BA Computer Visualisation and Animation: Year 3

Innovations in Computer Graphics

Bird Wing Development For Computer Graphics

Annah Hutchings

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Abstract

The aim of this project is to produce a fully modelled, textured and rigged bird wing that can fold, open and flap effectively. This paper discusses the various ways that the modelling and rigging could be implemented by looking at how various film and game companies have attempted this in the past. This paper charts the findings of this research as well as recording how the techniques identified could be applied to wings I create myself. After analysing various approaches, I create a tutorial that follows my attempt to create a bird wing myself. The tutorial is aimed at students who know enough about Maya to understand the controls for modelling, texturing and rigging, and how to use them.

Introduction

It is my intention for this project to act primarily as a personal learning experience as 'Innovations' to me, meant that I should introduce something new to myself, and not base it upon what other students have done before. However, I also wished to link it in with my major project so that one could benefit the other. Within my major project I have a character, that although is humanoid in shape, has huge feather wings sprouting from it's back. The character does not fly, but I felt that for this project I could look into bird wings in more detail and create wings that mimic the structure of real wings as much as possible. There will be many issues to address such as wing type – it's size, shape, how the feathers will be layered, how the wing will be modelled, and how the wing will be rigged for the best result.

Within this report I wish to look into how these wings could be modeled in a way that their structure can be used not only for my character, but also for birds and other creatures. I will look into a variety of methods that achieve the same goal and discuss how well they overcame obstacles. The software I will be using is Alias Maya for the modeling, and Adobe Photoshop for painting textures. I hope my tutorials will be of use to other students who wish to model birds wings.

Wings In Computer Animation

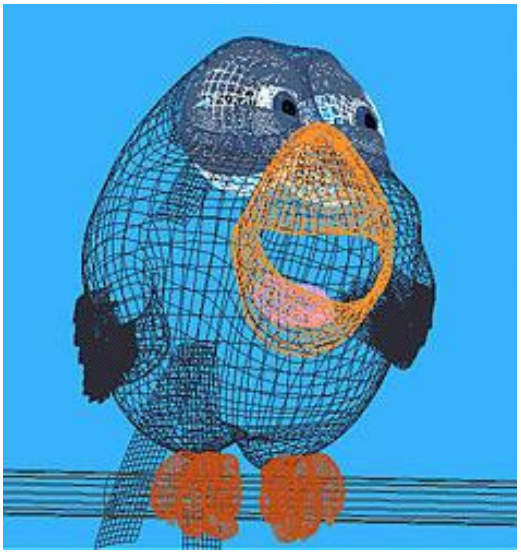
The characters in 'For the birds'. You can see the detail of the feathers clearly in this shot.

Source: http://www.pixar.com

The characters and scenes in "For The Birds (2000)" were modeled with Alias Maya and articulated with Pixar's proprietary modeling tools. The 15 small birds are all the same model - except for minor variations in the coloring. However, they were all given different personalities so that the audience could tell they were not just the same bird. The bird models contain around 2800 feathers each, which may look nice when rendered, but caused a lot of trouble when it came to animating them as each model's file size was huge.

"The feathers were difficult for as number of reasons. Even though the birds aren't realistic, we wanted to distribute the feathers over their bodies in a somewhat realistic manner. That in itself wasn't hard; we simply came up with a space-repositioning scheme. But it was a real problem in terms of weight. There are around 2800 feathers on a single bird, and that's a lot of geometry. It was about 400mb of pure geometry per bird.”

Bill Wise, 3dworld



The wireframe of one of the smaller birds.

Source: http://www.pixar.com

In the end they got it down to 60mb per bird, but it wasn’t enough for the animators. The models were good for basic positioning, but a lot of the animation was to be conveyed through the feather movement and a way was needed to display enough detail. Pixar worked out a control to show one in every ten feathers so it showed the motion better, and a render would show the finished effect.

In Valiant (2005), the characters sometimes needed to use their wings as hands and fingers, as well as being realistic in shape and design enough to fly. To do this they made the wing as flexible as possible, and gave the main primary flight feathers the ability to bend and twist to mimic fingers.

