ROCKY: VIRTUAL SCULPTING AS THE BASIS FOR COMPUTER GENERATED CHARACTER DEVELOPMENT

by

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MASTER'S THESIS

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To the most supportive family on the planet: Jackie, Tate, Chase, I love you more than you'll ever know.

One thing is for certain, the more profoundly baffled you have been in your life, the more open your mind becomes to new ideas.

Neil deGrasse Tyson
Astrophysicist

ABSTRACT

Human beings have two perfectly aligned eyeballs working together sending three-dimensional images to the brain and providing accurate depth perception. I lack true stereoscopic vision. When I was five years old I had my second eye surgery and I remember lying blind and terrified for two days in the children's ward of Reid Memorial Hospital in Richmond, Indiana. I later learned that my eyes didn't align properly and for the rest of my life my right eye would "wander". Because of my condition, I was given a list of jobs that I could never perform, jobs where human lives are entrusted to skilled professionals wielding scalpels or landing jets. I could never be one of those people. Or so I was told.

I've always had excellent vision, nearly 20/20 my whole life and I've never struggled academically. It's just that my eyes don't point in the same direction like everybody else. Those who know me best can see it, but I've learned ways to make it not so obvious. It's all I've ever known. But, in an ironic twist of fate, it's become clear that my lazy eye has taught me to "see" better than the average artist.

Having spent the last five years of my life studying 3D Design and exploring the most advanced creative technology on the planet, I've created a series of computer-generated environments, objects and characters. This is my latest attempt to prove to the world that I can see just fine. I could've been a doctor or a pilot after all. In this paper I present to the world a digital friend manifested from my slightly skewed interpretation of the world. Rocky is part of my imagination brought to life in perfect three-dimensional clarity for the world to see. He's a symbolic representation of my childhood love for cartoons and science fiction. He is strong yet gentle, modest, intelligent and noble. And, he is fiercely protective of that scared and blind five-year old boy.

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CHAPTER I

VIRTUAL SCULPTING

The Platform

The use of new virtual sculpting software called Leonar3Do in combination with other conventional modeling software programs allowed me to complete an extremely challenging task in four months. However, Leonar3Do requires some very necessary mesh optimization features in order for models to evolve past concept stages. The incompatibility when working with other programs limits this new creative platform. Rocky's persona and realism would not have evolved on so many levels had I only used Leonar3Do. But Rocky would have never existed at all without it.

A distinguishing feature of this new virtual sculpting software is the intuitive ease at which a designer can generate a highly detailed organic object. The sculpted meshes are very different from those generated by conventional modeling software.

For this project, the end result is a culmination of all my science fiction influences mixed with my highly technological creative process. I will detail the complex process by which Rocky was created and subsequently animated. Throughout this process, the initial form was not changed. However the appearance went through several phases. Rocky's relative personality and mannerisms have always maintained a stoic and humble demeanor. He is in my mind a curious and patient gentle giant.

The basis of this research started in Professor Monica Correia's 3D Design course titled *Digital Forming* (Figure 1). This course explored the unique capabilities of a new

virtual sculpting software program called Leonar3Do. Compared to conventional 3D modeling software programs like 3DS Max, a powerful geometry-based design and animation software program made by the Autodesk Corporation, Leonar3Do (Leo) allows an artist to free-form sculpt a digital mesh in virtual space. Rather than using a standard mouse for point-click-drag combinations, Leo utilizes an array of infrared sensors located atop the computer monitor that records the movements of a specially designed sculpting wand called a *bird.* With relative ease of use and a quick learning curve compared to the robust 3DS Max platform, users can adjust the size and capabilities of the Leo brush to transform a standard geometric sphere into a wildly asymmetrical undulating fluid mesh.

Figure 1. Example of Leonar3Do virtual sculpting. This image was made using augmented reality software called *Leocapture*.

Students taking *Digital Forming* were asked to create and develop a humanoid fantasy character inspired by popular sci-fi gaming and movie genres. This challenging assignment was meant to fully utilize the benefits of Leo to create objects that are notoriously difficult and tedious to compose in other programs.

I was given the distinct honor of instructing this course alongside Professor Monica Correia to a group of design students with various levels of 3D computer modeling proficiency (Figure 2). I quickly became skilled at sculpting and working within the Leo creative platform, and after producing several rough character concepts, one form began to stand out as a suitable subject for further development.

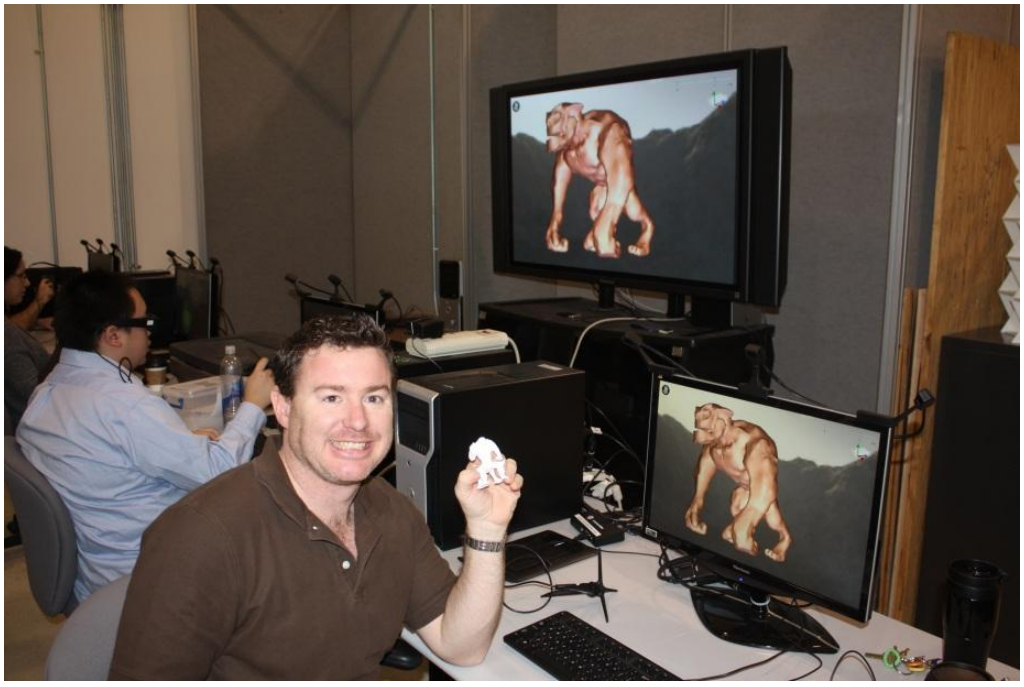

Figure 2. Displaying a 3D printed character that was developed using Leo in the *Digital Forming* computer lab.

