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A study in computer animation

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A Study In Computer Animation

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ABSTRACT (100-200 WORDS):

This capstone project was focused on obtaining a basic understanding of both the technical and creative processes involved in creating a computer animation. The process of obtaining this understanding involved practice in creating small sample still images, animations, stories, and storyboards in order to learn the basics of the chosen computer graphics package, 3D Studio Max. After these practice projects were completed, I applied what I had learned to a final, 30 second computer animation of my own design.

The thesis materials include my practice and final stories and storyboards, a CD containing my practice images and animations as well as my final animation, and a paper documenting the project and my processes.

A Study in Computer Animation

By: Sean Woods

Art 490H
Kurt Schultz
Honors Capstone Project
Fall 2000

This capstone project has certainly not been the project I envisioned when I started the process. This difference has been one of the most enjoyable and beneficial aspects of the project. It has allowed me to explore a subject with which I had no experience or knowledge. In my exploring I found that many of my previous notions about computer graphics were wrong, and that the process, both the creative and technical aspects of it, was only vaguely similar to that which I had in mind when I began. This discovery is one of the main reasons that I chose to do this project. Because of my interest in pursuing computer graphics outside of school, I wanted to understand what the process is truly like. I have had the opportunity to deeply examine all aspects of the process of creating a finished CG (computer graphics) animation. From the artistic challenge of storyboarding to the very technical challenge of character animation, I have been able to understand the general processes and also expand my technical knowledge of this art form. The knowledge I have gained from this experience will be invaluable in future projects that I would like to pursue. I feel that I have gained a solid foundation and introduction to computer graphics, and that I have the tools necessary to continue exploring and working with this art form in the future.

The project consisted of several main topics. These are the creative process, the modeling and animation projects used in learning, the process of creating the finished final animation, and the application of the principles learned to future projects. In terms of the goals outlined in the proposal, the main objective was to create a thirty second to 1 minute computer animation. In

preparation for this final animation, several sample projects were to be completed, in both the creative and technical aspects of animation. Sample storyboards were to be created for the creative aspect, and sample models and animations were to be completed as an introduction to the technical aspects of animation. Before these can be discussed however, a brief history of computer graphics is important to understand the context in which the study was carried out.

The field of computer graphics is a very new and still developing art form. By definition it requires the use of computers, and therefore could not trace its history any farther back than the 1930's. However, while not directly working with computer graphics, many advances were made throughout history that set the stage for computer graphics to become the prominent and fascinating field it is today. According to "A Short History of Computer Graphics" compiled by William Shoaff from the computer science department of Florida Tech, a certain "pre history" of computer graphics exists. Many of the events he cites are advances in mathematics and especially geometry which form the basis for a mathematical understanding of images, which in its simplest form is the basis of computer graphics is. Schoaff begins by looking at Euclid and his invention of geometry, without which computer graphics would obviously be impossible. He then discusses Descartes and his work with analytic geometry. A large part of this work dealt with coordinate systems, which form the basis for modern day graphics software. Schoaff then mentions Leibniz and Newton, who were the co-inventors of calculus, without which there would certainly be no computer

graphics. Schoenberg is also mentioned in regards to his work with splines, which are a type of curve widely used in computer graphics. This brings us to the twentieth century and the invention of the first electronic and digital computer, the ENIAC, in 1943 (Schoaff). These inventions and advances in science laid the groundwork for what would become computer graphics as we know them today.

