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Character Surfacing and Feathering for UFO

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CHARACTER SURFACING AND FEATHERING FOR *UFO*

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In Partial Fulfillment
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Master of Fine Arts
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by
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ABSTRACT

This thesis focuses on the methods used to create the look of the unusual flying ostrich in *UFO*, a short, stylized film about an earthbound bird with his head in the clouds. That this aspiring aviator is not an ordinary ostrich is visibly indicated by his unusual markings, reflecting his unusual mindset that allows him to achieve the impossible. The techniques used to accomplish the final appearance of the unusual ostrich will be explored in this thesis, with a particular focus on the methods used to create and style the feathers, and the techniques used to hand paint the assorted markings on the character.

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CHAPTER ONE

INTRODUCTION

UFO is a short film that focuses on a specific moment when the flight ambitions of a naturally flightless bird are realized. The title, an abbreviation of Unusual Flying Ostrich, plays off of a well-known acronym to imply a hint of otherworldly appeal that is further echoed in the stylization of the film. The story itself revolves around an inquisitive ostrich with a knack for achieving the improbable. As a member of a species saddled with a head-in-the-sand reputation, the curious character for this project is not an average ostrich. Rather, this aeronautically adventurous avian is a unique bird, portrayed with a happy-go-lucky personality, and possessing an unusual look to match his unusual mindset. The distinctive coloring of the character supports the implausibility of this story and expresses the underlying themes of curiosity and creativity, two concepts that are applicable not only to innovative ostriches, but also to innovative storytelling.

This thesis will focus on the techniques used to create and texture feathers for the flying, saucer-eyed bird in *UFO*, and will explore several methods including fur, hair, and instanced geometry that were combined in order to achieve the final results. Additionally, the methods used to paint and surface the entire character will be discussed, including mapping for diffuse color, specular highlights, displacement, and subsurface scattering.

CHAPTER TWO

BACKGROUND

Figure 2.1: Concept development from sculpture to final storyboard

The concept of a curious ostrich who manages to achieve a seemingly impossible feat was initially developed as a sculpture project in early 2014 (Figure 2.1). The final sculpture (Figure 2.3), which was built from a combination of scrap metal and tin foil, consisted of over three hundred feathers that were individually painted and attached to the body. To create this pseudo ostrich plumage, duct tape was shredded and shaped to denote fibers while wire coat hangers were repurposed to represent quills (Figure 2.2).

Figure 2.2: Duct-tape-and-coat-hanger feathers for the Flying Ostrich sculpture


Figure 2.3: The Flying Ostrich sculpture

In the midst of the duct tape-to-downiness transformation, a story was developed to provide the sculpture with additional context, and from this narrative hatched the initial idea to digitally recreate the project. After the completion of the sculpture, storyboards were illustrated (Figures 2.4 and 2.5) to officially begin the transition from tape and tin foil to a computer-animated production focused on character surfacing in Mari and feather creation in Maya, with the final results rendered using Renderman for Maya.

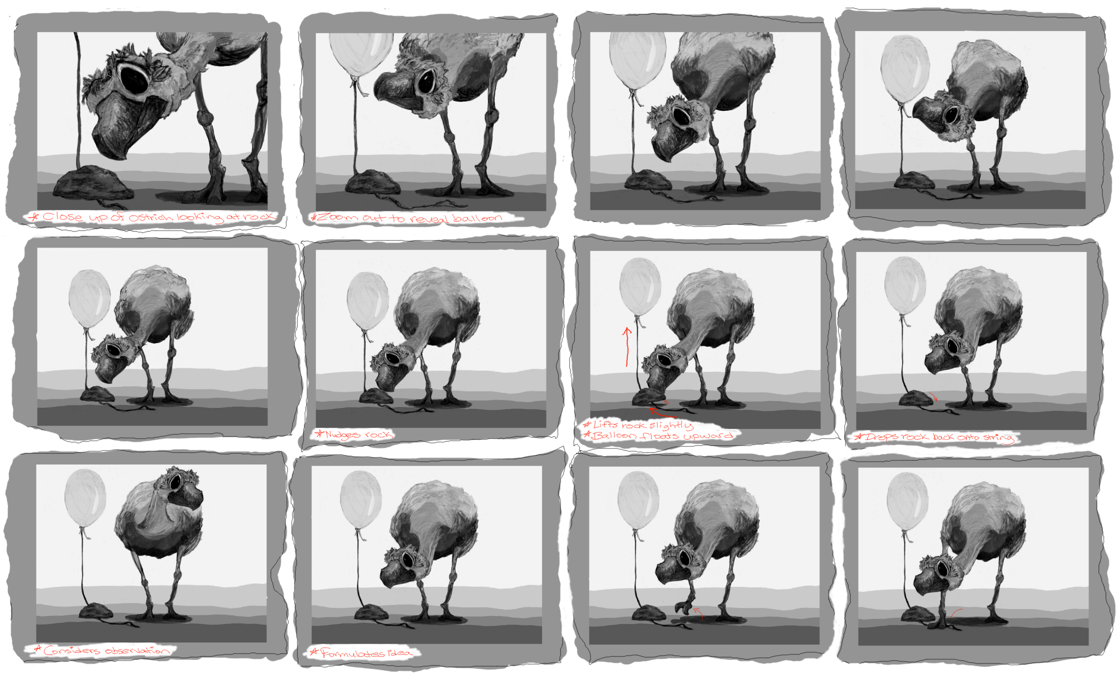

Figure 2.4: Storyboard drawings for shot 01

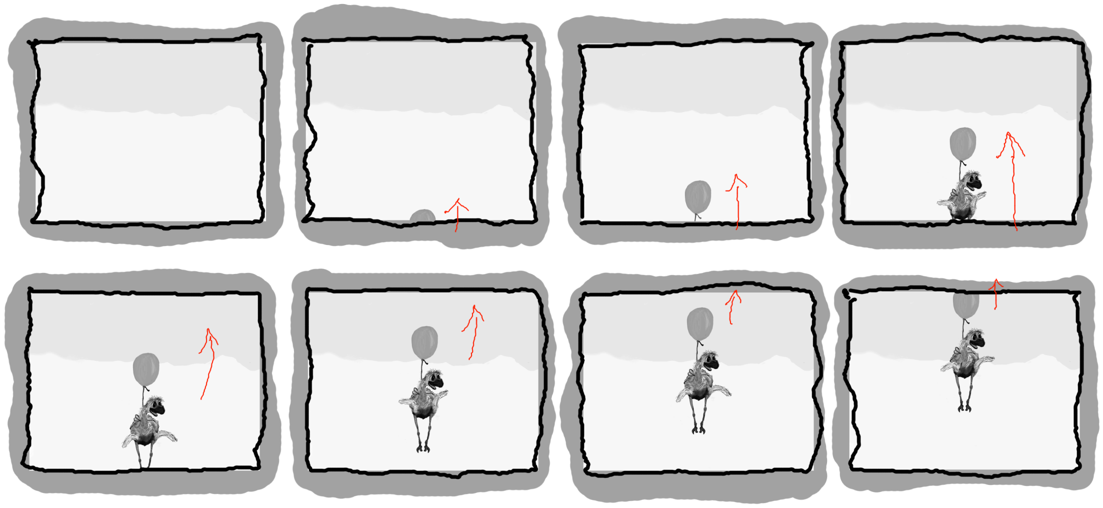

Figure 2.5: Storyboard drawings for shot 02

2.1 Texture Maps

For a surfaced object to react realistically to light and integrate properly into the scene, a variety of maps must be painted. The first and most important map is the color map. This map reacts to diffuse light to provide color values and acts as a base for all additional mapping. Directly shadowing the color map is the diffuse map, a grayscale map created from the color map and charged with controlling the amount of color saturation from global illumination. Following color and diffusion, specularity and shine are determined, respectively, by the specular map and the gloss map, two maps that highlight the color map with glowing sparkles and glittering energy. Together, these maps describe the reaction to both the amount and direction of light in the scene (Figure 2.6).

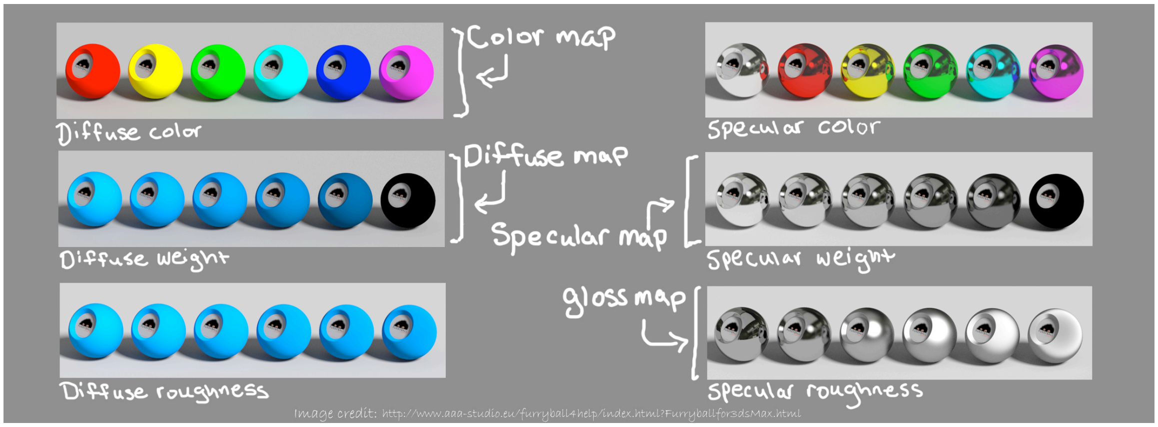

Figure 2.6: Diffuse and specular attributes [ARTA14]

The bump and displacement maps are grayscale maps that create the appearance of bumps, scratches, or cracks on an object, without physically altering the model before rendering. While bump maps change only the appearance of the object and not the actual geometry, displacement maps alter the actual geometry at render time, allowing transformation from a relatively basic model to a far more complex object. Figure 2.7 illustrates the effects of bump mapping using an assortment of patterns.