“In all productions, the modeling technique is usually dependent on the pipeline or structure of the production. For Valiant, we started using only Nurbs surfaces for the sets, but towards the end we used more polygons and subdivision surfaces. However, for the current project I'm working on, everything is modeled using polygons, then subdivided later. In the majority of cases, technical issues are at the heart of how something is modeled, e.g. the rendering process that is going to be used, what way the textures should be applied to the models if fur or feathers are needed, etc."

Leo Sanchez, Senior Modeler

An image of the characters, showing their multi-functional wings.

Source: http://movies.apple.com/trailers/disney/valiant/assets/characters.jpg

For Valiant, the film production company – Vanguard studios, used Houdini to create the realistic feathers.

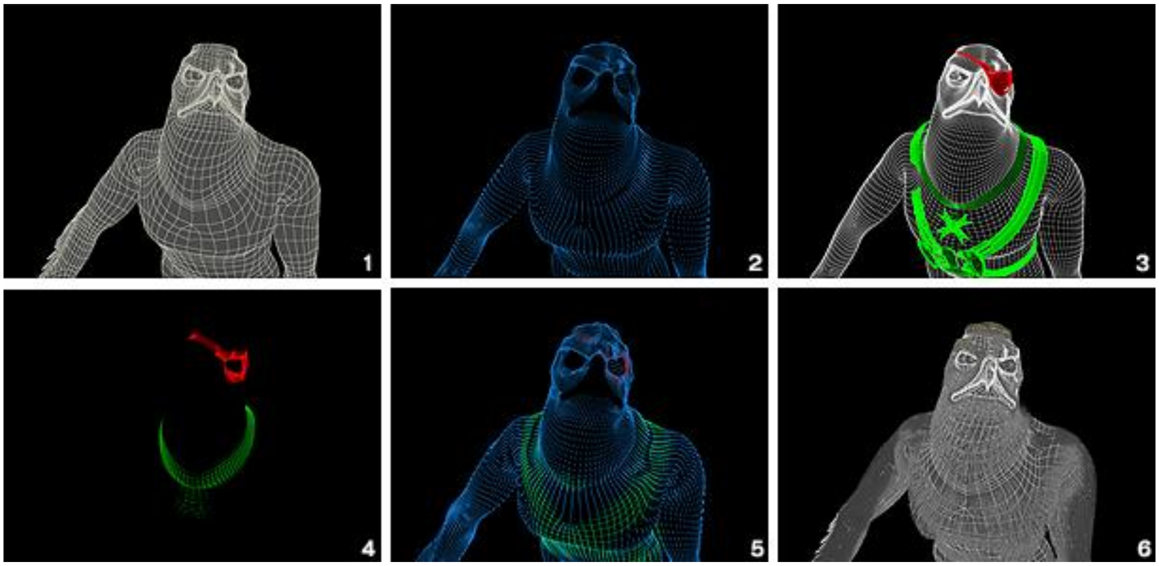
"Each of the 30 main bird characters went through a rigorous grooming process to form the basis for feathering throughout the film. Houdini was the best choice of software to achieve the incredible realism and fine detail we were aiming for with the feathers and character interaction."

Rod McFall, CG supervisor,

http://www.sidefx.com/index.php?option=com_content&task=view&id=297&Itemid=68

They imported the characters into Houdini as geometry files to begin the long 'grooming' process. They all needed maps to define their own feather size and density, which would form the basis for the entire feathering throughout the film.

Since the birds would be wearing clothes, they also had to define where feathers would be in contact or underneath cloths so they would need to be pushed down. This tool worked procedurally so the feather would change with regard to the clothing and the surface of the bird over time.



Images showing the various stages of grooming. 1 shows the main geometry, of which the surface normals are altered to reflect the size of the feathers – 2. 3 shows the clothing, 4 and 5 show where the clothing would push down on the feathers, and 6 shows the rough layout of the feathers.