One of the first landmarks in computer graphics of the 20th century, according to the Visual Effects Resource Center web page, was the first radiosity image created at MIT in the 1940's. The goal of the project was to create global lighting models, and this was achieved by hand selecting bits of paper that matched the computer's output and piecing these bits together. Other innovations in the 1940's, according to Schoaff, were the Whirlwind project, which was an early military attempt at a flight simulator, and the SAGE project, which was an air defense system to protect against nuclear attack. The SAGE system used a wireframe outline on a large radar screen and employed light pens (Schoaff). In the 50's John Whitney Sr. began to use computer "mechanisms" (The Visual Effects Resource Center, 1) in his art and short films. Also, Bill Fetter at Boeing began to develop CAD (computer assisted drafting) which would develop into a very sophisticated engineering tool, which is still being used today. In the 60's, one of the bigger advances was made with Ivan Sutherland's presentation of his "Sketchpad" paper at the Summer Joint Computer Conference. This program allowed the entry of lines and curves via a light pen directly on the screen. Also in the 60's, the first ever graphical video game, Spacewar, was developed by students at MIT. Its display was a large round CRT

(cathode ray tube) screen and handmade joysticks controlled it (Masson). Other work done in the 60's included Jack Bresenham's work on algorithms for drawing lines and later circles on raster devices, Author Appel's work at IBM on hidden surface and shadow algorithms which would eventually lead to ray tracing and the development of the Mouse at Xerox. Pierre Bezier's work on parametric curves also came to light during this time (Shoaff).

Schoaff goes on to say that in the 1970's the developments in hardware lead to the IBM 360 being the new state of the art machine. Gouraud and Phong at the University of Utah developed rendering. Phong developed a "reflection model that included specular highlights" (Shoaff). Keyframe based animation was developed, Turned Whitted created recursive ray tracing, and Pong and Pac Mac were the hot video games.

In the 80's, Tron, the first feature film to include a great deal of CGI work, was released. Although a great deal of the animation in the film was still accomplished through traditional animation, there was approximately 15 minutes of CGI work in the film, which was quite something for the time (Masson). Schoaff mentions several major advances in the 80's, such as the release of the IBM PC and the Apple Macintosh along with the Intel x86 chip architecture. In terms of algorithms and data structures, the Binary Space Partitioning (BSP) tree was the new thing. Loren Carpenter began to experiment with fractals on the computer and what possibilities existed with this combination. Adobe was formed and began to market Photoshop, a popular 2d graphics creating and editing program that is still the premiere package available today. Steve Cook was

working with stochastic sampling and its application to ray tracing. The new goal for animators in the 80's was character animation, which is still one of the most complex and challenging areas of computer animation. In terms of hardware, SUN's were becoming popular platforms for graphics work. IBM came out with the VGA (Vide Graphics Array) card that has become the minimum standard for computer displays. Later in the 80's, SGI (Silicon Graphics) workstations were the platform of choice, as they better supported raster line drawing and polygons. NASA was working on the data glove, which was a precursor to the gloves used to interact with virtual reality today.

In the 90's, computer graphics really began to come into the mainstream. Schoaff mentions things such as Mosaic, which was the first graphical internet browser. Mosaic was developed by the NCSA (National Center for Supercomputer Application) at the University of Illinois. MPEG (Moving Pictures Experts Group) was also developed in the early 90's. MPEG is a video compression standard that is used with a great deal of computer video. Another standard, OpenGL became widespread and used in almost all graphics API's (Application Program Interface). In terms of graphics capabilities, Dynamical systems came into being. These allowed animators to more easily create scenes with more realistic properties. Things such as collisions and force put upon an object could be truer to real life. In terms of hardware, graphics cards were being introduced for PC's. This opened the door for the wave of 3D video games to follow, such as Doom and Quake. Finally, motion capture technology was advanced and used throughout the industry (Schoaff).