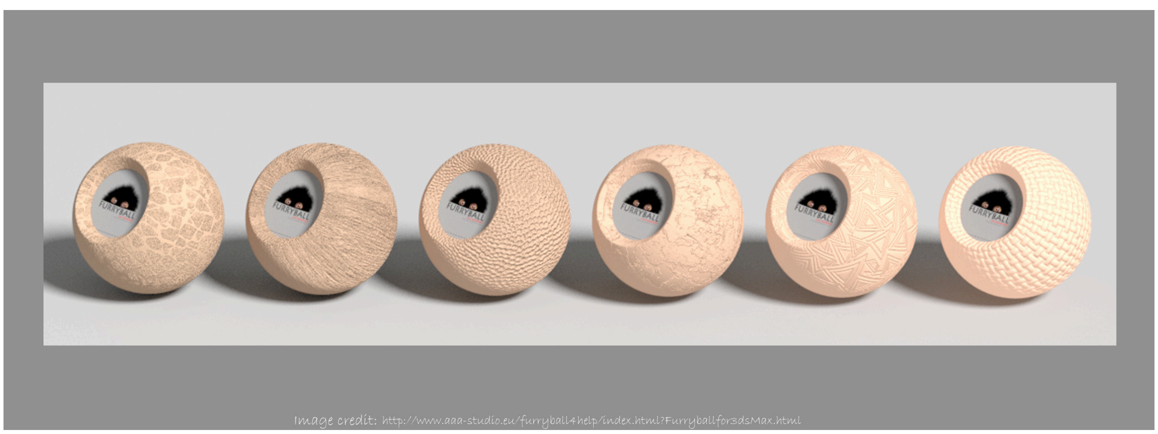

Figure 2.7: Bump mapping [ARTA14]

The reflection and transparency maps are both grayscale maps that affect the rendering of reflection and transparency, respectively, of a given object. The transparency map, like the bump map, can be a convincing way of creating the illusion of complexity in simple models. Finally, the subsurface scattering map (Figure 2.8) determines the amount of light that penetrates the surface of a translucent object, which is then rendered as internal reflections.

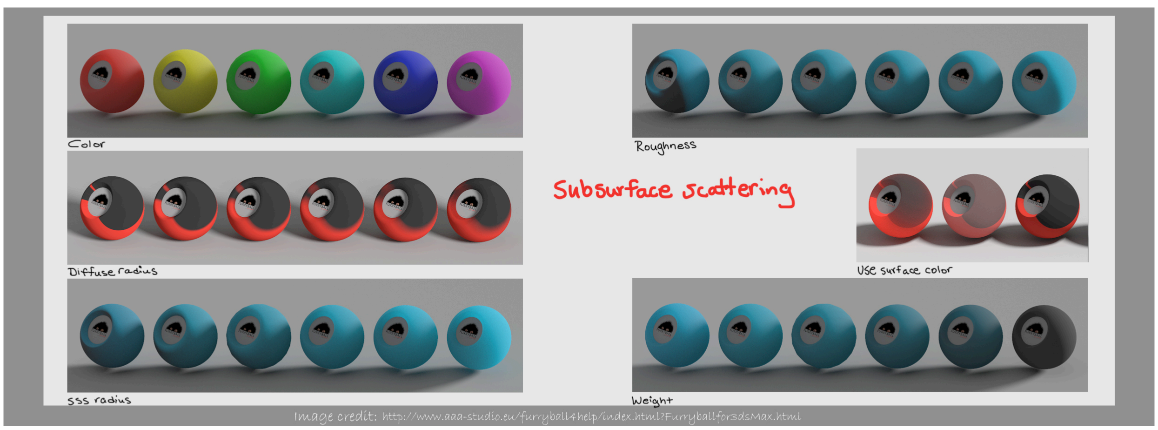

Figure 2.8: Subsurface scattering attributes [ARTA14]

2.3 Creating CG Feathers

Many CG productions that feature animated birds have approached the task of creating feathers using a variety of methods. To achieve the appearance of feathers, typical methods include feathers modeled from fur as well as feathers generated procedurally from simple geometry. In many cases, feathers are created using a combination of these two techniques. In nearly every case, however, after the feathers are created, some manual adjustment is required to accomplish the desired visual results.

Creating feathers using fur systems is a method that allows each individual hair to be rendered, resulting in finely detailed feathers. Feathers created in this way, however, can be particularly challenging to render in certain situations. Alternatively, procedurally generating feathers using geometric shapes placed in specified locations with basic manipulation or grooming controls can be advantageous at render time, as feathers can be generated as instances of the original geometry. The final appearance of feathers created in this way, however, relies heavily on the alpha value of the assigned texture to create the illusion of detail.

For the animated feature film *Rio* (Figure 2.9), Blue Sky Studios developed a double fur system to achieve the appearance of feathers. This technique used the first fur system to define the quill, while the second fur system described the individual hairs on each feather. The resulting feathers were both realistic and aesthetically pleasing.

Figure 2.9: Blu, the feather-covered protagonist in *Rio* by Blue Sky Studios [SHEE12]

During the production of *UP* by Pixar Animation Studios, a slightly more complex method for feather creation was used. This method incorporated a third fur system that calculated the location of the specular highlight in relation to the angle of the camera, creating illumination controls for iridescence that gave the feathers a soft appeal. This technique granted further artistic control in the final appearance, with the resulting feathers interacting believably with light while retaining the desired fluffiness. As shown in Figure 2.10, this method ultimately enhanced the already spectacular charm of the character.

Figure 2.10: Kevin, covered in iridescent feathers for Pixar's *UP* [DUNL09]

For a commercial produced for Paseo Dove, TVC by Yukfoo Animation (Figure 2.11), the feathering was accomplished with an in-house tool that generated and placed plane geometry onto the models. This tool used multiple reference feather geometry for variation while controlling the density of the placed feathers with greyscale maps. These feathers were then adjusted where necessary and assigned a variety of textures that resulted in very realistic feathers.

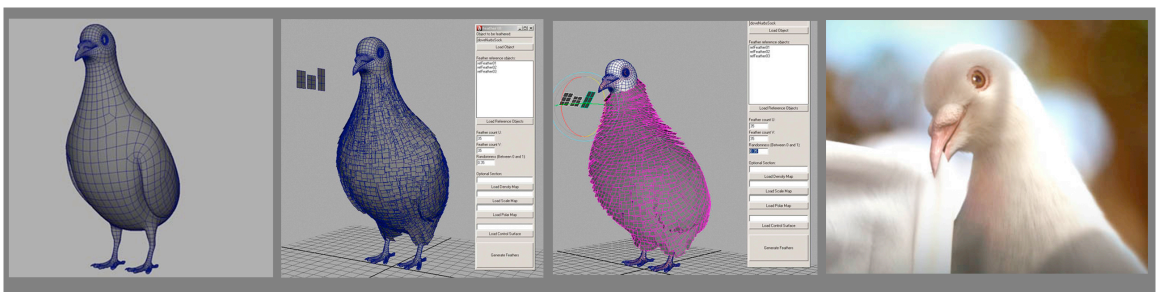

Figure 2.11: The Paseo Dove (various stages of production) [YUKF10]

While attempting to create feathers for *UFO*, experimentation with variations on these methods as well as several others were tested, including vector displacement, paint effects, and dynamic nHair systems converted to polygons. Results from the majority of these methods were not ideal for the project in question; however, the final outcome of the unusual ostrich is based on the experience and knowledge gained though this investigation. Additionally, although the extent of the experimentation is not a renderable aspect of the feathers, the research and discovery of alternate methods is an important part of the creative process in general, and was important in the development of this project in particular.

CHAPTER THREE

IMPLEMENTATION

A story revolving around a physically impossible concept requires a certain degree of artistic freedom. When the laws of physics are challenged in film, suspended disbelief is necessary in order to accept the substituted laws of the imaginary world. Creating cohesion between elements that appear real and that react realistically to light, but that disregard gravity and weight in certain circumstances, can be a balancing act between photorealism and stylization. This balancing act is addressed through the distinct look created for the character in *UFO*, serving as an aspect that visually supports the unique personality of the investigative ostrich while further implying the possibility of an alternate reality.

Constructing this atypical appearance began with the creation of concept art (Figure 3.1) and continued through multiple iterations of research, illustration, modeling, and surfacing. These refinements are apparent in the development of the designs, the evolution of the model, and the experimental creation of textures that resulted in the final appearance. This chapter will briefly discuss each of these stages, and in addition, will explain in detail the techniques used to create the feathers, fur and hair that sprout from this oddity of ostrich society.