The Mesh

The Leo platform has some texturing and animation capabilities, but because this software is so new, it contains some bugs. For example, I was unable to link multiple objects so that they work in unison or restrict their relative motion by adjusting the central pivot. Both of these tasks are easily done in 3DS Max. In hindsight, I'm glad I elected not to process or animate the figural mesh in the Leo creative construct. By working across multiple programs, I refined many other modeling techniques that would not have been addressed otherwise.

Compared to the robust technical software programs we've been using, Leonar3Do is relatively simple. After practicing and learning approximately fifty sculpting commands and keyboard activation shortcuts, I could generate very complex and highly detailed digital models in just a few hours of computer time. The final product was non-geometrical, very different from what I was accustomed to working with. The geometric arrangement of the mesh vertices happens automatically as more detail is added to the Leo mesh. It's hard to achieve the same kind of vector precision using Leonar3Do compared to standard Computer-Assisted-Drafting (CAD) software. But you can create more organic, flowing curves and lifelike analogues. Modeling a human digestive system, for example, would be quick and easy in Leo, but would require advanced knowledge and a high working proficiency in 3DS Max. Conversely, a geometric Autodesk product is better suited for modeling items requiring extreme precision, such as a microchip.

Despite the relative ease and quickness at which Leo created a complex digital mesh, the resulting geometry was somewhat difficult to export into a universally acceptable file format. More specifically, the higher detailed parts of the Leo mesh are very dense in data containing many more vertices than less detailed and flat portions (Figure 3). The location-specific polygon management is a notable feature for Leonar3Do. However, when translated into 3DS Max, the non-uniform asymmetric arrangement of polygonal data and vertex concentration becomes problematic. To get the same type of detail in a mesh generated using a geometry-based modeling program like 3DS Max, the entire object's geometry must be subdivided evenly into more segments regardless of the proximal detail. Also referred to as resolution, the concentration of data points within the mesh determines the smoothness and accuracy of the finished surface texture. More data equals greater resolution. This results in a more life-like detailed surface appearance. Until then, I had yet to manipulate a mesh with varying resolution.

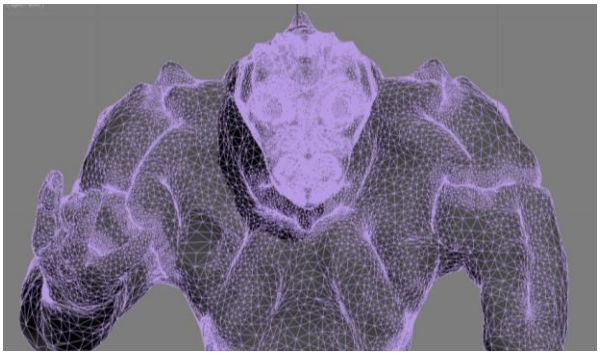

Figure 3. An example of the varying vertex concentration within a Leo-generated digital mesh. The highly detailed portions of the face and head contain much more topographical geometry than the flat portions of the torso.

CHAPTER II

ROCKY IS BORN

The First Renderings

As the semester progressed, I explored several humanoid forms. The first creature to take shape I called *The Warrior*. His body and lower appendages were sculpted from a standard sphere with mirrored bi-lateral symmetry. His arms were sculpted independently to create an armed-and-ready soldier's stance that could easily accommodate a weapon, staff or other handheld accessory. His final detailed physique took about 7 total hours of sculpting in Leo (Figures 4 and 5).

Figure 4. Screen shots from of first Leo-generated form known as the Warrior.

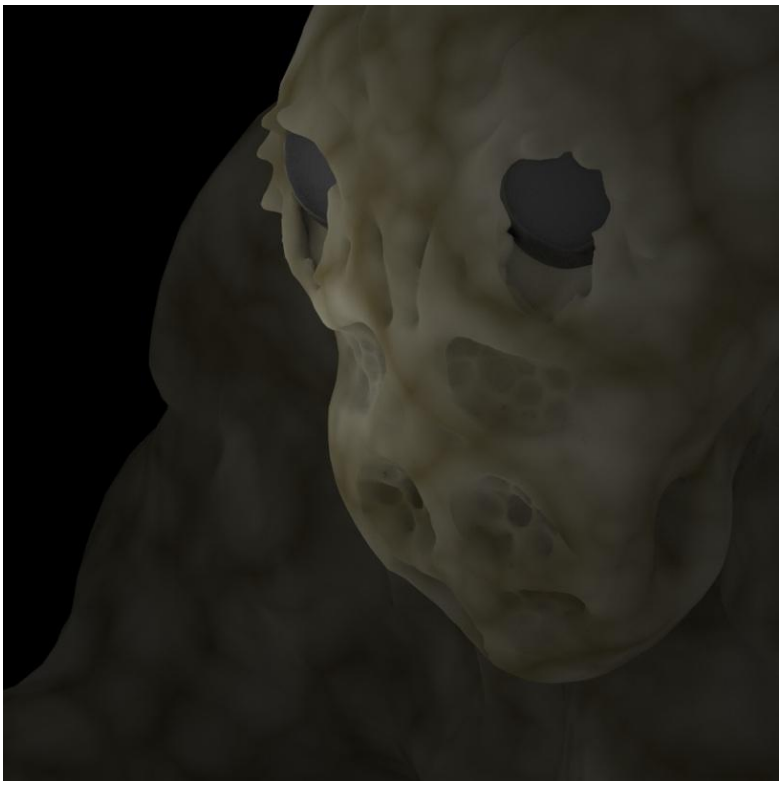

Figure 5. High resolution computer generated rendering of *The Warrior* done in 3DS Max.