The 90's, as mentioned above, proved to be the grand entrance of computer graphics into mainstream media, especially film. Several key films are outlined in the web page of the Visual Effects Resource Center. 1995 would see two major breakthrough films in terms of computer graphics content. The first, and perhaps most obvious, was Toy Story. This was the first feature length motion picture to be done entirely with computer graphics. Nothing of this sort had ever been done before and although there had been CGI content in films before, this achievement brought the art to the attention of the masses. The second major film done in 1995 using CGI was Jumanji. Although containing much less CGI content than Toy Story, Jumanji was a breakthrough in another respect. This film was the first to feature new technology that allowed realistic hair modeling and animation. This made it possible to use computer graphics in any film where realistic human or animal hair was needed. In 1996 Dragonheart made a breakthrough in character animation and synching an audio track to the digital characters lip movements. In 1998 Geri's Game, from Pixar, an entirely CGI short film, won academy awards. This short featured subdivision of surfaces, which was a recently re-discovered technique. Also in 1998 was ANTZ, and A Bug's Life, both of which were one hundred percent computer graphics. In 1999, Star Wars - The Phantom Menace was released and featured nearly 2000 digital shots (The Visual Effects Resource Center).

There is no telling where computer graphics will go in the future. They are so widely used in film and television today that they no longer create the amazement that they used to. As both graphics and computer technology grows

by leaps and bounds, these two will surely continue to create new and wondrous visual spectacles.

Now that a background of computer graphics has been presented, an analysis of the project at hand is in order. As mentioned in the beginning of this paper, there were are several main topics that warrant discussion. These are the artistic processes necessary before the actual creation can begin, the actual modeling and animation, the process of creating the final animation, and how all of these will be applicable to future projects.

The first topic, the creative process prior to actual creation, is one of the aspects of computer graphics of whose importance escaped me when I began this project. Computer graphics seemed to be a very technical process, requiring more a mastery of the computer than of the arts. However, I was very wrong. As Hayward says in Scriptwriting For Animation, "The bulk of the creative work - be it script, design, dialogue or music, is conceived and finalized before the first frame is animated". Once this was realized, I put a great deal of effort into thinking of an idea for the animation, and creating a basic "script" and storyboard. Not knowing exactly what I wanted my story to be, I set out to create several sample storyboards in which I could both put my ideas to paper, and also gain experience in storyboarding. In order to best organize these storyboards, at the suggestion of my faculty advisor, I began to put the key frames of my sample storyboards on note cards, thereby allowing the ability to insert and delete from the flow of the animation. The first step was to learn what it is that is important in a storyboard. The first source I turned to was Scriptwriting For Animation. While not written

specifically for computer graphics, the same principles apply in both mediums. I used this source to gain a basic idea of what the purpose of a storyboard was and how to go about accomplishing this purpose. The author lays out four main points; idea, outline, and storyboard. Idea refers to the basic point of the animation. The author suggests that this is as simple as the title. In my case, the titles are very simple, stemming from the fact that the animation ideas themselves are very simple. The outline is just that, and outline of the key frames of the animation. Things such as beginning/middle/end are made clear. This gives a basic idea of how the animation will flow. Lastly, is the actual storyboard itself. This is a comic strip like drawing of the key parts of the animation. The characters, "camera" angles, and basic surroundings are sketched out for the purpose of giving a visual outline to compliment the written outline. The details between the key frames are left until later (Hayward, 10 – 13).

With this in mind I went about creating various outlines for several animations which I had in mind. As these were each to be approximately thirty second to one minute animations, the outlines are fairly simple and do not contain some things that one might expect to see in an outline for a full scale animation, such as dialogue. The outlines I created give a verbal description of the main points of the story and provide a basic structure and idea for creating the storyboard. The outline I decided on to be my final animation, with the help of my faculty advisor, was the "Hammer and Nail" story. I had not originally intended to attempt character animation as would be inherently involved in doing this particular scene, but it seemed that this might allow me the maximum exposure to

the various techniques involved in both modeling and animation. The idea for this scene had originally come from a Pixar short, Luxo Jr. This short animated film used two lamps as characters. The idea of bringing an otherwise inanimate object to life seemed very interesting to me, which is why I did the outline, and later decided to use this outline for my final project.

