Stylized Character Rigging: Building a 3D Rig from an Originally 2D Character in Autodesk Maya

A Thesis Submitted to the faculty of the Visual Effects Department in Partial Fulfillment of the Requirements for the Degree of Masters of Fine Arts in Visual Effects

at

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Amanda L Rabade

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Ahmed Elmatarawi, Committee Chair

Brian Schindler, Committee Member

Ashwin Inamdar, Committee Member

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Abstract

2D to 3D Character Rigging: Creating Iconic 2D Characters in 3D without Custom Tools or Plugins

Amanda L Rabade

November 2025

Brief Description - With a focus on stylized facial rigs, a rig was created to demonstrate the challenges of translating an originally 2D character into 3D while maintaining its original style and keeping it on model. The particular rig created uses multiple methods, such as switching between multiple different facial setups and surface based facial rigging, and how that can be achieved without needing to write any custom tools or plugins. Following will be an in depth explanation of the research and development of the rig.

Keywords: Rigging; Facial; 3D; Maya; Tutorial; Stylized

1.0 Introduction

Many artists that take on the challenge of learning how to rig are met with many repetitive tutorials that simply reiterate the same information to get the same results. This may be helpful in terms of creating more realistic facial rigs, as they all will require similar setups that vary in proportion. However, in the case of hyper-stylized rigs, there is not a designated way to create those rigs because they vary so greatly from each other and have incredibly varied desired results. The goal of rigging is to find the most effective solution in the most efficient way possible, and that does not always mean sticking to a single method. The research provided is intended to show how to combine multiple techniques to successfully create a stylized 3D facial rig based on an originally 2D character while properly maintaining the character's style established in the previous medium. The challenges and overall process detailed below are intended to further guide future artists who intend to build a similar rig.

1.1 Purpose/Thesis Statement

There's been a resurgence of older 2D series and films being reiterated into 3D for newer generations in the past decade. This trend has led many studios to develop proprietary tools in order to recreate these characters in a new medium while maintaining their original style and silhouette for them to remain recognizable. Unfortunately, many individual artists don't have access to such tools, therefore the following will explain how such stylized rigs can be created without the use of custom tools or plugins and showcase the challenges that come with bringing characters from a 2D medium to a 3D medium.

2.0 Literature Review

2.1 Innovation for Feature Films

The largest reference in terms of rigging techniques and reconstructing an established 2D world completely in 3D, was *The Peanuts Movie* from Blue Sky Studio. Starting out as a comic strip in 1950, the cast of *Peanuts* have come a long way from newspaper clippings. Popular holiday specials such as *It's the Great Pumpkin, Charlie Brown* and *A Charlie Brown Christmas*, have established a colorful animated spirit to the comic strip characters with hand painted animation cels. The release of *The Peanuts Movie* in 2015 introduced a brand new yet familiar look to the already popularized children.

During production of *The Peanuts Movie*, the most important thing was to remain as true to the original art style as possible. This led to the research and development team to engineer new proprietary tools and a new pipeline as discussed in a SIGGRAPH paper from 2015 in order to preserve the creator's, Charles Schulz's, vision in a brand new medium. Due to the large, round nature of the characters heads, blendshapes, a traditional method typically used to correct any blemishes caused by joint based setups (otherwise known as corrective blendshapes), were unable to successfully deform the characters heads without experiencing volume loss. This is due to linear interpolation, which is how the distance between two points is calculated. Thus, the Translate UVN Deformer was the solution. Developed by software engineer Adam Burr, this tool allowed for deformations to be calculated in UVN space rather than Cartesian space to avoid volume loss by using a NURBS surface to get the closest point to the corresponding vertices on the head mesh and then transforming back to Cartesian space after deformations. This was then used on all the characters' heads to provide the majority of the expressions needed for the film.

The extreme poses needed for certain shots were obtained by having to reshape the head mesh and NURBS surface accordingly.

Another film produced by Blue Sky Studio, *Spies in Disguise*, had to get innovative with their development of characters to keep very graphic silhouettes. This was the studio's final feature film that posed very similar challenges *The Peanuts Movie* did four years prior. In a SIGGRAPH paper from 2019 written by James Gu, Ozgur Aydogdu and Steven Song, the studio had gone back to their proprietary UVN tool and made some improvements in order to art direct the birds easier while maintaining smooth deformed surfaces. The update to the tool allowed the feathers of the birds "to maintain their shape in Cartesian space while being driven in UVN space," according to Gu, Aydogdu and Song (2019). A new proprietary system was developed to drive joints along a surface to produce a more stable tail rig for the birds in conjunction with the UVN deformer.

2.2 Blog Posts by Jonah Reinhart

Research commenced with an exploration of surface-based facial rigging, a technique widely utilized in feature film production, however little information is easily accessible. One of the primary sources of information was a series of blog posts by Jonah Reinhart, a SCAD alumnus with both personal and professional experience in facial rigging. A significant portion of the experimentation and development came from Reinhart's (2016) post titled *"Surface Based Facial Rigging."* This post consisted of multiple techniques that Reinhart had tested, including detailed instructions on NURBS surface creation and step-by-step procedures for implementing each method. The content provided a comprehensive understanding of surface-based facial

rigging and the foundational knowledge necessary to replicate and adapt the approach independently.

3.0 Background/History

3.1 The Development and Use of the Translate UVN Deformer

A conversation with Adam Burr and Ignacio Barrios (2025) offered significant insight into the rigging methodologies employed at Blue Sky Studios. Burr, a software engineer, and Barrios, a character rigger, were both involved in the production of *The Peanuts Movie*. Initially, the research aimed to replicate the Translate UVN Deformer developed specifically for that film using only the standard tools available in Autodesk Maya, avoiding custom plug-ins. However, discussions with both professionals highlighted the inherent complexity of the original deformer. Consequently, the research direction shifted to focus more broadly on surface-based facial rigging techniques rather than attempting to manually reconstruct such a sophisticated tool.

While Burr contributed to the Research and Development team, Barrios was responsible for constructing the actual rigs used in the film. His showreel demonstrated the versatility of the eye setup used for all the characters, specifically Snoopy, particularly the integration of dynamic ‘ink lines’ used as eyebrows, eye outlines, or even elements of a character’s smile. These features were essential to preserving the comic strip aesthetic in a 3D environment. Further inquiries regarding the eye setup led to speaking with Sabine Heller, the developer of that system. Figures 1-5 illustrate the versatility of the eye setup created by Heller, the proprietary tool developed by Burr, and the overall facial rig by Barrios.