Source:

http://www.sidefx.com/index.php?option=com_content&task=view&id=297&Itemid=68

Angel, from 'X-men 3 – The Last Stand (2006)' is an excellent reference for using 'bird wings' on another creature. This effect that Framestore CFC brought to the X-Men movie was built on the proprietary feather system based on technology the company had developed for the Hippogriff for Harry Potter and the Prisoner of Azkaban and the Pegasus in Harry Potter and the Goblet of Fire:

"It was all of our custom code. It's legacy code, which is a good and a bad thing because we adopted another show's work. We took the code from the Hippogriff, (which was like a Pegasus,) in the Harry Potter movie. That was part of the reason why we got the work. We used a lot of that code to create the wings for Angel. Parts of the wing was procedurally generated, specifically the smaller feathers."
Craig Lyn, http://www.cgnews.com/Features/p2_articleid/1323

They used Maya and Renderman to add CG wings to a live action actor, as well as replacing him altogether with a full CG double in some shots. They used hundreds of thousands of feathers on each wing due to all the small downy feathers that have to be shown. The rigging had to be very dynamic and flexible to allow the wing to fold and open without the feathers bunching up in the wrong place.

The character 'Angel' as he takes flight. The film company used CG wings and model wings for different shots.

Source: http://entimg.msn.com/i/gal/X3/FX-1_400.jpg

It took the animators at London's Framestore CFC 15 months of cutting-edge computer wizardry to bring over 80 Hippogriff shots for 'Harry Potter and the Prisoner of Azkaban (2004)'. Buckbeak, a hippogryph, is a combination of both the front end of an eagle, and the back end of a horse. This requires fur, hair, and feathers, and a way of blending them in so the arrangement looks as natural as possible. The animators compromised on nothing to make Buckbeak as real as possible. They made every feather for him, and then wrote a program to get all the feathers to move together like the real thing.

Source: http://encyclopedia.quickseek.com/images/Buckbeak.jpg

"A big challenge was to develop a wing that could move from fully outstretched to fully folded without interruption. The grooming and packing of the feathers have to be precisely correct."

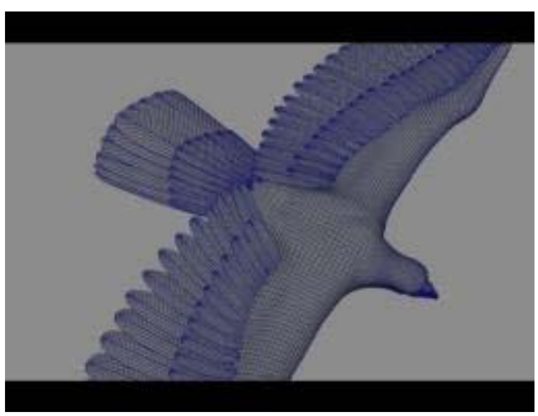
David Lomax, http://www.framestore-cfc.com/feature/harrypotter_azkaban/index.html

However, to fly something as heavy as a horse, you need proportionally big wings. Framestore CFC worked out that the right proportions for the wingspan were about 28 feet. There was only one problem: Wings that big would drag on the ground and even trip a hippogriff. But being a computer creation you can do anything, so Buckbeak was given smaller wings when he wasn't flying.

The first model of Gwailhir, the bare minimum needed due to the time frame.

Source: portal.acm.org/ft_gateway.cfm?id=1103911&type=pdf

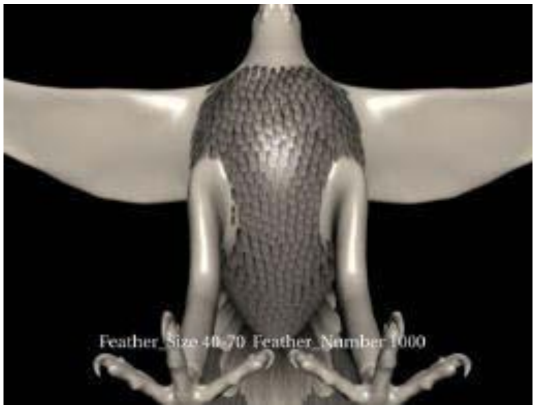
Lord of the Rings (2001, 2002, 2003) was a fest of computer animation, one of the computer-generated creatures being Gwaihir The Windlord – a giant eagle.
There were two different versions Gwaihir used in the films. The first one was modeled to the bare minimum needed at the time and used in the first film for a brief nighttime appearance. The second model used for the last film was a re-build of the first, moving from nurbs to a sub-division topology and rigged with a muscle model. The detail was added using displacement maps created in ZBrush.



The wireframe of Gwaihir. You can see the amount of detail put into the feathers and muscles.

