2D Versus 3D

by
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A thesis presented to the Honors College of Middle Tennessee State University in partial fulfillment of the requirements for graduation from the University Honors College

March 20, 2023

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Abstract

This thesis goes through the history of 2D and 3D animation, and debates why 2D animation rarely receives 2D animated movies in theaters anymore. Along with this investigation of animation, I also created an animated short film in 2D and then recreated it in 3D to give direct comparisons between the two mediums. I cover topics such as why 2D dominates television even though it fails to come back to theaters, how Pixar led the 3D animation renaissance, and much more. This link leads to my 2D and 3D animated short films that will be compared in this essay.
https://www.behance.net/gallery/167803433/Creative-Thesis-Project

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I: Introduction

Once upon a time, 2D animated movies were regularly released in theaters. That is no longer the case. If an animated feature film is released in theaters today, it is 3D animated. Why is this? Is the idea of 2D animation returning to theaters that much of a fairy tale? My purpose of this thesis is to study the history of animation, learn the 2D and 3D animation processes, record and review their respective pros and cons, and determine why 2D animated films rarely receive theatrical releases anymore.

II: The Beginning of Animation

Throughout human history, art has been used to tell stories, express emotions, and reflect ideas that often could not be put to words. From the first cave paintings, to Egyptian hieroglyphics, stories were created by simple drawings. Art would continue to evolve into many new styles, going anywhere from expressionism to cubism, but they often continue to tell stories, express feelings, or capture a single moment in time.

It would not be until the Victorian Era that a new invention would create a way for drawings to give the perception of movement to the viewer. In 1868 the first flip-book was created and patented by John Barnes Linnett based on a design by Pierre-Hubert Desvignes. It was originally called the kineograph, which, when translated from Latin, means “moving picture” (McDaniel, 2022). This creation would both be a breakthrough for animation and for film.

While flip-books were mainly a bunch of similar drawings strung together that, when quickly flipped through, would give a sense of motion in the drawings. Another invention was made during this era that also played with the idea of moving images. This was a device that had several images on the inside of a cylinder. When the device is spun really fast, the pictures seem to merge between each other and give the perception of a moving object. This device was called the Zoetrope which translates to 'wheel of life' and was created in 1867 by William Lincoln, but had previous iterations of this device under different names since 1833 ("Zoetrope animation explained: Definition, history and ideas"). According to Leonard Maltin, zoetropes at the time "were considered little more than novelty toys—a more sophisticated version of the 'flip-books' that were also popular at this time" (Maltin, 1980, p. 2). Zoetropes would also help lead to the future of film and animation.

Figure 1

Image of a Zoetrope

In 1878 Eadweard Muybridge set up dozens of cameras in a line that would take photos of a horse as it was running by (San Francisco Museum of Modern Art, 2017). These pictures were compiled and, if flipped through, would show the actual motion of a galloping horse. This would go on to be the first iterations of live action motion.

In 1896 J. Stuart Blackton met Thomas Edison while interviewing him. Edison noticed and liked some drawings Blackton had done, and later, in 1906, the two of them would use Edison's new motion picture camera to record Blackton drawing on a chalkboard and bring the characters he drew to life using stop motion. This film was named *Humorous Phases of Funny Faces* (1906), (Beck, 2023).

Soon after, in 1911, Winsor McCay, who was a comic strip artist, animated one of his *Little Nemo in Slumberland* comic strips, which received high praise, but also gained skepticism. According to Leonard Maltin's book, *Of Mice and Magic*, McCay had written: "While these films made a big hit, the threatre patrons suspected some trick with wires,". He made a new film in 1914 called Gertie the Dinosaur, which was made to show audiences that he was "making the drawings move" (Maltin, 1980, p. 3-6). These animations mark the turning point in animation history.

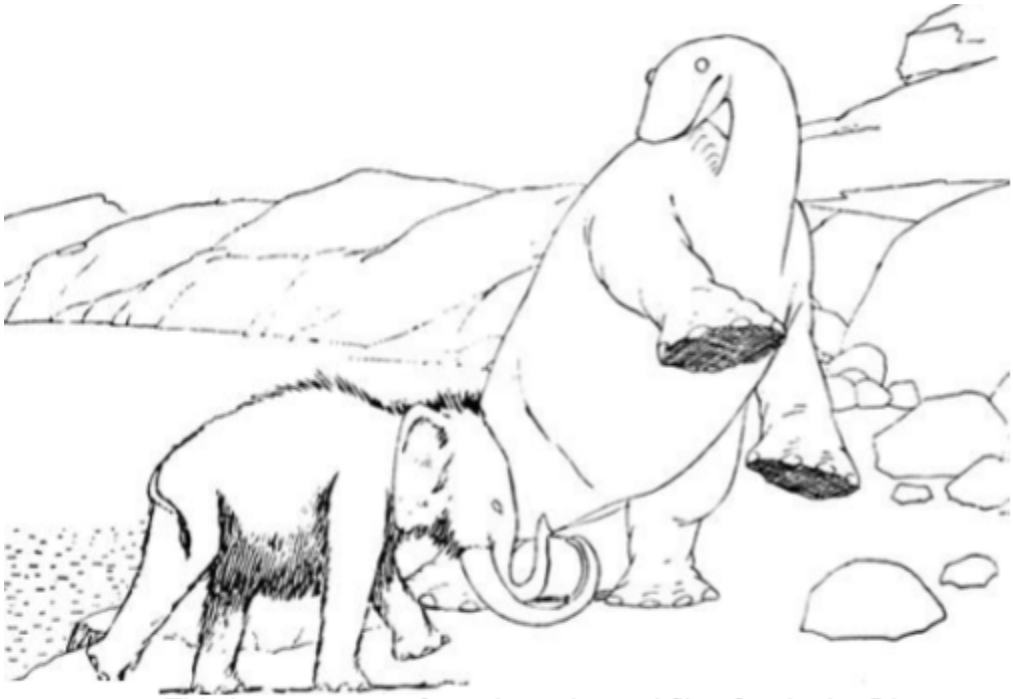


Figure 2 This image comes from the animated film *Gertie the Dinosaur*.

III: The Rise and Fall of 2D animated movies

In the following years, companies such as Warner Brothers, Winkler Pictures, Fleischer Studios, MGM, and others would create cartoons. These cartoons would play in theaters before the movie started (Beck, 2023). One of these cartoons was called *Steamboat Willie*, created in 1928. This cartoon was both the introduction of the iconic character Mickey Mouse, and the "world's first fully synchronized sound cartoon,", (Walt Disney Archives). along with being Walt Disney's true start to fame.

In 1937, Walt Disney made *Snow White and the Seven Dwarfs* (Cottrell et al., 1937), which was the first feature-length 2D animated movie (Walt Disney Archives). According to MTSU's Animation History Professor, Jerry Beck, many people doubted Disney and his idea to create an entire animated movie, but Disney proved them wrong as his film was a massive critical success (Beck, 2023). Disney continued to be the frontrunner in creating feature-length 2D animated films for many years to come ("A guide to the history of animation", 2021). Since then, few other studios have made many feature-length animated films, and rarely did one get the level of success that the Disney films were getting.

In 1966, Walt Disney died, and without his direction, many of the upcoming 2D films also started to fail to live up to the Disney legacy. According to an article from BFI (British Film Institute, 2021), after Disney's death, the company started creating more live action films. "...animated films were no longer the sole focus. The films of the era were made with lower budgets and more recycled animation than previous eras" (BFI, 2021).

Figure 3

This picture shows how Disney Studios recycled animation of Baloo from *The Jungle Book*, (1967), for Little John from *Robin Hood*, (1973).

Disney would make a huge comeback in the 90s which is often dubbed as the Disney Renaissance. This was the era of films such as *Aladdin* (1992), *Lion King* (1994), *Little Mermaid* (1989), along with many more classics. During the 2000s, however, many of the 2D animated Disney films were not as big of box office hits as they were expected to be. Disney's *Treasure Planet* (Clements et al., 2002), even lost money (BFI, 2021). The oddest thing about these movies is that most of them were considered box office failures, but are now considered cult classics. Films such as *The Emperor's New Groove* (2000), *Treasure Planet* (2002), *Atlantis: The Lost Empire* (2001), etc. are well received by fans today (Alfar, 2022; Moore, 2022).

For a while, *Home on the Range* (2004), was Disney's last 2D animated movie. It came out in 2004 and was a box office flop, along with several other Disney films that had been coming out around that time. (Bomb Report). The last 2D animated Disney

movies to be shown in theaters were *The Princess and the Frog* (Clements et al., 2009). which was released back in 2009 (Hunt, 2019), and *Winnie the Pooh* in 2011 (Anderson et al., 2011). As of 2023, Disney has not put out a single 2D theatrical movie since 2011.

Of course Disney is not the only company that made 2D animated films over the years, but Disney was the leading force. If Disney could not profit on making 2D animated films, then other companies likely did not even try. There have been some 2D theatrical films from other studios since Disney stopped, but only a handful.[1]

IV: Who Killed 2D Animated Movies?

As previously discussed, Disney Studios, the animation king, was having trouble making a profit on their 2D animated films in the 00s. However, there was a possible outside influence on why their films were failing. 3D animation had finally made it to the big screen, and audiences were amazed.

In 1986 a short 3D animated film called *The Adventures of Andre and Wally B.* was produced (Smith, 1984). This film was created by a group called the Lucasfilm Computer Graphics Project. It was first shown unfinished at the 1984 SIGGRAPH conference, which is a huge computer graphics convention. The audience was in awe. This was not the first 3D animation by any means, but this film was made by people who previously studied and worked on 2D animations.

[1] 2D animated theatrical films do exist in other countries. Japan alone produces numerous 2D animated movies every year. This thesis is specifically talking about 2D animated theatrical films made for Americans and English speaking audiences.

What made this film stand out was that while it used 2D animation techniques, such as squash and stretch, exaggeration, follow through action, etc, the animators also found a way to give a 3D animated film motion blur (Ultimate History of CGI, 2019). Motion blur is when something moves too fast in front of a camera that the camera can not get a perfectly clear frame. Instead, the fast moving object becomes a blur line in the picture or in the scene. This team of animators were able to bring motion blur to an animated film.

Figure 4

Example of motion blur in live action compared to in animation using a picture from the animated short film, *The Adventures of Andre and Wally B.*

Later in 1986, this group of animators would make another 3D animated short called *Luxo Jr.* (Lasseter et al., 1986), but this time under a new name: Pixar. This film was about a desk lamp that plays with a ball until he jumps on it too hard and accidentally pops it. This short film was the first to be nominated for an Academy Award at the Oscars (Cohen, 2000). It would also later be incorporated into their iconic logo, with the same desk lamp jumping on and flattening the I in the word Pixar. This short was quite well

received and would help Pixar move forward in popularity. Pixar would continue putting out one short a year up until 1989. Around this time, instead of making short films, Pixar was making 3D animated commercials for products like Life Savers, Tropicana, and Toys R Us, among others (Pixarfan the Second, 2018).

In 1995, a film came out that would forever change the animation industry. This film was *Toy Story* (Lasseter et al., 1995). the first fully 3D animated feature length movie (Zorthian, 2015). It was Pixar's first movie, and the film was an hour and twenty-one minutes long. This was the longest a 3D animated film had ever been at the time. History was being made in the animation world and this was just the beginning of it all. The 90s would see a couple more 3D feature films hit the big screen with plenty more on the way made by several companies in the 2000s. 3D animated movies were starting to dominate the animation industry.

With 3D's popularity, 2D animation started to dwindle in popularity. One reason I believe Disney's 2D animation was failing at the box office is because it was competing with something so new and different. *Toy Story* was making history and *A Bugs Life* (1998), and *Toy Story 2* (1999), were right around the corner. Pixar's first real competitor, Dreamworks, came out with their first 3D animated film, *Ants*, in 1998 which was the same year Pixar released their second film, *A Bug's Life*.

Eventually Disney would stop releasing 2D animated feature films altogether and stuck with 3D animated films instead. Their first 3D animated film was *Chicken Little* in 2005 which was much more profitable than their recent 2D animated box office failures.