The second figure was finished in just under two hours of Leo modeling time. His muscular torso and massive jaw contained a cartoonish resemblance to some of my childhood toys. The low head and strong gaze resembled a perched gargoyle's guardian figural stance and the jagged skin texture depicted a stone or rocky surface, hence the name *Rocky* (Figure 6).

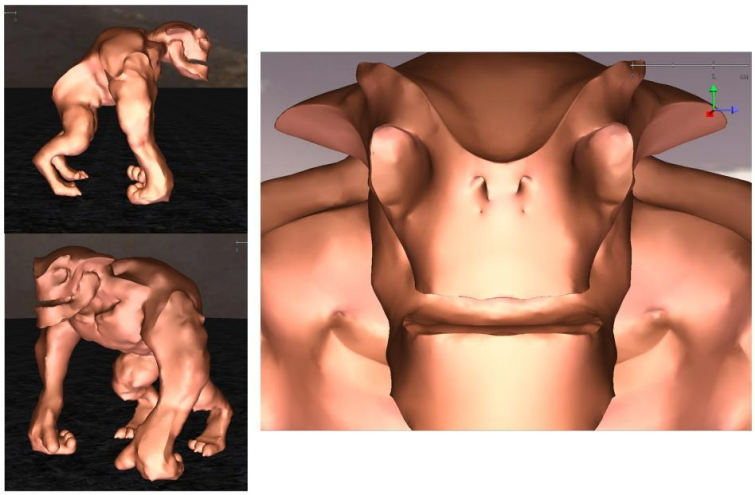

Figure 6. Rocky: the newborn computer generated product of my imagination. These are screenshots from his first Leo-generated forms.

This was a very exciting time for me as a graduate student. In all my years of intense and devoted study of some of the most popular 3D computer modeling software, I had never been able to master the techniques that allowed me to create the types of meshes that I generated in the *Digital Forming* class.

My first inclination was to bring the Leo mesh into 3DS Max and use its robust materials and texturing library to add some more realism to the newly created monster. The resulting imagery was, again, unlike anything I had ever created. I started with some standard lighting and bumpy gray surface attempting to mimic a granite-like chiseled stone surface appearance. The backstory I was composing in my mind was that Rocky would be a nocturnal cave-dwelling gentle giant who keeps mostly to himself. His facial features began to reveal a variety of emotions as I explored different camera angles and varying illuminations (Figures 7 and 8).

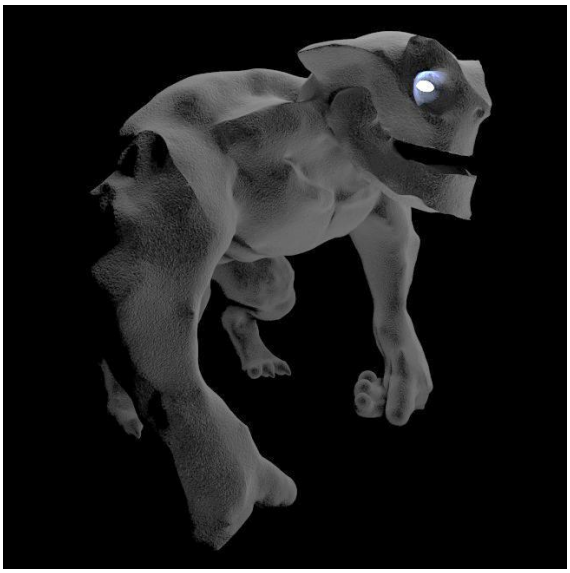

Figure 7. Computer rendering of Rocky with glowing eyes and rock-like skin texture. This pose depicts a smiling, harmless and gentle persona.

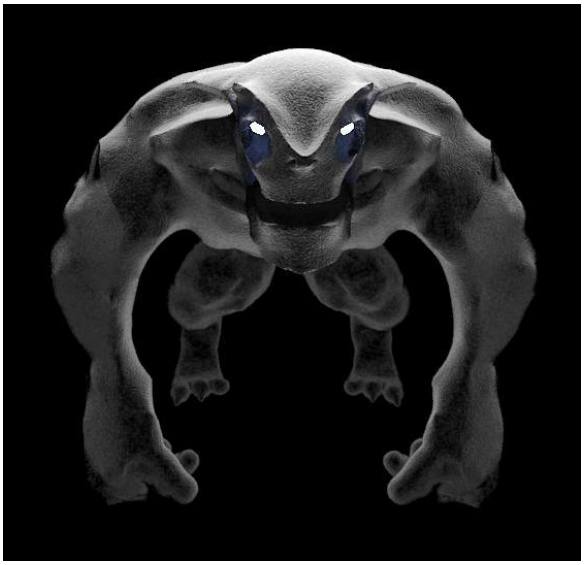

Figure 8. From the front viewpoint, Rocky appears more menacing. His lowered stance and hulking frame becomes more intense.

From certain perspectives, his gaze was more menacing and fierce yet his persona maintained a cartoonish friendliness. I did some closely cropped renders with very dramatic lighting sources. His slightly squinted glowing eyes help bring out an emotionally triggered stare (Figure 9).