Source: portal.acm.org/ft_gateway.cfm?id=1103911&type=pdf

The feather setup was created using a separate subdivision surface to the main body of the bird for the main (primary and secondary) feathers which were under a rig so the animator could control them. The 1000 smaller body feathers were created using fur and code. These were all modeled individually out of polygons and manually placed across the body as painting them on gave the impression of a plucked bird.



All the feathers had to be placed manually on the model as painting them on left the feathers sticking out at odd angles and not lying flat against the bird.

Source: portal.acm.org/ft_gateway.cfm?id=1103911&type=pdf

Unfortunately, due to the sheer number of feathers overlapping, when the wings flapped they produced a ripple of colour change as the body feathers penetrated each other with the movement. Collision detection between feathers was tried, but it made the bird look puffed out rather then sleek and powerful. Finally they decided to ignore the feather penetrations and wrote a shader to render each feather on top of another in the order they were originally placed by using the original bindpose as the feather position.

Source: http://www.phoenixdown.it/FF9/FF9/wp/alexandria_1024.jpg

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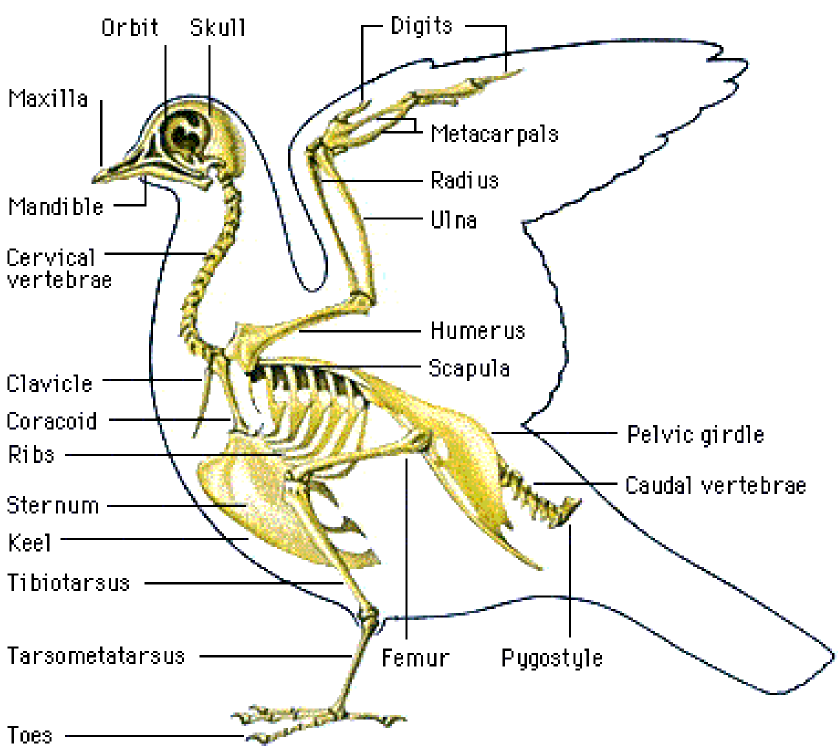
The many different uses of feathered wings can be easily seen in video games, the examples above and below from Final Fantasy 9 show you can stick a pair of wings onto literally anything. In this case, the wings do not have to be able to fly, they are there to protect the castle -this is Final Fantasy where anything can happen. Although these images are from a cinematic and not game play, polygons are still used. The wings only have a thin main stem from where all the feather plains originate, but it still manages to create something that looks like feathers on a wing, and functions well enough for what is needed.

Source: http://www.phoenixdown.it/FF9/FF9/wp/alexandria_1024.jpg

Introduction to Wing Structure

The most diverse group of flyers ever to evolve is the birds. Fossil records show that birds have been flying for millions of years, even before we could walk. Computer animation research has produced a number of models for the natural motion of land animals, but perhaps more intriguing is the motion of animals in flight. From the very start of recorded time we have been watching birds fly. They can do amazing acrobatics in the air, and fly as fast as any land-bound animal can run. Birds show a marvelous diversity not only of species but also of flight adaptations. Compare the hummingbird with the albatross, and the albatross with the hawk, and you'll get a good picture of how differently animals can fly.