In 2006, only one year after *Chicken Little*, Disney saw the success in 3D animation and bought Pixar ("Walt Disney announces $7.4 billion purchase of Pixar", 2006).

The future for theatrical animated movies was getting ever brighter for 3D, but dimmer for 2D. While this was not necessarily the explicit reason for the demise of 2D animated films, it was most definitely a factor. Toy Story brought huge innovations in animation and technology, and would soon become the norm for animated theatrical films. 2D animation was not nearly as profitable at this time. "The late-1990s weren't a great financial period for traditional animation, especially at Disney" (Spiegel, 2014). With 2D already declining, the innovation and huge success of Toy Story and other 3D animated films would only further reflect the fall of 2D theatrical films.

V: Is 2D Animation a Dead Medium?

NO! Not in the slightest! Up until now I have made it a point to only describe animation as 2D or 3D animated theatrical movies, or some combination of these words. The reason for this is because 2D animated theatrical movies do seem to be dead with 3D animated movies having taken their place. Disney has not shown interest in releasing a 2D movie in theaters for the past 12 years, and the amount of 2D animated films by other companies during these years is shockingly small.

Most 2D animated movies in America seem to be straight-to-DVD movies. Warner Bros. makes dozens of 2D feature length DC Comic animated movies every year,

but they do not release them in theaters. When a 2D animated movie is put in theaters, the film is usually based off of an already established and successful 2D animated show. Often, animated shows will have a straight-to-television movie, but every once in a while a show will receive a theatrical released movie. Some 2D animated movies that are based on shows include; *The SpongeBob SquarePants Movie* (2004), *The Simpsons Movie* (2007), *My Little Pony: The Movie* (2017), *Teen Titans Go! To the Movies* (2018), *The Bob's Burgers Movie* (2022), and many others. These shows get theatrical releases because they already have fan bases that companies expect will be willing to go out and see them in theaters. In many companies' eyes, a 2D animated movie that is not based on already popular characters is too big of a risk for them to make. Disney proved this to them by having box office failures of their animated movies in the 70s, 80s, and 00s. Even films like *The Bob's Burgers Movie*, which has a decent sized fan base and name recognition were not box office successes. SpongeBob's second film, *The SpongeBob Movie: Sponge Out of Water* (2015), was only half 2D animated. The second half of the movie was 3D animated characters running around in the real world, which was what the movie was mainly being advertised as to begin with (SpongeBob SquarePants Official, 2014). To put the nail in the coffin, SpongeBob's third movie, *The SpongeBob Movie: Sponge on the Run* (2020), was completely 3D animated.

The reason why I specify that 2D animated theatrical movies are dead is because 2D animation outside of theaters continues to be done today. 2D animated TV shows are very popular, and there are a wide variety of shows for different age groups. There are

cartoons made for young kids, teens, families, and adults. Most streaming services have wide selections of 2D animated content. While 2D animation is rarely on the big screen, it continues to thrive on the small screen.

Animated cartoons were produced and successful before television was invented. In the 50s, it was popular for animated cartoons to be shown in theaters before a movie would start. (Beck, 2023). The invention of the TV helped bring cartoons to people's homes. TV channels such as Hanna-Barbera, Kids' WB, Cartoon Network, and Adult Swim were created to be channels specifically for cartoons and several channels like Nickelodeon and Disney Channel embraced creating animated content as well. Most straight-to-TV movies are often based on existing cartoon shows, but every now and then, there are movies that are completely original. For instance the film *Klaus* (Pablos, 2019), was a high quality 2D animated movie that was made for the Netflix streaming service rather than theaters. When theaters are out of the equation, it is clear to see that 2D animation is anything but a dead medium.

VI: 3D vs 2D on TV

If 3D animation is able to replace 2D in theaters, why have they not done so in television? While there are several 3D animated shows made every year, it does not compare to the amount of 2D shows made each year. Before *Toy Story*, there were a few 3D animated cartoons on TV, but most of them had rough animation and the characters

were all incredibly blocky and looked terrible. The first successful 3D animated TV show was *VeggieTales (*Nawrocki et al., 1993-2015). This was able to be both appealing and animated in a reasonable amount of time due to one very specific key element, which was that these talking vegetables had no arms or legs.

Figure 5

These are pictures of 3D animation on television back in 1993-1994. On the Left is a series called *VeggieTales* and on the right is a series called *ReBoot. Veggietales* had a more aesthetically pleasing look to their style because the creator recognised the 3D animation limitations of the time.

When the characters in *VeggieTales* picked an object up, the object simply levitated next to them. When a character needed to walk around, they would hop around instead, which was much easier to animate. All of their motions and movements were expressed with animator's squashing or stretching the character models, and the only real thing that needed to be fully animated were the faces. In an interview with Yahoo!news, Phil Vischer, the creator of *VeggieTales*, said, "I tried to make a fully limbed character…It was just a disaster, a nightmare… I finally realized the only way I was going to make a

character was if it didn't have arms, legs, hair or clothes," ("Secret DIY origins of '*VeggieTales*' success", 2014). Overall, the animation was as simplified as it could get. Simple animation aside, it was the most appealing 3D animated show at the time and the show was a huge success.

Many other TV shows have been 3D animated since then, but 2D animation still thrives in this format. This is mainly due to the drop in quality that is necessary for 3D animated TV shows to have if they want to get new episodes out on schedule. The more detailed the backgrounds and characters are, the longer it takes to render the scene. *Star Wars: The Clone Wars* (Filoni, 2008-2020), along with other Star Wars animated shows, often use blocky character designs and give characters with very stiff almost lego-esque hair pieces to make render times quicker. Rather than animate hair that can flow, which would take a long time to render, they model out the hair making it very stiff (Reece, 2023).

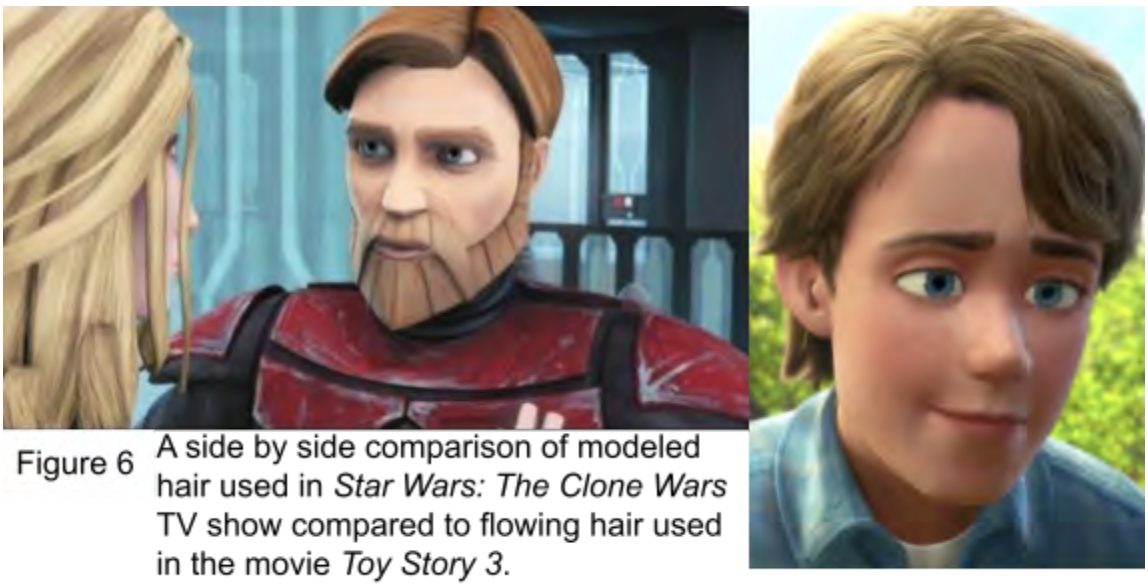


Figure 6 A side by side comparison of modeled hair used in *Star Wars: The Clone Wars* TV show compared to flowing hair used in the movie *Toy Story 3*.

The SpongeBob Movie: Sponge on the Run (2020), and *Kamp Koral* (2021), are perfect examples of movie detail and show detail. *Sponge on the Run* was a 3D animated SpongeBob movie that was meant to gain hype for their new upcoming 3D animated SpongeBob show, *Kamp Koral* (Ceccarelli, 2021-Present). While both are 3D animated, Kamp Koral does not look nearly as detailed as the movie was, even though they were both using the same character models as shown in the pictures below.

Figure 7

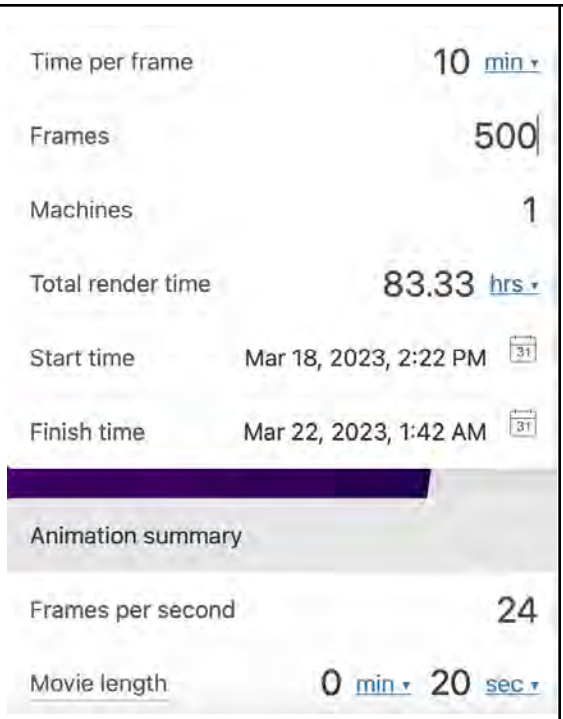
Picture from the *SpongeBob Movie: Sponge on the Run.* Compare the circled details between figure 7 and figure 8. Notice the higher level of detail in figure 7 even though figure 8 came out after.

Figure 8

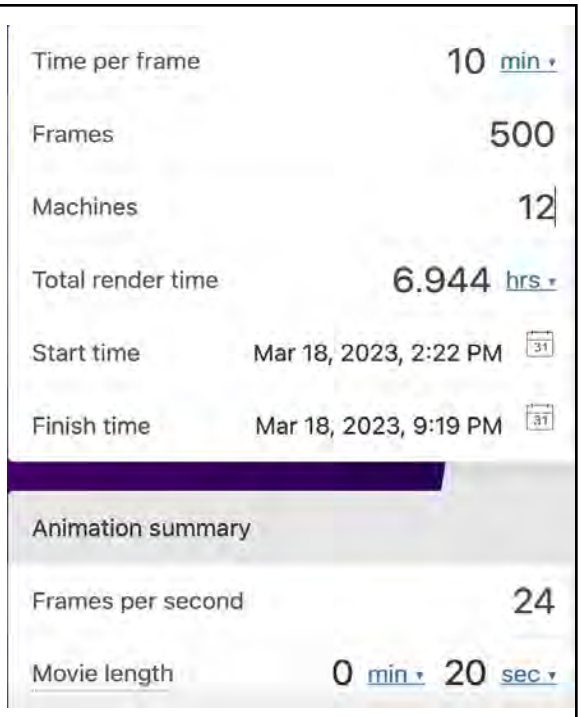
To save on render time, the SpongeBob show *Kamp Koral* had to take many of the details out from *The SpongeBob Movie: Sponge on the Run*, models and designs. Some examples of this include SpongeBob and Patrick (right) no longer have their badges, Sandy's (left) fur is less fluffy, her flower is now flattened onto the glass bowl, and the sand is less detailed. Picture of the show *Kamp Koral*.

A 3D animated movie can be extra detailed, because they only need to render the whole finished movie once. A TV show requires each finished episode to be rendered out. For context, every single frame needs to be rendered to get the highest detailed version of that frame. One frame equals one picture. In my experience, rendering one frame of my animated films can take 7-12 minutes. Although the animations that I have made are short, just a 20 second film would have 500 frames. If each frame rendered for 10 minutes, it would take around 83 hours to finish rendering everything.