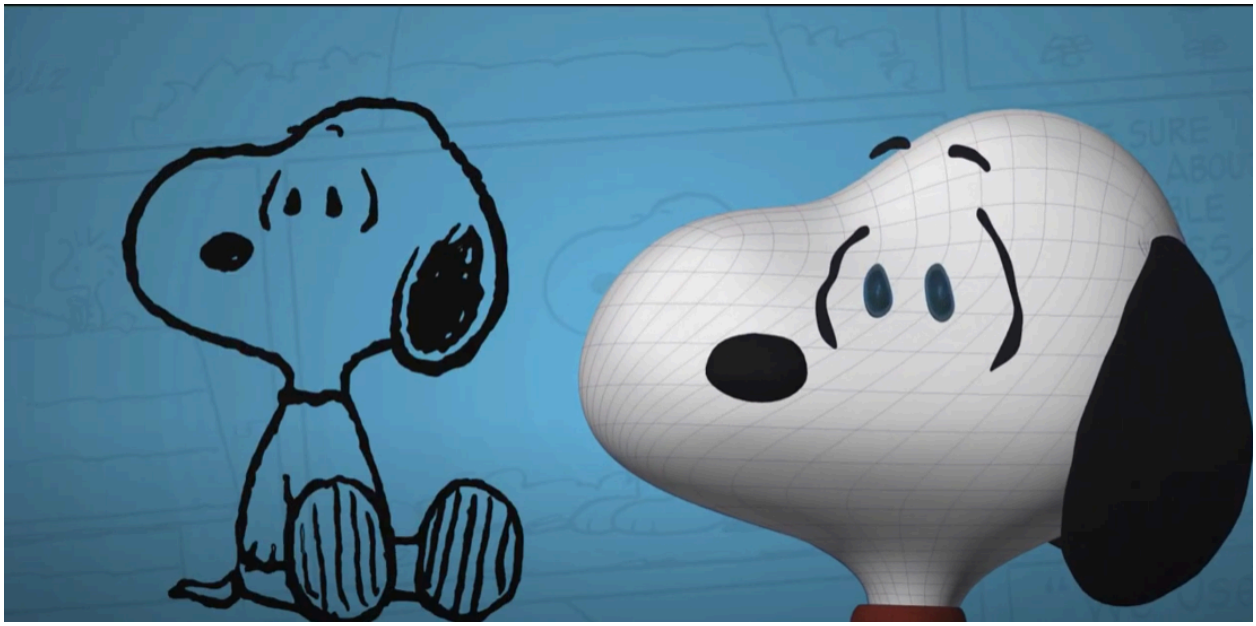


Figure 1. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

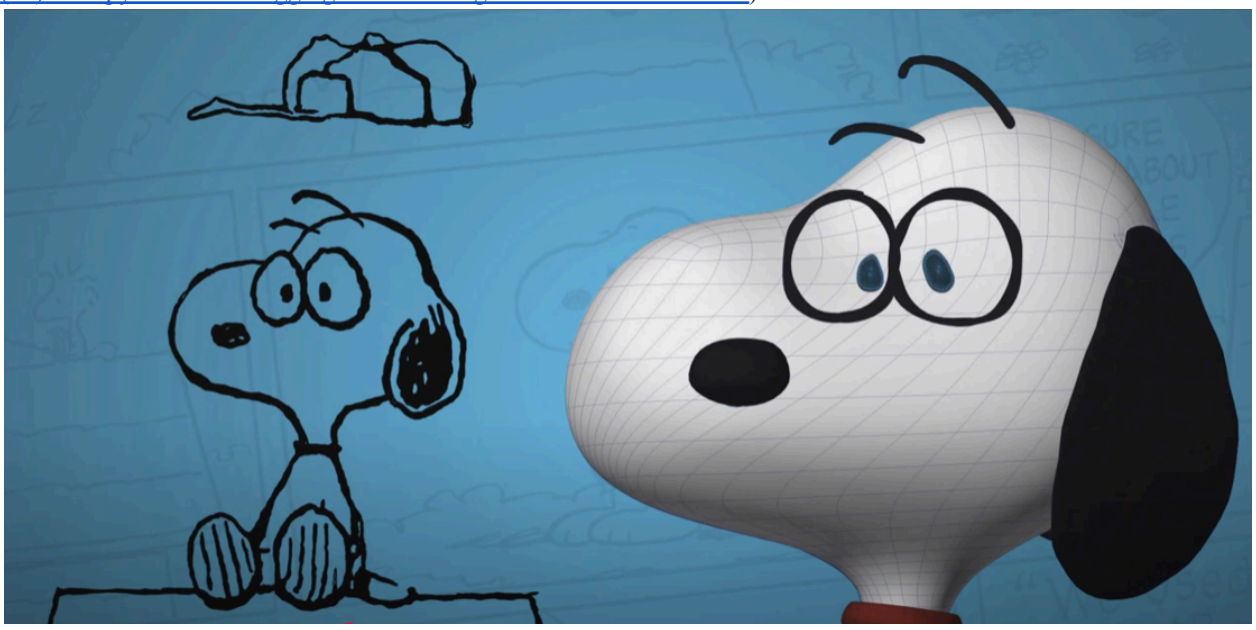


Figure 2. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

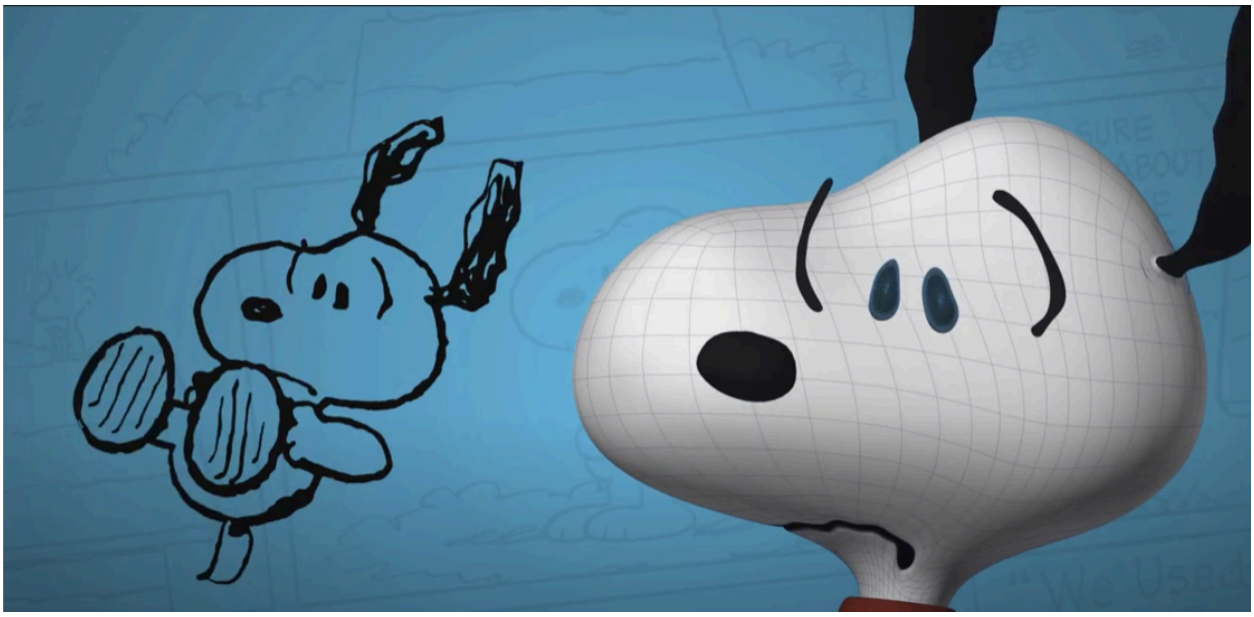


Figure 3. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

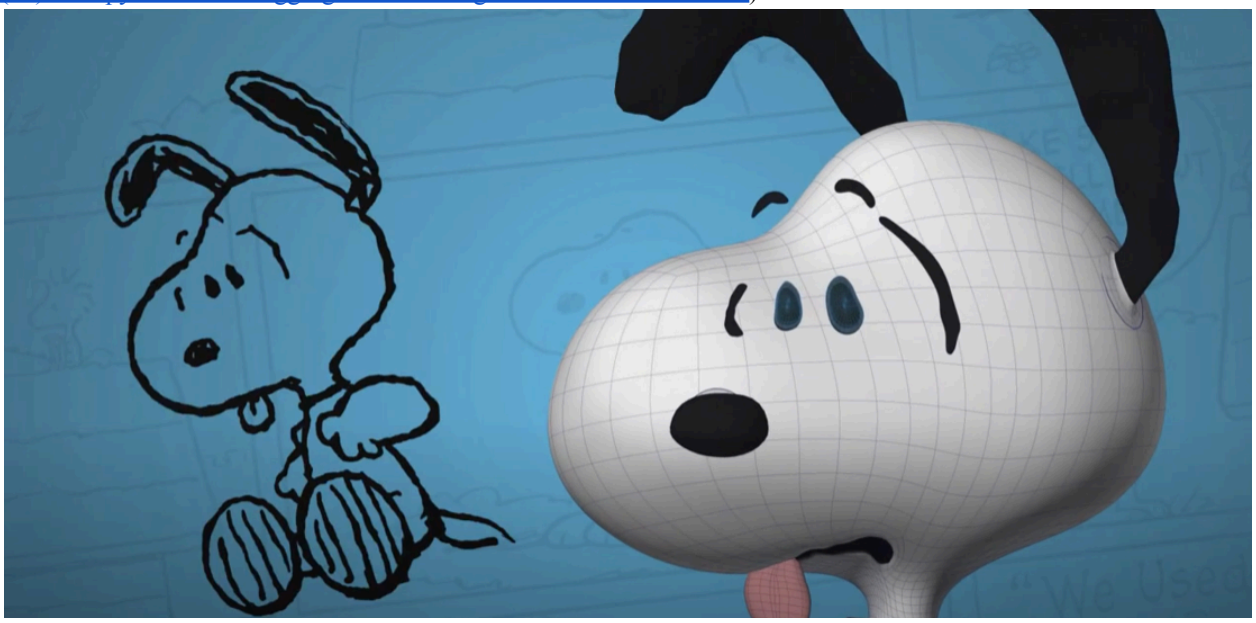


Figure 4. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

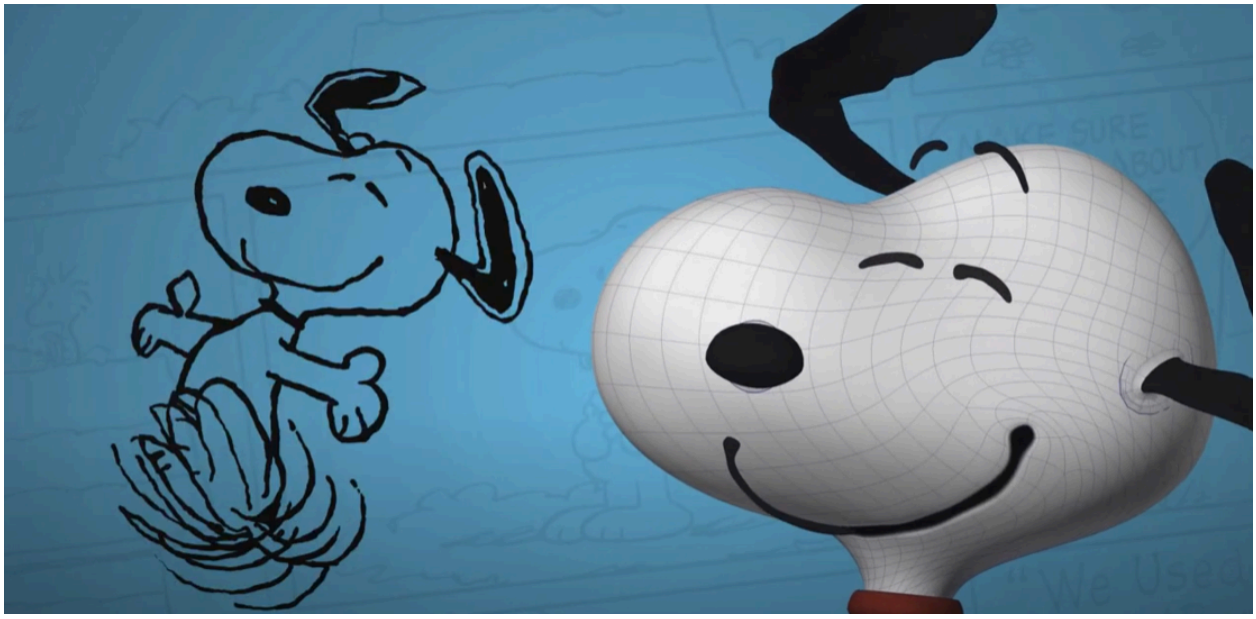


Figure 5. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

Ongoing communication with Burr provided additional technical insights, critical feedback on model development, and access to scholarly resources and articles that further supported the evolving scope of the research. His continued engagement proved invaluable as the project goals adapted over time.

3.2 Meeting with Sabine Heller

Although the meeting with Sabine Heller (2025) was brief, it yielded important details about the versatile eye setup used in *The Peanuts Movie*. Heller designed the 'ink lines' to be multifunctional—serving as eyebrows, eye outlines, and in some cases, parts of character expressions such as Snoopy's smile. She detailed the necessary components that constructed the setup; using a low resolution 2D mesh, adding one joint per edge loop to keep it smooth, shrink wrapping the 2D mesh to the character's head, and ensuring everything was set to the camera. These elements were enhanced with a bump map to make them appear recessed into the

character's surface, aligning with the visual style pursued in the film. The use of 'ink lines' can be incredibly helpful when building stylized facial rigs as not all stylized characters will have natural looking eyes. Simpler shapes tend to be used for simpler characters, and 'ink lines' can help further the character's expressions despite a lack of detail.

3.3 Meeting with Stephen Gressak

Stephen Gressak was a Character Technical Director at Blue Sky Studios while working on *The Peanuts Movie*. The discussion with him centered around surface based facial rigging, something he had been using on films since he started working at Blue Sky, the first of which was *Ice Age 2*. Figure 6 is a performance test of the character rig Sid from *Ice Age 2* demonstrating the use of a surface volume for his mouth.

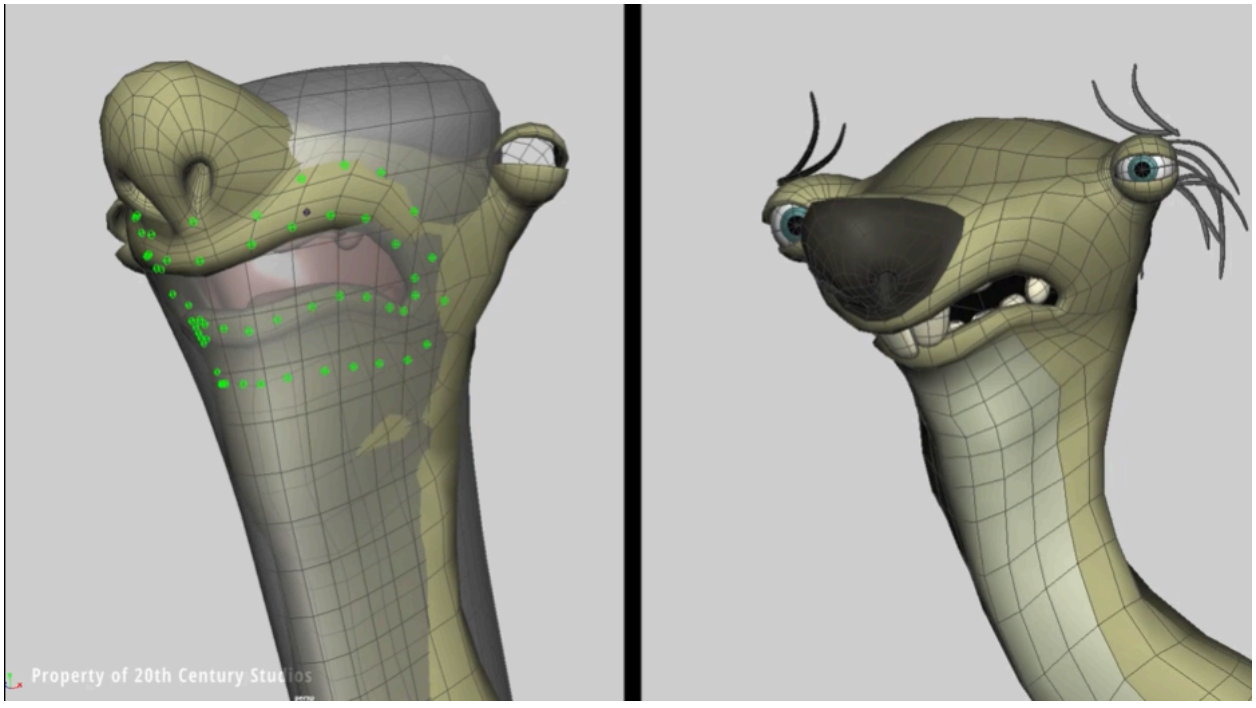


Figure 6. Stephen Gressak, *Face Rigging Technical Demo - Stephen Gressak,* 2021 (Vimeo:Stephen Gressak, Face Rigging Technical Demo - Stephen Gressak on Vimeo)

In discussing specific challenges related to the current research project, Gressak recommended transitioning between various setup types (2025). Given the exaggerated poses required in order to keep this particular rig on model, reliance solely on a joint-driven mouth set up proved problematic due to the limitations of the geometry. The solution was to use a joint based setup for expressions that stretched the geometry (such as a smile and frown), and use blendshapes to control expressions that squashed the geometry (such as puckered lips). This developed further into layering blendshapes and needing to 'head switch,' control the visibility on multiple head meshes that deformed based on a particular expression.