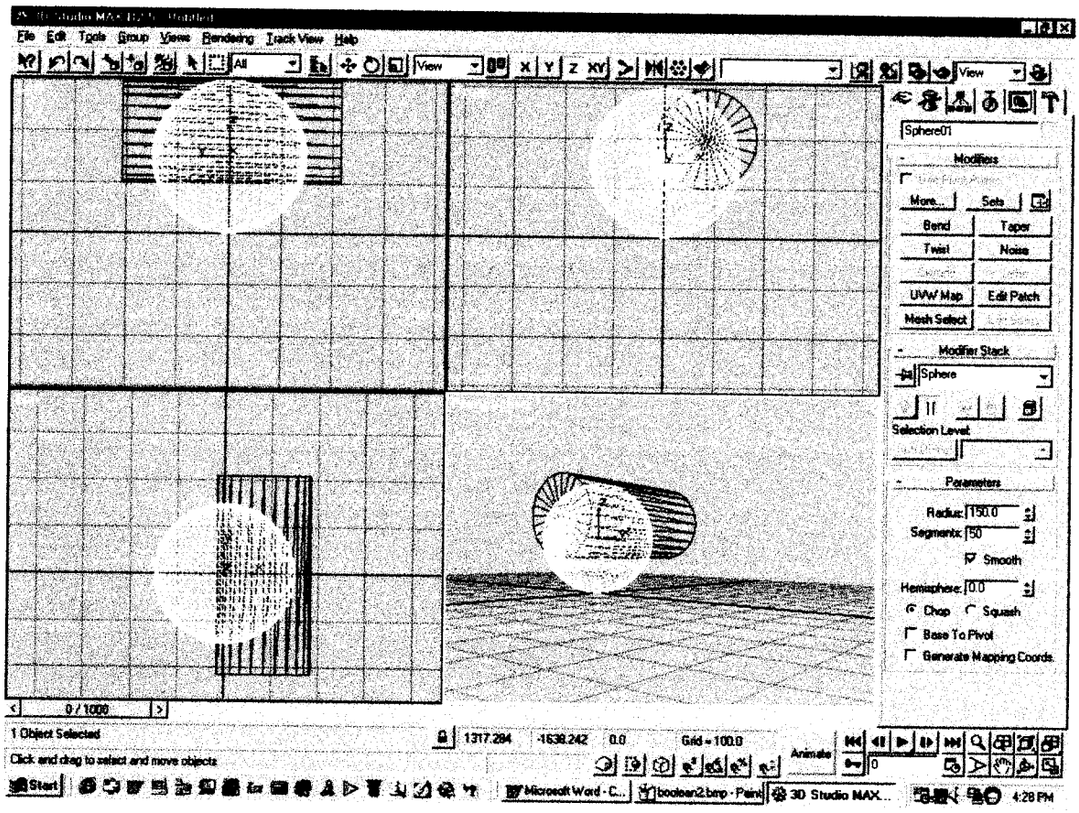
Once I had outlines for each of my scenes, I set out to create storyboards, or visual outlines, of each of them. This was a challenge for me, because I had no experience in art. However, since the object of the storyboard was to serve as a reference, and not so much to look pretty, I concentrated more on functionality. In these storyboards I tried to accurately reproduce the key points originally laid out by the outline. Each "frame", or card in my case, represents a key movement or action in the animation. In the "flythrough" storyboard, I concentrated on camera angles and viewpoints, as the actual objects in the scene were not moving, but instead the camera was "flying" through a house. Overall, these storyboards gave me a more concrete idea of what the animation might look like, and in doing so, helped me in making my decisions about what would be best for the final animation of the project. Because of copyrights, I was not able to provide actual industry examples, but I have provided a sample storyboard Pam Cox-Otto, who is a professor of Electronic Media at the University of Minnesota (Cox-Otto).

