound in, the vertices of the mesh will get a double transform- meaning they will move twice the distance that they are supposed to in world space. This is bad because the model will then become distorted.

Blend shapes can be added to the rig at any time. In order to get them to function properly they must come after the weighting in regards to hierarchy.

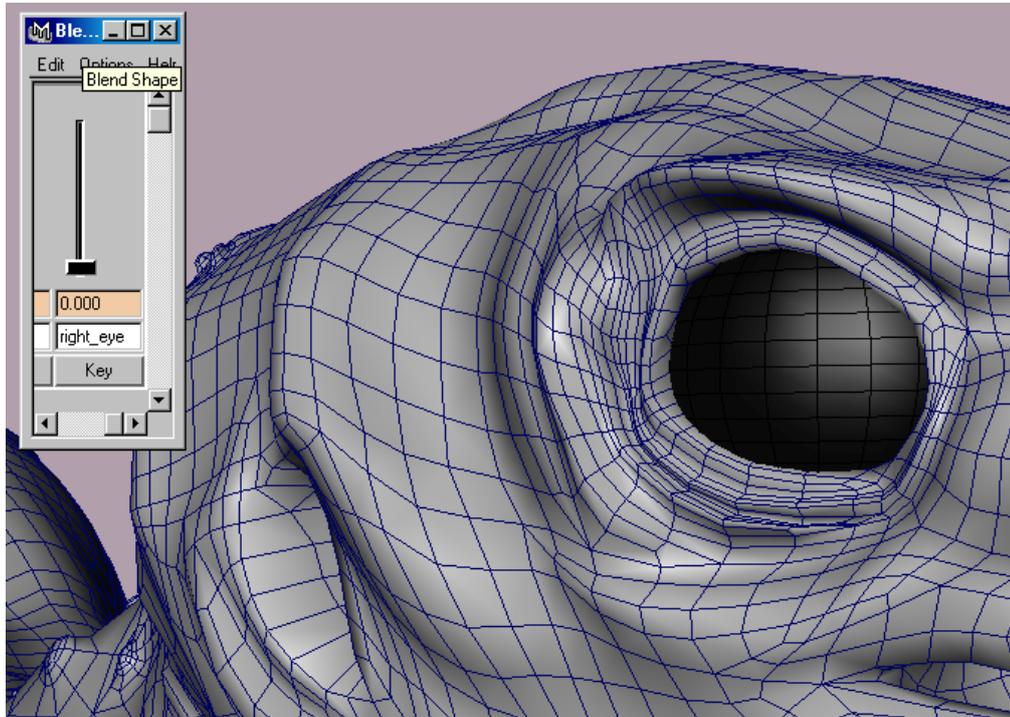


Figure 44

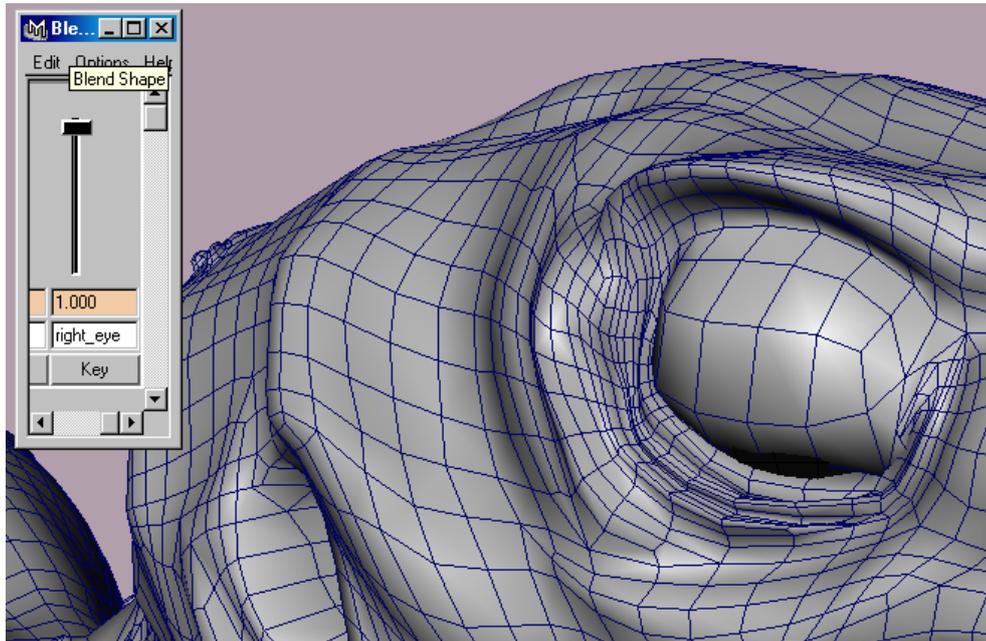


Figure 45 Screen shots of blend shapes being used to close the eye.