Gressak shared a technical demo reel that featured a tool known as "Character Toon Expression Lines," developed in collaboration with Adam Burr. This tool serves as an alternative to the solution implemented by Heller for *The Peanuts Movie* and enables additional expression lines to be triggered when an animation control exceeds a certain threshold on the facial rig. This is a texture based solution for the same problem; adding expression lines.

3.4 From 2D to 3D

Examples of film and television that have successfully converted originally 2D characters into a 3D medium are "Kamp Koral" and "Rugrats." "Kamp Koral" is a spinoff series of "SpongeBob SquarePants" with the same cast, but younger versions of themselves in a summer camp setting. Figure 7 is a frame from the original 2D series "SpongeBob SquarePants" where the main character SpongeBob is frightened and has an exaggerated scream. Figure 8 is a frame from the spinoff series titled "Kamp Koral" where the main character SpongeBob, now depicted as a child, expresses his shock when entering his cabin.



Figure 7. A frame of SpongeBob Squarepants from the original 2D series. (Frame from *SpongeBob SquarePants* Season 2 Episode 16 *Graveyard Shift*, 2002)



Figure 8. A frame of SpongeBob Squarepants from the 3D reboot of the original series. (Frame from *Kamp Koral* Season 1 Episode 8 *Camp SpongeBob*, 2021)

In a YouTube video uploaded by Pablo Smith (2024), the animation director for "Kamp Koral," he discusses the importance of staying on model while animating the rigs. The original

intention of this video was to help the animators working on the project to keep SpongBob on model while animating his rig. The process involves using the storyboards and animatics for the particular shot as a starting point for creating key poses for the character. When setting up his camera, he emphasizes that animators aren't trying to match the drawing, they're trying to match the pose. Despite the age and medium difference, the characters maintain their nautical style and are on model with their 2D counterparts.

"Rugrats" is a 2021 reboot of a children's television series from 1991 with the same name. The most recognizable aspect of "Rugrats" is the style, commonly referred to as 'ugly-cute,' and given that the reboot is in the same cinematic universe as the original series, it only makes sense to bring over the 'ugly-cute' style to their new 3D world.

Transposing these iconic babies from their hand drawn cel animation to clean 3D renders while maintaining their commonly referred to as 'ugly-cute' style posed a challenge. Figures 9 and 10 show the character Tommy as he watches his friend Chuckie scale a ladder to conquer his fear of the slide. In both frames Tommy is visibly worried, and sports his baby blue shirt. The subtle differences are due to the challenges and limitations that come with remaking an established character in a different medium, such as the bridge of Tommy's nose not being as visible in 3D or his ears being a different shape. The most important thing to keep in mind when reworking a character from 2D to 3D is to know where to compromise on the model without compromising on the style. "Rugrats" is an excellent example of how the creators needed to alter certain parts of the characters in order for them to work in a 3D space.

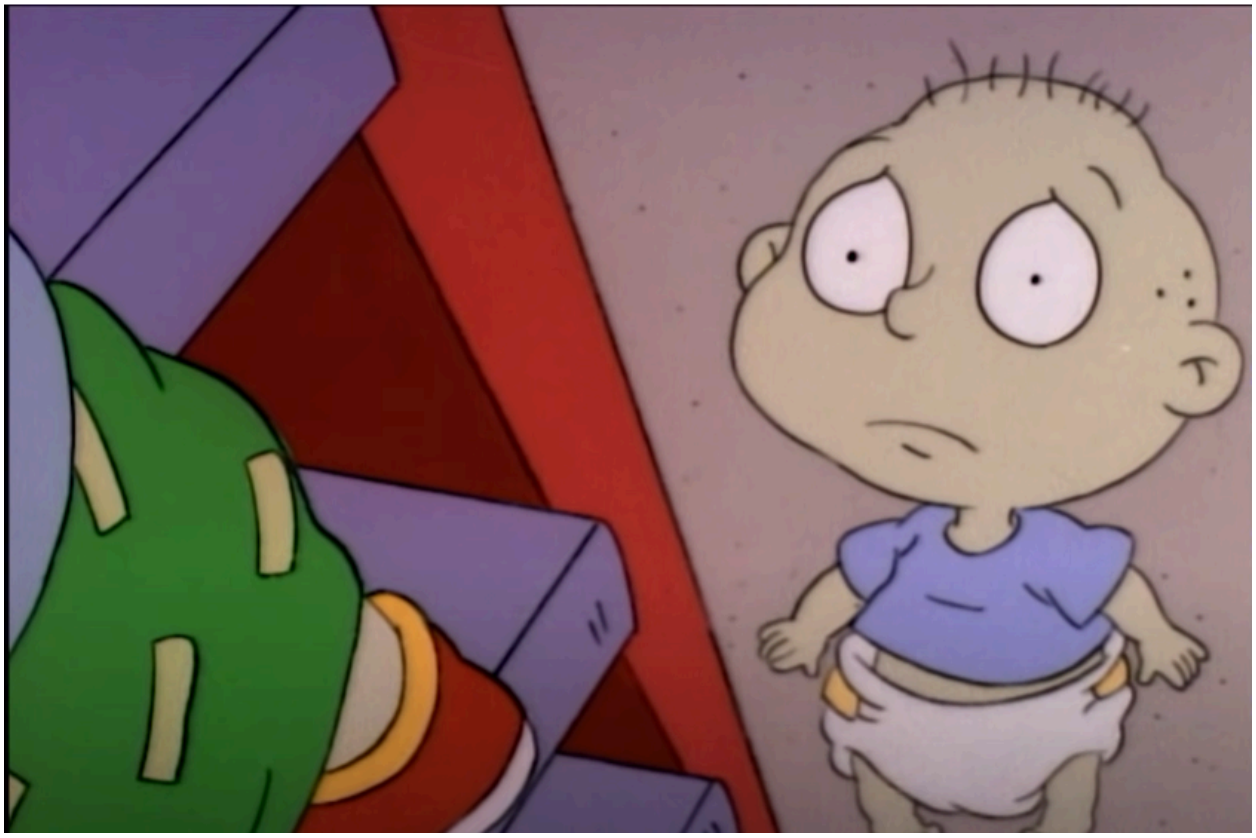


Figure 9. A frame of Tommy from the original 2D series. (Frame from *Rugrats* Season 2 Episode 22 *The Slide*, 1993)



Figure 10. A frame of Tommy from the 3D reboot of the original 2D series. Rugrats Shorts, Episode 4 “The Slide”, 2021 (Nickelodeon Animation Studio)

3.5 Rig References and Inspiration

The Peanuts Movie serves as a primary reference for multiple reasons. Not only is it a successful example of translating originally 2D characters (in this case comic strip characters) into 3D, but it also uses surface based facial rigging to solve the issue of volume loss. Figures 11-13 show how Snoopy is able to achieve multiple different expressions while maintaining the overall mass of his head due to the NURBS surface (the gray shape in the bottom left corner of each figure) allowing the deformations to be calculated in UVN space, with a visual representation in the top left corner of each figure, before being translated back into Cartesian space.