Figure 3.1: Concept art for shot 01

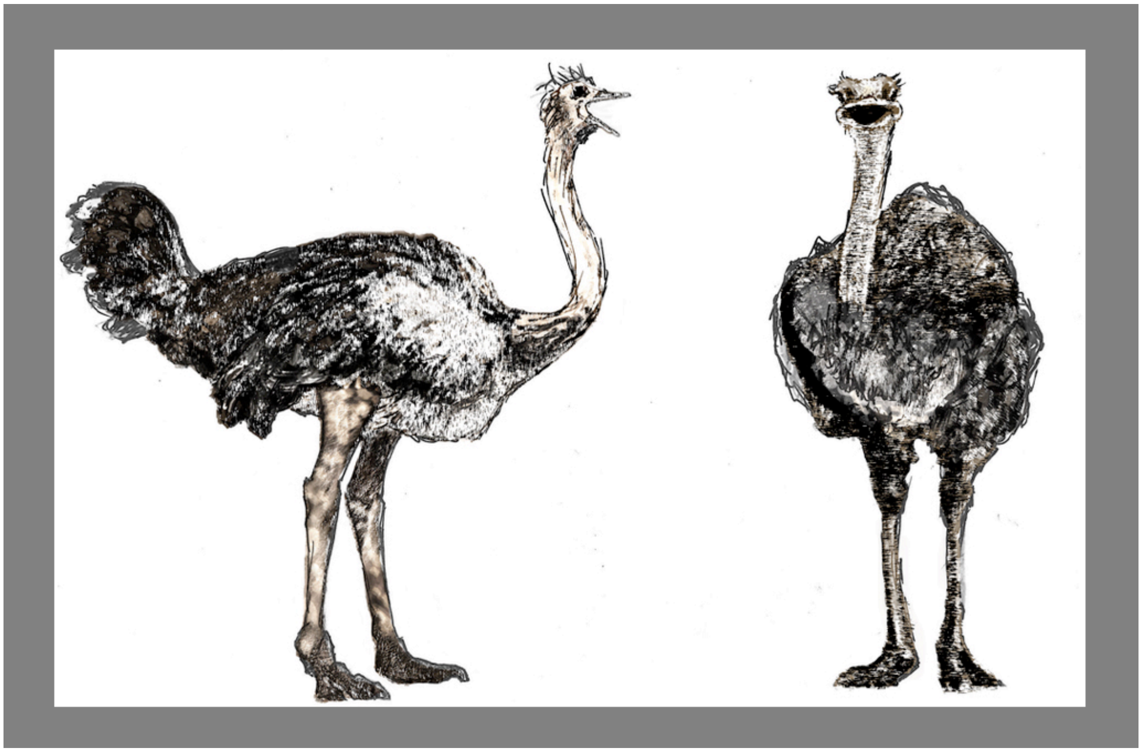

Figure 3.2: Initial character design

3.1 Character Design

Designing the character for *UFO* began with the construction of a library of reference images. This collection contained photographs of ostriches from different angles, and also included photographs of African landscapes and animals that share this natural habitat. Although the initial character design implied a traditional appearance (Figure 3.2), the development of an eccentric personality along with a desire for stylization sent the conservative ostrich back to the drawing board. The textures and colors belonging to co-existing creatures were then borrowed to develop a more unusual look, with the organic patterns creating a unique appearance as well as a sense of familiarity in an uncommon complexion. Figures 3.3, 3.4, and 3.5 show an assortment of images gathered for visual information and texture inspiration.

Figure 3.3: Ostrich reference images [LIVI14] [PETE14]

Figure 3.4: Landscapes and ostrich anatomy reference images from various websites

Figure 3.5: Images found online of co-existing creatures referenced for pattern inspiration

Contrary to conventional theory, the wings of an ostrich are not merely vestigial structures [SOCI10]. Instead, these appendages are sophisticated balancing tools that lend the ostrich extra terrestrial navigation skills, enabling the fleet-footed giant to sprint through uneven terrain and fly by predators with ease. Acting as both aerodynamic rudders and brakes, the wings stabilize the ostrich during quick turns and sudden stops, and are an evolutionary advantage that affords the oversized birds with an unexpected nimbleness. Designing the wings (Figure 3.6) for the unusual ostrich took into account these natural movements, and the limbs were re-modeled multiple times before achieving the precision necessary for rigging.

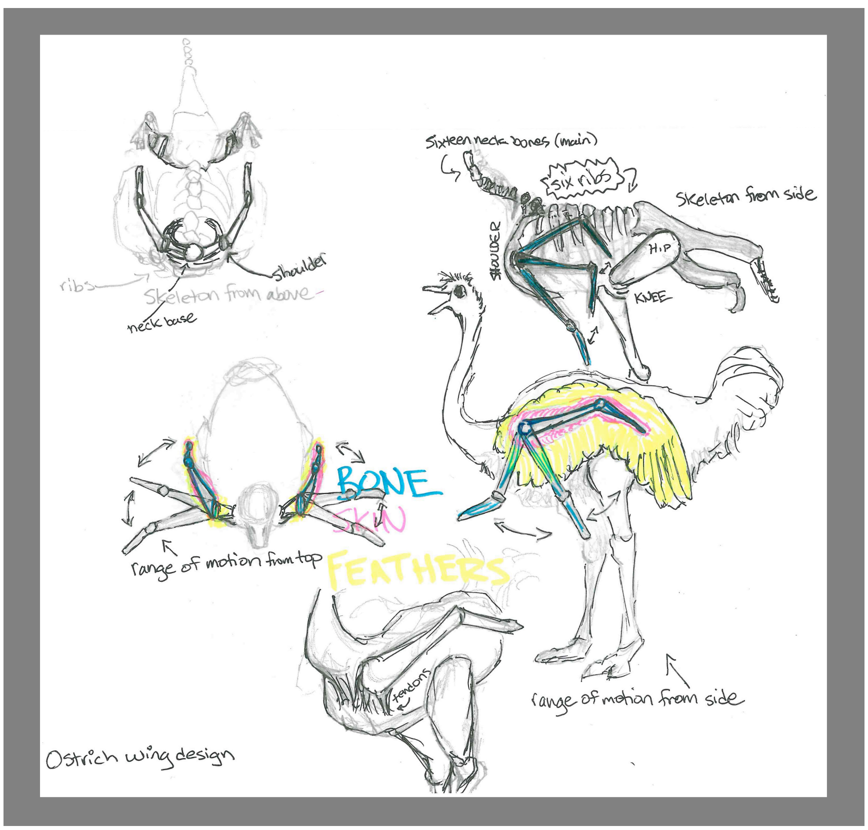

Figure 3.6: Character wing design

The collection of reference material indicated that feathers on an ostrich appear somewhat unkempt and shaggier in nature than feathers found on smaller birds. Additionally, because an ostrich has several different types of plumes, some variation in the degree of dishevelment was appropriate for this feathered phenomenon. Ultimately, this shaggy development added to the allure of the eccentric ostrich, as exaggerating the haphazard messiness of the applied hair and fur provided an additional opportunity to visually enhance the inquisitive personality of the character (Figure 3.7).

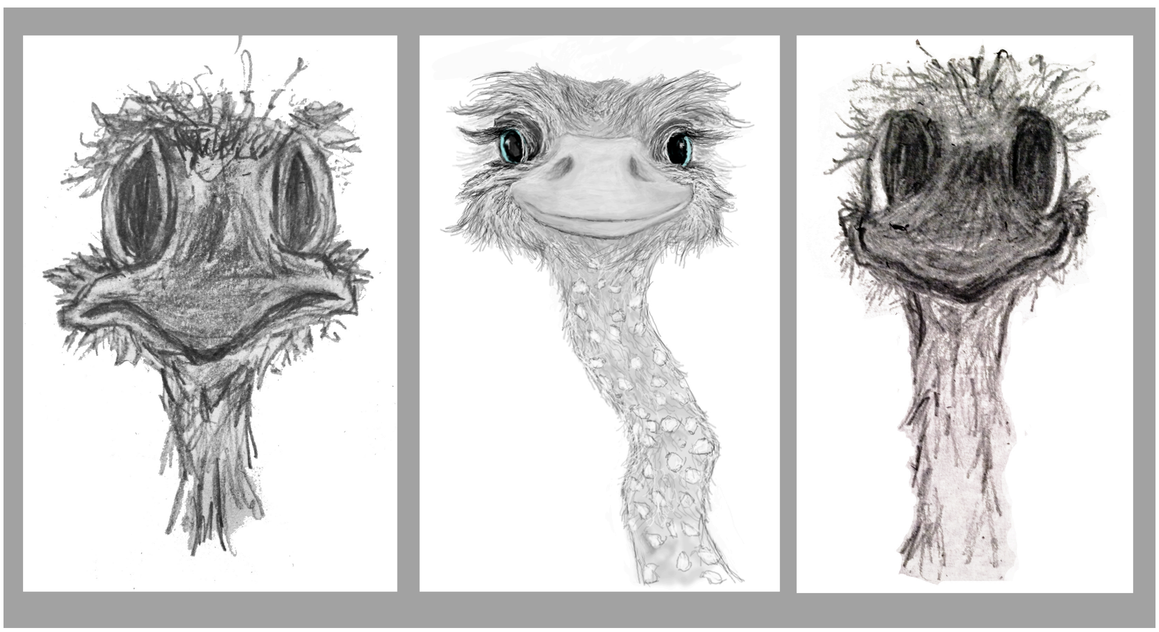

Figure 3.7: Exploratory character designs

3.2 Feather Design

Ostriches typically grow several different types of feathers, each of which must be handled in a unique way [WORL95]. Plume feathers, found on the wing of an ostrich, are large, full feathers that droop gracefully downwards towards the tip. Drab feathers are slightly smaller and less full, but stand somewhat more stiffly than plume feathers and

cover the majority of the body. Tail feathers are nearly as long as plume feathers, but generally lack both the fullness and the droop. Shorter body feathers cover the lower part of the neck, and transition upwards into a mix of downy feathers and fuzzy hair. Finally, the head of an ostrich is covered in short, straight, fur-like hair, and the large eyes are accented with long, glossy lashes.

Since only the shorter body feathers of an ostrich are similar in fashion to the feathers found on other birds, techniques from other CG productions that had successfully created shaggy-looking feathers could be employed. One such example was a stylized version of Xibalba (Figure 3.8), created as a character for *The Book of Life* by Reel FX. This archetypical trickster ruled the Land of the Forgotten, and had wings full of idealized ostrich feathers that were long, shaggy, and styled into an indifferent perfection. Unfortunately, due to the recent release of the film, available information concerning the methods used to achieve these results was lacking. Despite this limitation, however, Xibalba's feathers became the official inspiration for further feather development for *UFO*.