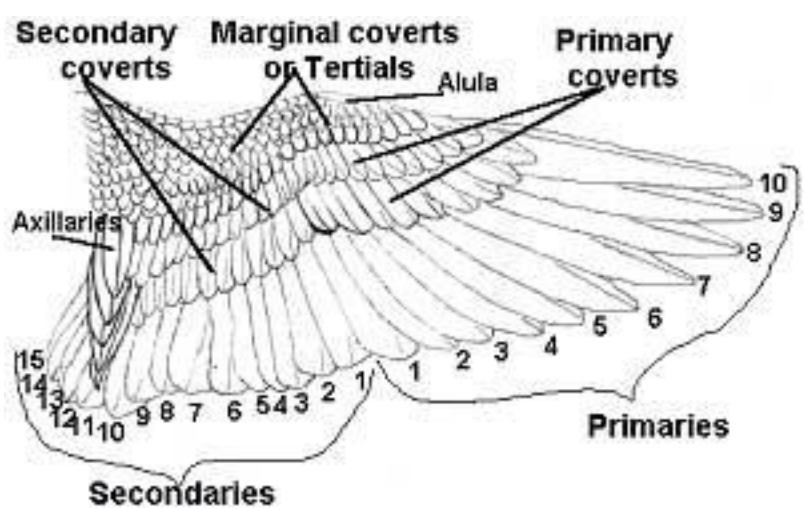
Wing Anatomy



World Book Illustration by James Teason

A bird's wing is the basic structure for flight. The actual wing is a modified forelimb, with a skeletal structure like an arm – birds have two bones in the lower part of the limb. The rest of the wing is composed of modified hand bones that are highly fused for strength and feather support.

The first digit is small and supports the Alula. The second digit is larger and flatter as it extends the wing, the purpose of which is to serve as an anchor for the primaries (as does the Ulna), one of two groups of feathers responsible for the airfoil shape. The other set of flight feathers that are behind the carpal joint on the ulna and originate from the humorous, are called the secondaries or cubitals. The third digit is very small, it arises from the same pint as the second digit and also helps support the primaries. The remaining feathers on the wing are known as coverts, of which there are three sets – primary, secondary and marginal (tertial) coverts. The largest wing coverts are adjacent the wing feathers digressing in size toward the wings leading edge. The upper wing coverts, like contour feathers, are convex. Under wing coverts are concave, which fits them up into the underside curve of the wing.



A diagram showing the various feathers on a wing.

Source: http://www.earthlife.net/birds/images/anatomy/wing.gif

It is the rigidity that makes the wing so strong. The bird's "elbow" is also designed so that it cannot bend in the direction that takes the most amount of stress during flight. The "shoulder" joint is also designed so that the inner wing is automatically held at the proper angle of attack for maximum lift. This section between the shoulder and the wrist moves very little during flight. The wing is concave and it is this curved surface that produces the lift as the bird moves forward.

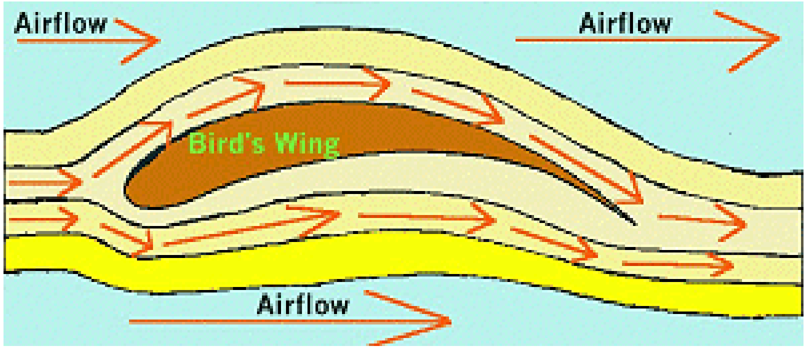


Diagram showing the concave curve of the wing, and how the airflow (orange arrows) works around the shape.

Source: http://birds.ecoport.org/Identification/EBflight-shape.htm

Following the arrows, the air first hits the wing at the front, whose shape forces the wind up over the top and down the back, and also underneath. The air has to travel further over the top of the wing then the bottom, which means the air has a lower pressure just above the wing and higher pressure below which induces lift. The more concave the wing, the more lift is produced. Birds who soar and glide have a more convex shape then those who flap.