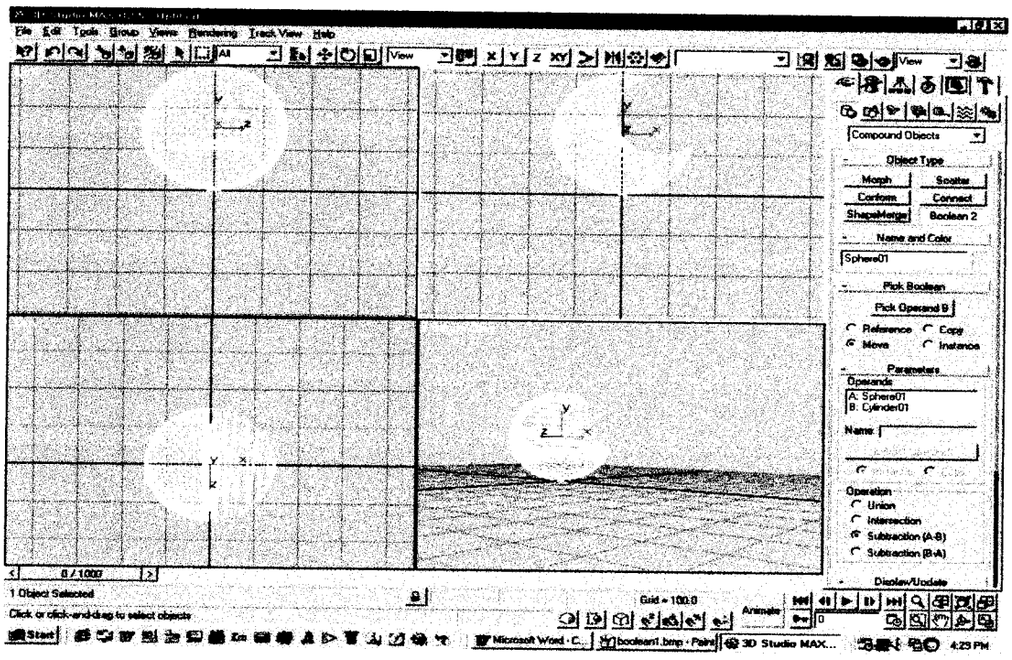
The next step taken in the process was to become familiar with the basics of modeling and animation using the chosen software package. In order to do this, I took advantage of a great many resources on the internet and also in various books on the subject. Both straight reading and tutorial exercises allowed me to become more familiar with how objects are modeled and animated in such a graphics package. These readings and tutorials helped me to accomplish my goals in two main ways. First, they taught me how to use the specific package I

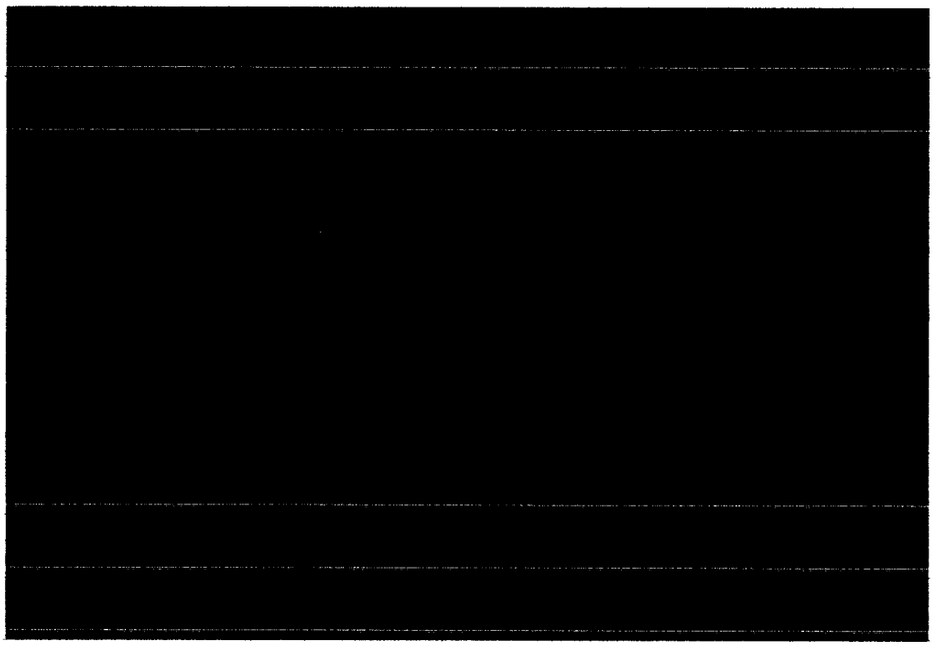
was dealing with. They explained various techniques and how to make use of them. Secondly, the techniques presented are not only applicable to the chosen software, but can be applied in many settings. This capability was one of the major goals of this project.