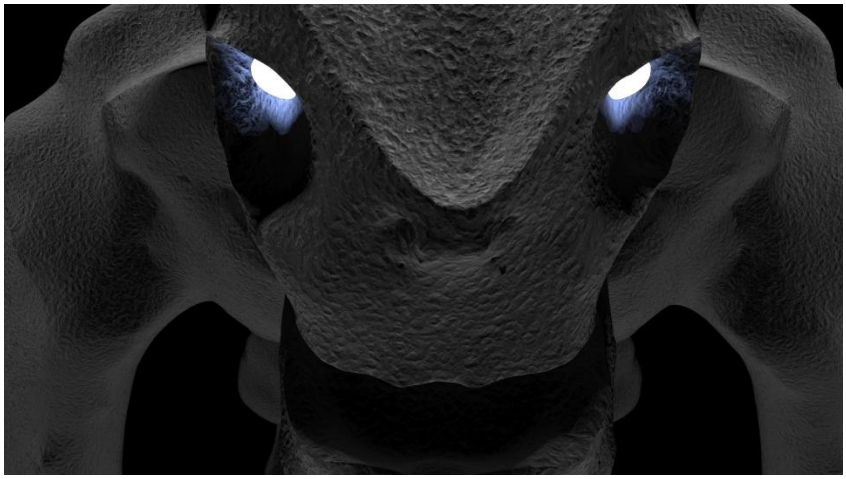

Figure 9. This scene depicts a more aggressive, yet still somewhat playful gaze.

These first renders were very different from my initial foray into digital art. The appeal behind this type of figural representation lies in the ability to portray multiple emotions without altering or re-configuring the original Leo mesh. As part of the assignment for *Digital Forming*, students were asked to create an accessory, some sort of handheld or wearable accompaniment to add to the overall scene. Items like clothing, armor and weapons commonly adorn fantasy figures. The accessory I chose to create for Rocky was Rocky's beastly form with a fragile and delicate living object in order to bring out more of his approachable, almost shy, gentle side (Figures 10 and 11).

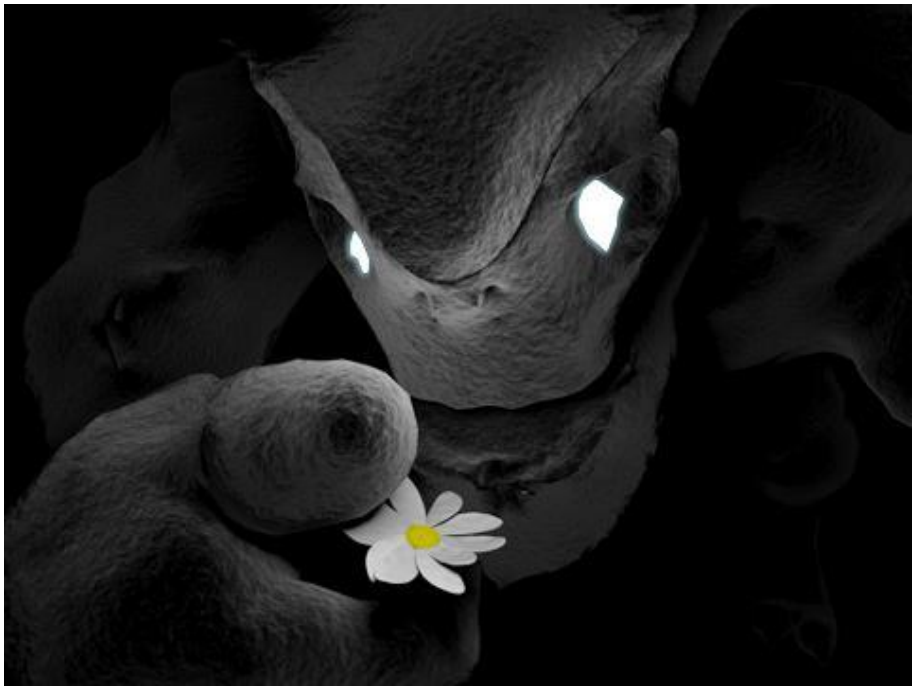

Figure 10. Rocky's first possession. The soft, delicate flower makes the creature an even gentler giant.

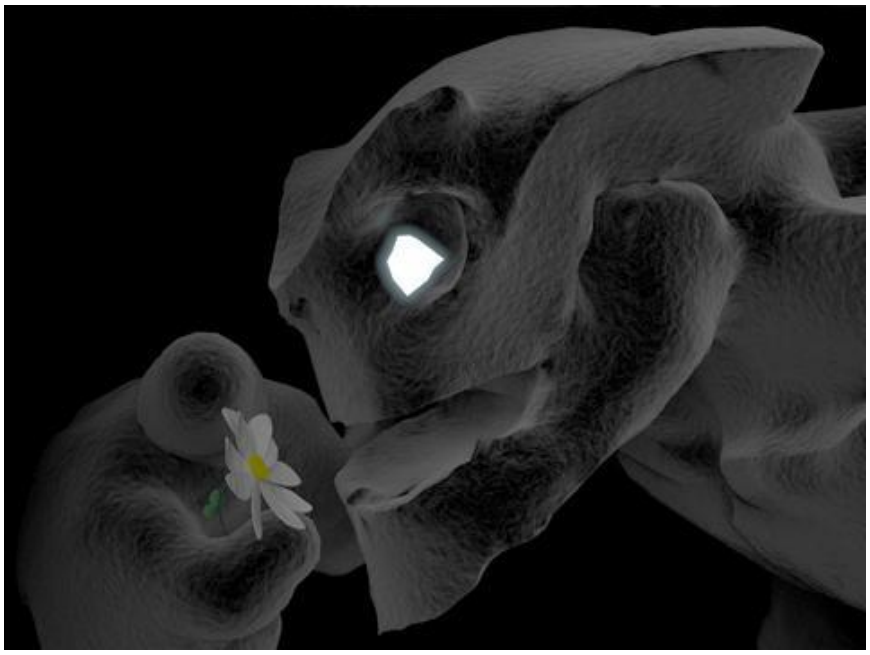

Figure 11. Positioning the flower close to his smiling face and enlarging the eyes gives Rocky a curious demeanor.

Rapid Prototyping

Popular culture is flooded with fantasy creations manifesting themselves in the form of collectible action figures. Video game heroes, sci-fi villains and movie stars eventually make their way to store shelves so that people can possess a plastic representation of their favorite characters. One logical step toward fully developing a character of my own imagination was to bring some version of him to physical reality. Aside from generating still imagery, I prepared the Leo mesh to be sent to our rapid prototype machines.