The other way is to deform the mesh indirectly with what is called a wrap. A wrap acts as an influence object that drives the geometry that it is “wrapped to”. For the Thescelosaurus, after the mesh of the character is created, muscles are modeled out of NURBS and then wrapped to the polygonal mesh on top of it (Figures 46). The muscles are sculpted and then modified to become enlarged using blend shapes. The blend shapes reflect the flexing that takes place when a muscle moves due to the rotation of the joint it is parented.



Figure 46 Screen capture of muscles being animated while being parented to the driving joint.

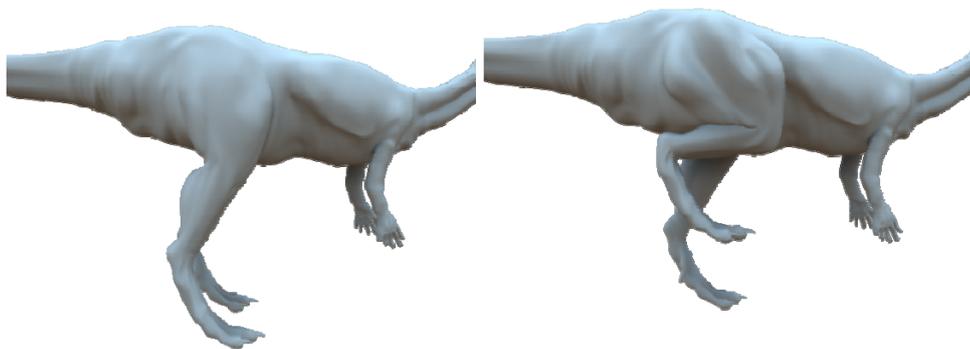


Figure 47 Illustrations of the leg being flexed with a wrap. The wrap creates creases and moves the vertices of the mesh in addition to the rotation of the joints.

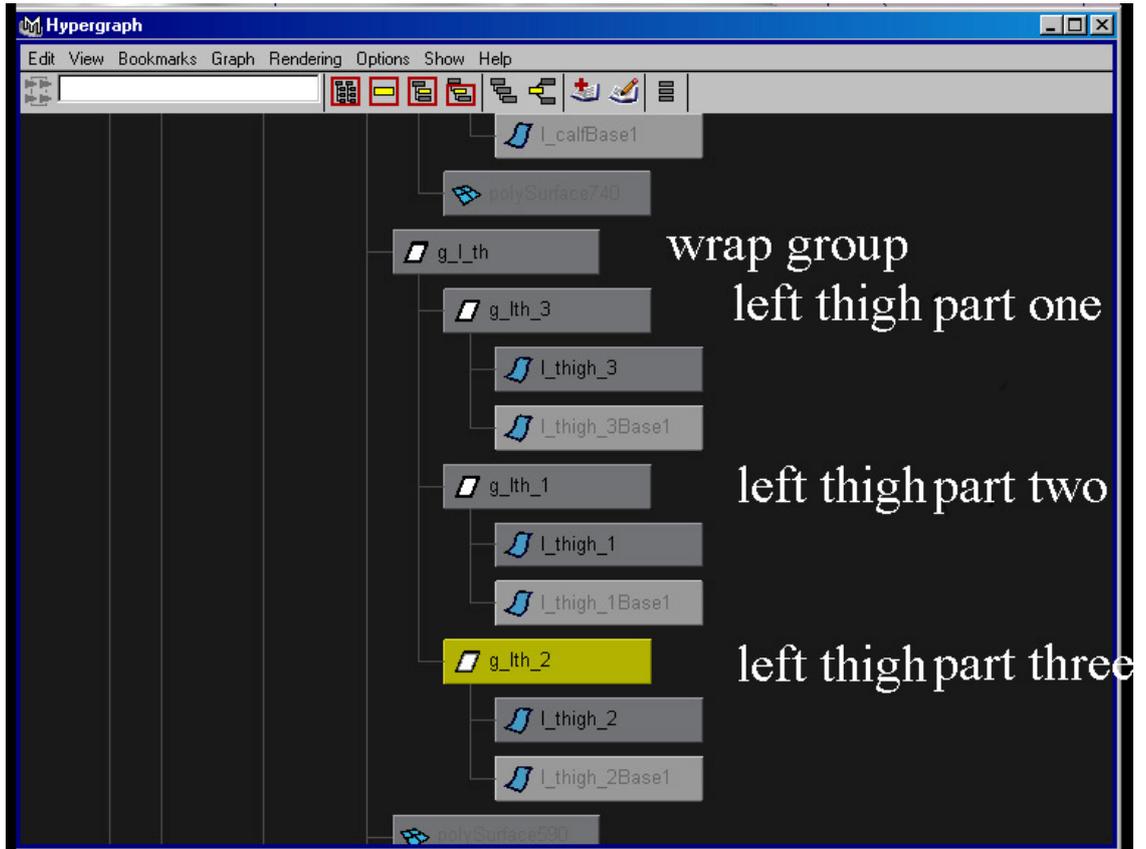


Figure 48 Hypergraph showing hierarchy of wrapped muscles. The muscles are the children of a group node, which is the child of the hip.