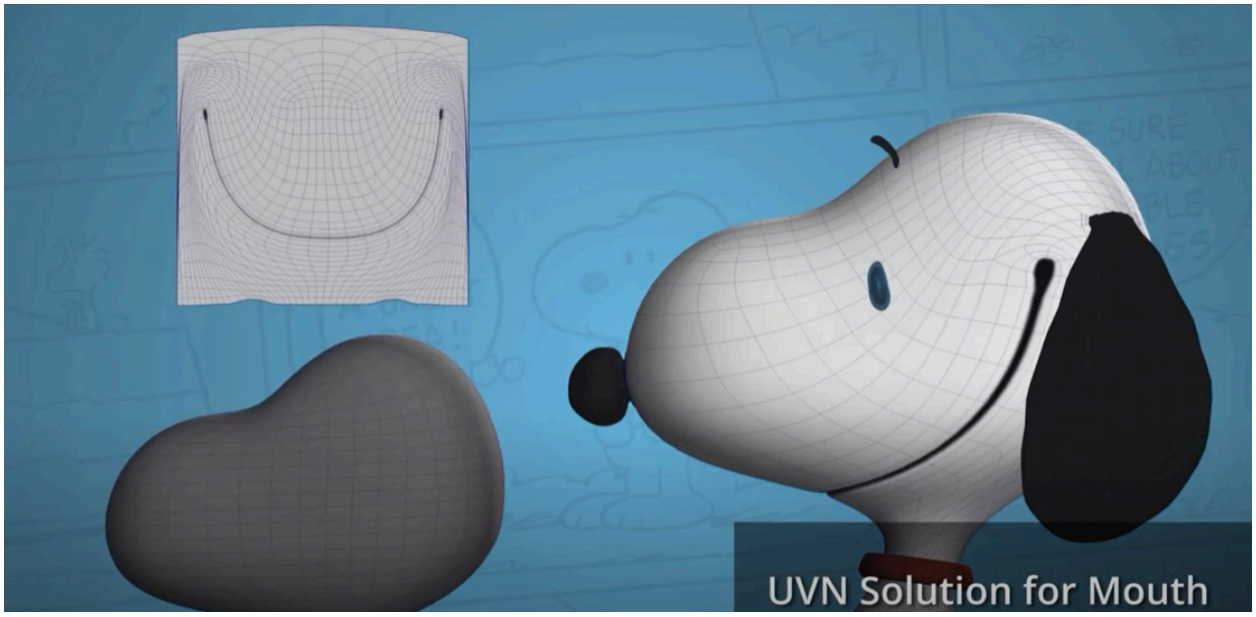


Figure 11. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

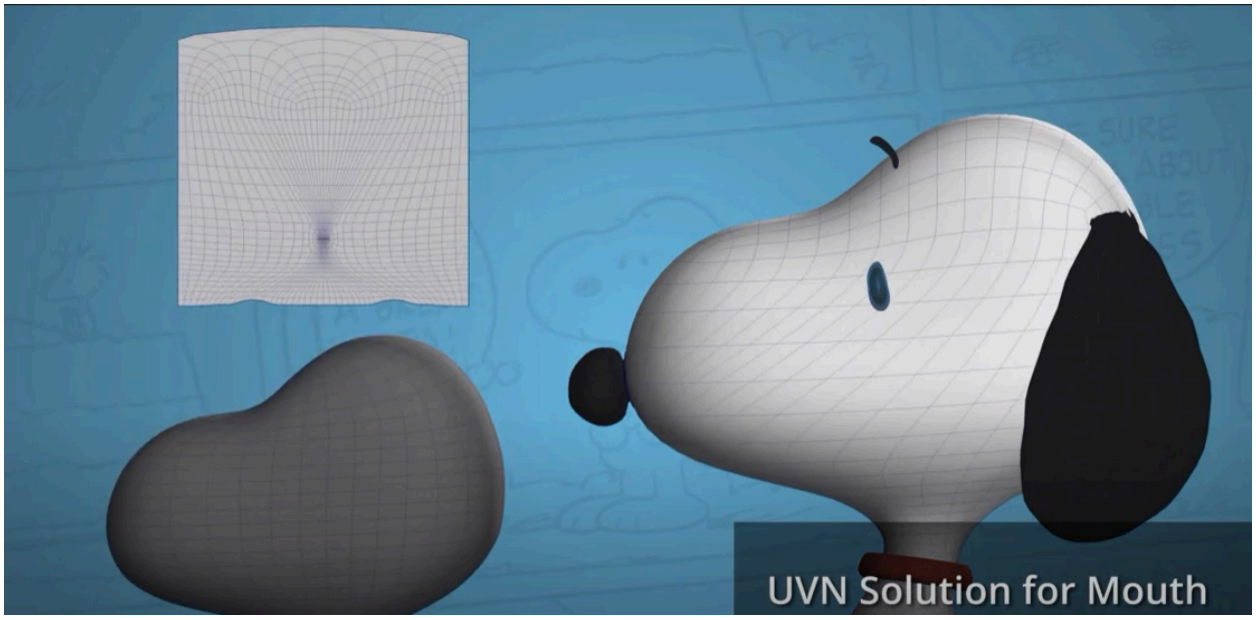


Figure 12. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

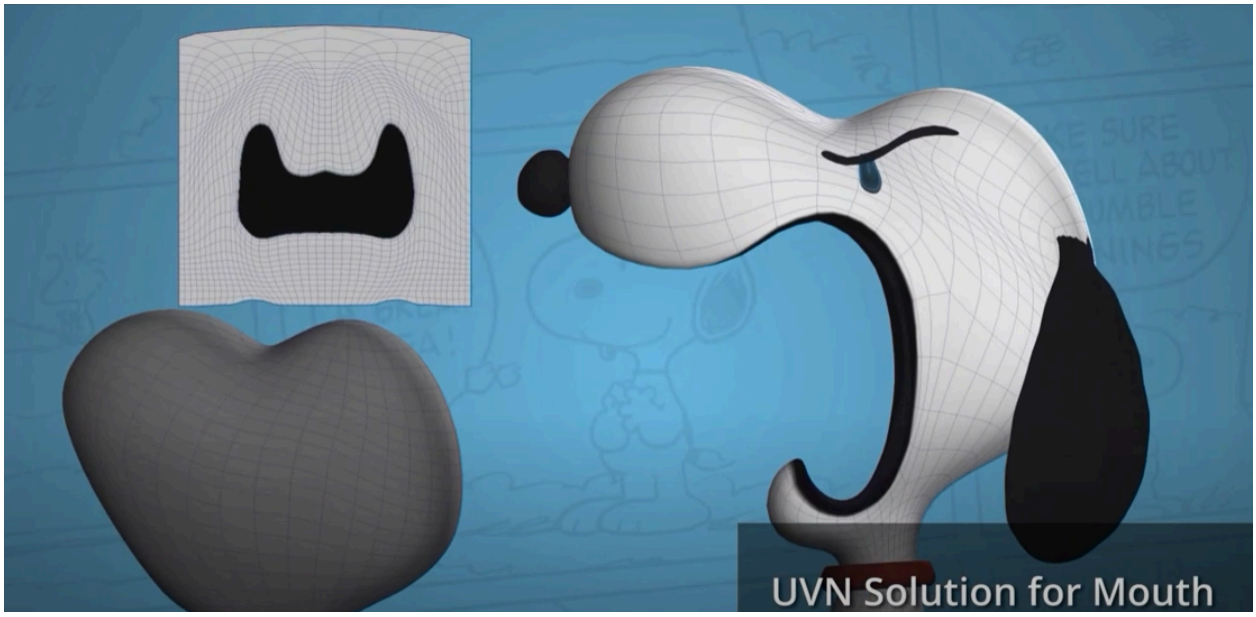


Figure 13. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

Cloudy with a Chance of Meatballs is a Sony Pictures Animation film that also uses surface based facial rigging for their characters' faces. Although the technique they used isn't as complex as the Translate UVN Deformer that was developed for *The Peanuts Movie* at Blue Sky, the end goal was still the same; maintain a stylized rig while preventing volume loss. Despite being a retelling of a children's book, *Cloudy with a Chance of Meatballs* is not an example of translating 2D characters into 3D because the art direction of the film is completely separate from the book.

3.6 Previous Attempts at 3D Billy

As is commonplace with many popular children's entertainment, other forms of media will be released in order to make the most profit off of the franchise, and "The Grim Adventures of Billy & Mandy" (Billy & Mandy) is no different. A television series created in the early 2000's which exhibited extremely expressive characters, "Billy & Mandy" garnered a large

enough following to result in a video game release with the same name. Released in 2006, “Billy & Mandy” was a 3D fighting game where the player can choose between a number of characters from the original series. This video game shows early versions of the originally 2D characters roam in a 3D world. Given the character Billy is being used as the avenue to further the current research, the knowledge of this video game is important. Due to certain limitations video games have, rigs must be built to run more efficiently than those made for film, leading to most game-ready rigs being mostly joint driven, which is most likely the case for the characters in the aforementioned game. This need for a fast rig led to the use of animated textures to accommodate the wide range of motion Billy’s mouth has.



Figure 14. Screenshots from *The Grim Adventures of Billy and Mandy* video game showing Billy's animated textures. High Voltage Software, Full Fat, Midway Games, *The Grim Adventures of Billy and Mandy*. Midway Games. 2006.

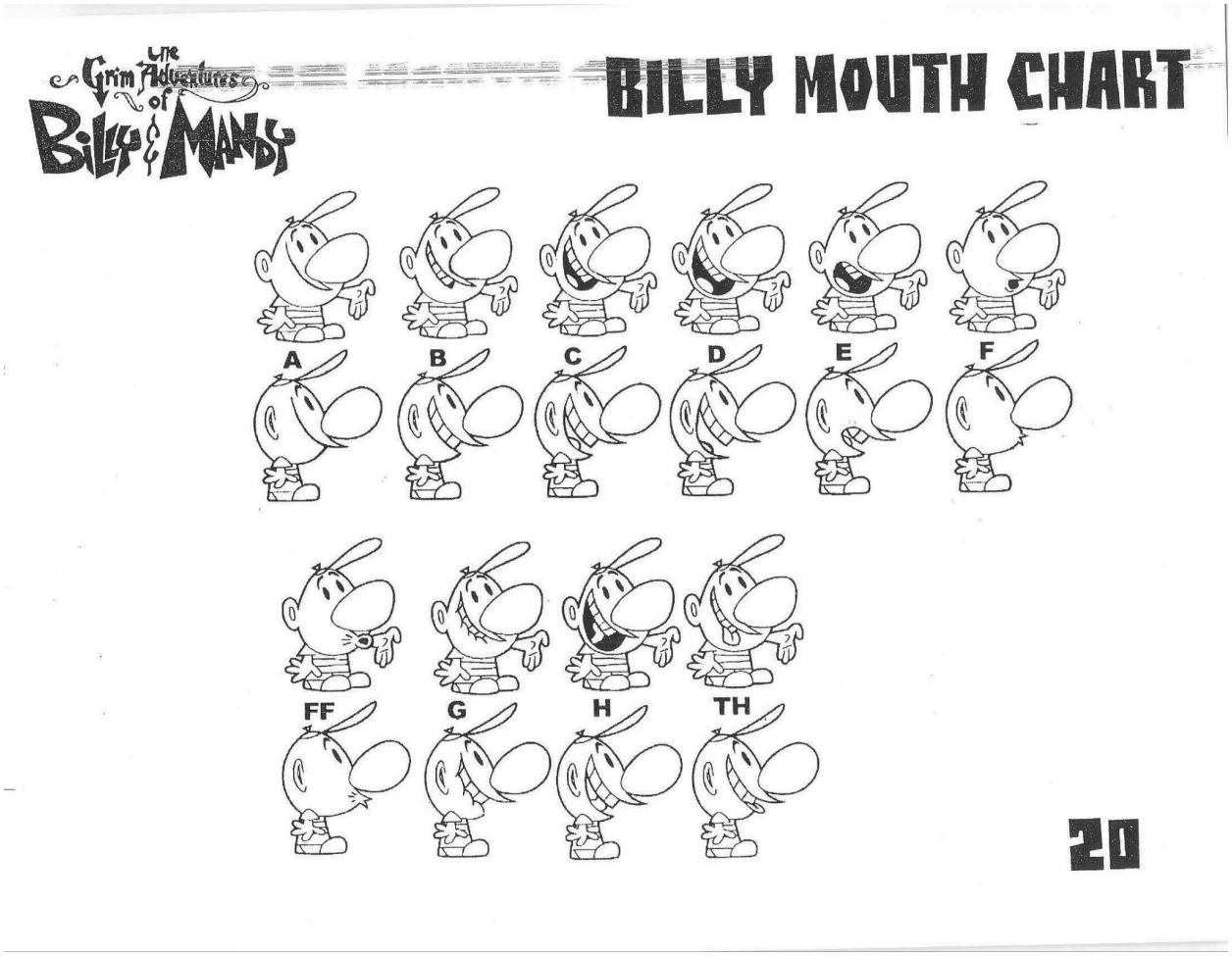


Figure 15. Page titled "Billy Mouth Chart" from *The Grim Adventures of Billy & Mandy: The Infernal Main Model Pack* that shows Billy's open mouth breaking his character's silhouette in profile view. Cartoon Network. 2004.

Although this solution worked for the video game, it doesn't account for changes in profile when Billy's mouth moves or teeth or tongue stick out, seen in Figure 14. It's these basic details that warrant trial and error when building a stylized rig. The needs of the project must be considered, this includes time and budget. However, an overtly expressive character like Billy can unintentionally lead to a very heavy and slow rig. The following key discussions will emphasize certain characteristics of stylized rigs that need to be considered with the intention of properly constructing an efficient and animation friendly rig.

4.0 Key Discussions

4.1 Importance of topology

Any good rigger understands the importance of topology. Everything needs to be in relatively even quads, and 5-point stars need to be placed strategically. This goes for any kind of rig, bipeds and creatures, and realistic and stylized. But what can differ is the resolution, or the density of the topology. More realistic characters with anatomically correct features would need to have a higher resolution mesh that would allow for wrinkles and creases to form when it is deformed. The age of the character will also impact the amount of visible wrinkles, in conjunction with whatever pose the character makes such as raised eyebrows, squinting eyes, or puckered lips. On the other hand, more stylized characters don't necessarily call for wrinkles and creases while deforming. The style of the character will heavily influence the resolution of the mesh. If the style is very graphic and has smooth shapes, you'll want to work with a lower resolution mesh. With fewer vertices to be influenced, there is less of a chance they will bunch up in undesirable ways, keeping the geometry relatively smooth.

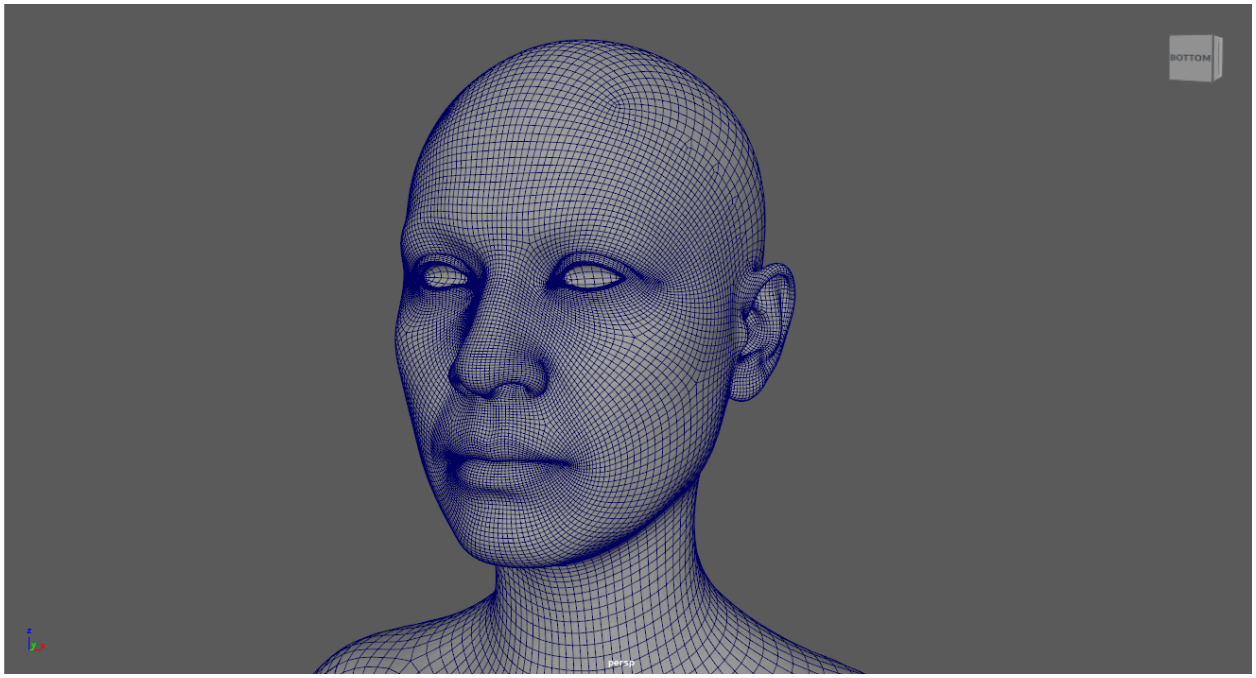


Figure 16. Wireframe for a MetaHuman, an example of a high resolution mesh. 2025 (MetaHuman Creator)