I created two 3D printed models from my Leo meshes. An earlier form known as The Warrior was sent to the powder printer which generated a small and fragile figure reminiscent of a board game or chess piece (Figure 12). I created a larger display-ready plastic model of Rocky that stands about six inches high and lives safely beneath an acrylic dome (Figure 13).

Figure 12. This fragile 3D printed powder model of The Warrior stands about seven centimeters tall, perfect for a fantasy chess board.

Figure 13. This plastic 3D printed model of Rocky stands six inches tall. He traveled to Las Vegas in January and was on display at the 2012 Consumer Electronics Show.

Rocky's Meaning

Being told at such a young age that I could never pursue certain careers gradually elicited some bitterness and resentment. This resentfulness was made worse following my eye surgeries because I often had to wear bandages or an eye patch as part of therapy and to prevent infection. I remember being picked on by older kids and I remember my teachers having to explain to my classmates why I looked like a pirate. But, my childhood memories aren't all bad. In retrospect, it's obvious to me now that I developed some psychological compensation tactics that determined some of my decisions later in life. In high school I excelled in athletics and academics. I developed an outgoing

personality perhaps in response to the emotionally damaging years immediately following my surgeries. My rationale for this is quite simple: things were already hard enough, why make them harder by becoming emotionally unavailable and anti-social? So my subtle rebellion began. If I couldn't be a doctor or a pilot or some other meaningful professional, I'd be something else even better. It wasn't until I went back to school at the age of thirty did I really acknowledge how much my lazy eye affected my aspirations.

Regardless of the underlying motives Rocky exudes strength and determination. His physicality implies immovable stubbornness. And the flower that he holds is symbolic of my fragile inner child that was crippled, but never stifled creatively. I like to think that Rocky embraced that pure creativity and held it close to his heart and nurtured it hoping it would turn into something even more beautiful.

I've become a uniquely strong, emotionally hardened adult with deep, deep creative energy and a gentle soul full of love and encouragement. Rocky is the embodiment of my psyche on many levels and he will continue to change along with me. Maybe in the future he will be more colorful and less serious. And maybe his scars will heal completely and the bitterness will subside. And maybe together he and I will continue to find inner happiness by overcoming even greater obstacles.

CHAPTER III

FURTHER DEVELOPMENT

Preparing to Animate

The imagery I was generating satisfied the course requirements, but I decided to pursue development further and bring more realism to the form. As I added more detail to the Leo mesh, several issues arose making it difficult to pose and maneuver Rocky into a different stance. The first animations were done in 3DS Max, but rather than posing the figure and creating various gestural stances, the sequences were limited to camera paths and sweeping zooms and pans focusing on the still figure and the environment. Preparing the Leo mesh for a posed body rig was a daunting challenge. I soon recognized the impending difficulty when I tried to re-position Rocky's hand to hold the flower.

Covering the mesh with a standard 3DS Max material and rendering photo-realistic images of the figure with specific lighting parameters does not require any adjustments to the underlying geometry. Certain modifying filters can smooth out any stray vertex placement, but the form never alters from its original state. Making a humanoid Computer-Generated (CG) model move freely with accurate proportions and joint rotations requires the entire geometric arrangement of the mesh to work in unison. All parts of the structure must maintain a relative position to adjacent components. The Leo mesh is created with varying concentrations of vertices throughout the entire form, animation becomes much more difficult. Making the underlying Leo mesh work in

unison became much more difficult than expected because of the asymmetry and varying structural geometry.

Rigging

Aligning a computer generated mesh to conform to a skeletal sub-structure that can be activated to maintain a standard uniform kinesiology is a technique called rigging. Many animation software programs will provide standard generic skeletal rigs that can be modified to fit various mesh arrangements. Because Rocky is essentially a humanoid – two arms, two legs, one head- I used the default human rigging and changed the proportions to match Rocky's hulking frame (Figure 14). This first rigging attempt was done without any drastic modifications to the original Leo mesh.

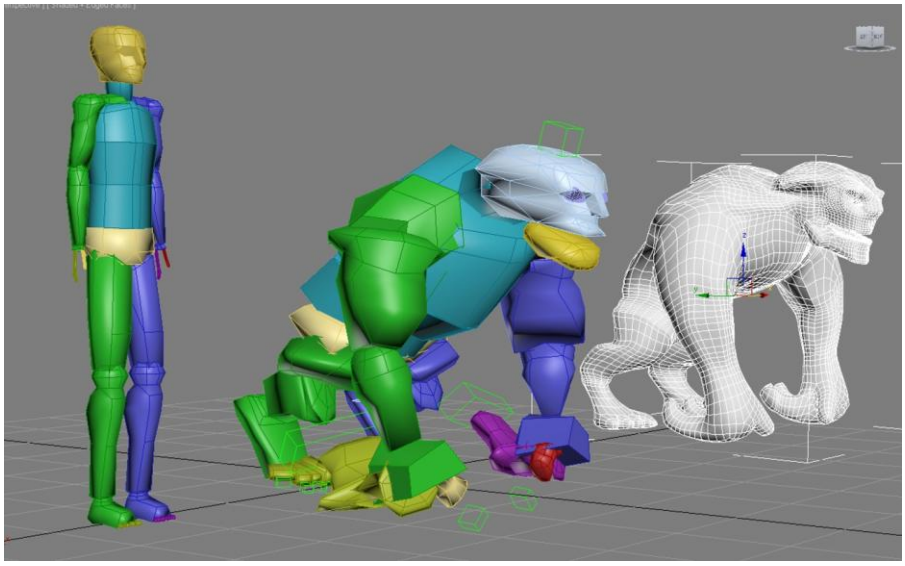

Figure 14. Demonstrating the modification of a standard human biped rig to conform to the Rocky mesh.