Most 3D animation companies will have something called a render farm, which are computers dedicated to only rendering out the frames. For example, if a company has 12 computers in their render farm, they can render out 12 of these 10 minute frames at the same time. This means each computer only has to render out about 41-42 frames of the 500 frames. This allows each computer to finish rendering in a little under 7 hours rather than waiting the entire 83 hours (J Mah, 2023).



The total render time with 1 render farm is 83.33 hours.



The total render time with 12 render farms is 6.944 hours.

Figure 9 Data created using Omnicalculator

Render farms can exponentially speed up the rendering time, however, remember that this example was for 20 seconds of animation. An animated movie is usually an hour and a half and a show is usually around 22 minutes with a varying amount of episodes,

usually anywhere from 13 to 22 episodes per season. While a movie is longer than an episode, 13+ episodes is much longer. TV animation uses less detailed models so render times can stay much shorter.

Render time is one of the main hindrances of 3D animation for television. 2D animation does not need to render at all, which is a huge advantage in favor of 2D animation. That said, 3D animated shows have started popping up more and more frequently over the years. While 2D has the upper hand for now, nothing is ever set in stone.

VII: Making a 2D and a 3D Animated Film

For the creative portion of my thesis, I decided to create a short 2D animated film and then recreate it in 3D. This allows me to go through the process and discover the pros and cons for myself. I used the program Krita for the 2D animation and Maya for the 3D animation. There are many other programs that can be used for animating, so not everything will be the same from program to program. It needs to be made clear that this section will contain many of my opinions formed by the personal obstacles that I faced. These experiences may not hold true for everybody in the animation world. This section is based on facts and empirical observations that follow my personal experiences as well.

Let it be known that I originally wanted to be a 2D animator, but I found that I had a greater love for 3D animation and that I personally was better skilled for 3D

animation. I am not the greatest 2D artist by any means and 3D animators do not necessarily need to be good at drawing to make something look highly detailed in 3D. In the same vein, if an individual is not good with technology, then 3D animation will be much harder to learn as there are an overwhelming amount of buttons that each have dozens of functions to learn. Many of these functions require that the buttons are pressed

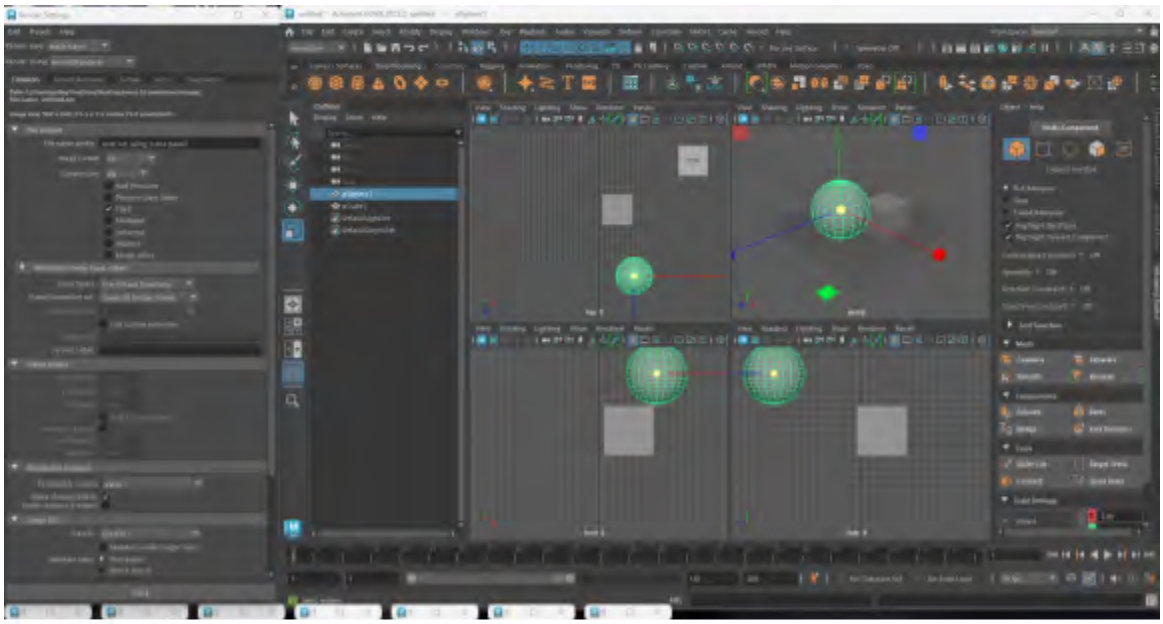


Figure 10 Example of the many buttons in Maya.

in the precise order to get the correct results in the animation process. Small mistakes can break models, rigs, and textures. Even the best professionals in this industry can get stumped or might need to review their notes at times. It is not uncommon for experienced animators to also look up tutorials. 3D software is always changing, and companies make new versions of their software every year. Certain methods used one year may become outdated and obsolete the next year. It is imperative to constantly stay up to date on what

is new in this industry. While digital 2D animation also has a lot of buttons and updates, it does not come close to the level that 3D animation has.

2D animation mainly depends on the animator's ability to draw more than their ability to keep up with technology. One thing I love about 3D is the fact that I do not need to be skilled at drawing. It still takes a level of creativity and ingenuity. As long as the animator knows how to use the software and has patience, they can create anything.

VIII: The Plot

In this section, I will give a quick summary of the characters and the story for my animated short film. This link leads to my 2D and 3D animated Smynko films. https://www.behance.net/gallery/167803433/Creative-Thesis-Project. The main characters are Smynkos and Smokos. Smynko is one of thousands of Smynko units that are plugged into the wall. The Smynko units carry data on them, which is what the Smokos are seeking. Smoko is one of the giant robots looking for a specific Smynko unit that is carrying sensitive data.

The film opens on Smynko plugged into the wall and sleeping along with all the other Smynko units around him. Suddenly he is awakened by a claw grabbing him and pulling him out of the wall. Smynko frantically waives its arms and legs trying to get out of the claw’s clutches, but to no avail. The giant claw brings Smynko up to a giant robot head. This giant robot is a Smoko unit. Smoko squints its eyes at the tiny Smynko unit as

if it is searching for something, but in disappointment, Smoko dismissively flicks Smynko away as if it were a worthless piece of trash. Smynko tumbles to the ground. As Smynko tumbles, it is revealed that there are multiple Smokos searching through thousands of Smynko units. Smynko sits up with a dazed and confused expression as he looks back at the robots. Hard cut to black. The End.

Smynko's design is based on a charging block. He is supposed to be made of hard plastic that can catch a dull glare in the light. While Smynko is meant to be hard plastic, he is also able to go limp and become floppy. His legs are metallic and shiny and are meant to go into a plug or outlet as seen in the short.

Figure 11
Side by side comparison of a charging block and my 3D and 2D design of Smynko.

IX: Pros and Cons: The Animation Process

Comparing my 2D and 3D versions of my animation, the 3D version is clearly unfinished. This is because in the process of making it, I ran into technical issues that corrupted all of my files. While I had made plenty of backups of these files, they were all

on one card. Because the card was corrupted, I lost all of my work. Luckily, I had rendered out a low quality version of my animation a couple days before everything was corrupted. I was able to put together a close to finished version of my 3D animated film. Because it is not complete, I will also be using some of my other projects that I made at MTSU for extra examples. This way I can still go over all the topics I planned to discuss. Let this be a lesson and a reminder to everyone to make sure to back up all work as often as possible and in as many places as possible.

When creating a movie, a show or a short film, there will always be a pre-production period, production period, and post-production period. For the most part, pre-production is the same for both 2D and 3D animations. Pre-production is when the story is thought up, the script is written down, characters are designed, concept art is created, and storyboards are laid out. At some point early in the pre-production period, it will be decided whether the film will be live action, stop motion, 2D animated, 3D animated, or another medium. Sometimes concept art will be the deciding factor, other times, the medium is decided before the story is even created. The production period is when the animating happens.

For the most part if an animation has voice acting, it is imperative to get the actor's voice recordings before the animating process can begin. This is because animators need to sync the animation with the voices. While the 2D animators have to wait on the voice acting to be done, 3D animation can be worked on way before the voice lines are recorded. 3D animators might have already started working before the storyboards are finished. This is because the animators first need to make models of the characters and objects. While it seems like having 3D animators start work on the

animation before 2D animators is an advantage, It should be pointed out that 2D animation does not need to make 3D models of anything. By the time 2D animators can start working on their animation, 3D animators will still be working on their 3D modeling.

A step by step of 2D animation starts with making a rough drawing of a keyframe. Keyframes are the major starting points and ending points of a specific action of a frame. For example, in my film, the individual frame where the claw stops moving towards Smynko and the frame where the claw grabs onto Smynko are both keyframes in my animation process. Because of that, I would draw those out first. This allows me to know where the animation will begin and end. The next step is to draw the frames between the two keyframes. This is called in-betweening. For my animation, I might add another keyframe for when the claw is at its most opened point. This allows me to know how many frames should come before the claw opens, and before the claw grabs Smynko. It also makes it easier to discern how much I should move the claw forward and how much I should open/ close the claw hand before I reach the next keyframe. This method of animating is called pose-to-pose. The other main method is straight ahead which is when an animator draws out each frame in a row (Williams, 2001). Pose-to-pose helps set goals of what needs to get done and helps make sure the size and shape of the drawing does not change throughout the animation process. For example, I know that the claw is a certain size in these key frames, so I need to make sure my inbetweens start and end the same size and shape as well. It is a great method for keeping animation on track and as accurate as possible.

During this point the drawings can look a bit rough, and there should not be any color. At this stage animators do a second pass, where they draw the lines out smoother, and make it look cleaner by removing any sketch marks. Following this process they add the backgrounds and color to the animation. Often, backgrounds will be drawn by someone else in a more detailed art style, and background elements that are interacted with by the characters will be drawn in by the animators. Something that seems to happen in many 2D animated cartoons, sometimes even in recent cartoons, there will be scenes with detailed backgrounds that have a less detailed door, object, or character. This is because the less detailed object will most likely be interacted with by a character and a less detailed item is easier to animate.

Figure 12

When a character needs to interact with an object, the object is drawn by the animators rather than the background artists. This is why they look less detailed and out of place. This scene is from *Scooby-Doo Where are you?* Season 2 Episode 6.

3D does not have this problem. While 3D animation is more realistic looking, most of the details are all a trick. Most objects are not modeled out to be incredibly detailed. Most objects are modeled out and afterwards, the models will be textured. Texturing is when animators wrap a realistic picture around their model. Texturing is very involved and includes a lot of complex steps. A simple way of thinking about it is to imagine that an animator has modeled a cube. To add a texture to it, the animator first needs to unfold the cube just like the cubes made by children with arts and crafts. The process of unfolding the model is called UV Unwrapping. Once the model is unwrapped, the animators can simply take a picture of something like a close-up of the wood of a table, or the stitching on a pair of jeans, and then they overlap that picture onto the flattened picture of the model.

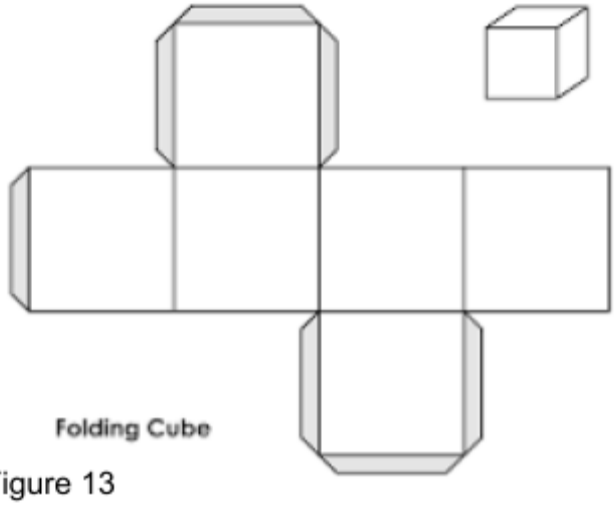


Figure 13

This unfolded cube is a good representation of what is being done in the UV Unwrapping process.