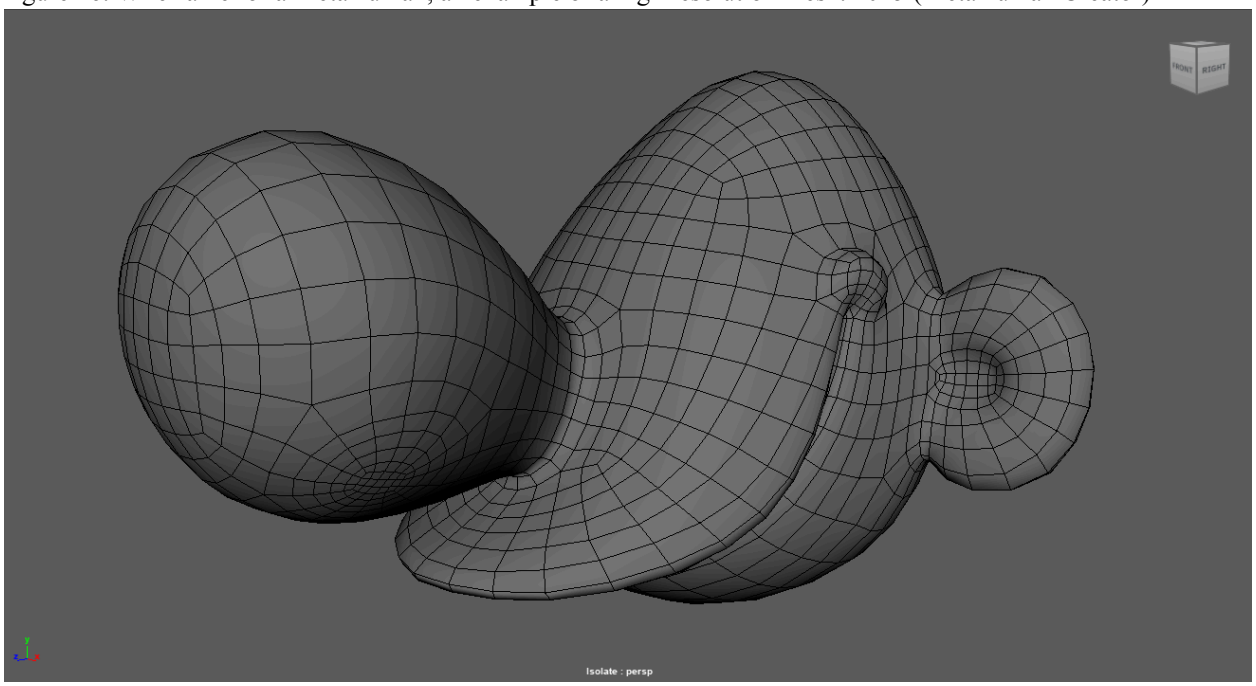


Figure 17. Wireframe for character head, an example of a low resolution mesh, Kate Eastland, 2025

In relation to the research at hand, the model went through many iterations in order to find the most suitable topology. Initially, the character started at a higher resolution and with sculpted eyelids. The original plan was to blendshape the eyelids to a head mesh that had the

same topology, but with the eyelids flattened. This didn't end up being a viable option as the sculpted eyelids didn't reflect the original style of the character. The head mesh progressively became lower resolution to allow for smoother deformations as seen in Figure 17. Due to the nature of the character's personality and the overall style of the series, the geometry would not be able to accommodate all of the necessary expressions. To fulfill this need, multiple heads were sculpted to general poses, and further rigged to customize those generic expressions.

4.2 Problems with Volume Loss

Rigging a character inevitably presents a unique set of challenges, as rig structures can differ significantly from one another. However, one common issue that arises across all rigs is the loss of volume during deformation. This is primarily attributed to linear interpolation—a mathematical method used to calculate intermediate points along a straight line between two known spatial coordinates. In simpler terms, linear interpolation determines the most direct path between two positions by computing points along a straight trajectory.

In the context of character rigging, these two known points can be conceptualized as distinct poses, such as a neutral mouth position and a smiling expression. The interpolated positions between them represent transitional poses. The issue arises because linear interpolation fails to account for the natural curvature and volumetric consistency of the character's anatomy. For instance, during the transition from a neutral expression to a smile, the teeth may intersect with the lip geometry due to inadequate preservation of facial volume, resulting in unwanted mesh intersection. This also proves true for translating joints, for instance an eyebrow moving along the surface of a character's forehead. However, simply translating the eyebrow will eventually lead to the eyebrow floating over the character's forehead.

A common solution to this problem is the implementation of corrective blendshapes, which restore the lost volume and prevent undesirable intersections. However, blendshapes are computationally expensive deformers. As the number of corrective shapes increases, the overall performance and responsiveness of the rig can significantly decline. This is why it is important to not solely rely on blendshape deformers to preserve volume. As previously stated, blendshapes are linearly interpolated, so sometimes corrective blendshapes need in-between shapes sculpted as work around the linear interpolation. This increase in correctives and in-betweens makes rig files larger and slower, thus not efficient for production. And for more stylized characters, more often than not, the forehead won't have any particular weight associated with the eyebrow joints, especially if the eyebrows are a separate geometry from the character's head. Very simple characters tend to not have visible wrinkles unless it is used as an indication of age.

4.3 Camera Based-Features

Many stylized rigs have features that are referred to as camera-based. This means that certain body parts or accessories will move around the rig, usually in ways that don't physically make sense in order to appear correct in the camera. A 3D head rig of Timmy Turner, from the 2D series, "The Fairly Odd Parents," created by Kevin Temmer (2022), founder and animator at Glitch Productions, is an excellent example of a rig with camera based features.

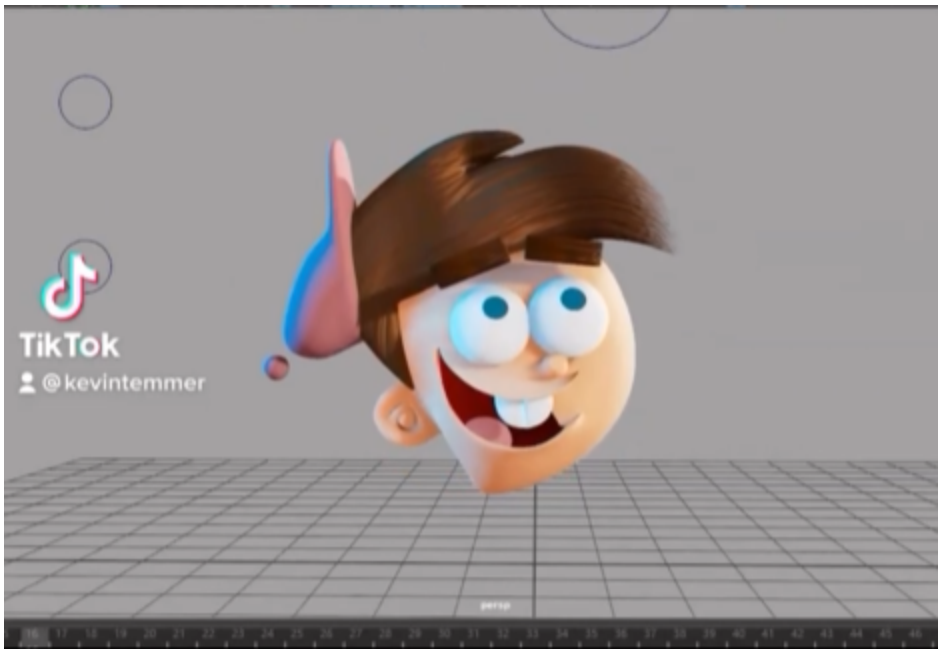


Figure 18. A Timmy Turner rig pose test showing off how to place certain features to cheat the camera. (Rig created by Kevin Temmer, 2022)

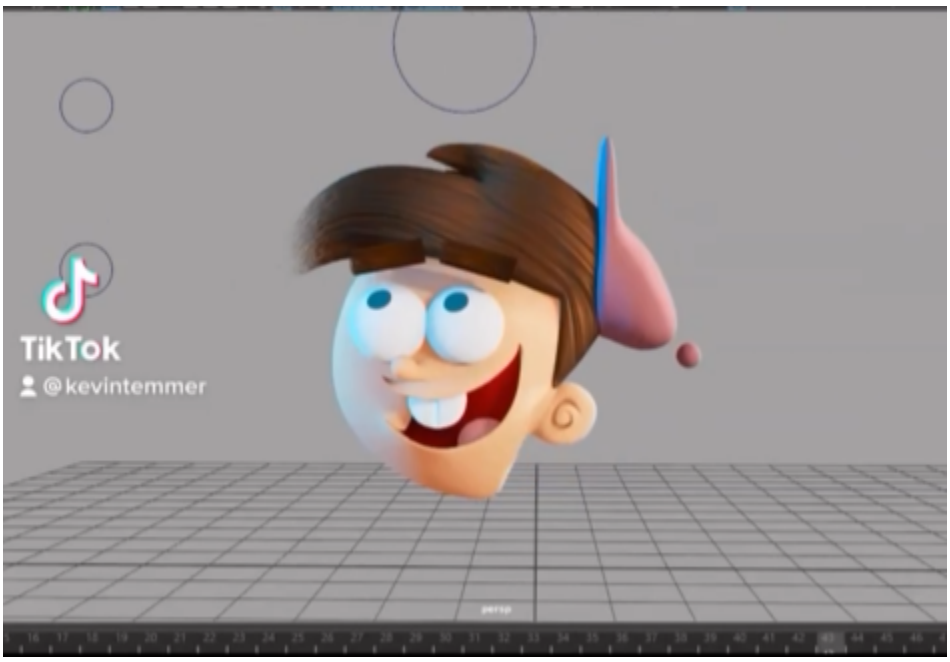


Figure 19. A Timmy Turner rig pose test showing off how to place certain features to cheat the camera. (Rig created by Kevin Temmer, 2022)

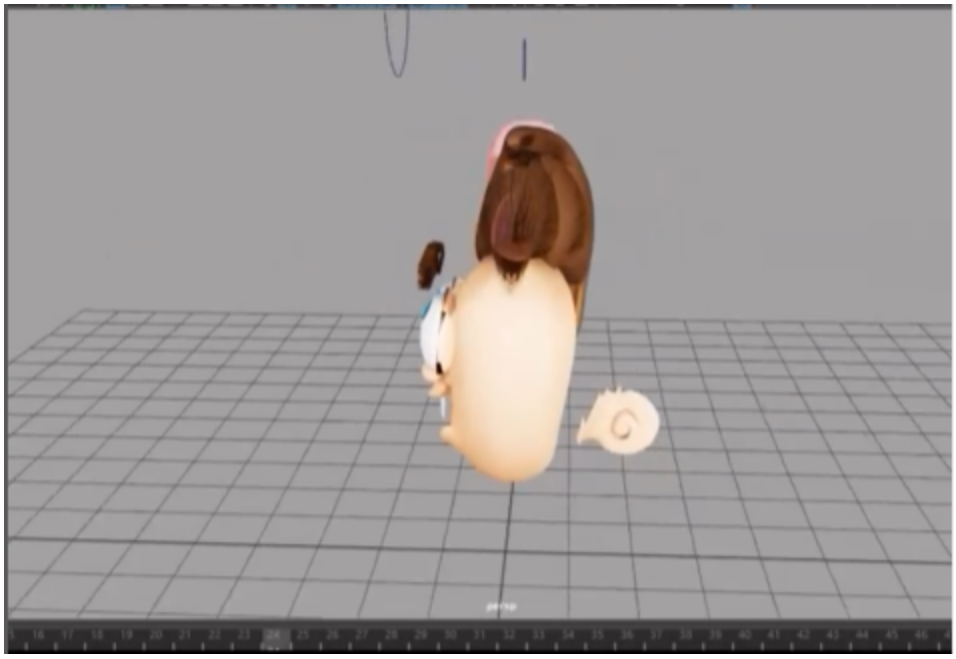


Figure 20. A Timmy Turner rig pose test showing off how to place certain features to cheat the camera. (Rig created by Kevin Temmer, 2022)