Muscles add to the realism of form. In this instance, NURBS surfaces are modeled in the form of muscles and used as a wrap deformer to the Thescelosaurus geometry. (Figure 46) NURBS are used because it is easier to get an organic shape quicker. A wrap deformer, as discussed earlier, is an influence object that drives the vertices into different positions in world space. These wraps

are commonly used in the industry for binding multiple pieces of geometry to objects as well as creating muscle deformation.¹²

The muscles, based on blend shapes that were set driven keyed based on the rotation of the joints that they are parented, would then drive the geometry on top. Blend shapes create different versions of a model with vertices manipulated in world space. The different versions become target shapes for the original mesh to be morphed. The advantage to doing this method over using a blend shape is that the rigger can turn the muscles on and off as opposed to having the blend shapes keyed on rotation all of the time. In addition, the rigger can pick which vertices will be influenced by the actual muscle. This gives the rigger direct control over what is moving when, and by how much.

Another advantage to using wraps over blend shapes is that if the muscle is to have jiggle, the NURBS geometry can be converted into a soft body with jiggle. A soft body is a conversion of a mesh into a dynamic with particles influencing the vertices. The particles cause the vertices to jiggle and sway with the motion of the character. This can simulate fat jiggle as well as muscle jiggle. This jiggle, once in motion, will then influence the skin of the character. The end result will be jiggling muscle deformation that will add to the realism of the character. This was the technique used by Industrial Light and Magic on Jurassic Park 3. The dinosaurs' muscles jiggled as influence objects as they walked, which enhanced

the realism. As a bonus feature on the Jurassic Park 3 DVD, walk cycles are generated with the dinosaurs showing the jiggle in the muscles.¹³

3.9.1. Forward and Inverse Kinematics Switch

When creating a rig for an animator, it is an impossibility to predict every method of key framing that will be used by the animator to complete the motion. Some animators enjoy using forward kinematics and some primarily use inverse kinematics. Electronic Arts, the world's largest game publisher, utilizes both in their rigs. The animator will use forward kinematics when he wants the joints to follow the root node; and use inverse kinematics when he wants the joints to move independently from the root. The IK handles will be parented to another control that is not in the same hierarchy as the root node, causing an anchor. Therefore it can move independently. The Thescelosaurus contains both on its limbs. The arms are either key able using "FK" or they are key able using "IK". A switch created as an attribute on the control and parented to the wrist joints can blend between the two joint chains.

A constrained setup is used on the tail using dynamics, forward kinematics, and inverse kinematics. The animator can key an attribute that switches the tail from a dynamic setup, to an IK setup, to a forward kinematics setup. By using Orient constraints, the tails can switch from one to the next and blend between motions.

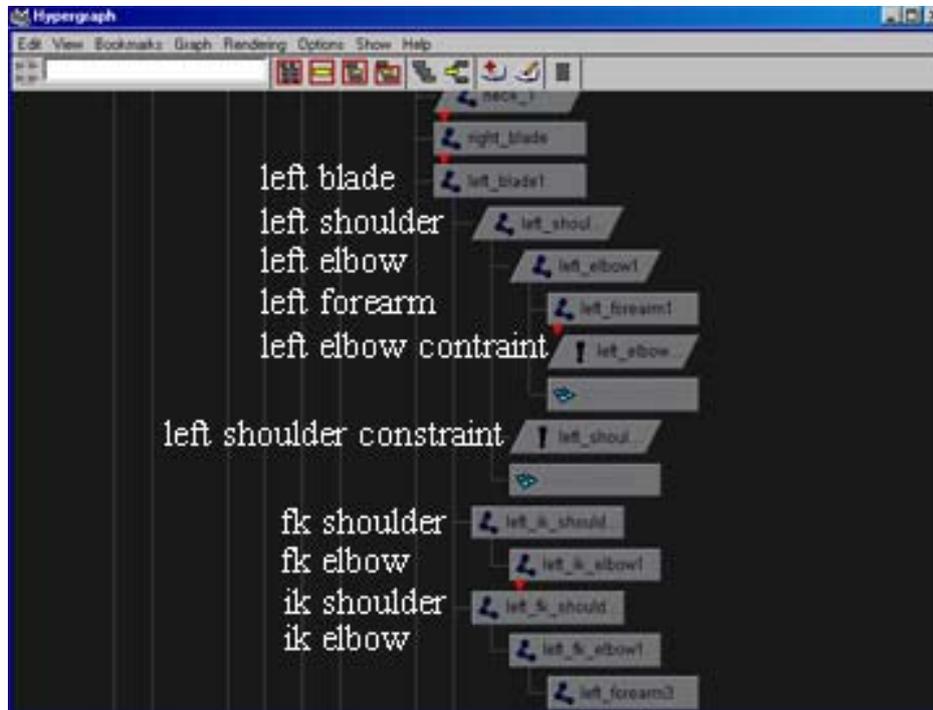


Figure 49 Hypergraph setup showing joint hierarchy of base arm with FK and IK joint setup.