Because an animator does not just want a flat texture on their 3D model, they will also use a tool called bump mapping, which gives smooth objects a rougher, more 3D, texture to them. The process is much more complicated than this small description, but it results in a high quality realistic model that is interactive with the lighting in the animated room and can be picked up by a character without it having to stand out from the

background unlike it does in an 2D animated scene. While it involves a lot of effort and many convoluted steps, the end result looks amazing and can look quite realistic.

Figure 14

These pictures show how much detail texturing adds to models. In this picture we can also see how bumpy the bumpmap was able to make the candlestick handle, even though the model is completely smooth.

Both animation processes take a huge amount of time and effort. Because 3D animation has a lot more steps than 2D, 3D animation takes a lot longer to make. 2D animation mainly consists of drawing each frame through the entire animation process until the entire movie is finished being animated. 3D animation, on the other hand, is broken down into multiple steps. The first main step is modeling. This step is when the animators model out and create the characters and objects for the film. The next step is UV Unwrapping (as explained in the previous paragraph). The next step is to rig the models. Rigging is when the animator builds joints for the characters making it so when they move a joint up and down the character will move their arm up and down. Another step is to texture the models. This is where the models get their details such as color, shine, and transparency, along with textures added and bump mapped to make models look as realistic as possible. When rigging is complete, the actual animation process can

begin. This is where the animators make their models come to life by moving them, giving them expressions on their faces, and choreographing the characters to follow the storyboards.

First the animation of the 3D model is blocked out, similar to the 2D process of making keyframes but in a 3D space. The next step would be in-betweening, however the computers are able to interpret how the model should move from one keyframe to the next. For instance, Smynko being grabbed by the claw was a very easy scene to animate in 3D because I simply made a keyframe of the claw open and a keyframe of the claw closed onto Smynkos head. The software was able to add the in-betweens of the claw closing in on Smynko. There often needs to be some tweaking to make sure the model moves the way the animator wants it to. Because the claw moves very robotically the animation is mainly based off of keyframes alone, but Smynko bends and flops around a lot in the animation, which can not be done with simple keyframes. Often that needs to be tweaked with multiple keyframes or on a frame by frame basis, to make sure the model and the rig are not breaking, and to give the animation the most realistic feel. Other steps include adding lights to the scene, adding cameras, and finally rendering the animation out. All of these steps are quite crucial to the 3D animation process.

While 3D animation is a lot of steps, several steps can be worked on at the same time. For example a team can rig the models and another team can texture the models. All of these steps help make animating much easier. Each step is very different from the other compared to 2D animation where animators will be drawing frame after frame for the entire film. I personally would be burnt out having to draw each frame out, which is why I enjoy 3D animating more. Each step brings a new challenge and the animation step is a

lot more fun and a lot less time consuming than it is for 2D animation. Overall it depends on the animator's mindset whether they like to draw a lot and do not experience frequent fatigue or are able to follow precise instructions and do not mind the multiple extra steps necessary prior to the animatting portion of the 3D animation process.

X: Pros and Cons: Lights, Shadows, and Glares

Previously, I mentioned that I never felt my drawing skills were great. It turns out that my digital drawing skills are even worse. In most cases, 2D animated art, in this day and age, is done on big tablets that are drawn on with an electronic pen. I found it very difficult to get used to using this system and I could never seem to get my drawings to look as detailed as I wanted them to. Practice can definitely improve my drawing skills, but as soon as I started learning 3D animation, all of their tools and steps immediately clicked with me. I found that I was better at creating 3D animations, and I found that I enjoyed it more too. Obviously this is not the case for everybody. In my classes at MTSU, I saw many students struggling to get all the technical aspects of 3D animation. 3D animation is not for everybody. It has a massive learning curve. I am currently in my third semester of 3D animation, and there is so much I still do not know. There are so many tools that I have yet to use, and I often need to look back on my notes. While I personally enjoy 3D more, 2D animation is a much simpler process to learn and can be done by anyone with a pencil and paper, while 3D animation is anything but.

I love 3D animation for how much detail it can show. In my 2D animation I gave Smynko white legs because I personally could not draw a good silver look for them. I decided to scrap the idea of the legs being the shiny metal pins of a plug, but I opted to bring that back when designing the 3D model of Smynko. Given to a better artist, my 2D animation could have had silver looking legs, but I was not artistically skilled enough to add things like shine, glare, and shadow to my 2D animation. That was not the case for 3D animation. In 3D animation, I can determine the model texture. If I modeled out a glass jar, I can go into my settings and add a glass preset. This will make my model see-through and look like glass. If I wanted a more stained glass design, I can use the frosted glass preset, and if I need a very shiny object I might go with chrome. If the glass is too clear or the chrome is too shiny and reflective, I can change any of those settings to get exactly what I want. For Smynko, I chose a thin-plastic preset as my base texture. I refined the settings a bit to get the amount of reflective glare that I wanted his body to have. If my work had not been corrupted, I would have added a picture of a real charger block as my texture image, and I would have

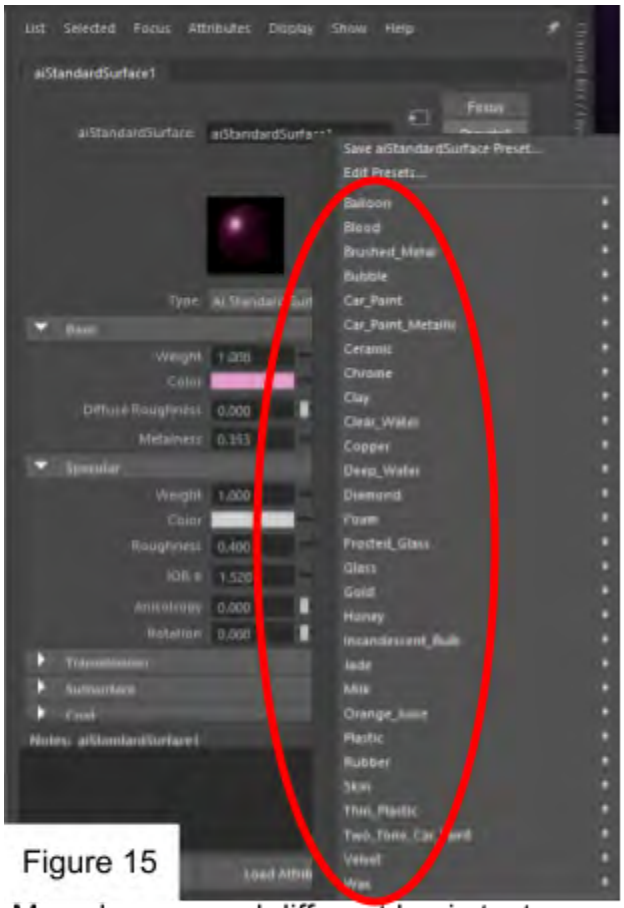


Figure 15

Maya has several different basic textures that can be added to a model.

added several scratches and dents for the bump map. Smynko would have looked almost realistic in its details. I believe I used Chrome for the legs, which is why they are so shiny and reflective. That amount of detailed shine on my 3D model would be quite difficult to recreate in 2D.

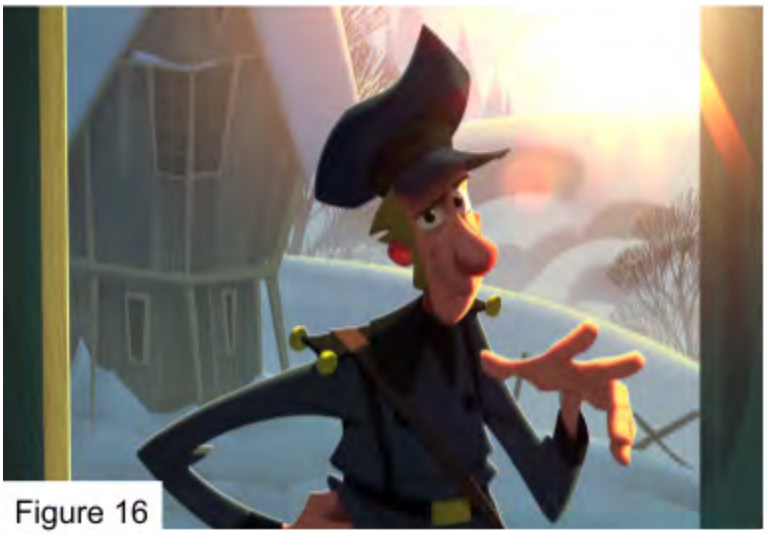


Figure 16

Example of light and shadows drawn in a 2D animated scene. Picture from the movie *Klaus*.

A good 2D shine or shadow requires the artist to know where and how shadows fall onto an object in comparison to the sun or light source. For example, in 2D, if I draw the sun on the top right of the image, then I need to draw all shadows on the bottom left side of the objects in the image. This will also need to stay accurate for every frame in animation.

When it comes to 3D animation, shadows and shines require a completely different way of problem solving. In 3D, the animator can simply put a light in and move it around in the 3D space. If there is supposed to be a sun in the top right of the scene, then all that needs to be done is to create a light source and move it to where the sun will be in the scene. An animator can move the light anywhere in the scene, they can change which direction the light is pointing, they can change how bright it is, and they can even change the color of the light.

The computer is able to figure out how light should bounce from one object to the next. The main flaw with light in 3D animation, is that each light added to a scene can make the scene take exponentially longer to render. Lights take the longest to render in 3D animation because it is trying to solve exactly how light and shadows should fall on all the objects in the scene. It is always wise to have as few lights in a scene as possible.

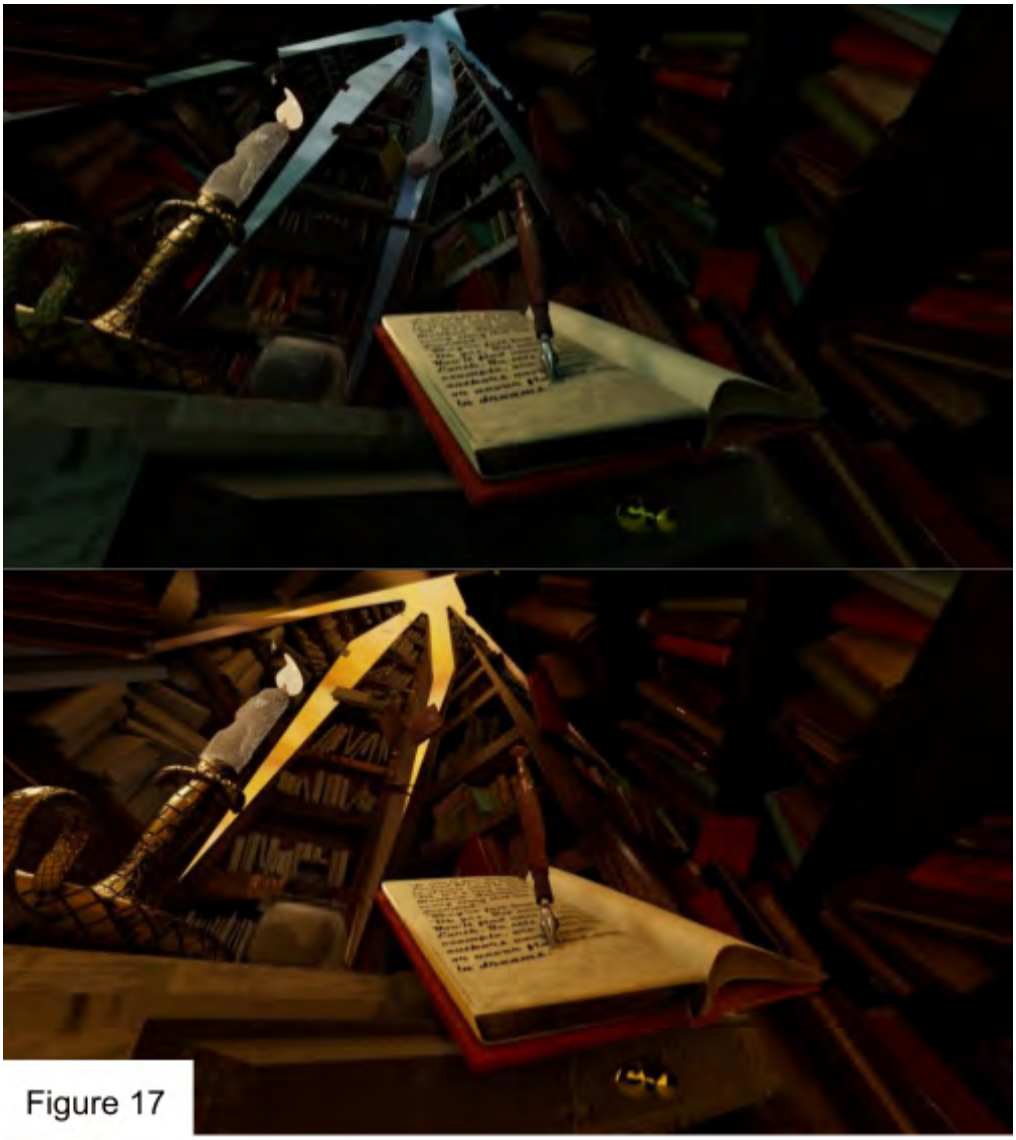


Figure 17

A comparison between two different lights in the same scene.