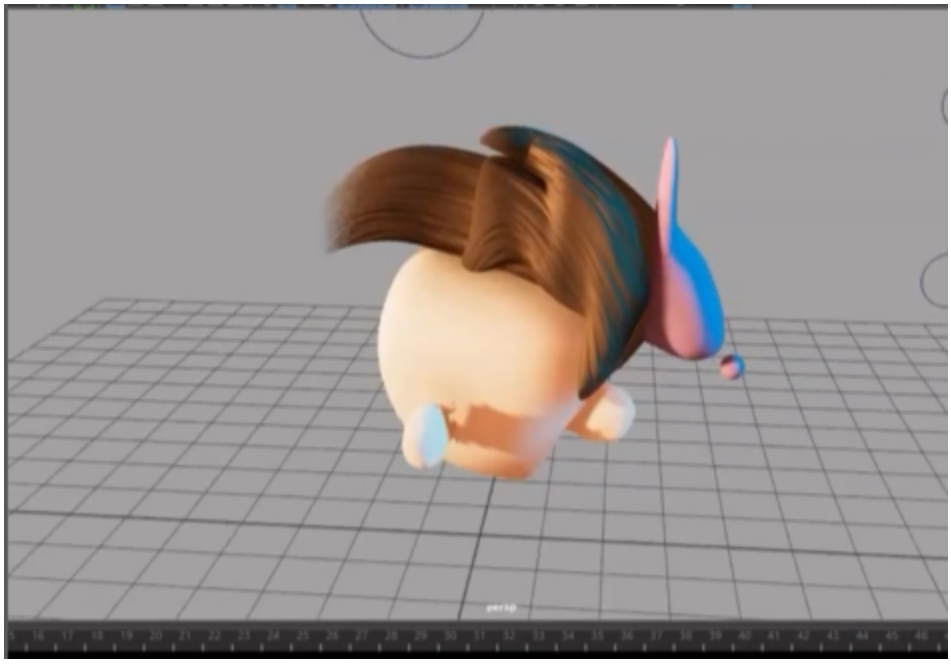


Figure 21. A Timmy Turner rig pose test showing off how to place certain features to cheat the camera. (Rig created by Kevin Temmer, 2022)

In the figures above, you can see that when the character turns to face either screen-left or screen-right, all of the facial features and accessories adjust accordingly in order for the character to stay on model. But once the camera moves to show the back of the rig, you can see how

broken and disjointed it really is. This is also something notable from Snoopy's rig in *The Peanuts Movie*. Figure 22 shows how Snoopy looks according to the designated camera for the shot, and Figure 23 shows how the rig was manipulated in order to achieve the desired results.



Figure 22. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)



Figure 23. Ignacio Barrios, *Snoopy Character Rigging Showreel - Ignacio Barrios,* 2021 (YouTube: Ignacio Barrios, (13) Snoopy Character Rigging Showreel - Ignacio Barrios - YouTube)

The characters above are almost always seen at a three-quarter angle, Billy included, which is important to note when building a rig. These stylistic details can determine the particular techniques and tools used when creating these kinds of characters in 3D.

5.0 Methodology/Artist Statement

5.1 Researching Uncommon Techniques

During the course of thesis research, it became evident that character rigs were often constructed in a similar fashion. A significant number of tutorials available online follow nearly identical workflows, with the most notable exceptions incorporating custom plugins or autoriggers to enhance rig functionality. However, as any skilled technical artist understands, there are multiple ways to achieve a desired result. This realization served as a catalyst for exploring alternative rigging approaches, particularly for stylized characters. This line of inquiry led to the discovery of the Translate UVN Deformer—a technique developed by Blue Sky Studios for *The Peanuts Movie* and discussed in blog posts by Jonah Reinhart. Upon examining the complexities of the Translate UVN Deformer, the decision was made to pursue a comparable method without relying on plugins.

5.2 Making Certain Methods More Accessible

Another objective is to make surface-based rigging more visible and approachable, particularly for self-taught artists or individuals without access to formal instruction. Much of the existing discourse on surface-based facial rigging focuses on proprietary tools designed to automate the process. This suggests that comparable results can be achieved without developing custom scripts or tools, by simply creating the setup manually. While surface-based facial rigging is not a new concept—having been used as early as the original *Ice Age* film—detailed technical information remains limited. Even papers presented at conferences such as SIGGRAPH

often lack sufficient depth to fully convey the methodology behind these rigs, further isolating it from public knowledge.

Another technique that had surprisingly little information was the addition of ‘ink lines’ to a 3D rig. The reason could be artists prefer to add them either through textures or with 2D effects composited onto the 3D animation. The resulting rig from this research was intended to include all aspects of the original 2D character without the aid of textures or any effects added in post production. As inconvenient as it may be for larger productions, it was a challenge for myself to see how inclusive this rig could possibly be. In circumstances that entail a smaller team for a project, due to various constraints, or simply a client that has this particular request, it may be necessary for a rigging artist to incorporate ‘ink lines’ in the 3D rig. And with scarce resources on the matter, the large gap in readily accessible knowledge can be inhibiting.

5.3 Focusing on the Challenges 2D Characters Pose for 3D Rigs

In recent years, there has been a resurgence of rebooted animated television series aimed at younger audiences. These reboots often reimagine 2D characters in 3D while maintaining the original visual style. This makes the topic both current and forward-looking. The research examines how these modern adaptations preserve the aesthetics of their 2D origins despite needing to compromise on certain aspects due to the limitations of a 3D medium. A key challenge in this endeavor is staying ‘on model,’ especially when translating characters between 2D and 3D. Each medium offers unique strengths, but achieving visual consistency across both requires addressing significant technical and artistic challenges.

For Billy in particular, the largest challenge was trying to match his upper lip on the 3D rig to his original 2D character sheets. His sharp upper lip is one of his most prominent features,

so it felt necessary to try and match it as closely as possible. Due to Billy almost always being portrayed at a three quarter angle, his upper lip always appears in front of his face closest to the camera. The solution in 3D was to have his upper lip protrude from all angles. Although not a perfect match, it was a compromise that made sense for the needs of the rig.

Another challenging style accommodation was adding ‘ink lines’ to a 3D rig. As mentioned in section 3.2, using ‘ink lines’ for characters with very simple eye shapes can aid in exaggerating the characters’ emotions, common practice in 2D mediums such as 2D animation or cartoon strips because they are quick details that can be added to a more finalized piece. However, due to perspective issues in a 3D space, ‘ink lines’ tend to be more work then they are worth. In Figure 24, there are examples and notes for how to keep “Billy & Mandy” characters in style when drawing eye expressions. This applies to most characters in the series as they have visible pupils and scleras, one of which is Mandy, Billy’s main character counterpart shown in Figure 25.

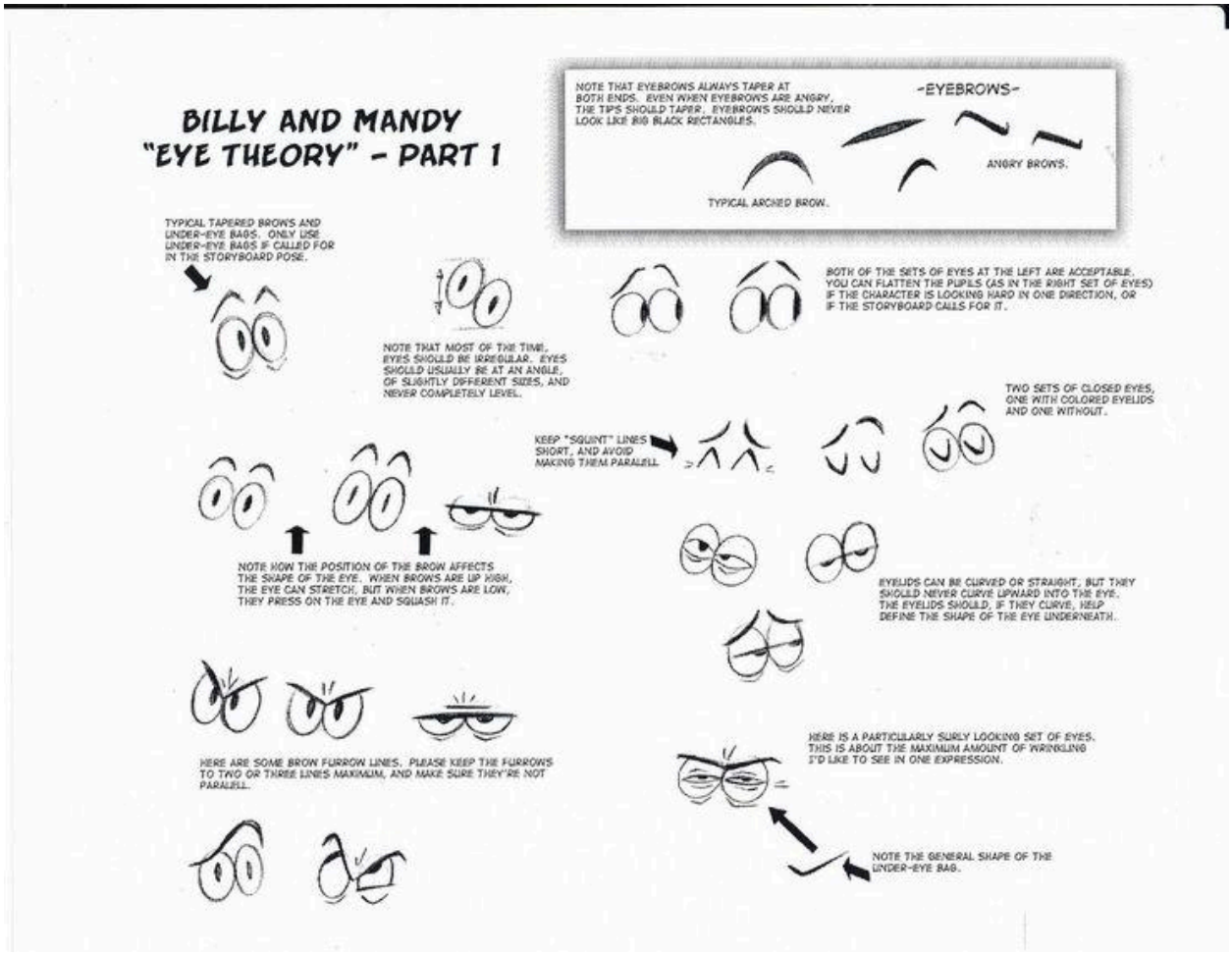


Figure 24. *Billy and Mandy "Eye Theory" - Part 1.* A guide for animators when drawing character eyes for the original 2D animated series. Cartoon Network.



Figure 25. A frame of Mandy showing her eyes have visible scleras. (Frame from The Grim Adventures of Billy & Mandy Season 6 Episode 9 Wrath of the Spider Queen 2007)

Another guide was provided for the animators of the series, particularly for Billy and Grim's eyes, as they do not have visible scleras like Mandy and other side characters. This style of eyes is referred to as "dot" eyes, and is a continuation of the "eye theory" in Figure 24. This was a main reference when building the eye setup for Billy's rig.