This will enable the animator to do a seamless blend between forward key framing and inverse key framing. Image 49 shows the hierarchy of both joint chains. They are both parallel in hierarchical order but are both driving the same parent at different times, depending on the setting of the FK/IK attribute.

3.9.2. Set Driven Key

Set Driven Key is used in this rig to help automate the joint rotation of particular joints. Set Driven Key is a function in Maya™ that creates an attribute that drives the rotation of a joint in a “set” position, predetermined by the rigger. This puts a clamp on the joint rotation. In a situation where the joints are not going to be moving that much, this feature could be utilized, such as the fingers. Having predetermined joint rotation based on the input of an attribute is a common procedure used in character setup. On all fingers an attribute is present to make a key able set driven control that would enable the animator to do both “finger spread” as well as “finger crunch” (Figure 50).



Figure 50 Fingers being spread and opened using set driven key.

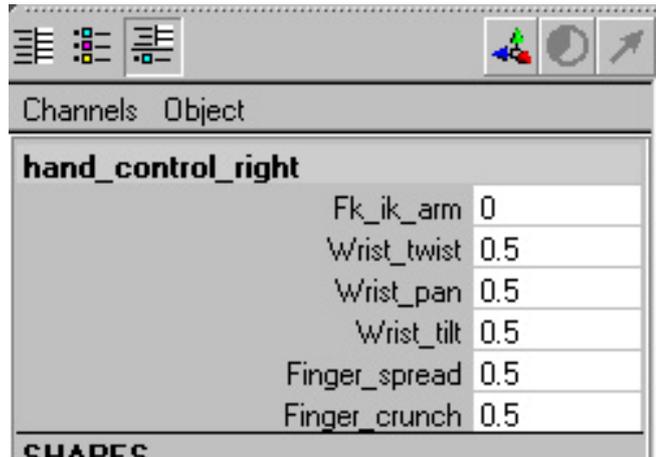


Figure 51 Attributes of set driven hands and fingers.

Set driven key is used on the toes. A “foot roll” is used that keys group nodes whose children are IK handles. The toes that are extensions of the ball of the foot are set driven to contain a “toe spread” as well as a “toe crunch”. This is an effective method for creating a foot that can move in all directions. Set driven key is used to create an entirely animate able limb.

The negative to using set driven key is that often at times the animator would like to key a control that is a piece of geometry with rotation, like a NURBS circle. When using a slider, the set driven attributes can become quite tedious to use. It is much easier for an animator to rotate a control as opposed to using a slider at times. The flip side to this is that the rig will have a tremendous amount of NURBS controls on it as opposed to few controls with several attributes. This can potentially make the rig look messy.

3.10. Stretch Tests

Once the first rig is completed, it is good to immediately pass it on to the animator to test out. The animator will do a series of stretch tests. These stretch tests, which can even be walk cycles, will help to determine the maximum rotation of the joints of the rig. This will not only establish basic movement of the character, it will show if there is any tearing or stretching of the geometry. For example, in the *Thescelosaurus* it was important to determine the maximum rotation of the hips. It needed to be determined how far apart the character's gait is going to be. This was determined by extensive talks with both the Burpee and the lead animator. Stretch tests can be the most helpful stage when doing the rig. Often times a rigger needs to pass along his rig in the production pipeline and will be unable to test it. This gives the rigger the opportunity to see how easy his rig is to use once it is passed off.

3.11. Revisions

This rig is a basic setup with controls that were easily findable and key able to the animator, a success. The only revisions made were to the FK/ IK setup of the neck. The neck is both created with set driven attributes as well as a key able control handle that was based on an IK spline. A double transform happened on

the clusters that are parented to the IK controller. To fix this problem a group node is added and the cluster controls are set to “relative” which totally eliminated the double transform (Figure 52).