XI: Pros and Cons: Anatomy of a Cartoon

Back in pre-production, character designs are drawn out to get an understanding of what a character will look like from several angles, usually consisting of a front and side angle view. They are also used for accurate size measurements and color schemes. These character sheets are used a bit differently in 2D and 3D animation workflows.

For 2D animation there is usually a character design that is set in stone as the main reference. This is called an on-model design. These pictures are to help give reference on how the character should be drawn. An artist will look back on these drawings for the entire animation process so the character never looks off-model. In 3D, the character sheet is used to create the model of the character. Once the model is created and textured, the character sheet is no longer needed.

Figure 18

A character model sheet for a 2D animation, and a model sheet of an inkwell, a candlestick, and a pen for a 3D animation.

When it comes to 2D for TV shows, on-model references need to be referenced for every scene of every episode throughout the entire show. As the show goes on, animators may leave or be replaced. In that case the new animators need to learn to draw the characters in the on-model design. If they can not, then the art style needs to change to match how these animators draw. 3D animation only needs to have the model created, and then the finished model can be used for the entire show. The 3D model will always be on-model as long as the character was rigged properly. If the rig is improper, then the entire model might break when the animators try to animate it, which means the model needs to have a new rig created so it will not break in the future.

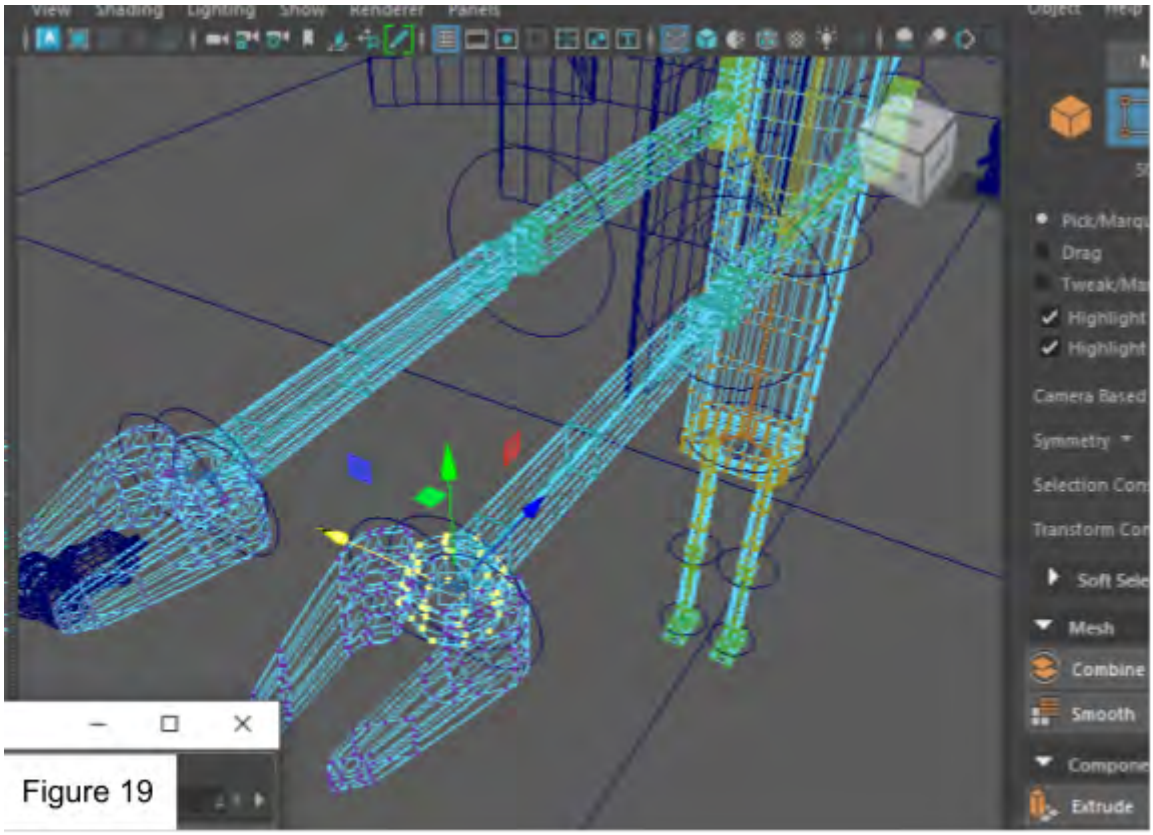
The process of creating the characters in an animation are very different in 2D and 3D animation. In 2D, the animator will need to draw out the character for every frame. While they will likely be using an on-model reference, no frame will look exactly like the reference picture. Each action needs to be drawn out, and each frame will likely look slightly different than the last. While the character needs to look the exact same from the beginning to the end of the film, it is also likely that different scenes will be animated by different people. To combat this, after the animators finish a scene, a cleanup artist will make sure everything was drawn on-model, and when it is not they will fix the drawing to be more accurate.

2D animation only needs to make the model of the character once, but that does not mean that it will be easy. Modeling out an object requires near perfect geometry. Models need to be made up of thousands of squares. This allows the geometry to be even, which in turn will allow it to be UV Unwrapped more easily, and for there to be less chance for the model to break during animating. There are many times when the

geometry will be triangles or pentagon shapes. These will need to be split up until they have all become squares as well. It is a complicated process trying to get the geometry to all line up properly, and there are many other hurdles in the modeling process, but once it is completed, the model will be ready to move onto the unwrapping and rigging stages, and later can be used in animating the scene. While it is hard work to create the model, it only needs to be modeled out once, rather than having to draw the model out for each frame. Does that make it better though?

Both 2D and 3D animation require a good understanding of anatomy and bone structure. Besides having to know how to model a good face and body for the 3D model, it is also needed to know how the body moves. While it is not required to have studied anatomy, it is very important to know things, such as how the clavicle bone works, how the jaw moves the mouth, what parts of the foot bend, and so on. It is also important to know where the body's joints are, what joints bend, which direction they bend, and which bones move with which joints.

Technically, anatomy is more important when creating 3D models. When creating a character in 3D, it is important to know how the body can bend. To properly animate and move the character, the animator will need to basically build a skeleton of the character using joints. When thinking of joints, think of where the bones in the body are located and then put a joint between them. Placing a joint at the elbow will allow the animator to move the arm, placing a joint at the wrist will allow the hand to move, placing a joint in the front of the jaw, and connecting it to the back of the neck, will allow for the jaw to be opened and closed, and so on, and so forth. These joints are what allow our model to move, so it is imperative that everything that will need a joint gets a joint.



The blue lines are an outline of Smoko's 3D model, the orange lines inside the model are some of the joints created for the model to move.

Smynko and Smoko do not have the same bone structure as the human body. Even though I made up a bone structure for Smynko and Smoko, it was still important that I knew the basics of where the joints should go before I created my own joint system. Smynko does not have fingers, nor does my Smynko model grab anything, therefore, I only needed an elbow joint in the arms. The body needs to flop around, so I needed several joints so the body could bend and contort like a noodle. Smoko has claws for hands, which means a joint needed to go in the middle of the claw so it could open and close properly. If Smoko's antennas needed to move around then they too would need to

be connected with joints. Joints can be used for objects as well. If a door on a car needed to swing open, then the hinge of the door would need a joint to allow the door to move separately from the car.

While joint systems tend to be more necessary for 3D animation, there are 2D animated rigs that use joint systems as well. It mainly uses the same idea as 3D animated joints but the joints are all connected to flat pictures rather than in a 3D space. These 2D rigs are called cut out animation or puppeting. Not every animation company will use this method of animation, but it does exist, and it also comes with its own benefits and disadvantages. Puppeting allows the animator to move an arm, or other body part, around without having to draw the arm for each frame. While this method can speed up the animation process, it can also end up with varied results. If done well, it will allow the animator to grab the joint of an arm from one keyframe and move the arm down at the next keyframe. Just like 3D animation, the computer will automatically move the arm down for all the in-between frames until it reaches the last keyframe. Then the animator can either tweak how the arm moves, or leave it and move on with the rest of the animation. The downside of these joints are they can only be moved in a 2D space. The arm can point any direction that the hands on a clock can point. If the arm needs to point forward towards the screen, then those frames will need to be drawn. Relying too much on puppet animation can also make characters feel very flat
and stiff. While joint systems are necessary for 3D animation, it should only be used sparingly in 2D animated projects. As long as it is not overused, and does not hinder the quality of the animation, it can be a great tool when animating.

XII: Pros and Cons: What can't it do?

Some concerns I had going into making my 3D animation were that I would not be able to make my character look as bendy as I had made him in the 2D animation. While I wish I was able to exaggerate the amount he was bending in some scenes, overall I think I was able to accomplish this goal.

I was also impressed with both my ability and the Maya software's ability to allow me to perfectly recreate the shots and camera angles of my 2D animation. One of the best things about filming in a 3D space, is that the cameras can be placed anywhere I want, and they can be changed to a different spot at any time as well. One of my biggest problems with 2D animation is that I am stuck with whatever camera angle I draw for the shot. If I decide I need the angle to be different, I need to redraw the shot. It is remarkable how much freedom 3D animated spaces provide. 3D can create shots that 2D artists and live-action camera operators wish they were capable of achieving.

The last thing I wanted to compare with my 2D and 3D films was the amount of Smynko robots I could make before crashing the Maya software. Sadly, I was unable to test this with my 3D animated Smynko film. While my corrupted card kept me from trying it out with the hundreds of Smynko robots, I was able to test it out in one of my other school projects. Thanks to Professor Gomez, A 3D animation teacher at MTSU, I was able to learn how to duplicate several dozens of books for my 3D animated library. This method allows the duplicated objects to make little to no difference in terms of how

long it takes to render. This is because rather than the computer rendering every book, it simply renders out the book that was duplicated and copies that information to every duplication of that object. Because the books are duplicated, they will have to look exactly like the book that I duplicated it from. This would have been perfectly fine for my Smynko robots as they were already meant to look identical.