Figure 3.8: Xibalba character design for *The Book of Life* [TURI14] [MCMI14]

3.3 Modeling and UV Layout

After a rough character design was completed, an initial model was sculpted and assigned a corresponding UV layout that allowed for relatively easy updates. This approach permitted further development in the modeling stage while allowing surfacing tests for color and pattern experimentation and alteration to be initiated. While surfacing techniques include the use of procedurally generated patterns, the shading networks created to surface the character in *UFO* were exclusively built from hand-painted maps and textures. This method is commonly used in character surfacing, as hand-painting the model offers optimal artistic control; the downside to this method, however, is found in the time-consuming precision required by the UV layout. For *UFO*, the accuracy of the UV layout was nonnegotiable, and the layout was re-created several times in search of an ideal arrangement that would maximize the allotted space without compromising the ability to easily update specific areas. Figure 3.9 shows the final model and UV layout imported into Mari for texture painting.

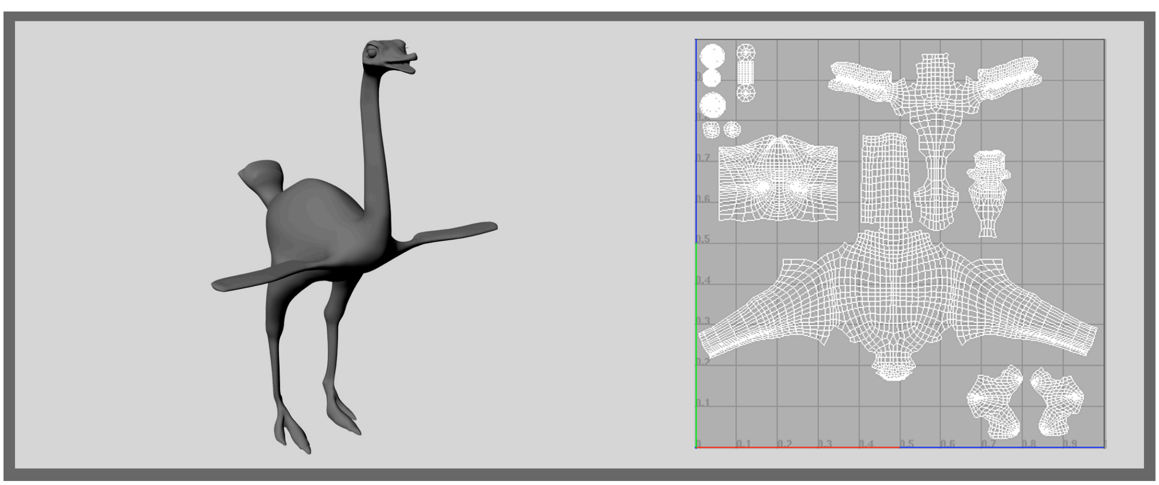

Figure 3.9: Model and UV layout

3.4 Surfacing the Beak

Surfacing the beak provided a unique challenge. Reference material indicated a somewhat bonelike, translucent substance, with color variation ranging from pinks and reds to yellows, browns and greys. For this project, a yellowish tan color was chosen for the similarity it shared with the desired base color for the legs. The smoothness of the beak indicated specular highlights that spread softly outwards, and the material itself required translucency with subsurface scattering throughout. Figure 3.10 shows the reference images used for painting the beak, and includes images of duck bills used for pattern inspiration and character appeal.

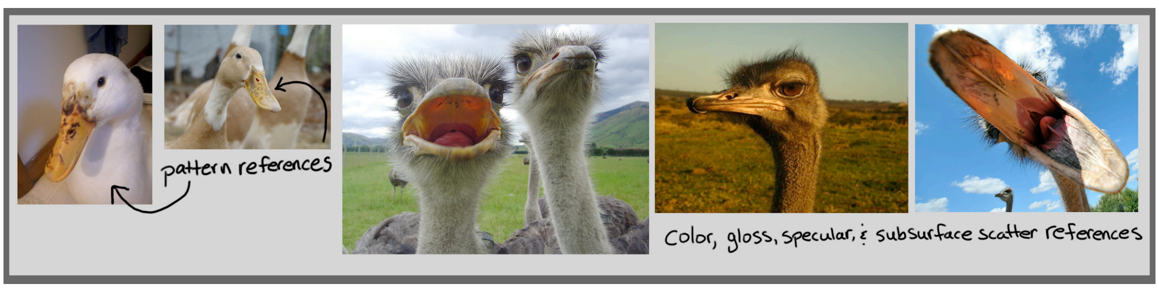

Figure 3.10: Beak reference images collected from various websites

To accomplish the desired appearance for the beak, a variety of maps were painted in Mari and then assigned to a Renderman shader in Maya. The color map was painted using blended layers and a variety of brushes to attain an underlying speckling for color variation, while the specular map contained light grey values that smoothly merged together. A displacement map that slightly detailed the nostrils and the beak edges was added, followed by a gloss map that supported and enhanced the specular map. Finally,

subsurface scattering was attained through the use of a SSS Tint map that was multiplied and mixed with the color map in the Renderman surface shader. The individual results of each of these maps with flat lighting are shown in Figure 3.11.

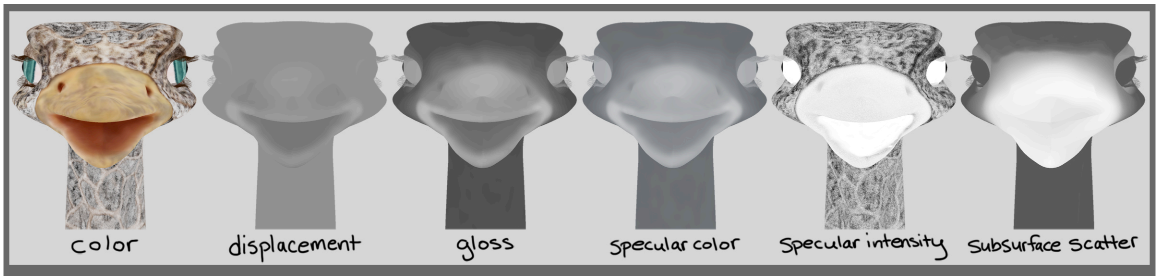

Figure 3.11: Beak texture mapping

3.5 Surfacing the Neck and the Head

The base of the neck is covered in small feathers that transition to fuzzy hair midway up, and end in the straight, short hair covering the head. The color varies slightly among ostriches, but is typically a light, neutral color. For this project, the color map was created using a mixture of patterns, with the dominant shape based on a pattern typically found on giraffes, then overlaid with the smaller spots of a leopard. The colors of the resulting arrangement were then altered, substituting the original hues for a mix of white, grey, and tan to better suit the appearance of the ostrich.

For the fur system on the neck, a baldness map was painted that excluded the rest of the body, and the color map was duplicated twice. The first duplication was then multiplied by itself for darker color values. The second duplication was set to a screen mode that resulted in lighter color values. The darkened color map was then assigned to the base attribute of the fur and the lightened color map was attached to the fur tip

attribute, allowing for an additional range of color in the final fur appearance. These maps are shown individually applied to the model in Mari with flat lighting in Figure 3.12.

Figure 3.12: Neck texture mapping

The head used the same pattern as the neck, with the addition of tan and white masking around the eyes for contrast. The same basic procedure that was used for the neck was used to create the color map for the head, as well as the fur base color map, the fur tip color map, and the baldness map. Because the head was modeled to contain higher resolution than the neck, a fur equalizer map was also painted and assigned to both the head and the neck to ensure a smooth transition of fur between the two. Lastly, although the head of an ostrich is typically covered in straight hair, the chosen look for this character embraced a more haphazard hairstyle, and an additional fur system was required to accomplish this messy mane. This fur system was applied solely to the head, with values in the attribute settings altered for longer, sparser and scragglier fur.

3.6 Surfacing the Eyes

To surface the eyes, a reflectivity map that allowed for maximum reflection along with a transparency map set to full transparency were painted and attached to the shader for the cornea. The cornea model was a slightly enlarged duplication of the iris model, and when viewed in the Maya viewpoint, hid the iris model completely. Once the shader was applied, however, a render of the cornea showed the underlying iris and pupil covered by a thin, reflective sheen that mimicked the wetness of an eye. The iris was surfaced with a variety of freckled brushes to achieve the color variation naturally found in an eye, and the blue color was exaggerated to enhance the stylization. A bump map with a low bump value was added to allow the light to react realistically within the eye, and a specular map with high specularity completed the shader. To finalize the look, the pupil was painted a solid black, and the eyelashes were assigned a deep brown color with high specular values. The individual results of all maps used for surfacing the eyes are shown with flat lighting in Figure 3.13.