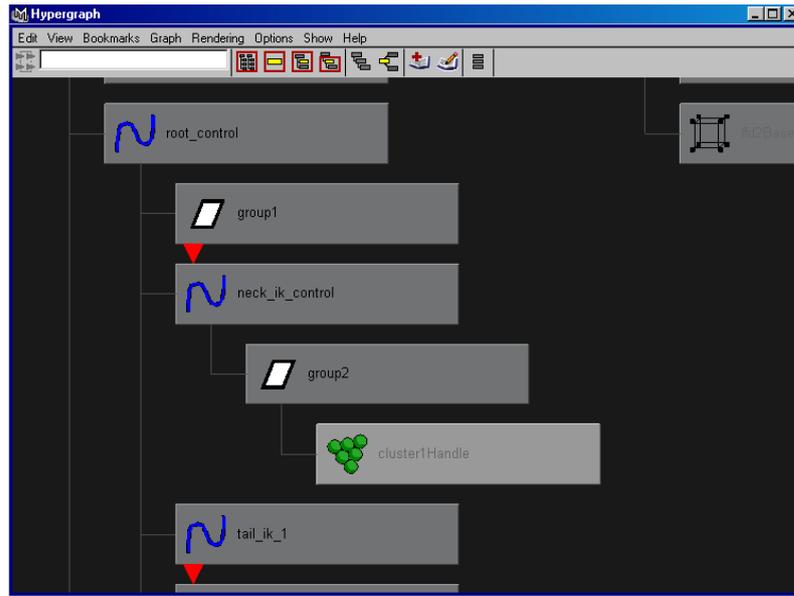


Figure 52 Image of Hypergraph showing hierarchy of neck.

3.12. Controls

The controls for the character were made to be very simple and easy to select and manipulate. The image below shows the basic design of the controls. They are easy to select and easy to animate with.

Thesc. Model Sheet

- | | | |
|---------------------|------------------|-------------------------------------|
| 1. IK control neck | 5. Elbow control | 9. IK tail controls |
| 2. FK joints | 6. Knee control | 10. Upper chest/
FK neck control |
| 3. Wrist control | 7. Foot control | |
| 4. IK wrist control | 8. Root Control | |

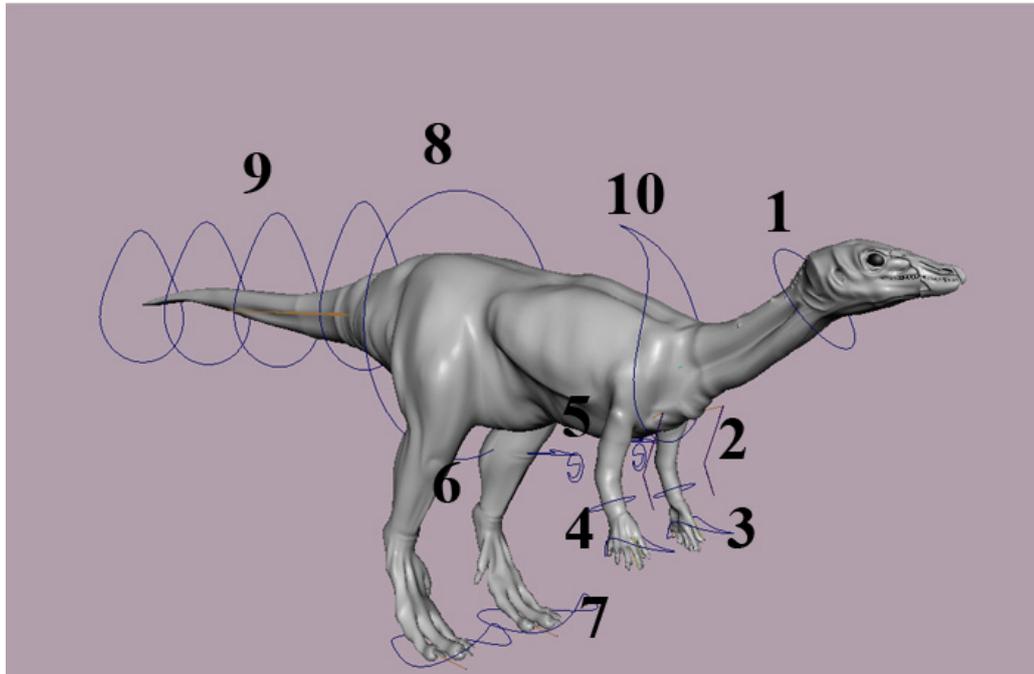


Figure 53 Illustration showing controls for the character.

3.13. Reflections on Strengths and Weaknesses of the Rig

In conclusion, the Thescelosaurus rig is successful. It is entirely animate able after its second pass. The strength of this rig is its weighting. Creating proper hip rotation in a biped dinosaur is one of the more difficult skinning aspects to do.

What makes this rig successful is its ability to have proper hip rotation without

tearing of vertices. The hips can move at an incredible degree of rotation which enables a tremendous amount of animation to be made possible. This is key to the animation because the storyboard animatic required a tremendous amount of squatting and spreading of its legs. The skin movement was a key to its success.

On the negative, too many set driven attributes were used in the creation of this rig. It would have been far more productive to the animator if key able controls were used to orient constraint the movements of the joints. The animator would much rather rotate a control as opposed to sliding an attribute.

3.14. Chapter Three Conclusions

This chapter has illustrated the controls and skeletal positions of the thescelosaurus. In addition, it has given the guidelines used by a character technical director in this industry.

CHAPTER 4

NEXT STEPS: THE MAYA EMBEDDED LANGUAGE (MEL) AND PYTHON

4.1. MEL Scripting

MEL (Maya Embedded Language) is a script based language within the Maya software package that helps to automate the rigging pipeline and process. MEL enables the rigger to type in code that will procedurally create tools and software applications that will speed up the production. The language is used by most professionals in the character setup pipeline on both film and game development.