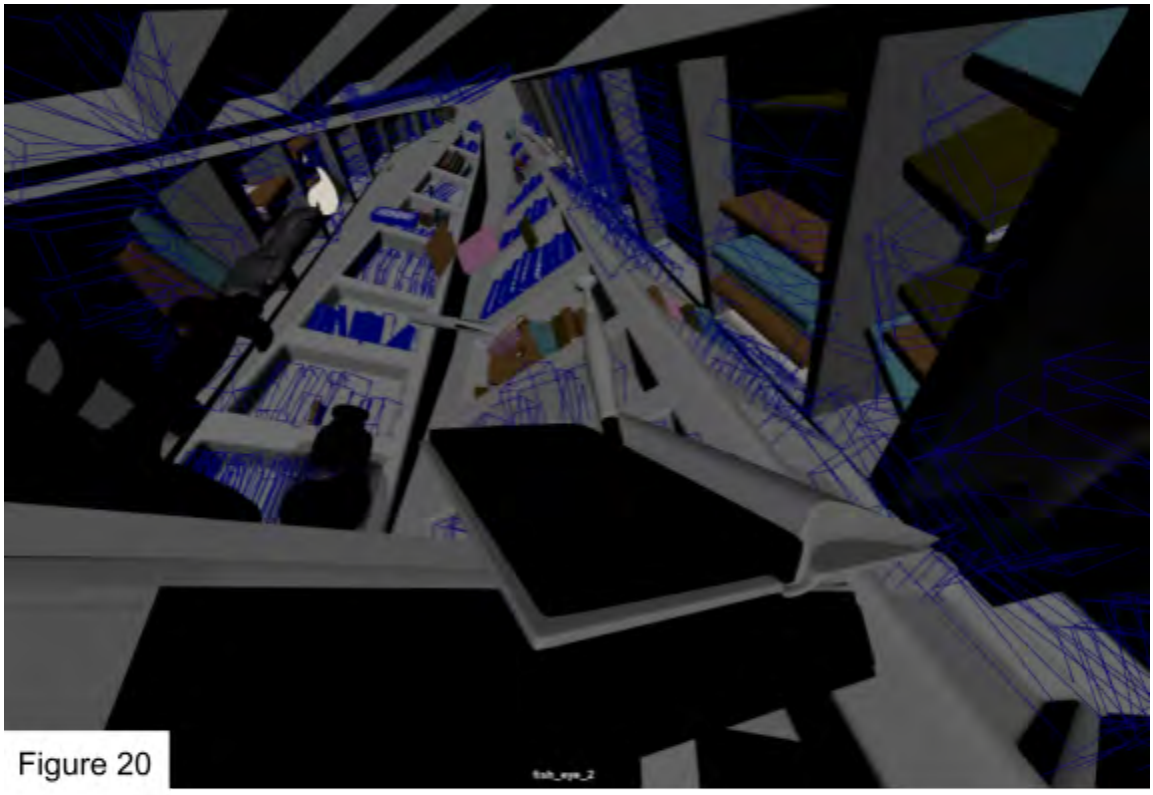


Figure 20

Each blue outline is a duplicated model of a book which uses a method where it will not take up any extra render time nor will it cause Maya to crash.

XIII: Conclusion

While I enjoy making and watching 3D animated content more than 2D animation, 2D does deserve another chance to come back to the big screen. There are tons of 2D animators out there who I guarantee would love to work on a movie, and I

guarantee there is an audience who would love to see a new 2D animated movie in theaters, especially from Disney, but at the moment it does not look like it will be happening anytime soon. On the bright side, there are plenty of 2D animated shows out there, with more being produced every year. Kids entertainment continues to be saturated with 2D cartoons, and adult animated shows have also been getting more popular throughout the recent years. While it does not appear that 2D will be making a comeback to theaters any time soon, 2D animation will not disappear. It continues to stand strong on the small screens.

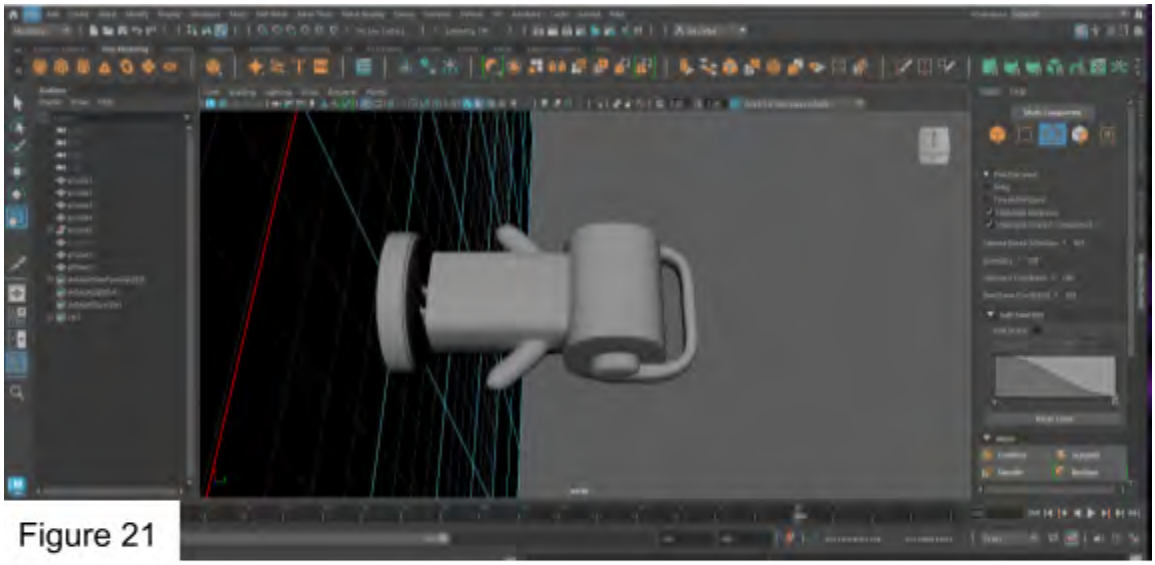


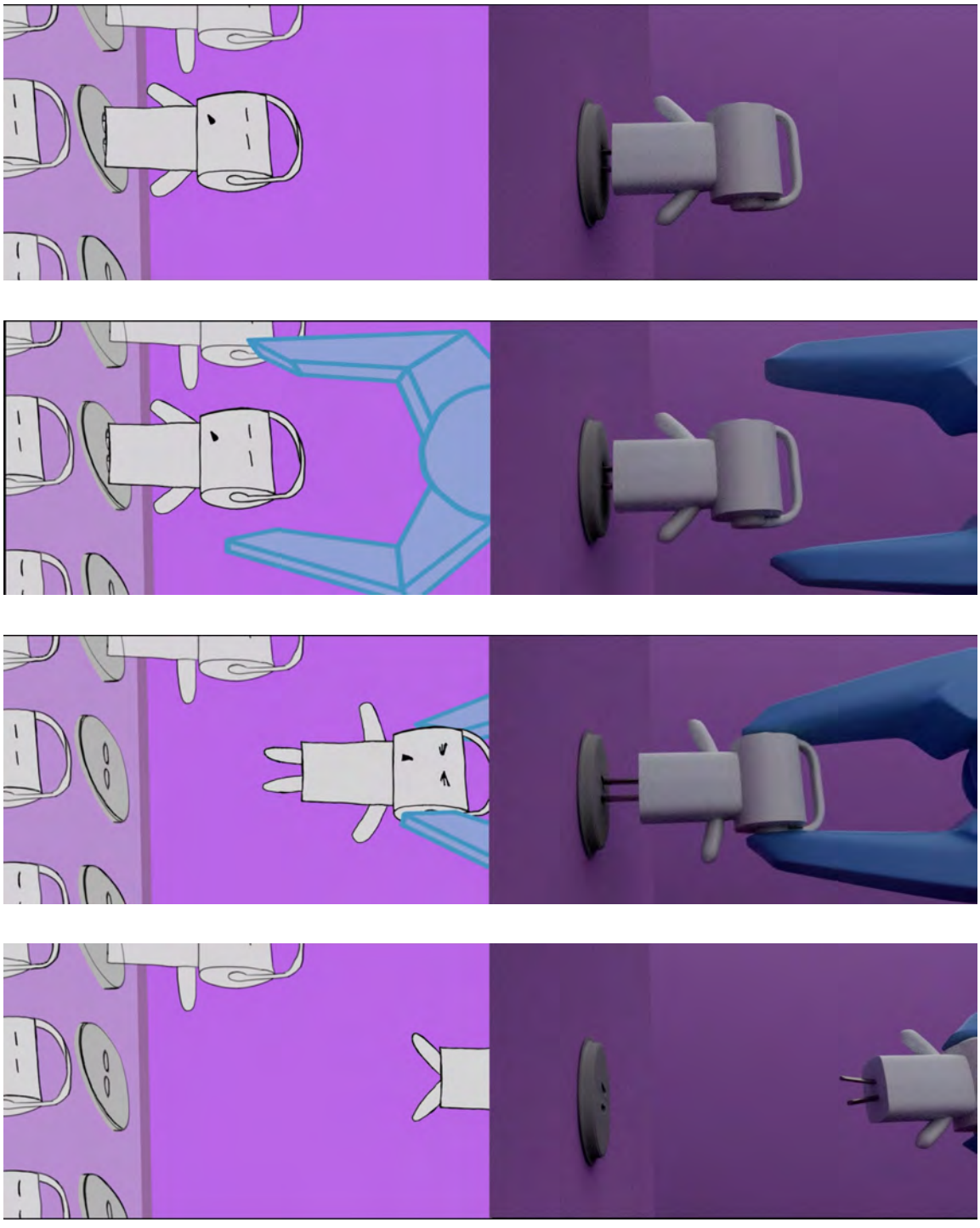
Figure 21

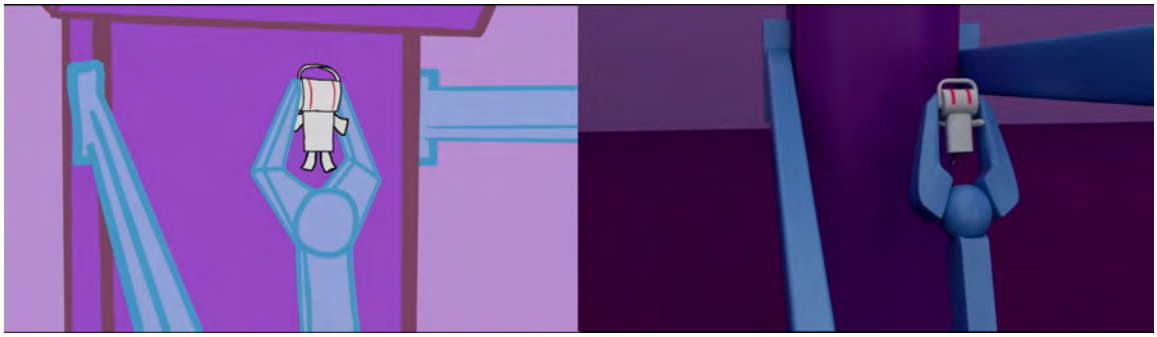
My Model of Smynko modeled out in Maya.