Some of the first tutorials I worked on were very simple and were designed to teach the reader how to create lines and other very simple objects. One of the first of these that I did was creating a basic scene. The tutorial was actually designed to teach basic animation, but as I was not to that point yet, I decided to just do the modeling portion of it. The basic idea was to create a primitive (pre-made object) and build it into a scene (teapot.bmp on the cd). The tutorial went on to animate it, but I instead decided to use lighting and to position the object so as to make a scene, without animating. Through this I learned the basics of how to create a primitive, how to use lighting, how to position objects, and how to render a scene (Stegner, 1).

The next two tutorials I completed, both from Teach Yourself 3d Studio Max 2 in 14 Days, were designed to teach what are called boolean operations. These are basically operations in which one object is removed from or added to another. For instance the shape of a sphere might be removed from a cube, thereby leaving a gap in the cube. The first tutorial I did with this was very similar to my example. It involved removing a cylinder shape from a sphere. (boolean.bmp on the cd). The tutorial used a box, but a sphere seemed more interesting to me. Here I have included screen-shots of the process of creating the object.


File Edit Tools Group Views Rendering Track View Help
Sphere01
Modifiers
More... Sets
Bend Taper
Twist Noise
UVW Map Edit Patch
Mesh Select
Modifier Stack
Sphere
Selection Level:
Parameters
Radius: 150.0
Segments: 50
Smooth
Hemisphere: 0.0
Chop Squash
Base To Pivot
Generate Mapping Coords.
0 / 1000
1 Object Selected
1317.284 -1638.242 0.0 Grid = 100.0
Animate
Click and drag to select and move objects
Start
Microsoft Word - C...
boolean2.bmp - Paint
3D Studio MAX...
4:28 PM


File Edit Tools Group Views Rendering Track View Help
Compound Objects
Object Type
Morph Scatter
Conform Connect
ShapeMerge Boolean 2
Name and Color
Sphere01
Pick Boolean
Pick Operand B
Reference Copy
Move Instance
Parameters
Operands
A: Sphere01
B: Cylinder01
Name:
Operation
Union
Intersection
Subtraction (A-B)
Subtraction (B-A)
Display/Update
0 / 1000
1 Object Selected
Grid = 100.0
Animate
Click or click-and-drag to select objects
Start
Microsoft Word - C...
boolean1.bmp - Paint
3D Studio MAX...
4:25 PM



The second boolean tutorial involved the use of the connect tool. This tool is much like a boolean addition in that it joins two objects, however the connect tool creates a "bridge" between the objects so that they seem to be one flowing object. In this tutorial I joined a taurus shape with a cylinder (boolean2.bmp on the cd). This technique of using other objects to create a mixture of the two was very helpful in my final project. I found myself presented with the problem of how to model a hammer's claw. Thinking back to these tutorials, I created a non-notched claw by simply drawing an outline and extruding it. I then created a second object in the shape of the notch I wanted to create in the claw. Then, using boolean subtraction, I removed the shape of the second object from the claw and was left with a rather nice hammer claw (Kakert, 91 - 95).