4.2. MEL Tools Addressing the Needs of Dinosaurs

MEL covers a broad spectrum of potential custom tools that can be made. When thinking of ways in which MEL can assist in the creation of prehistoric animals, it

is a good idea to ask the question, “What is the setup task trying to be solved that can be automated through the use of a custom tool.” First, identify if this tool can be used for more than one character. Once the time is spent on the tool’s creation, that tool can be stored and called upon at a later time that will end up saving the rigger billable hours. Then, ask what the steps and procedures are for creating this tool. Then, begin the production of the tool. For the tools that are created as next steps in this case study, the tools created will be applicable to the Thescelosaurus as well as other characters. If the rigging operation is to only happen one time, it might not be a wise decision to invest hours upon hours of time on the tool. Rigging the design problem straight through is a better use of time. These decisions on a project are typically made by the project manager.

4.3. How MEL Could Be Used In This Case Study

Although the Thescelosaurus is a unique biped dinosaur, there are certain features of the animal that are applicable to all bipeds. The foot roll is unique from that of a typical human foot roll (one in which the toes are covered by a shoe) because the Thescelosaurus needs independent toe rotation for flexing. A human foot roll, especially one that is clothed in apparel covering the toes, does not require the toes to move for any reason. However, the basic, underlying, computer generated, and skeletal structure in the Thescelosaurus matches that of a biped human in regards to joint count. Dr. Stuart Sumida described the leg similar to the

Thescelosaurus in one of his presentations to our team. When designing the IK setup of the animal, the rigger is to imagine that the backwards knee is the ankle of the foot. The ball of the foot comes right after in the hierarchy followed by the toe. The process used to create the inverse kinematic and grouping setup can be automated by the creation of a custom tool that would speed up production. This tool would then address the basic foot roll for all biped characters.

In addition, another tool could be created that would enable the character setup artist to quickly create controls enabling the joints to have limitless rotation. The majority of the animators that I have worked with do not want limits on the joints they are animating with. An animator might want to hyperextend a pose for one frame of the animation in order to make the sequence more dramatic. I personally do not recommend this because actions like this go against biomechanics, or the science of motion. This decision is typically made by the animation director on the project. The current setup of a limitless control is a tedious process that can be easily automated through the use of a MEL tool. This tool would not only be applicable to the toes of the Thescelosaurus, but all rotate able joints within the rig.

4.4. The Application of the MEL Tool

The tool that is being created is a custom window that will setup the rig of a biped dinosaur leg, similar to the Thescelosaurus. The premise behind this tool allows the rigger to create the proper requirements to make the leg function according to its biomechanics. The tool adds the IK and FK controls to it to make it function. In addition, controls will be added to animate the toes without limits. The controls are parented to the joints within the hierarchy. The animator will be able to rotate the controls on the individual joints to manipulate them. The tool creates as many controls on the joints as possible. That way if the animal has more than three toes it can be created easily. Lastly, a pole vector on the knee is created by a knee control that will manipulate knee orientation. This automates the process from taking ten to fifteen minutes done by hand to shorten to approximately thirty to forty five seconds. This tool could be used to assist in the rigging pipeline of animation.

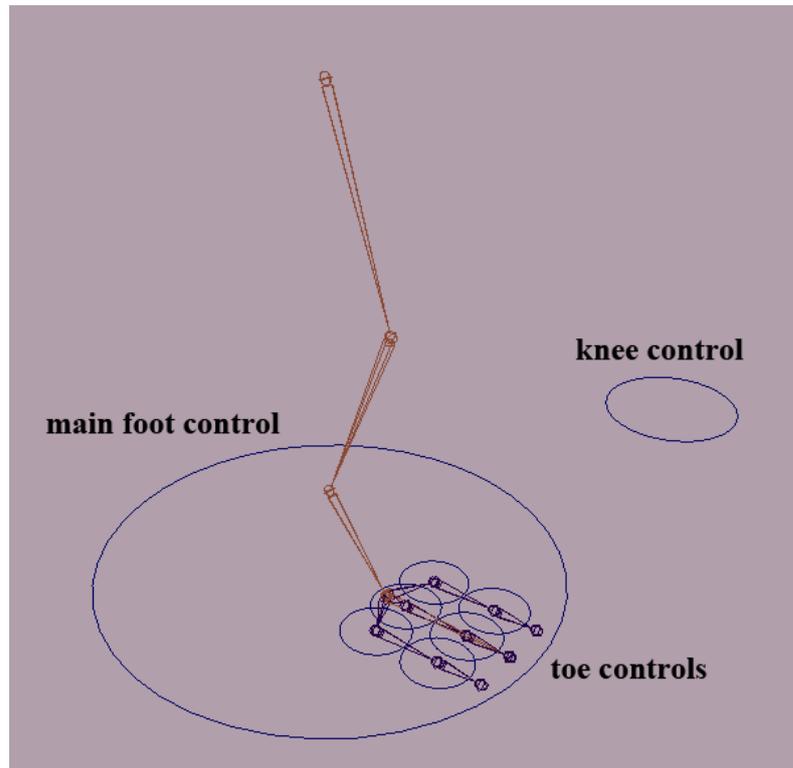


Figure 54 Leg setup.