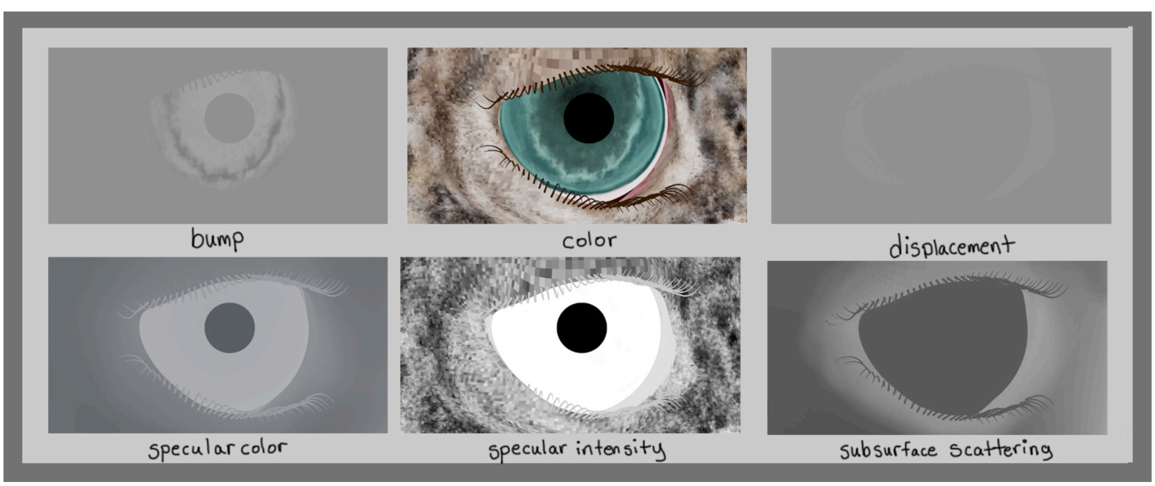

Figure 3.13: Eye texture mapping

3.7 Surfacing the Legs and the Feet

The skin found on the upper leg of an ostrich has a distinct bumpiness on the thigh that can be imitated with a displacement map. The knee and the lower leg are smoother and bonier, with a scale-like material appearing below the knee and continuing downwards along the wrinkled toes. The color of the skin is a pale, cool beige, with a bluish tint visible in the lower legs and varying degrees of red on the scales. The toenails are slightly darker and contain varying degrees of translucency and subsurface scatter. Finally, the wrinkled roughness of the feet allows specular highlights to dance amidst slight displacement, mimicking the crevices and nicks found on the foot of a bird that was born to run.

For the ostrich in *UFO*, color changes were made to the scales that complemented the natural shade of red. A zebra-based pattern was added and then toned down with the substitution of colors found on an African wild dog. Although the scales on the feet retained a more zebra-like pattern, blurring and smudging the scales on the upper leg in imitation of the seemingly random markings of the wild dog helped to integrate the pattern into the overall look. The skin was then created using multiple layers set to various blend modes and opacities, an assortment of organic brushes that simulated the appearance of veins, freckles, and sun spots, and colors ranging in shades of blue, tan, yellow, and red.

The displacement map created skin folds around the ankles and the back of the knees, wrinkles of varying depth in the feet and legs, and the distinct bumpiness of the thighs. The scales were also taken into consideration by this map as it elevated them

away from the leg and the foot to create additional detail. This detail was confirmed by the treatment from the specular map and the gloss map, ensuring a shine that reflected from the top of the scales while encouraging light absorption in the cracks. A specular color map was painted to reflect the underlying blue tint commonly found in skin. Finally, a map for subsurface scattering was created by altering and blurring the specular map and then mixing it with the color map in the Renderman shader. Figure 3.14 shows a close-up of the color map and the displacement map individually with flat lighting. Figure 3.15 shows the entire assortment of texture mapping for the legs and feet individually in Mari, with flat lighting, and from different angles, while Figure 3.16 shows images of the feet rendered using Renderman for Maya with a focus on the wrinkles created from the displacement map.

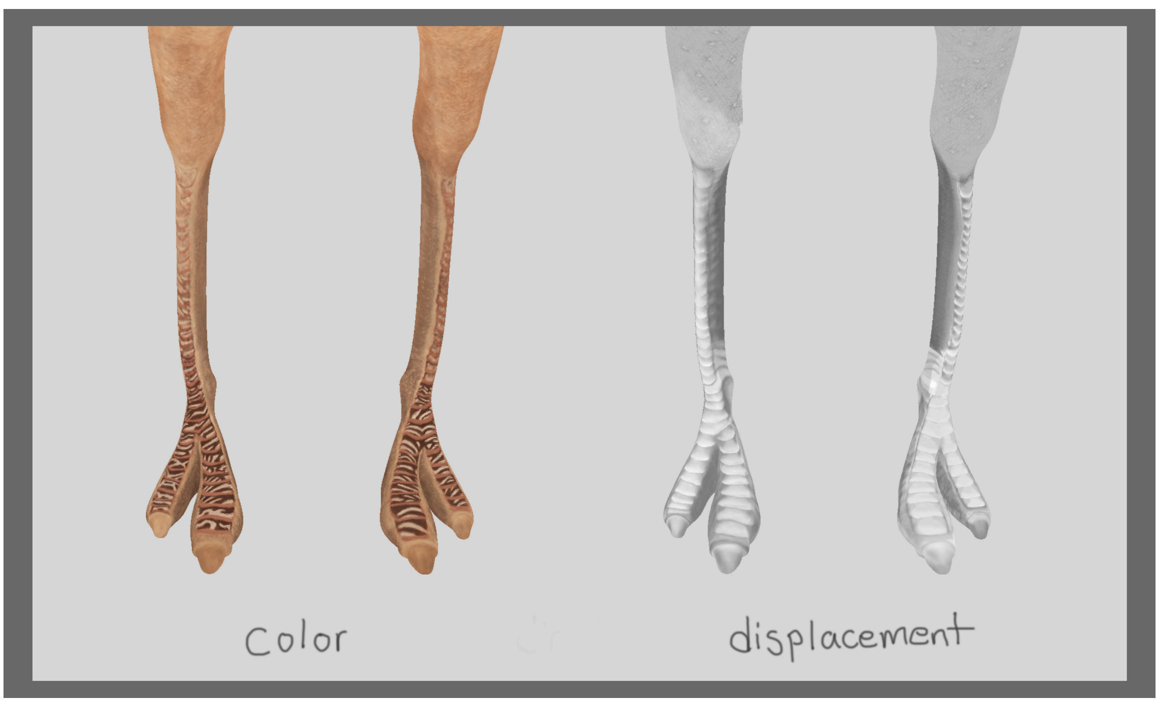

Figure 3.14: Close-up of color and displacement mapping for the legs and feet

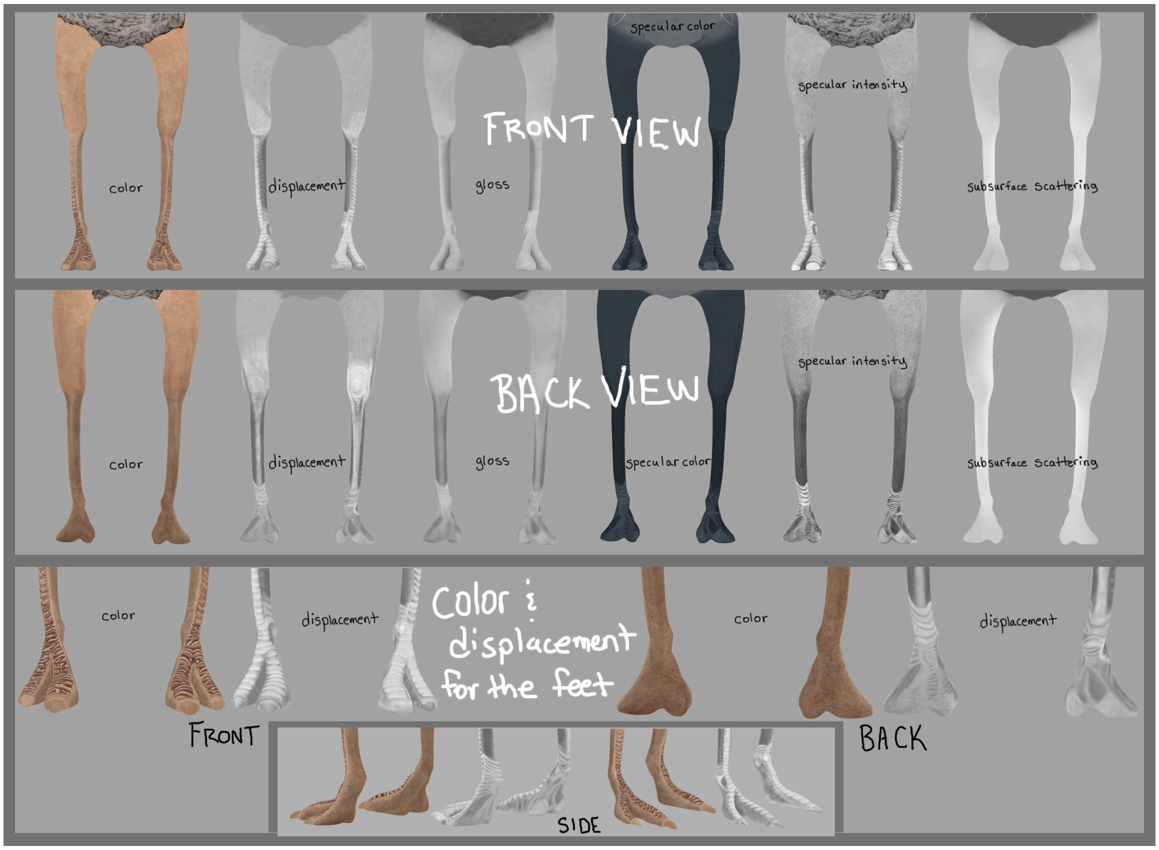

Figure 3.15: Texture mapping for the legs and the feet

Figure 3.16: Feet with color, displacement, specularity, gloss, and subsurface scatter

3.8 Creating the Fur-System Feathers

Procedurally generated geometry enhanced with fur systems created the desired shagginess of the larger feathers that cover the body. To achieve this look, a polygonal cylinder resembling the quill of a feather was created to act as the reference geometry for the placement of multiple feathers. This placement was accomplished using a feather placement tool called Dodo Master [EYEF10] that is capable of creating, styling, and animating feathers in Maya.