The next tutorial was duplication of a single object. However, it is designed to teach duplication while controlling the location of the duplicated objects. The array tool is used to create the spokes of a wagon wheel. Once one is created, the others can be duplicated, and by automatically rotating each spoke 36 degrees as it is duplicated, a perfect circle is formed. While I did not use this technique in my final animation, it is a very useful tool. It can be used to create such things as the seats of an auditorium or anything else where a structured array of objects is needed (Kakert, 80 – 81).

One other modeling tutorial I completed dealt with lathing objects. This is a technique that takes a profile drawing and 3d object out of it by rotating it around an axis. For the example I did (glasswwine.bmp on the cd) I created a basic outline of a wine glass and then lathed it, which created the cylindrical glass. This technique can be used on other things such as bottles, table legs, etc. This technique was used twice in creating objects in my final animation, and made modeling the objects much easier. Both the nose section of the hammer and the spike section of the nail were made using this technique (Jefferey).

Having completed these modeling tutorials, I worked on two animation tutorials to learn more about that aspect of creating the final project (glassappearing.avi, logo.avi, logo2.avi, and logo3.avi on cd). The first tutorial was designed to teach the reader how to animate visibility. For this tutorial, I created an object of my own, a glass on a table, and slowly increased the visibility from zero to one hundred percent over the length of the animation, thereby creating a fade-in effect (Armstrong). This technique would be especially useful

in an animation that sought to emulate cinema effects, such as the fade-in, or a cross fade between scenes .

The second animation tutorial I completed was a logo rotation. This tutorial explained how to attach one object to another and then animate one object, thereby animating the second object (Taranto). The previous tutorial came into play in that the first object was made invisible so that it would appear that the second object was rotating by itself. To this scene, I also added a ball rolling across the screen. This addition was merely for practice. This rotating logo is a technique used in many web graphics and other such animations where one wants to call attention to an object. Again, it was not used in the final animation, but was well worth the time (logo.

Although it turned out that some of the techniques used in the tutorials would not be used in the final animation, doing these tutorials gave me a good understanding of computer graphics and specifically how computer graphics can be generated using the chosen software package. The fact that these tutorials were not used was very interesting to me. It showed that my ideas about computer graphics and my initial assessment of what techniques would be used in the final animation were wrong. Completing the final animation gave me a great deal of perspective on what techniques would be used in certain situations. Therefore in the future, I will be able to understand what I will need to do in order to produce a certain effect or scene.

Completing the final animation was by far the most challenging part of the project. The modeling of the characters was difficult, but not nearly as difficult as

the animation. That is a second example of where my initial ideas were incorrect. I had no idea how complex the process of character animation was. Through the various books I read and through attempting to make the animation look realistic, I realized that there is a lot more to character animation than I originally thought. One example of this complexity is making the characters jump. I initially thought that there would be a few motions to a jump and that would be all. However, in trying to create this movement, I became aware of all the motions that an object would make if it were to jump as the characters in my animation do. What I originally thought would be a fairly short process turned into a fairly long and complicated one. However, I am very glad that it did for it taught me a great deal about character movement and how to accomplish such movement. Although my animation is by no means perfect in that respect, it far exceeded the expectations I had when I started out to create a simple scene.

Modeling the characters, although not the most time consuming element of the project, was complicated. For the hammer, I started out with the handle, simply creating a cylinder and applying a modifier to create a more oval and realistic shape for the handle. I then began working on the head, which is composed of four parts. The first, and most simple, is the striking surface, which is simply a very short cylinder. The next piece is the connection between that surface and the central part of the head. In creating this part I looked back to the lathing tutorial and used the techniques it taught. I drew a curved line, and then lathed it to make it three dimensional and cylindrical. The next part is the center of the head, and is simply a cube. The final part of the hammer was by far the

most complicated and by far the most interesting to create. The claw bore no resemblance to any of the primitive objects that the software offered, and so I had to make it from scratch. I began by drawing a two-dimensional side-view of the claw. I then extruded this drawing into three dimensions. From here, I needed to cut the groove in the claw as I explained above in my discussion of the boolean tutorial. As I mentioned, I used boolean subtraction to "cut" a groove of just the right shape. I then went about linking all of these parts so that when they were animated, they would act as one object rather than five separate ones.