Figure 54 is an illustration of the proposed setup for the biped animal. The main foot control will play host to the set driven attributes. The toe controls only have the ability to be rotated- thereby manipulating the joints that they influence. The knee control that is to be created will be a simple NURBS circle, similar to the other controls and will influence the rotation of the knee area. The tool must be able to create the biped dinosaur leg with ease as well as fulfill all requirements needed for proper biomechanics. It is hopeful that the end result of this tool will

be a simple MEL command that can be posted on a shared website and easily downloadable for all users.

4.5. The Dinosaur Leg Tool

The window, or graphic user interface (GUI), will be designed accordingly so that the tool can be easily picked up and understood. The GUI will have both drop down menus as well as sliders. The sliders will scale the size of the controls and the drop down menus will ease the design of the GUI by creating the operations of the tool.

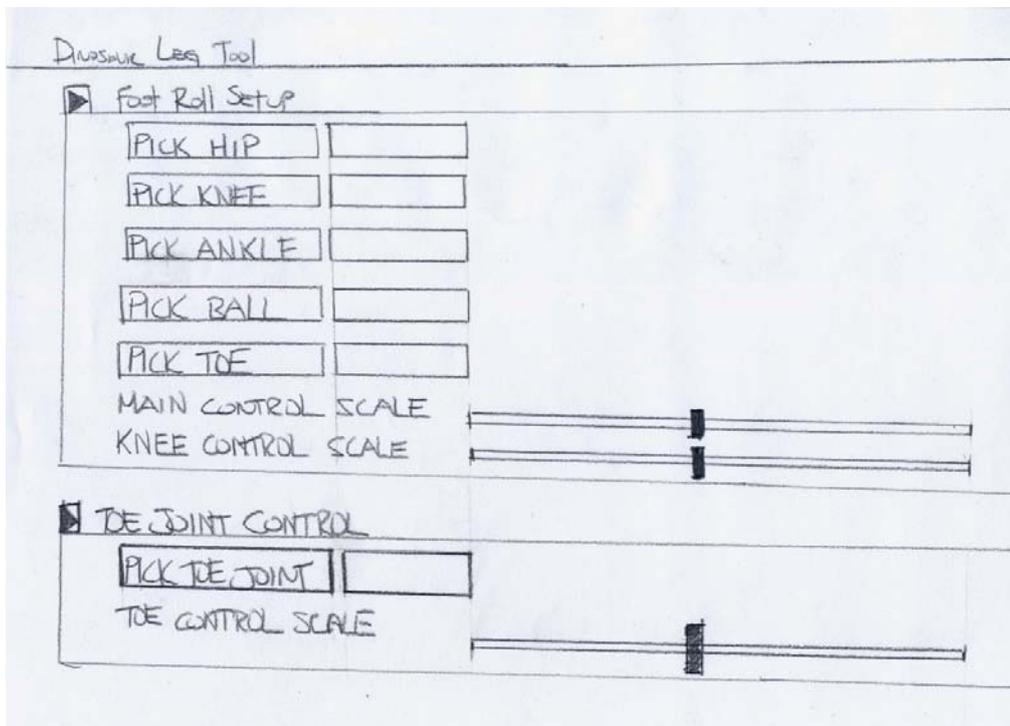


Figure 55 illustration of the schematic design of the GUI that will create the leg set.

Whenever designing a graphic element it is always a good idea to sketch out an idea of what you want the piece to look like. This gives the designer a goal to aim for and gives a reviewable sketch that can be easily modified without having to worry about changing a lot of code. (Figure 56).