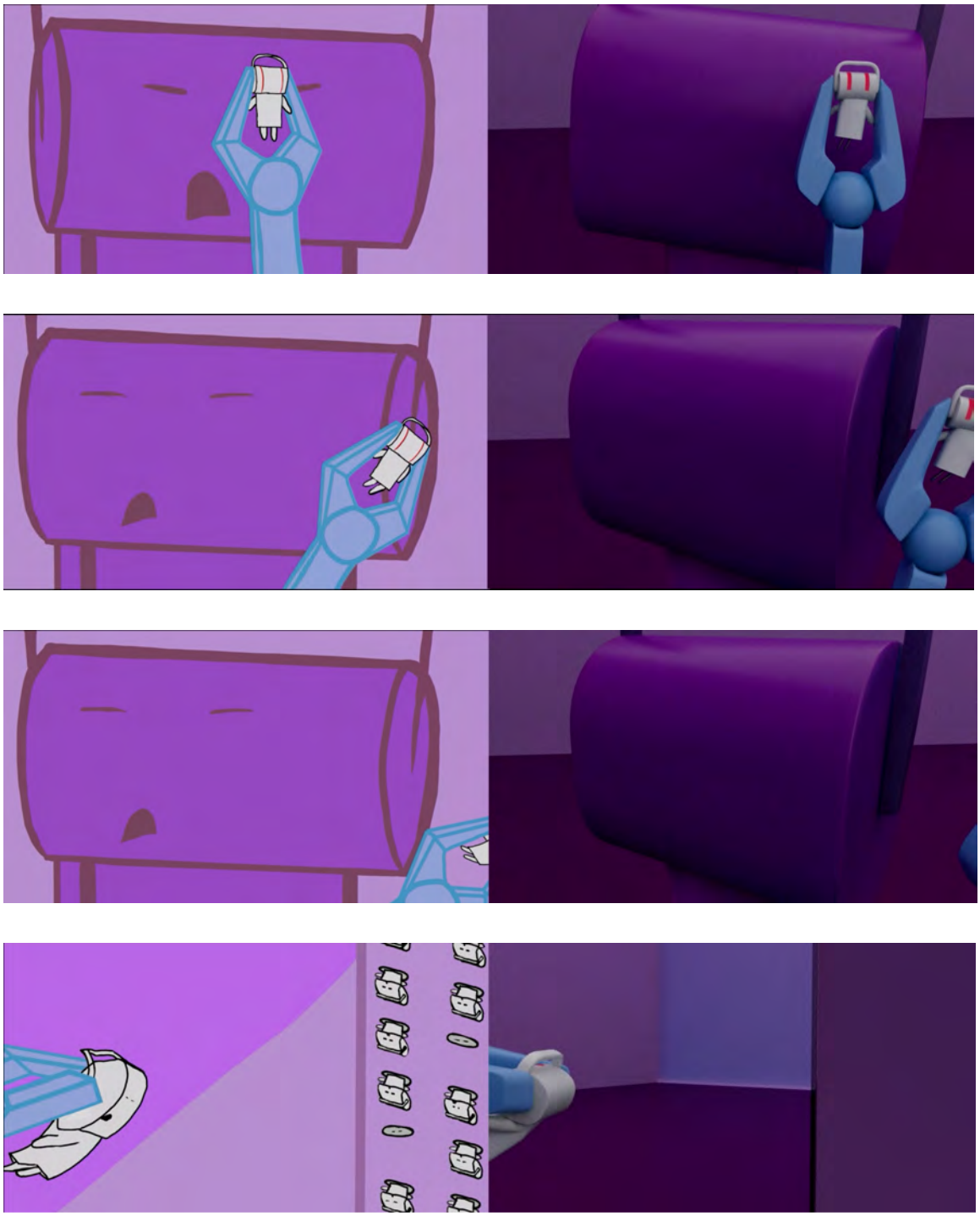
This link leads to my 2D and 3D animated Smynko films.

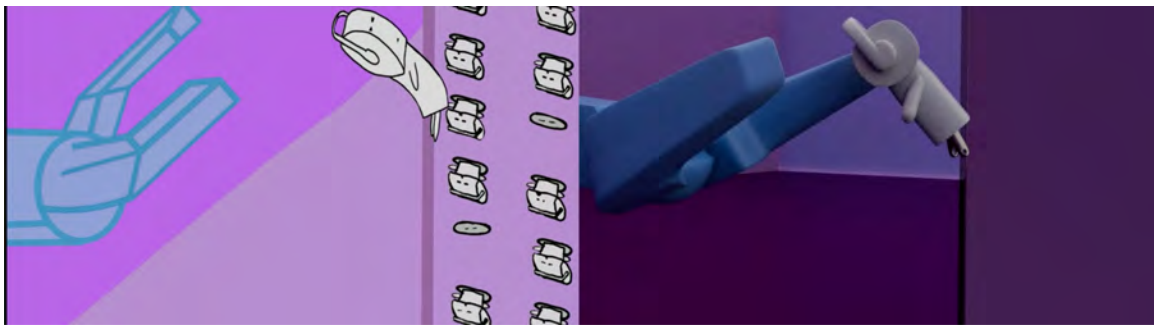
https://www.behance.net/gallery/167803433/Creative-Thesis-Project

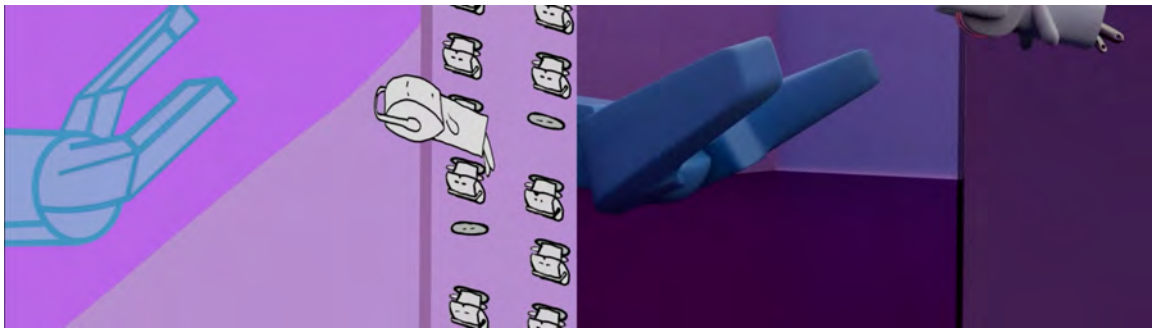
A Side by Side Comparison of Smynko 2D/ 3D