Since the ostrich had been modeled as a polygonal object, but Dodo Master works exclusively with NURBS geometry, the body of the ostrich was duplicated and converted to a subdivision surface. This conversion then allowed for an additional conversion to a NURBS surface. The process of initially attaching the instanced quills to the converted model allowed the tool to be used for the placement and grooming of quills that could then easily be transferred to the original polygonal model. Figure 3.17 shows the instanced quills after placement and grooming.

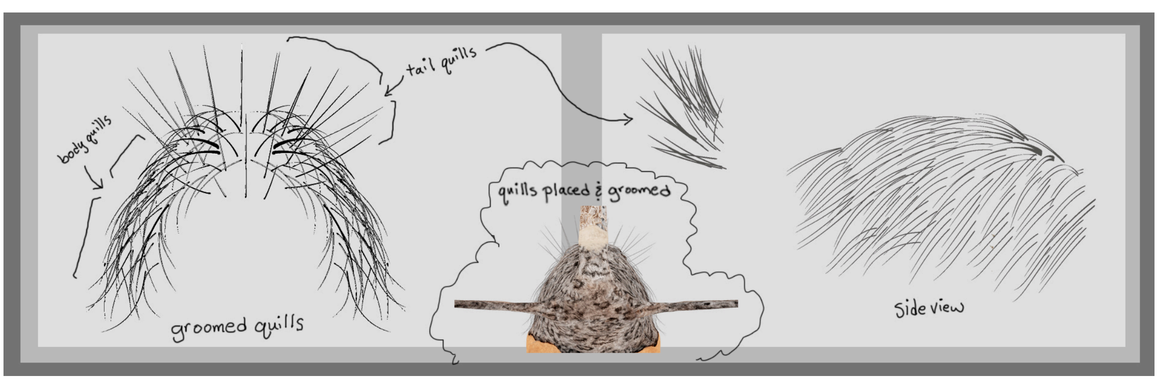

Figure 3.17: Quills after being placed and groomed

Because the UV layout of the original quill had been performed before referencing, each newly placed quill included an identical UV layout to match. This approach was necessary to avoid the tedious task of painting multiple maps for baldness and length when assigning the fur system to the quills. With each quill initially possessing identical attributes, the overall look could be generated with relative ease, and individual quills could be edited as desired.

While building the fur system for the body feathers, multiple attributes were considered. For the baldness attribute, a map was painted in Mari that was entirely black except for two thin, white stripes located on opposite sides of the quill (Figure 3.18). After baking this map into the fur system in Maya, the fur sprouted exclusively from the strips of white, resulting in the appearance of a rough, featherlike object.

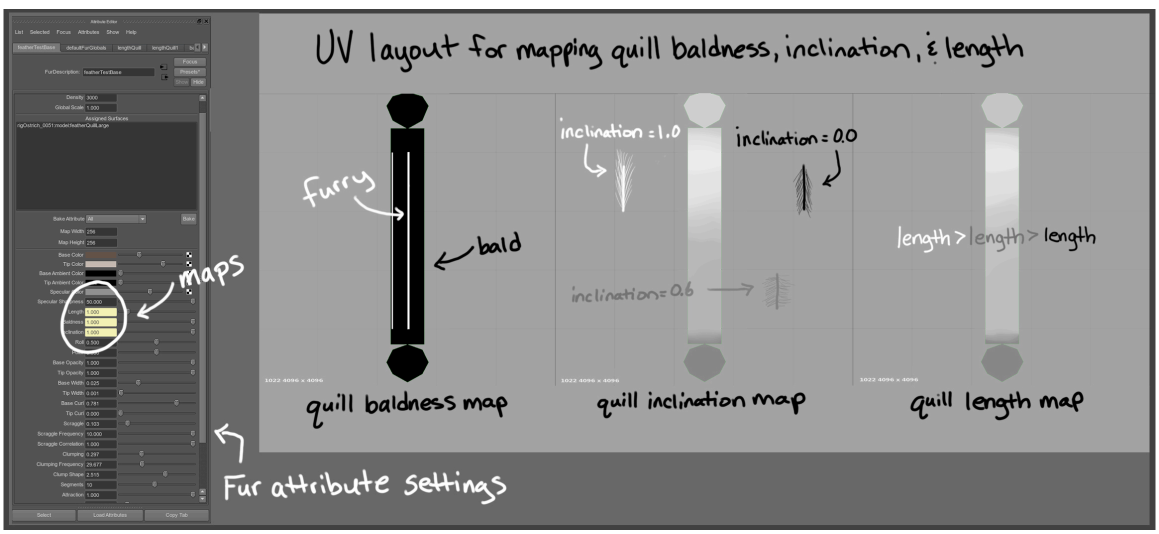

Figure 3.18: Quill maps and fur attributes

After adjusting the roll, polar, and color attributes, adding varying amounts of base and tip curl, and introducing a slight amount of scraggle and clumping, the feathers began to take on the desired look. Additional adjustments came in the form of two greyscale maps used to assign inclination and length, as shown in Figure 3.18. The resulting feathers are displayed in Figure 3.19, while Figure 3.20 shows the effects of the maps and the attribute settings individually.

Figure 3.19: Fur system feathers (side view)

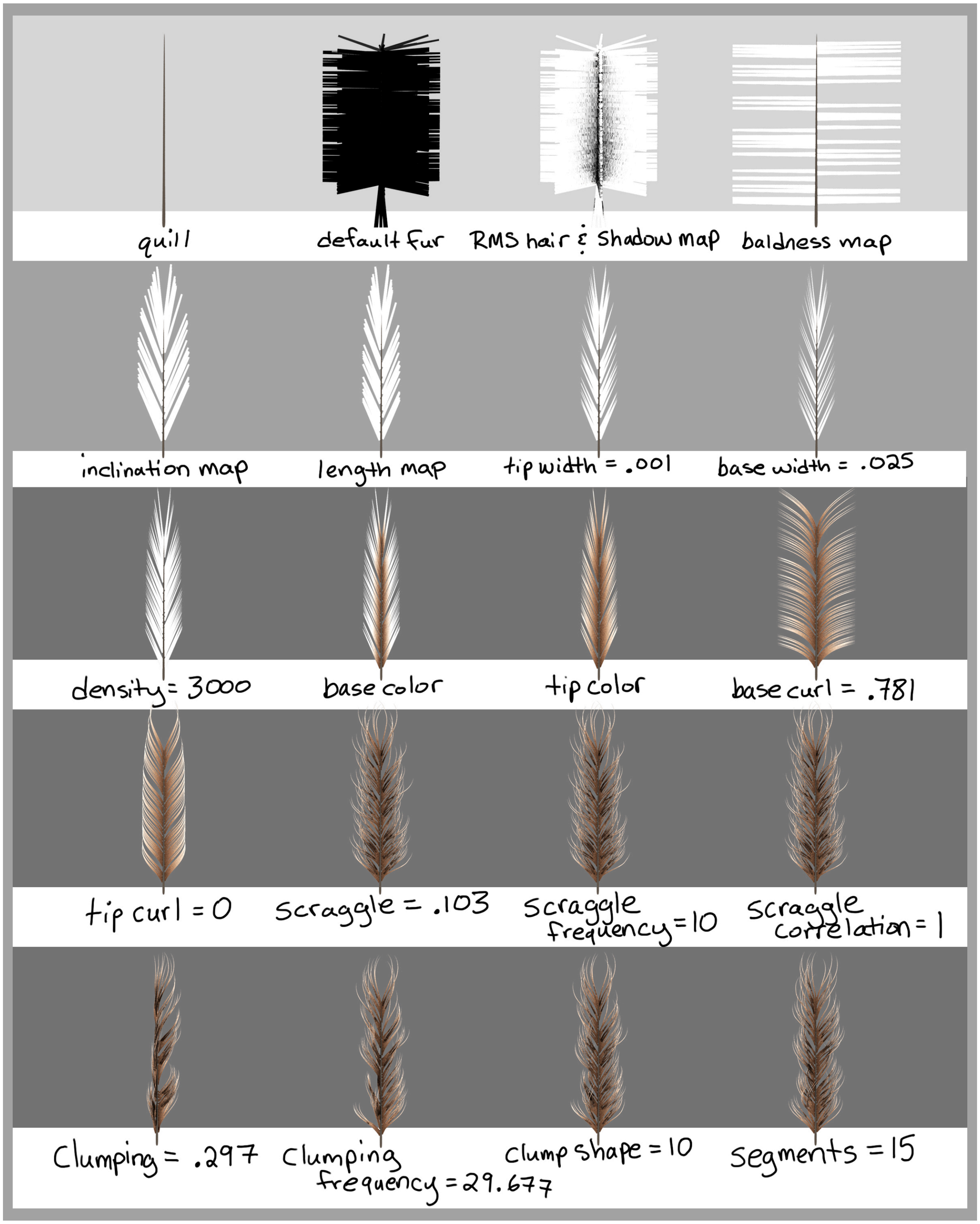

Figure 3.20: Quill mapping and fur system attribute effects

3.9 Creating the Polygonal Feathers

To create the smaller feathers, a single plane was first created and shaped into a basic feather-like form. From this plane, Dodo Master was again used to create, place, and style instanced geometry. Unlike the quills, however, the UV layout for the feathers required more individuality to allow for greater control when painting the color, specular, and transparency maps.