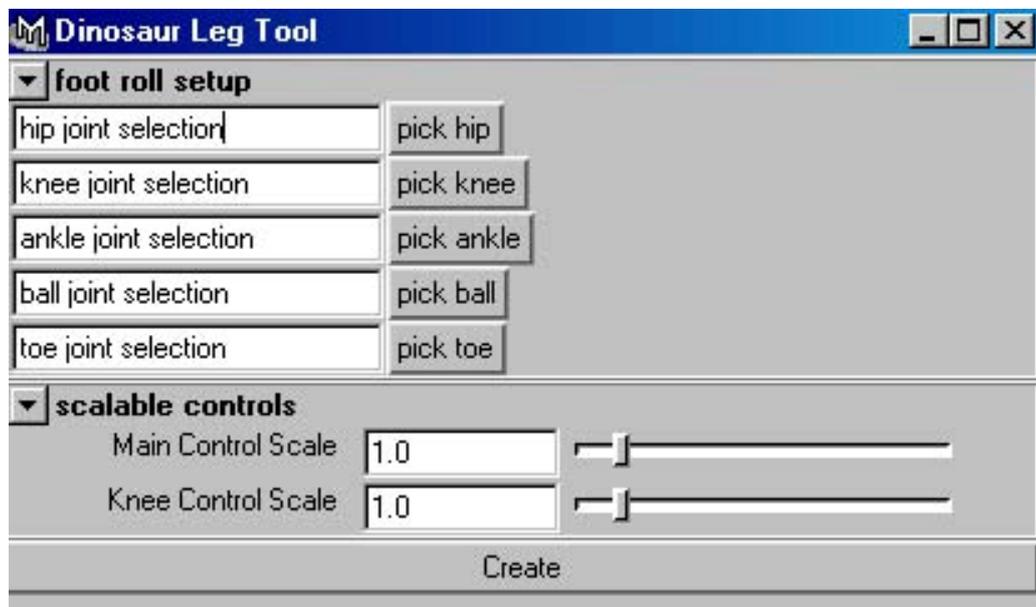


Figure 56 GUI of “foot roll setup”

Figure 53 shows the GUI for the “foot roll” portion of the tool. The user selects the portions of the computer generated dinosaur leg that correspond with the text in the field box. Afterwards, the create button is selected and the dinosaur leg

controls are created. Both the knee and main controls of the rig are scalable through the use of the sliders. In addition, multiple legs can be created with the “Dinosaur Leg Tool”.



Figure 57 GUI of “rotator joint” tool.

Figure 57 shows the GUI of the “Rotator Joint” tool. This tool is created so the character setup artist can create controls for a rotate able joint that can be animated. First, the setup artist selects the parent joint of the rotation joint; then he selects the joint itself; then selects the “Create” button. This activates the procedure which creates the NURBS circle that can be used as a control for the animator. This NURBS control is parented in the proper hierarchy with the proper constraints.

These tools can not only be used for dinosaur character setup, but for all character setup involving biped “foot roll” and joint rotation. Both of these tools can be posted as plug-ins for character setup artists to download and install in their Maya GUI.

4.6. PYTHON

Python is an object oriented programming language that is used in collaboration with MEL in Autodesk software. The language itself is incredibly diverse and utilized within all animation software packages owned by Autodesk, the industry leader in computer software. PYTHON is used in this industry the same way in which MEL is used; to help automate the rigging process. This software utilization is not only becoming the standard in computer setup, it is also beneficial to a rigging team due to the fact that it saves budgeted time and hours. Automation is essential to any rigging department. The quicker that a skeleton and controls can be created, the more time can be spent on deformation. The 2010 version of the Thescelosaurus was auto rigged using PYTHON starter scripts. I wrote these scripts to give the rigger a quick and versatile starting point during the rigging process. On a standard biped that is based off of my professional experiences between Lucasfilm, Take 2 Interactive, DreamWorks SKG, and EA Sports, launching these scripts will take me to 95 percent of the rigs completion. I have left the scripts open ended enough so they can be easily modified and added

to if so need be. These scripts function in the following way: a leg setup script; a wrist rotation script; a shoulder counter rotation script; a forward kinematic script; an IK and FK arm script; and lastly a spine creation script. These scripts were used in the 2010 version of the rig to create controls that gave me a rig instantly. The entire rigging process took me approximately ten minutes on the 2010 version including skeletal creation.

Lastly, writing all of the steps in PYTHON code and getting working scripts leaves less room for error in future projects. Once the code is written and executed properly, this will save time for future projects. The total rigging time on the 2010 version of the rig took approximately four hours and ten minutes, including the binding. The difference in total time taken on this project between 2010 (with automation scripts) and 2005 (without automation scripts) was approximately 21.3 hours.

4.7. Chapter Four Conclusion

Chapter Four has shown the use of MEL and PYTHON in the automation process of character technical direction of this rig. These two programming languages are essential to character technical direction because they reduce the number of billable hours spent on a project.

CHAPTER 5

CONCLUSION

Character setup is a growing discipline within the field of computer animation. This discipline challenges the character setup artist to not only pay close attention to aesthetics, but become a technical problem solver as well. As the discipline grows and more technological breakthroughs take place, the title of character setup artist will become coveted in both the technical and visual arts.

In conclusion, the character setup of the *Thescelosaurus* (2005) is a success. Although the techniques used in 2005 are not the same as the professional techniques used on the 2010 version, the rig submitted to the Burpee Museum was able to properly convey a *Thescelosaurus* being attacked by Jane. The animator easily operated the controls to create the animation. The final biomechanical motion, model, and action are approved by scientists from the Burpee Museum; which classifies this character as a segment of scientific visualization.

For basic understanding and benchmarking purposes, this paper can be used to give guidance to a junior to intermediate character setup artist. Furthermore, PYTHON, used by Industrial Light and Magic, and MEL, used by the majority of this profession, can also be further explored through the use of plugins and scripts for further automation.

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