The nail was somewhat simpler to model because there were fewer parts and the parts were much simpler. There are three parts to the nail, the head, the shaft, and the spike. The head is simply a cylinder, the shaft is also, and the spike is a lathed outline, much as was the nose section of the hammer.

Animating the characters was by far the most complex part of the project. In order to accomplish this, I combined bending, scaling, and movement of the objects. The bending was used to make the characters appear to be leaning into the jumps and reacting to their momentum as they landed. Scaling was used to lengthen the characters as they jumped, and shorten them as they landed, much as a person would extend themselves in a jump and crouch slightly to soften the impact of landing. The scaling was also used to control the distribution of mass in the objects. As an object lands and compresses, it must grow in diameter. Likewise as it jump and lengthens, it must shrink in diameter. The scene where the hammer attacks the nail is a combination of bending and rotation of the hammer.

This final animation caused me to pull together all that I had learned with the tutorials and also, because the tutorials did not cover all the needed material, to learn and experiment as I went along. This was one of the most beneficial parts of the project, as it allowed me the opportunity to experiment with the software and to figure out how to accomplish various aspects as I came across them. Through the various reference books I used and also experimentation, I feel I was able to create an animation that exceeded my original goals and taught me a great deal about the process of creating a computer animation.

Overall, the process of creating this animation was one of suprises. When I began, I knew nothing of the process, either creatively or technically. My goal in this was to create a finished work, and in doing so, to learn enough about computer animation that I would be able to then apply that knowledge to other works and to continue to learn and explore the possibilities of the medium. I am very glad that the project expanded beyond what I originally anticipated. If it had not, I would not have had the opportunity to learn all that I have and to gain the experience that I feel will be very useful and practical in future projects. I consider this project to be a success in that I accomplished everything that I set out to accomplish and more. I feel also that I have not just learned one specific software package, but that I will be able to apply the knowledge I have gained to other environments and other platforms and become equally familiar with them. I feel that I have gained a great deal from this experience and that I will take what I have learned with me and enjoy using it for the rest of my life.

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Outline for capstone animation

Scene 1

Title: Hammer Meets Nail

Idea: The idea of this scene is to serve as an opportunity to model and animate otherwise inanimate objects. The idea for this scene came from Pixar's Luxo Jr. short. I was interested by the idea of creating a personality for an object that would not normally have one.

VISUAL	AUDIO
Medium length shot of hammer "walking" along a wooden plank.	
Cut to same distance shot of nail "walking" (hopping?) along same board in opposite direction.	
Hammer and nail meet. Stopping and staring at one another, sizing each other up.	
Hammer swings down at nail. Nail dodges and hammer misses.	
The above repeats, with the hammer striking and the nail dodging repeatedly.	
Hammer hits brick, knocking its head off.	
Hammer falls over.	

Scene 2
Title: Building fly through.

Idea: The basic idea of this scene is to allow me the opportunity to model a building, both interior and exterior. The building will consist of several rooms, each with unique features which will allow me to create a number of different spaces and especially to work with camera angles and shots.

VISUAL	AUDIO
Exterior of building	
Camera begins flying towards and into building as door opens.	
Camera flies from room to room, using different angles.	

Scene 3
Title: Golf

Idea: A man hits a golf ball down a course. The golf ball rolls up to and into the hole.

VISUAL	AUDIO
Golfer's perspective of fairway	
Cut to view of golfer preparing to swing	
Golfer swings	
Camera pans to follow ball	
Ball lands on green and rolls into cup	

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