Even though I was able to modify the rig to match Rocky's physique, the alignment of the sub-structure was not enveloping all of the asymmetrically arranged vertices. When activated, only part of the mesh moved fluidly with the rigging. If certain parts of the mesh don't associate with the appropriate structural rigging element, the figure becomes wildly distorted when moved (Figure 15). Some vertices can get associated with the wrong rigging component and the mesh moves when it's not intended. Conversely, some geometry doesn't associate with any rigging component and it fails to move at all.

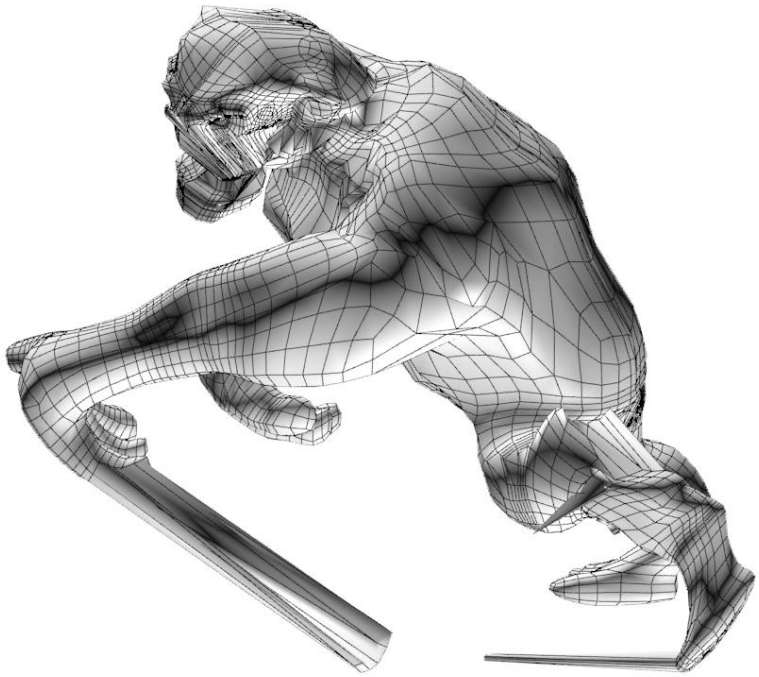

Figure 15. An example of mesh deformation caused by misalignment of the rigging.

By making numerous fine-tuned adjustments to the skeletal rig I was able toachieve only a few accurate poses from the mesh. The movements were minimal and limited to the arms and head. These movements were greatly restricted. Even the simplest bends and joint rotations caused deformations in the mesh. Walking, talking and other complex actions were not possible with this setup. The geometric variations of the Leo mesh are too unpredictable and random for the rigging structure to accurately envelop.

A More Reasonable Mesh

Rather than abandoning the original Leo mesh entirely, I decided to use it as a template for a newer and geometrically simpler mesh. Regardless of how many 3DS Max filter combinations, procedural adjustments and modifiers I applied to the original Leo mesh, I could not achieve a uniform alignment of geometry. The embedded data inside the Leo mesh could not be altered to evenly disperse the mesh concentrations throughout the form. The vertex density remains variable. Manually removing and merging vertices to make the high density areas more manageable changed Rocky's physique and appearance beyond acceptable levels.

I came to the conclusion that the only way to get a successful rigging setup was to create a new mesh in the likeness of Rocky while keeping a low concentration of vertices throughout. From just a simple geometric plane, I built a new mesh around the original. The new low-poly Rocky mesh contained about one percent of the original vertices (Figure 16).

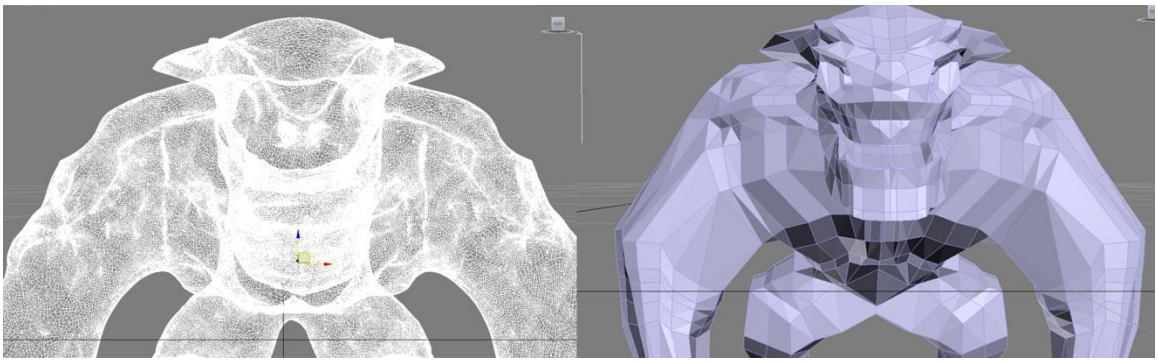

Figure 16. Compared to the high-density original mesh (left) the new low-density version is more suited for fully articulating body movements.

The process of re-making the topographical mesh was necessary for fully developing Rocky into an animated being. There are several advantages to having a low-poly mesh. Most importantly is the ease by which a rig will accurately envelop the adjacent vertices. This means that the mesh will stretch and deform properly even during complex movements (Figure 17). The jagged and crisp edges of a low-poly model can be easily softened using a smoothing modifier in 3DS Max. The resulting form is still low in geometric data size, but smooth in appearance.