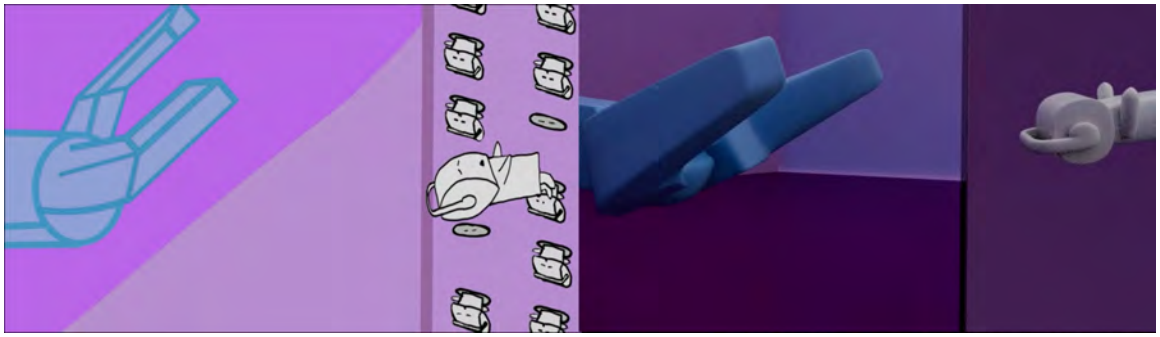


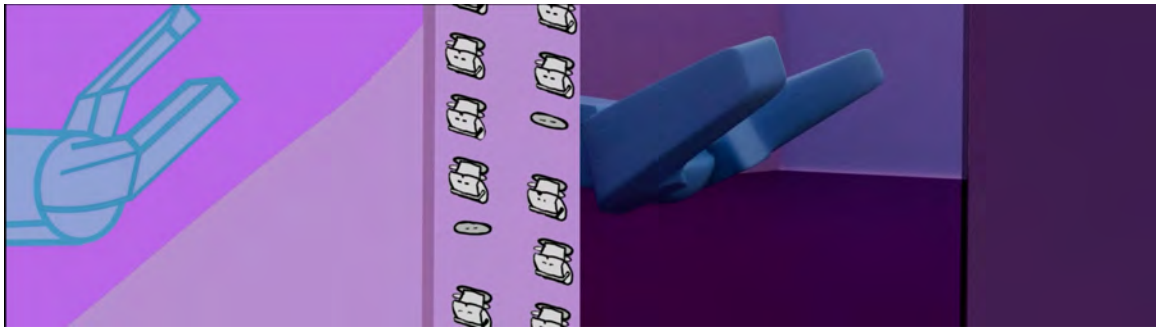


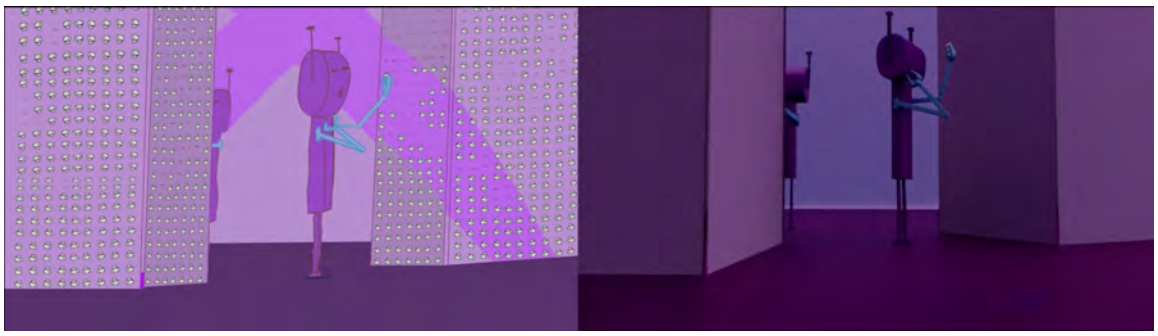


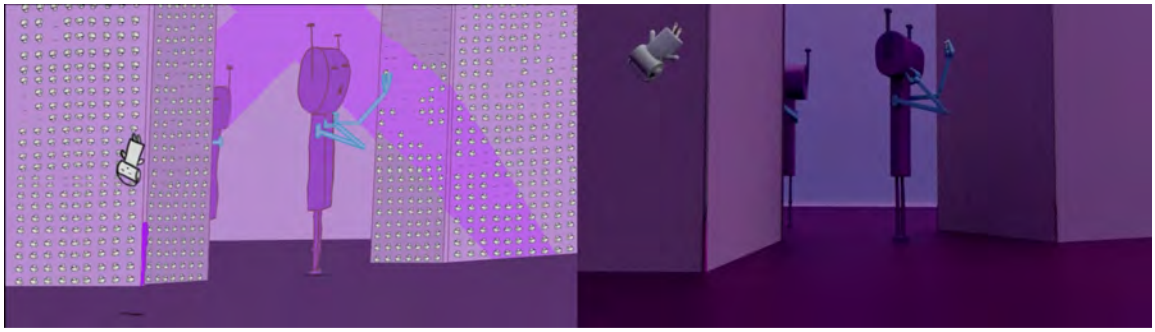


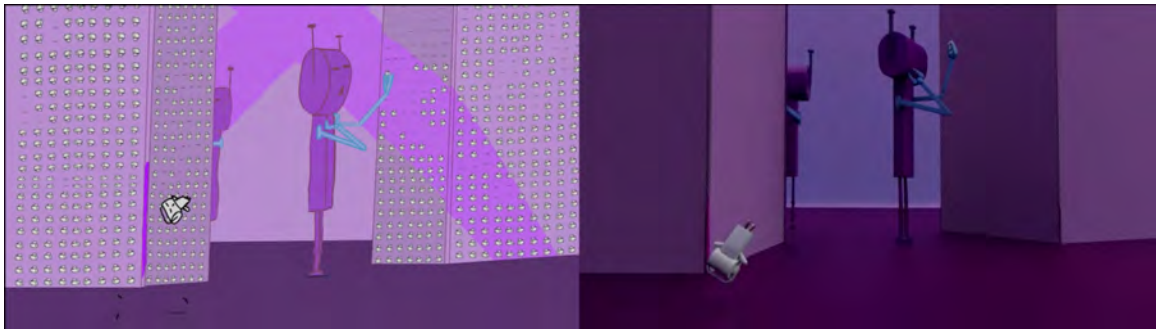


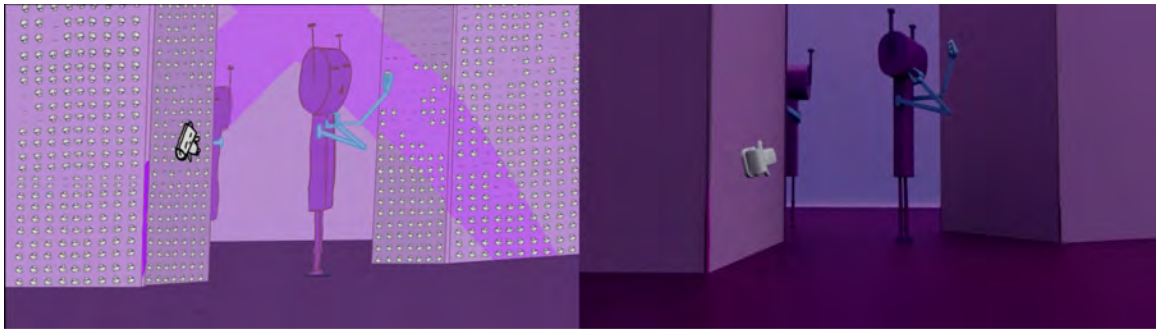


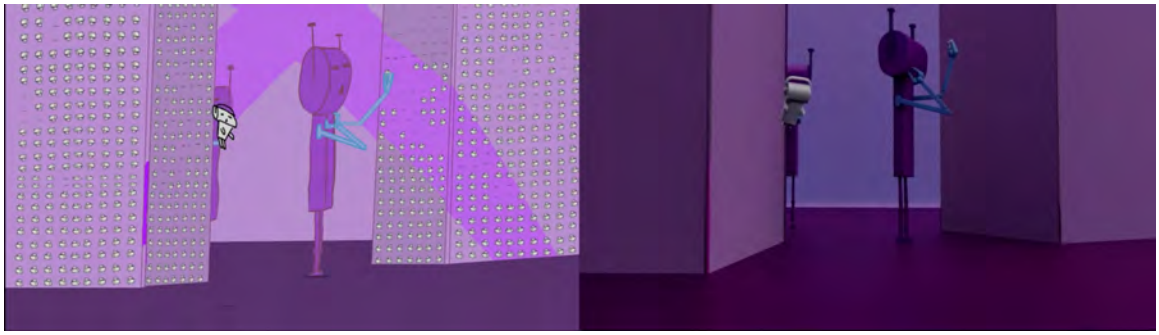


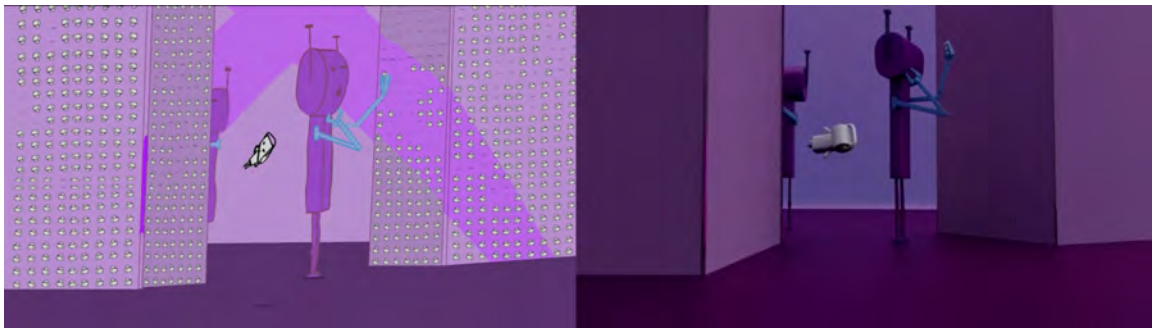


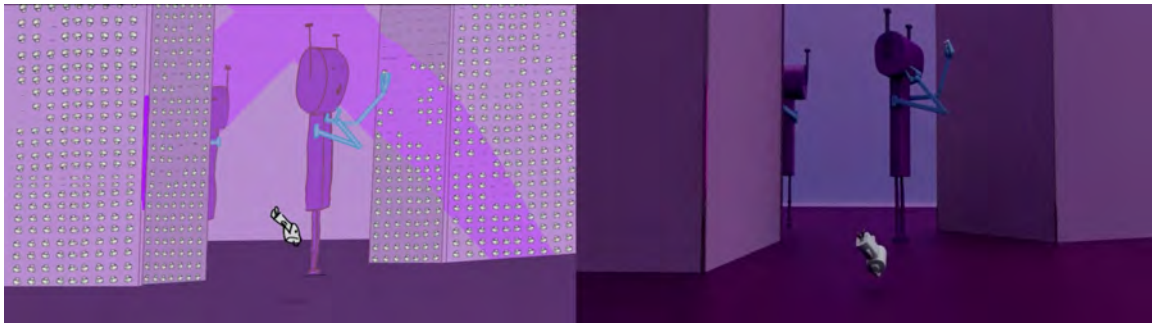


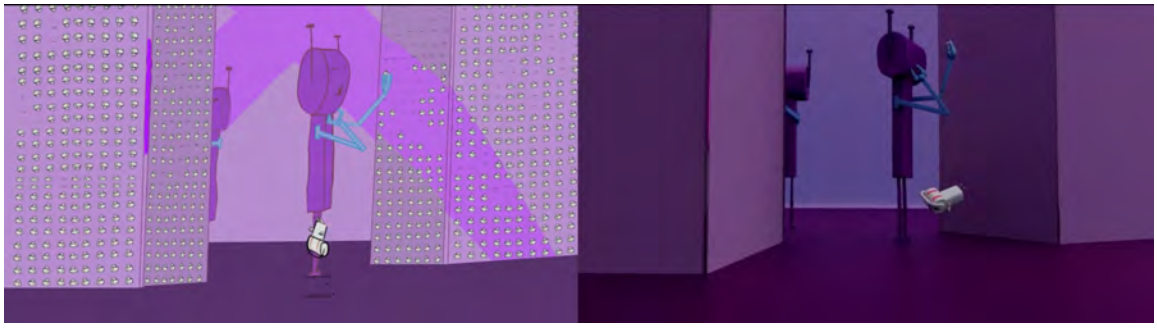


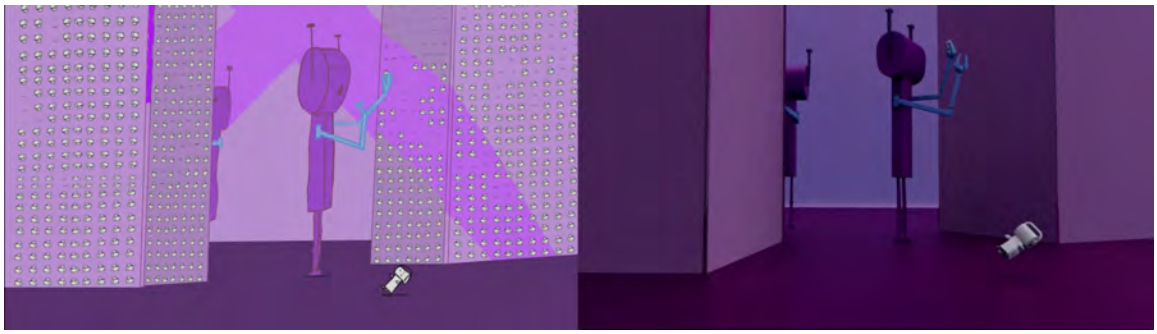


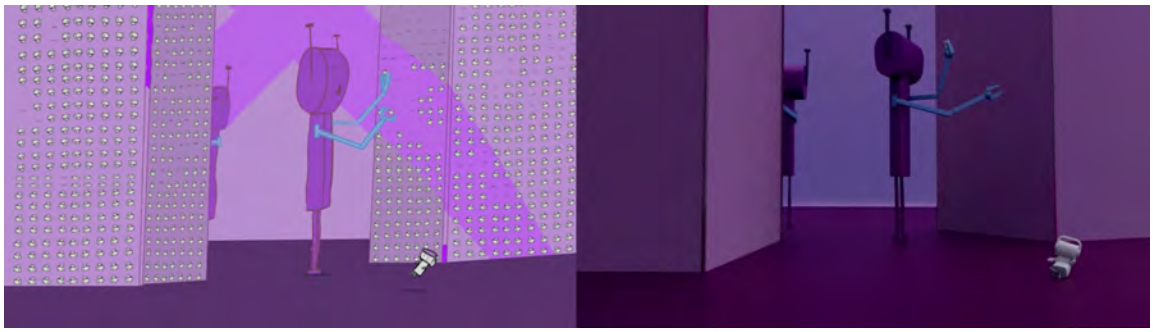


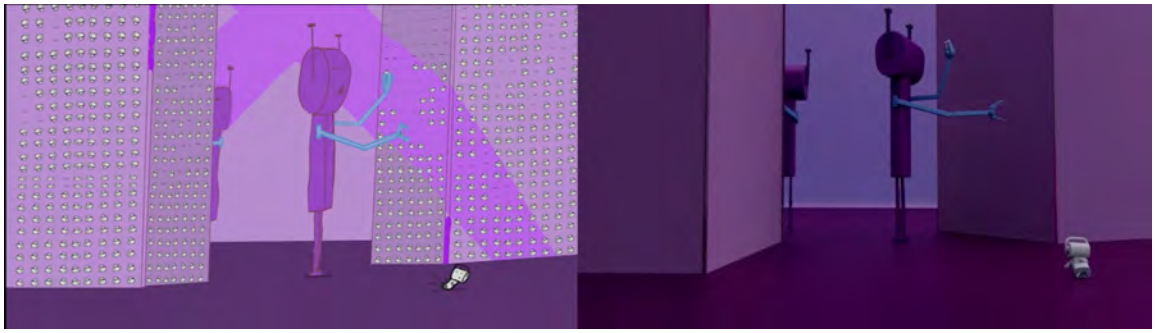


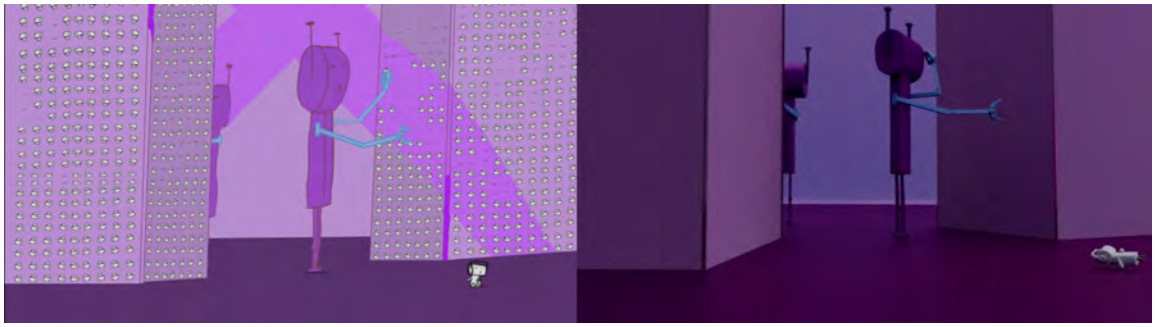


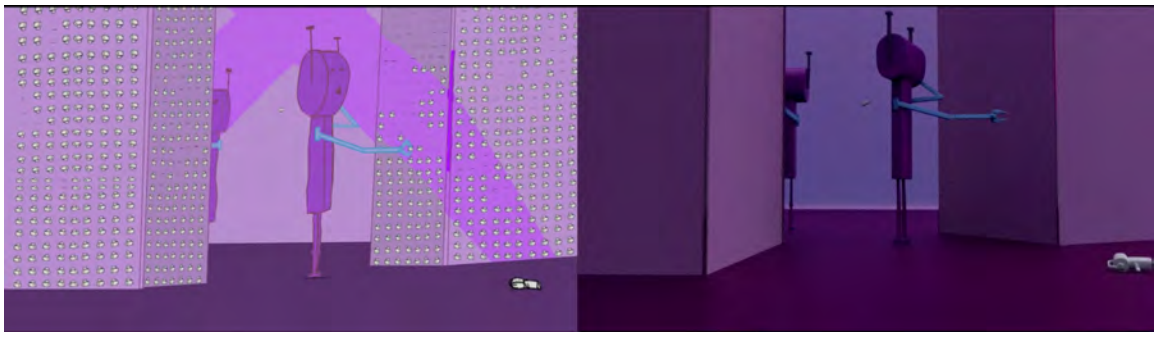












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