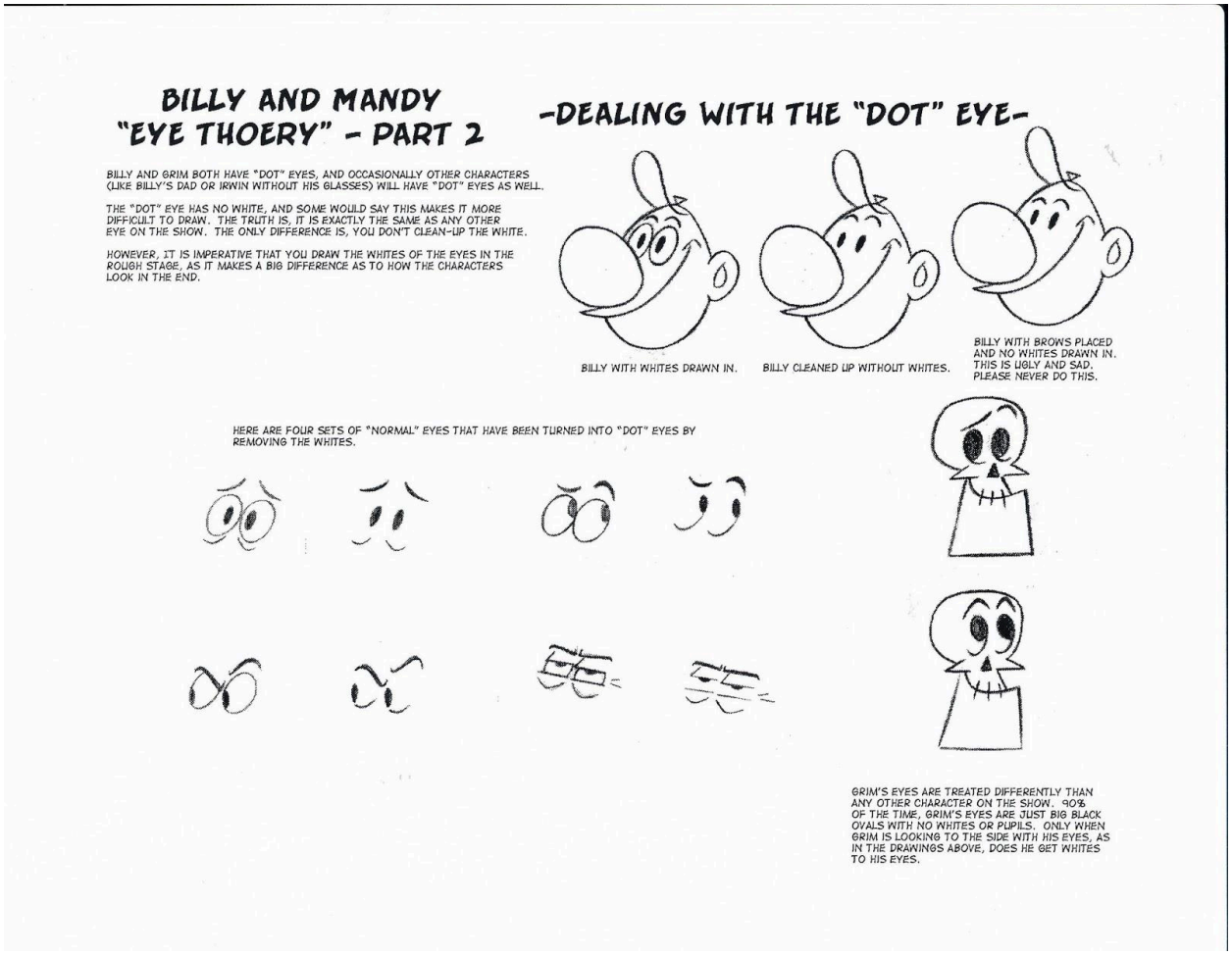


Figure 26. *Billy and Mandy "Eye Theory" - Part 2.* A guide for animators when drawing character eyes for the original 2D animated series. Cartoon Network.

5.4 The Final Process

Many iterations took place while building Billy's rig. It was a difficult balancing act of finding appropriate techniques that could work together to result in a flexible and easy to use stylized rig. The largest challenges were to solve how to compensate Billy's wide range of mouth expressions, and how to appropriately represent his eyes in the style of the original series. Finding expression sheets and character turnarounds were crucial to ensure Billy would stay on model in 3D. Figures 27 and 28 exhibit Billy's wide range of emotions and how animators

needed to pay close attention to certain details, such as expression line placement, to ensure he stayed consistent and in style.

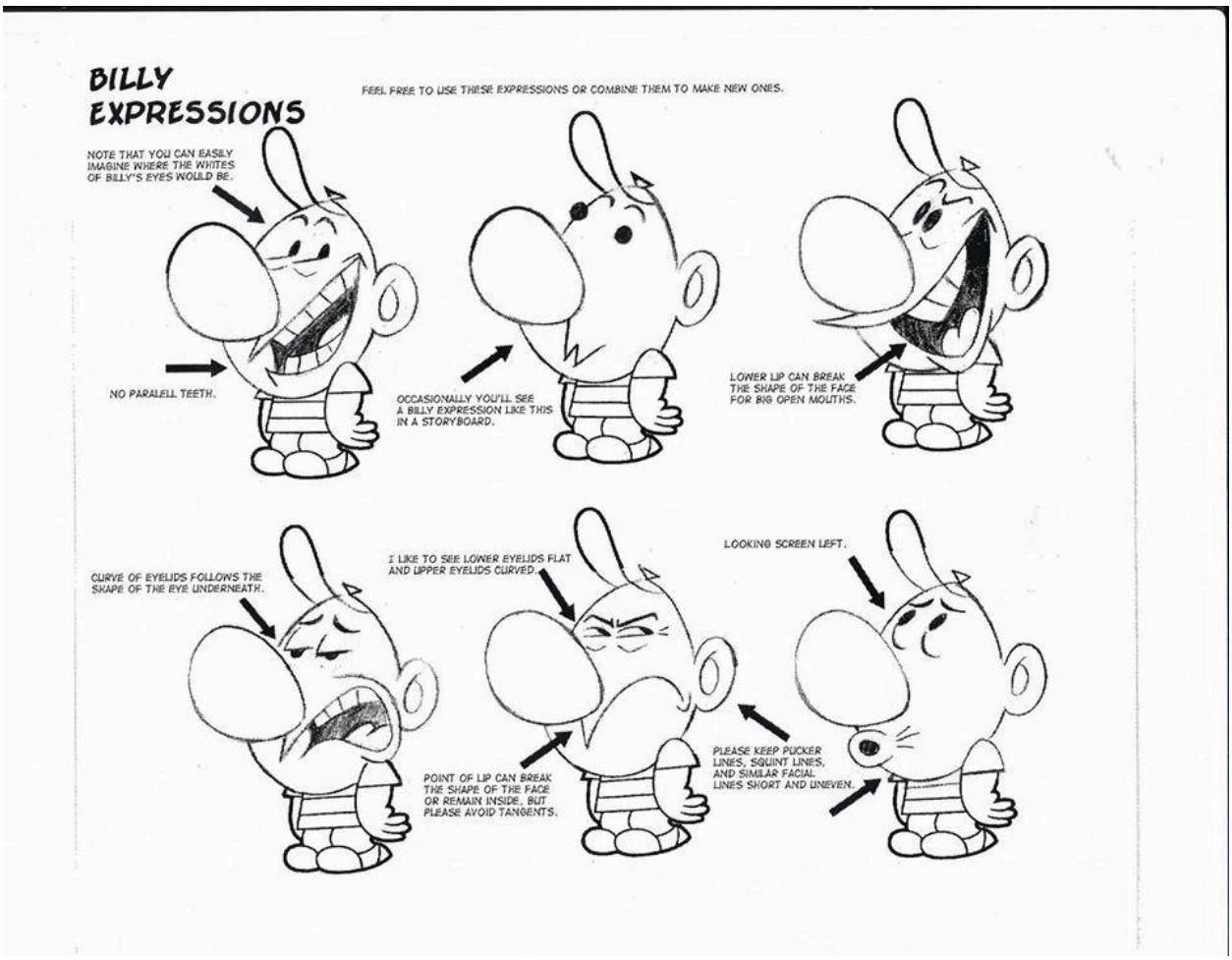


Figure 27. Billy Character Guide for animators to keep him consistently on style. Cartoon Network.

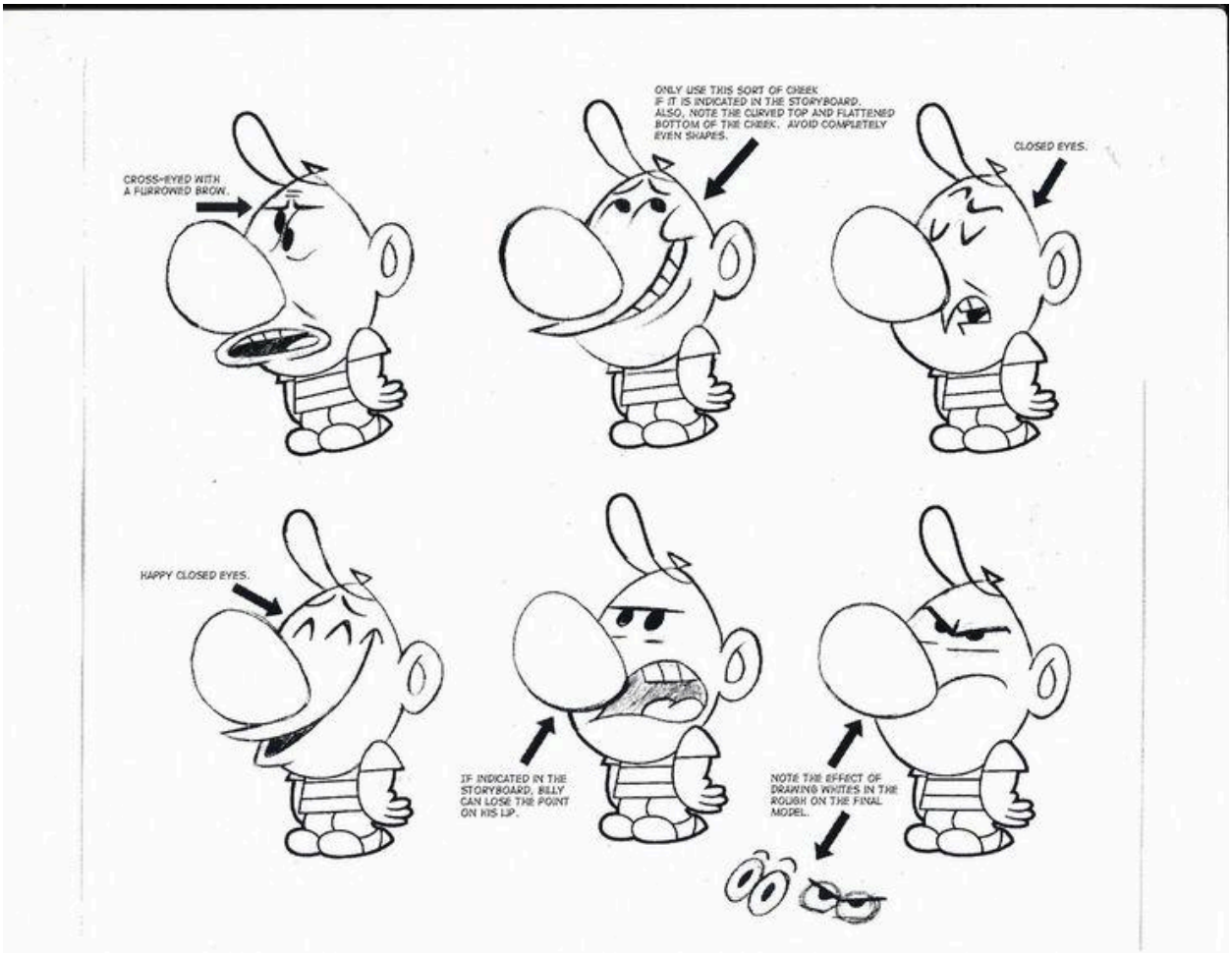


Figure 28. Billy Character Guide for animators to keep him consistently on style. Cartoon Network.

Due to Billy's large round head, much like the heads of *The Peanuts* characters, the goal was to implement a surface based setup for his eyes and eyebrows to stay on his face. Depending on the lighting setup, having the eyes and eyebrows move in local space will eventually have them floating over the characters head, which can lead to unwanted shadows being cast and breaking the style. Following along with Jonah Reinhart's blog post, *"Surface Based Facial Rigging,"* the intention was to try all three of the described methods and implement the one that worked best for Billy. Ultimately the final setup for the upper face was a version of method 3. A NURBS surface was created to mimic the curvature of Billy's head and span up his forehead

down to his nose. A node network was created for each joint to not only slide along the NURBS surface, but match its normal at any given point. This worked very well when translating the joints, but additional changes needed to be made to the network to allow for rotations. Figures 29 and 30 show the node network initially established for each eye and eyebrow joint and Figure 31 is the final node network.