Wing Shape

The shape of wings differs greatly in the bird world according to a species natural habitat, their size, flying style, and is the basis of their survival value. The ratio of the length of the wings to its width is called the aspect ratio. Birds with a low aspect ratio have high maneuverability and fast takeoffs. On the other hand, high aspect ratios allow birds to sustain high-speed flight for long periods – but these kinds of wings cannot be flapped as rapidly as the low aspect ratio ones. There are seven main types of wing:

Rapid Takeoff and Dodging Wings

Woodland birds must fly slowly to maneuver between branches and trees, as well as take--off frequently. They have short, broad wings and wide feathers that allow rapid takeoffs, good maneuverability, and short glides. They cannot fly as fast or as long as birds with longer, streamlined wings.

For example: Pheasants, Thrushes, and blackbirds.

An image of a Male Cardinal - an example of short, broad wings.

Source: http://www.gregscott.com/rwscott/rwscott.htm

Soaring Wings

Birds that soar have large wings with broad secondary flight feathers, which greatly increase the surface area of the wing so they can ride easily on the warm air currents. These types of wings were used for the hippogryph in Harry Potter. This suited the creature as it was big and heavy and needed a large wing ratio to be able to lift it.

For example: Broad-winged hawks, condors, ravens, and eagles.

An image of an eagle – an example of large, broad wings.

Source:

http://jrscience.wcp.muohio.edu/birds/ohio_birds/images/bals_eagle_underview_02_27-54.jpg

High Speed Wings

Birds who fly fast in open air have developed high-speed maneuverable wings. These wings are extremely flat, moderately long narrow, and triangular. They tend to be swept backwards and can be flapped rapidly to provide speed with little drag.
For example: Swallows, swifts, and falcons.

An image of a swift – an example of flat, narrow and triangular wings.

Source: http://www.londons-swifts.org.uk/Apuapu19%20(600%20x%20450).jpg

Slow Flapping Flight Wings

Large birds need large wings, but large wings are better for gliding and harder to flap quickly, and are therefore not much good at quick acceleration. Therefore they have large arched wings for greater lift without the need to flap fast.

For example: Herons, Ibis, and flamingos.

An image of an Ibis – an example of large arched wings.

Source: http://www.gregscott.com/rwscott/rwscott.htm

Long Distance Oceanic Soaring Wings

Many seabirds have long, narrow pointed wings for gliding long distances over the ocean into the ocean winds. The length generates lots of lift, while the narrow, pointed shape helps reduce drag while gliding.
For example: Albatross, gulls.

An image of an albatross – an example of long, narrow and pointed wings.
Source: http://www.leelau.net/chai/images/antarctica/albatross.JPG

Motionless, hovering flight

These wings are short and pointed. They can be inverted and turned upside down during the upstroke; therefore these wings develop equal amounts of lift during both halves of the wing cycle. They do not rotate at the wrist like other wings, but at the shoulder in a figure of 8 pattern.
For example: Hummingbirds.

An image of a hummingbird – an example of short pointed wings.

Source: http://www.gregscott.com/rwscott/rwscott.htm

Feather Anatomy

It is the shape of the wing that enables a bird to fly - and the shape is determined by the feathers - there is a direct correlation between form and function. Feathers are necessary for flight, insulation, and courtship displays.

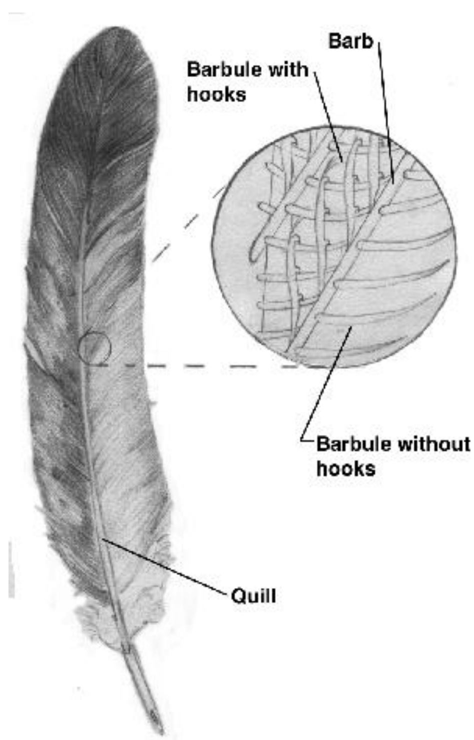


Diagram of a flight feather showing in detail the barbs and barbules and how their hooks lock on to other barbs.