The desired UV layout was accomplished by creating an initial UV layout using planar mapping for the original piece of plane geometry only. The feathers were then grouped according to location, and each group was assigned to the initial UV layout using a python script that transferred attributes from one object onto multiple objects (Figure 3.21).

```
import maya.cmds as cm

#grab all the selected objects

selectedObjects = cm.ls(sl=True)

#save first one into variable

#pop first one out of the selected objects list

driver = selectedObjects.pop(0)

#for each object in the selected objects list

for object in selectedObjects:

    cm.select([driver,object])

    #transfer attributes

    cm.transferAttributes(sampleSpace=4,transferUVs=2, transferColors=2 )
```

Figure 3.21: Python script for transferring attributes to multiple objects [PRAD12]

With each object now possessing an individual UV layout, an assortment of feathers were selected for variation in the final appearance. Using the layout option in Maya, these feathers were automatically placed in separate patches according to the assigned group. This technique allowed certain feathers to receive alternate designs without creating the need to paint each feather individually.

Since certain feathers had been scaled during the styling process, the final step towards optimizing the UV layout for the feathers was ensuring that each feather corresponded exactly to the UVs it had been assigned. To accomplish this likeness, the unfold option in Maya was utilized, causing the UVs to deform and scale where appropriate. Finally, maps for color, specularity, and transparency were painted and assigned to each feather. Figure 3.22 shows the groomed feathers with the color and specularity maps rendered with Renderman for Maya.

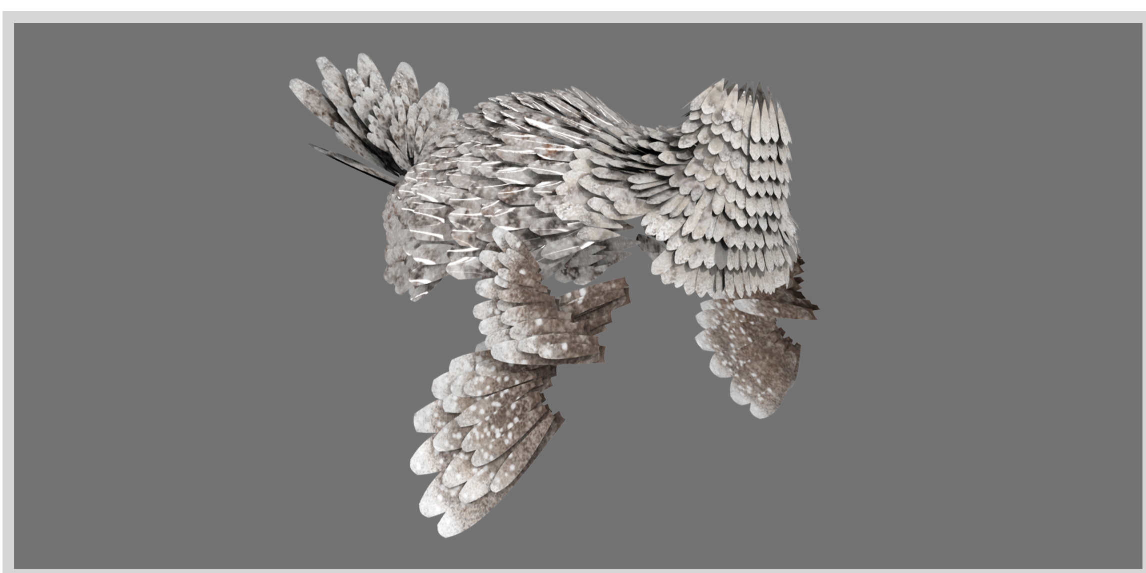

Figure 3.22: Groomed polygonal feathers

CHAPTER FOUR

RESULTS

The process of surfacing and feathering the unusual flying ostrich using a mixture of patterns, fur and geometry was challenging, yet ultimately rewarding. This chapter showcases the final results attained through trial, error, and iteration. The final texture maps for the entire character are shown individually in Figure 4.1 with flat lighting, while Figure 4.2 shows the final shading network and shader attributes and Figure 4.3 illustrates the final fur system attributes.

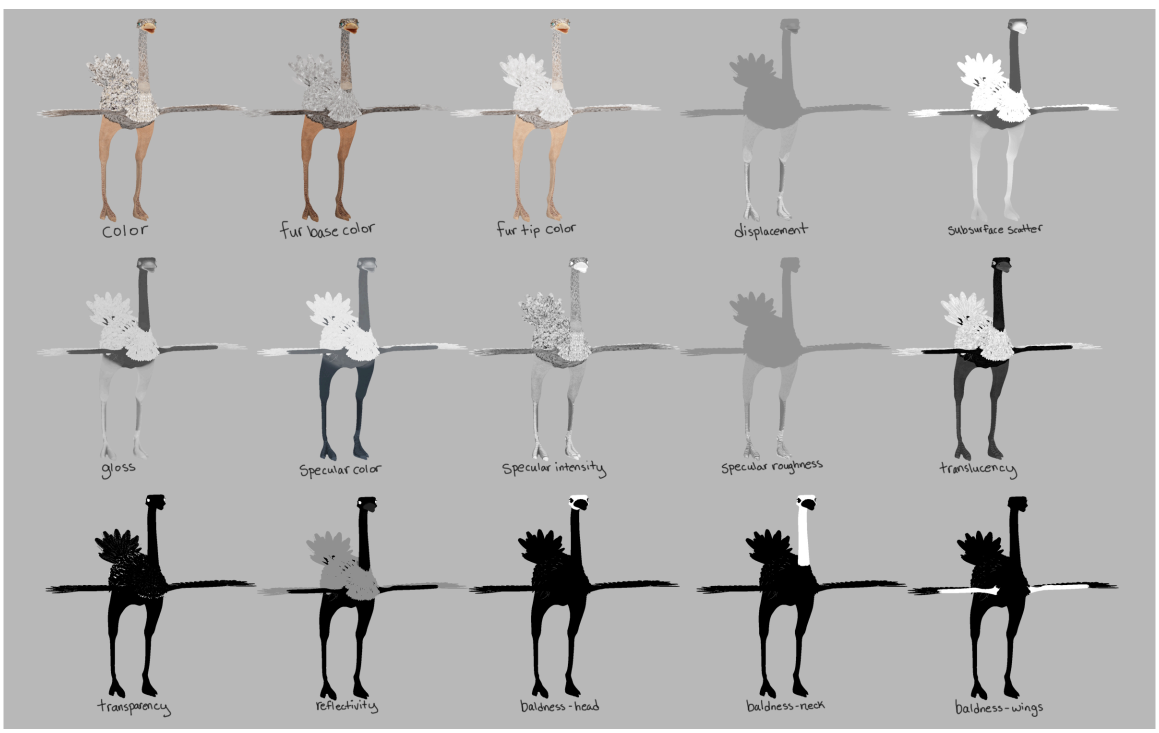

Figure 4.1: Character texture maps

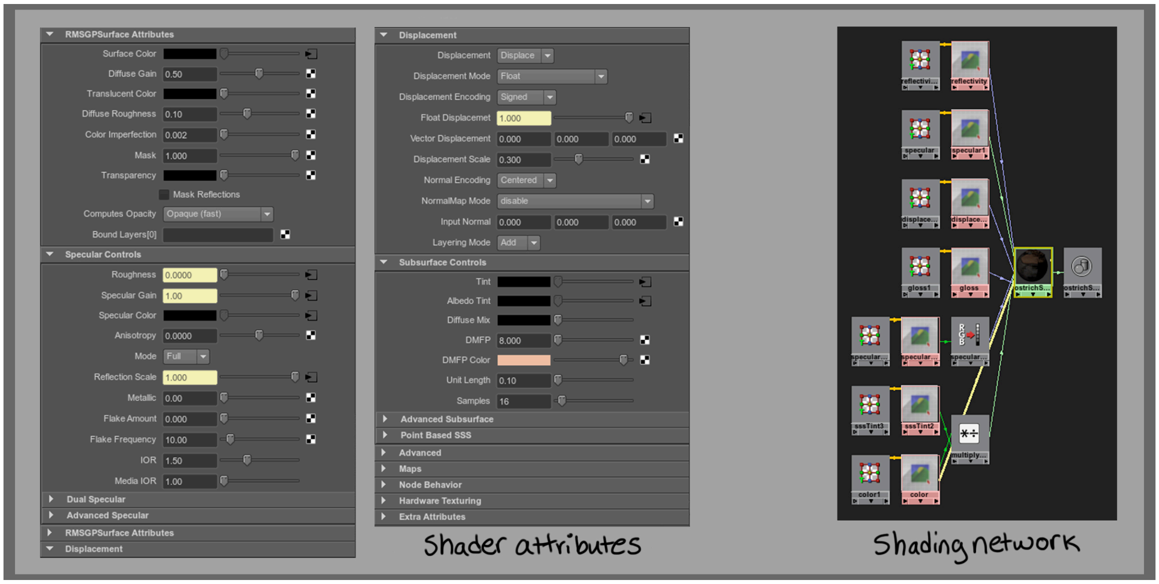

Figure 4.2: Final shading network and shader attributes

Figure 4.3: Final fur system attributes

Figures 4.4 – 4.9 show the final surfaced assets for shot 01, including the posed character with polygonal feathers and attached fur systems, rendered in layers and composited with an initial lighting setup. Specifically, Figure 4.4 shows only the rendered ground layer for shot 01, Figure 4.5 incorporates the matte-painted backdrop, and Figure 4.6 includes the rendered props. Finally, Figures 4.7, 4.8, and 4.9 show the rendered character, with the first image showing the character with polygonal feathers only, the second image including the fur system feathers, and the final image compositing in the fur systems for the neck, head, and wings.