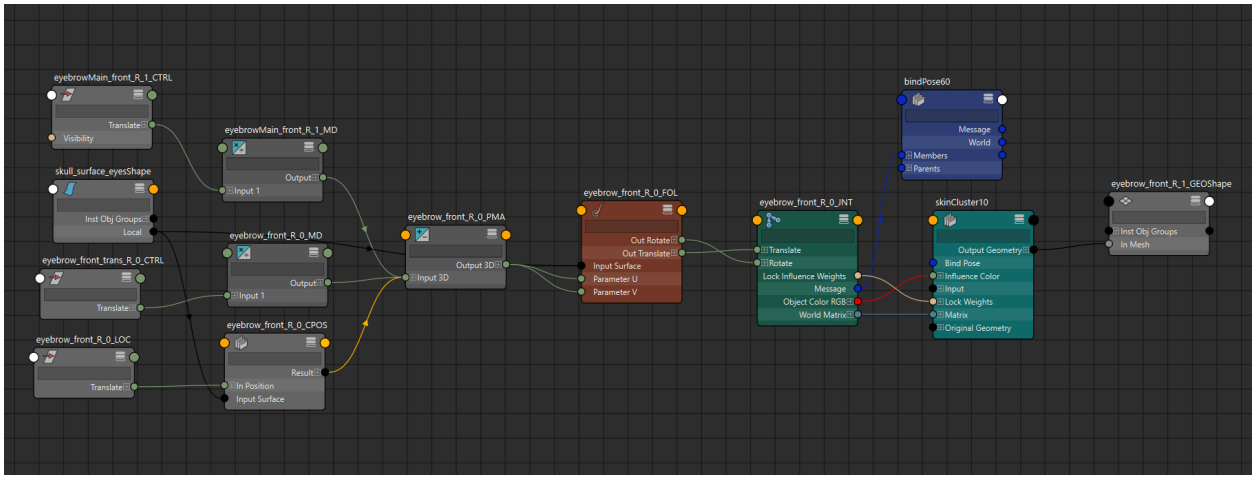


Figure 29. Node network for surface based setup for all eye and eyebrow joints. Only translation works. Screenshot by Amanda Rabade. 2025.

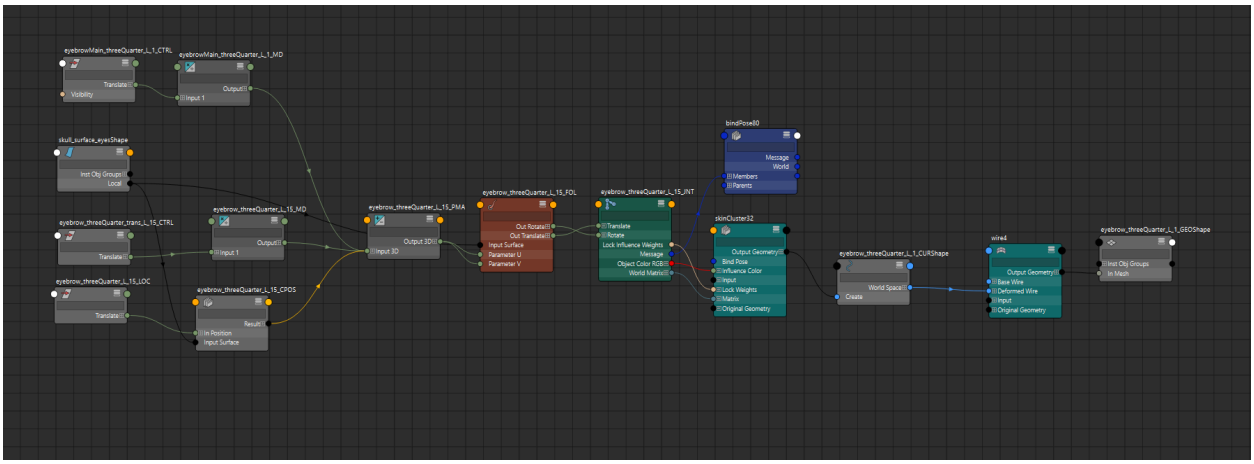


Figure 30. Node network for surface based setup for all eye and eyebrow joints. A wire deformer was added to include rotations, but led to double transformations. Screenshot by Amanda Rabade. 2025.

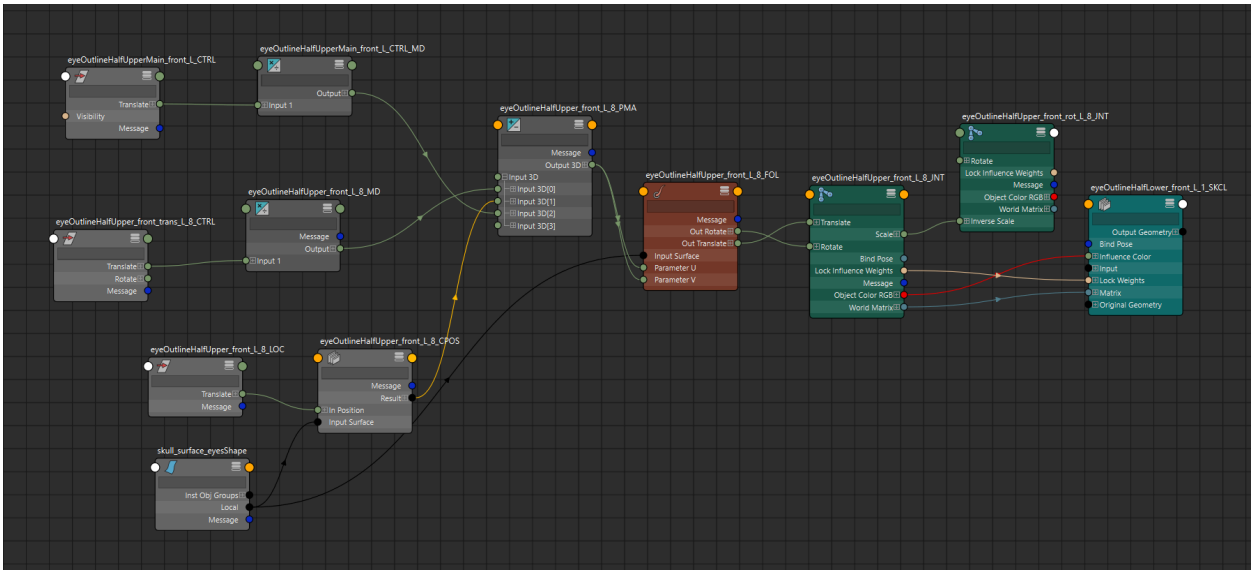


Figure 31. Final node network for surface based setup for all eye and eyebrow joints. An additional joint was added to include rotations and skinned to the geometry. The parent joint allowed for translations and eliminated the double transformations. Screenshot by Amanda Rabade. 2025.

In addition to the surface based setup for the eyes, Billy has multiple different eye shapes for the animator to use. The eye shapes equate to the ‘ink lines’ mentioned in the previous section. In order to comply with the “dot eye theory,” these additional eye shapes were added to allow the animator to add ‘ink lines’ in conjunction with the “dot” eyes at will.

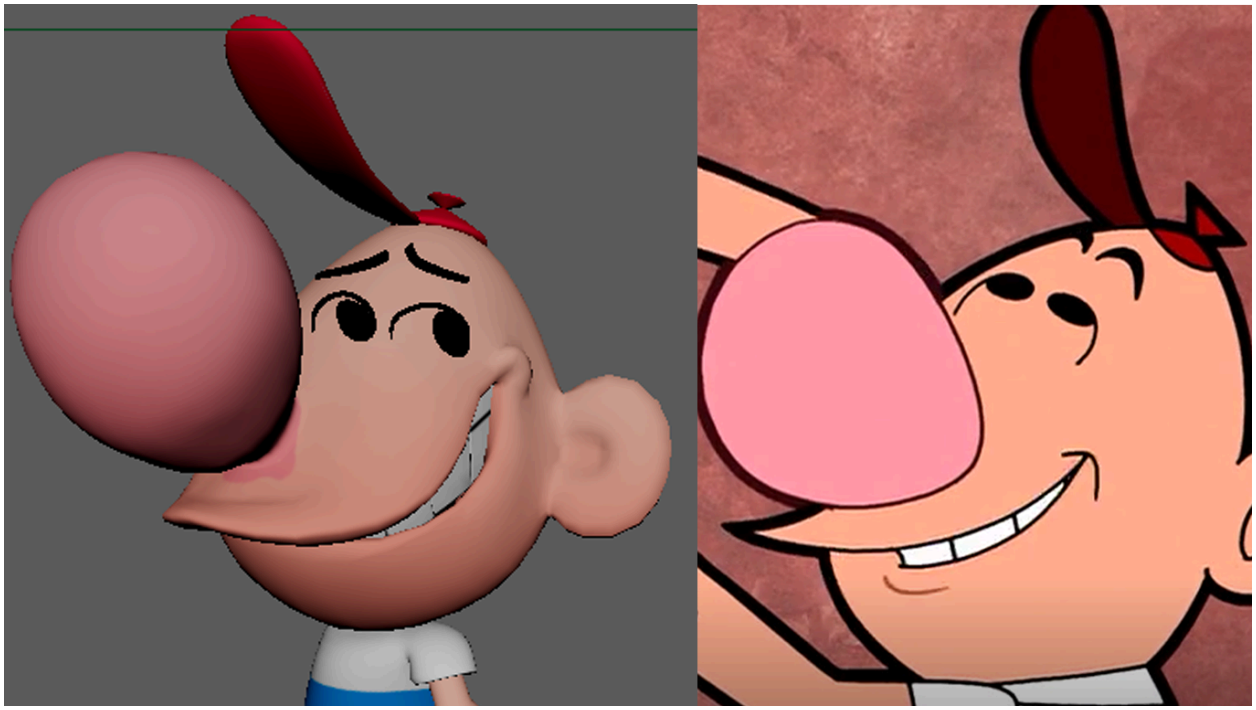


Figure 32. Side by side comparison of ‘ink lines’ used in 3D rig of Billy and “ink lines” added by animators from the original series. Rig created by Amanda Rabade, posed by AJ Johnson. 2025. Frame from The Grim Adventures of Billy & Mandy Season 6 Episode 9. 2007.

Billy’s mouth is a combination of skin clusters and blendshapes. Blendshapes were sculpted for more extreme expressions, such as smile and frown, and skin clusters were added for jaw and lip movement. The rig consists of multiple different heads being switched between to give the animator the most flexibility. Due to Billy’s lips resting in very different points in space, it was difficult to have the joints from one skin cluster follow the lips for the extreme poses. Switching between multiple head meshes allowed for each mesh to have its own skin cluster with separate controls in their rest position. This decision was driven by usability, having the controls physically near the joints they control visually conveys to the animator how the mesh will deform and not cause confusion.

6.0 Conclusion

Although most studios will have their own proprietary software and tools for their individual pipelines even beyond rigging that artists would have to learn once starting a position at that particular company, there needs to be base level knowledge before even getting hired. With the surplus of lessons and tutorials available to anyone with an internet connection, how truly accessible is this information? How are riggers able to distinguish themselves from one another if they all know how to create the same kind of rigs the same way? There isn't one way to rig a character, so why is it so difficult to learn how to rig characters any other way? Combining different methods and techniques shouldn't immediately lead to a broken rig, they should allow for more functionality and offer ease of performance.

Stylized rigs will never go out of fashion for as long as media exists. There will always be a need to push characters' emotions further, and there will always be a need to conform to a project's art direction. The goal of rigging is to allow for animation, to allow a story to be told. And sometimes these stories get retold in different mediums from which they started. This means artists will always be evolving with technology to make something unique and individual from something nostalgic and timeless. Whether the rig is exclusively joint driven with a single skin cluster, a combination of joints and blendshapes, surface based setups, or something entirely new and never seen before, there is always a way to bring 2D characters into a 3D world. And as long as there is a way, making that feat accomplishable should always be accessible.

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