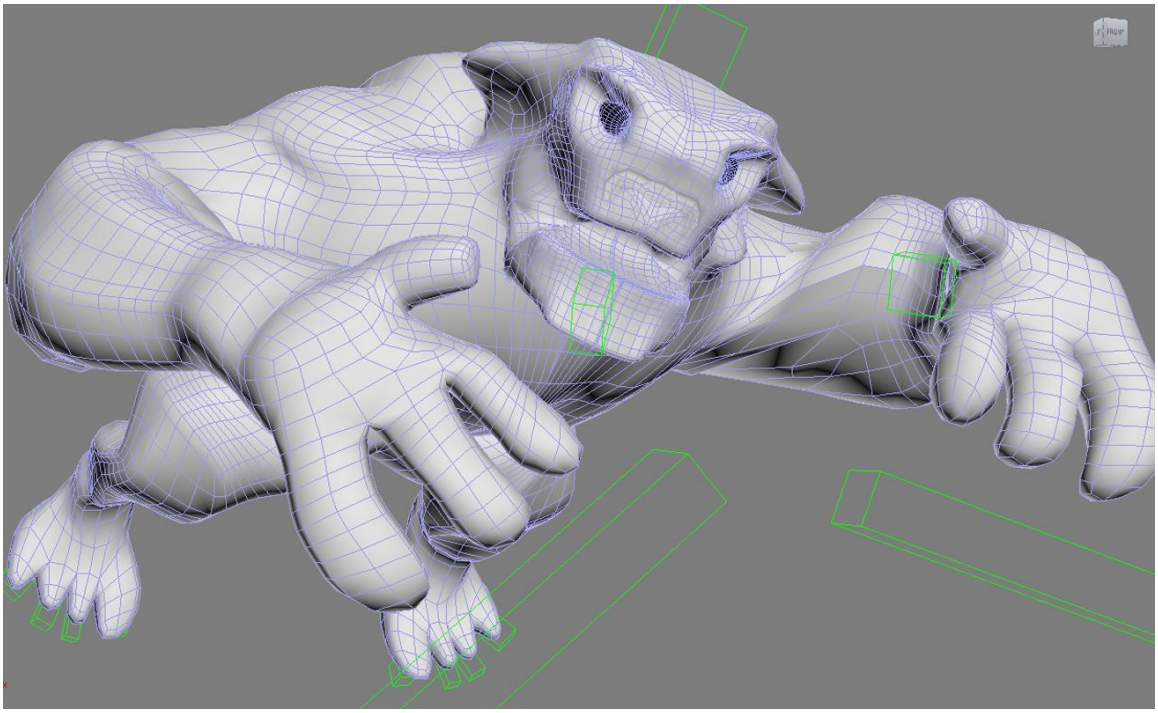

Figure 17. Demonstrating the rigging and accurate stretching of the new low-poly mesh.

Texturing

Now that I had a workable low-poly mesh that conformed to the rigging, I could focus on his skin texture and appearance. When standard materials are applied, they don't move in unison with the mesh deformations. Rather, they stay in place as if projected onto the surface while the rigged mesh moves beneath. Realistic surface texturing needs to be mapped onto the mesh so that it stays in place while the mesh is deformed by the rigging. The technique of preserving the surface texture's location relative to the mesh movements is called UVW unwrapping and mapping. Also known as skinning, this type of digital mesh unwrapping creates a series of digital images or "maps" that are peeled off the surface of the mesh. The resulting maps of peeled surface

can be highly detailed and decorated (Figure 18). The detailed maps are then reapplied to the mesh while maintaining the rigging alignment and vertex envelopes.

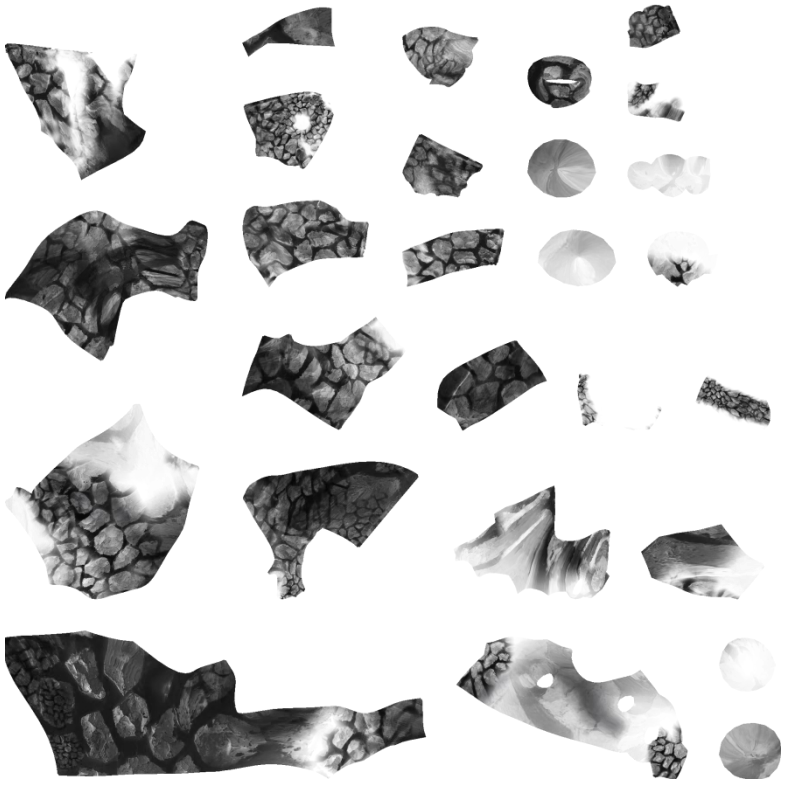

Figure 18. Example of UVW map segments generated when the rocky mesh is unwrapped. Rocky's stone-like mosaic skin texture can be seen on the individually flattened maps.

Texturing is a fun and creative process that allows the designer to develop the overall aesthetics and final detail for the character's appearance. Age, facial expressions, mood and habitat can all be implied by skillfully applying the skin texture. A powerful Autodesk program called Mudbox is specifically used for super high detailed surface texturing that preserves UVW mapping coordinates. When the Rocky mesh with his

unwrapped skin texture was imported into Mudbox, I could begin sculpting the finest levels of photo-realistic detail (Figure 19).