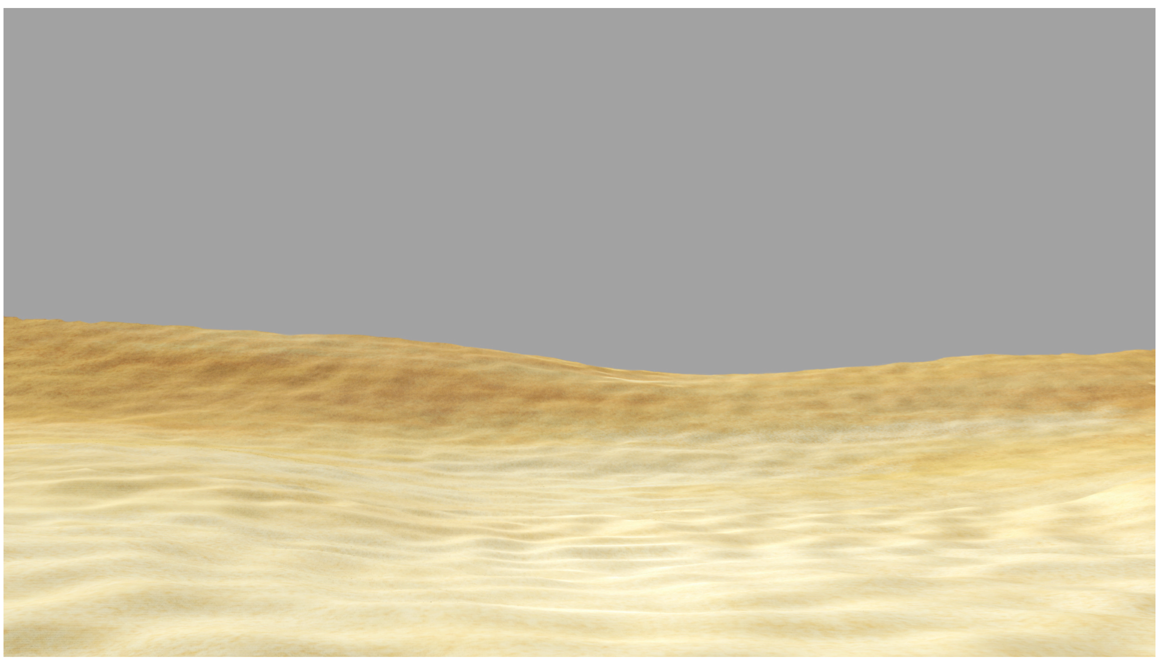

Figure 4.4: Shot 01with ground

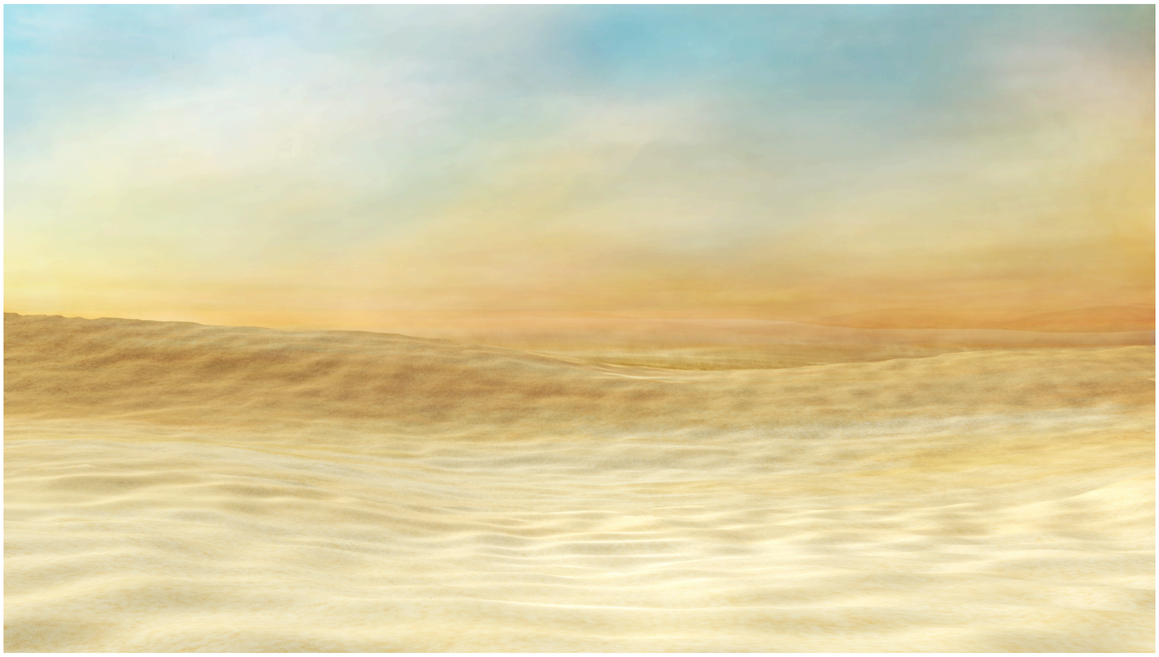

Figure 4.5: Shot 01 with matte-painted backdrop

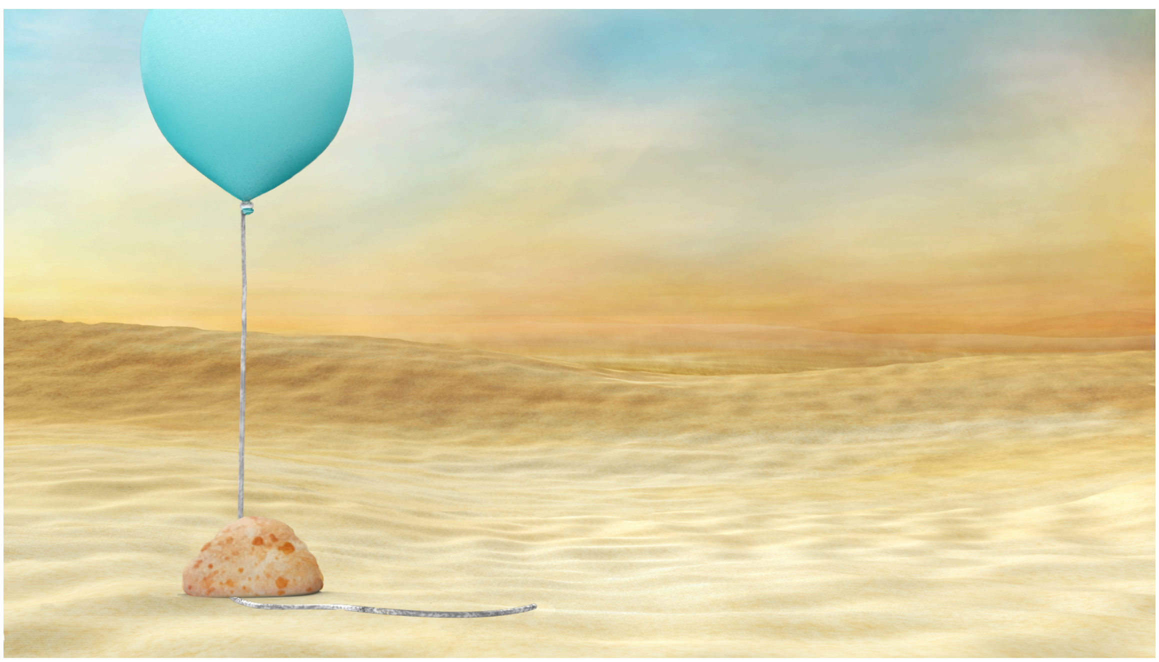

Figure 4.6: Shot 01 with props

Figure 4.7: Shot 01 with ostrich and polygonal feathers

Figure 4.8: Shot 01 with fur system feathers

Figure 4.9: Shot 01 with head and neck fur

CHAPTER FIVE

CONCLUSION

The aviation aspirations of the nearly quarter-ton bird in *UFO* created a simple narrative that served as a basis for character development. Creating this stylized character required research and attention to detail concerning all aspects of design, modeling, and surfacing. Although unusual flying ostriches are not found in nature, reference material featuring ordinary ostriches and organic patterns was used to keep the feathery, flightless fowl in *UFO* grounded and believable. After the initial character designs were completed, the modeling stage re-created and elaborated on these designs. This process included finding a balance between polygon count and texture resolution to attain maximum efficiency. Creating a logical UV layout that both maximized the available space and flowed in an anatomically consistent manner was vital, as texture maps gave the character color, life, and additional detail, and relied heavily on the UV layout.

Finally, character effects like fur and feathers are essential in creating a sense of realism for a majority of creatures, with many different ways available to approach this process. The desired results and the situation in question, however, were considered when choosing the method of application for this project, as stylized feathers can opt to omit the fine detail required for photorealism, and a far-off or motion-blurred shot is more forgiving then a close-up. For *UFO*, the methods discussed in this thesis were chosen for several reasons, both practical and artistic, that included pipeline considerations and tool availability as well as look development. The use of fur in particular was selected for the

equal contribution it made to both the quirky personality of the unusual flying ostrich as well as to the stylized tribute it paid to the feathers of an actual ostrich.

The concept of producing a feathered appearance using vector displacement was briefly investigated during the research and development stage for this project, and if time had allowed for additional experimentation, this method would have been pursued further. Another opportunity for feather creation lies in xGen by Pixar, a newly available plug-in for Maya 2015 [DIGI14]. This tool is used for creating and grooming instanced geometry, fur, and hair, and makes the creation of feathers considerably easier. Finally, customization of fur shaders to create feather systems is one of the many advantages of using Renderman, and allows for endless opportunities for creating both photorealistic and stylized feathers for a variety of situations.

While many techniques are currently used to create feathers for CG characters, plenty of room exists for further exploration. Most of the techniques discussed in this thesis are capable of producing excellent visual results, but also require some manual adjustment to avoid interpenetration. The development of methods that create realistic interaction between feathers is highly desirable, and improvement in techniques that encourage feathers to flock together will serve to enhance the look and believability of feathered creatures in future productions.

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