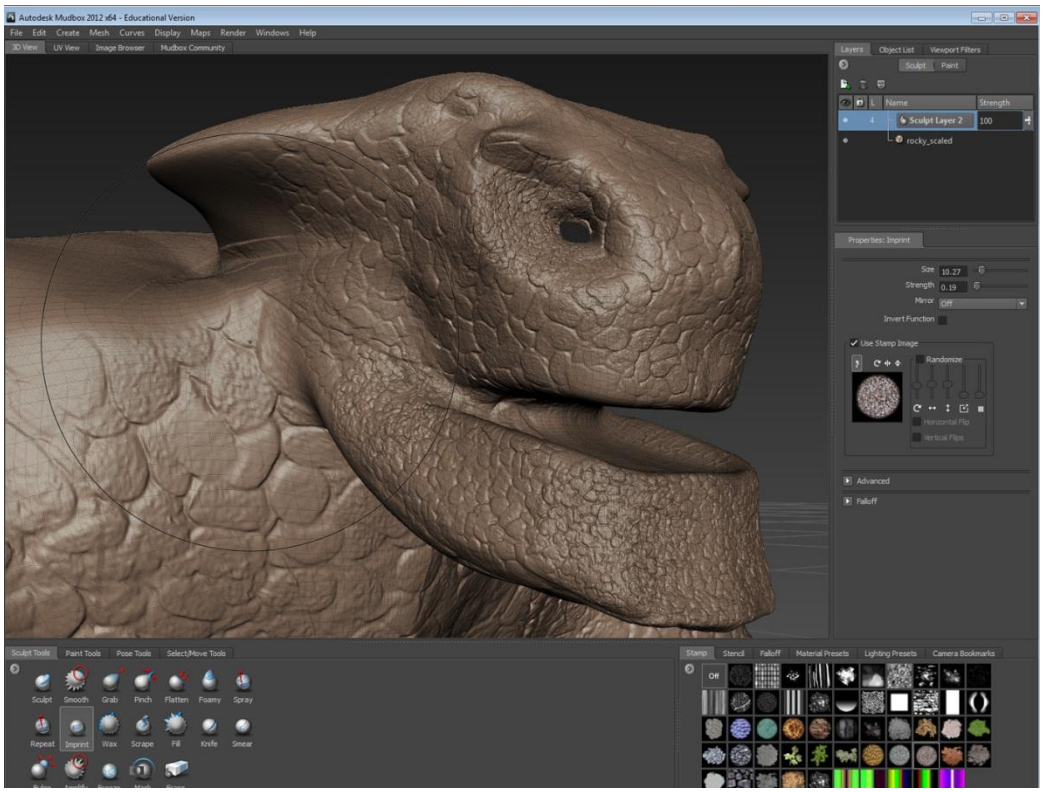

Figure 19. Demonstrating Autodesk Mudbox texturing software to give Rocky some of his earliest fine detail.

To maintain Rocky's hardened exterior and continue with his rough, stone-like surface material, I composed the fine detail to resemble a gray cobblestone mosaic (Figures 20 and 21).

Figure 20. Detail of Rocky's final skin texture in Autodesk Mudbox.

Figure 21. Rocky in his all his gruesome glory.

Facial Expressions and Emotions

His initial appearance is somewhat intimidating and even fierce. And regardless of how I posed his hulking physique, he would remain an unapproachable monster unless he could display some emotional expressions. Fortunately, his large, exaggerated jaw allows for easy contortion of the lips and obvious gestural positioning. Simple adjustments like covering the sharp teeth, widening the eyes and drooping his ears immediately soften his ferocious demeanor.

The unwrapped and textured surface maps are able to move with the underlying rigged mesh. This provides realistic skin stretching and proper surface deformations and brings out the greatest levels of anthropomorphism (Figure 22). Like a human's face, the skin creases, twists and folds depending on the movement of the layers of tissues and bones beneath the surface.

Figure 22. Rocky's first morphing facial expression. This portrait captures a sneering upper lip and glowing eyes.

At this point, I can build a library of different expressions. By manipulating the environment and adjusting the luminous glares around the eyes, I can add a dynamic element to the facial expressions (Figure 23).

Figure 23. Drooping facial features, widened eyes and pouty lips to cover his teeth make for a sad and pathetic expression.

CHAPTER IV

CONCLUSION

Concept Art Made Easy

The ability to generate a unique and believable animated character requires high levels of artistic creativity as well as high computer literacy in a variety of complex software programs. Professional production companies often hire teams of sculptors and multimedia design artists to contribute to the overall character identity. Some of my most imaginative ideas can never be fully developed because I lack the tools to adequately create them. With the help of virtual sculpting platforms, a single artist can generate an extremely imaginative and realistic concept in a relatively short amount of time. The computer gaming, television and movie production industries would certainly benefit by having skilled concept artists constantly supplying them with fresh and creative ideas that are nearly franchise ready.

Virtual sculpting is a significant addition to the arsenal of robust creative software products that are currently available. The Leonar3Do platform is very different from the conventional modeling programs because it not only creates high detail quickly, it is less restricted to a complex learning curve that designers must overcome in order to successfully build digital mesh structures. This makes virtual sculpting a skill-based type of modeling versus the traditional knowledge-based geometric modeling and animation. A student artist with novice computer abilities can quickly learn the basic Leo interface

and generate a rich conceptual identity in the same amount of time it would take a highly-trained computer modeler.

However, virtual sculpting requires some very necessary mesh optimization features in order for the character to evolve past concept stages. The incompatibility when working with more powerful animation and rendering programs limits the Leo platform. Rocky's persona and realism would not have evolved on so many levels had I only used Leonar3Do. But Rocky would have never existed at all without it.

Future Research

Character development was the first assignment ever given to the students enrolled in *Digital Forming*. It was a tremendously successful demonstration of the unique capabilities of virtual sculpting. There are other types of computer generated design assignments that can demonstrate virtual sculpting's advantages over geometric and CAD based modeling. Medical illustration, for example, requires highly detailed graphics of organic shapes and forms to accurately portray biological systems and principles. These can be easily sculpted using platforms like Leonar3Do.

The scientific and educational applications for virtual sculpting can be just as profound as the artistic and creative applications. Motion capture technology exists in many consumer gaming products and younger generations are becoming familiar with high-tech creative programs at a much earlier level of development. Virtual sculpting may play an important role in tapping into a child's creativity long before they learn to wield a pencil or paintbrush.