Source: http://www.fi.edu/wright/again/wings.avkids.com/wings.avkids.com/Book/Animals/intermediate/birds-01.html

Feathers have a central shaft, and from it extend at a 45 degree angle a set of filaments called barbs or branches. These barbs in turn extend smaller barbs called ‘barbules’ that often contain hooks to latch onto other feathers. It is this that keeps the feathers in the right shape.

Types of feathers

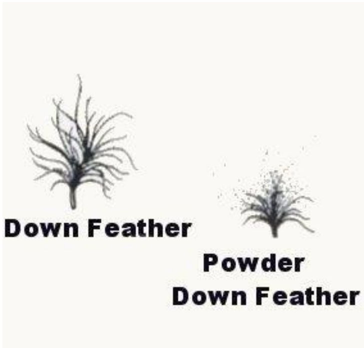
Birds have many different types of feathers, just like mammals have different types of hair, and reptiles have different scales. It is important to display the different types of feathers on a model as they will dramatically alter the appearance of the surface and make it appear more realistic.

Contour feathers: Contour feathers cover most of the surface of the bird, providing a smooth appearance. Often, these feathers are brightly colored and have different color patterns. Contour feathers are divided into flight feathers and those that cover the body.

Source: http://www.paulnoll.com/Oregon/Birds/Avian-feathers.html

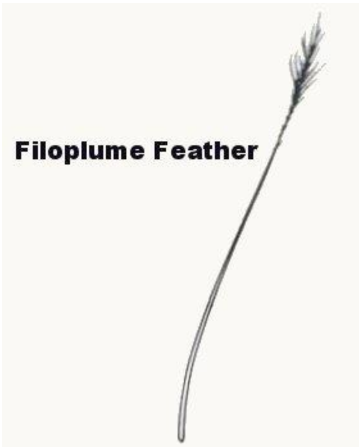
Flight feathers: Flight feathers are the large feathers of the wing and tail. Flight feathers of the wing are separated into three groups: primaries, secondaries, and tertiaries. The bases of the flight feathers are covered with smaller contour feathers called coverts. There are several layers of coverts on the wing. Coverts also cover the ear.

Down feathers: Down feathers are small, soft, fluffy, and are found under the contour feathers. They have no hooks on their barbs, which allows them to trap air to help insulate the bird.



Source: http://www.paulnoll.com/Oregon/Birds/Avian-feathers.html

Filoplumes: Filoplumes are very fine, hair-like feathers, with a long shaft, and only a few barbs at their tips. They are located around the base of contour or down feathers. Although their function is not well understood, they are thought to have a sensory function, possibly adjusting the position of the flight feathers and keeping contour feathers in place.

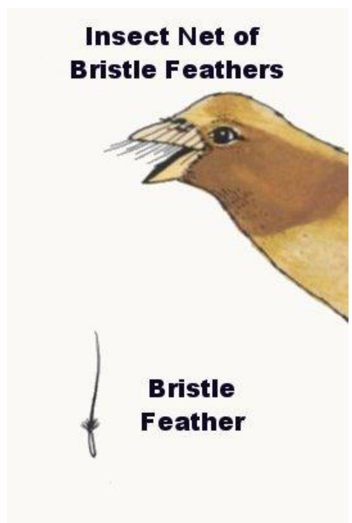


Source: http://www.paulnoll.com/Oregon/Birds/Avian-feathers.html

Semiplumes: They may occur along with contour feathers. Semiplumes provide form, aerodynamics, and insulation. They are halfway between contour feathers and down feathers.

Source: http://www.paulnoll.com/Oregon/Birds/Avian-feathers.html

Bristle feathers: Bristle feathers have a stiff vane with only a few barbs at the base. They are usually found on the head and are thought to have both a sensory and protective function



Source: http://www.paulnoll.com/Oregon/Birds/Avian-feathers.html

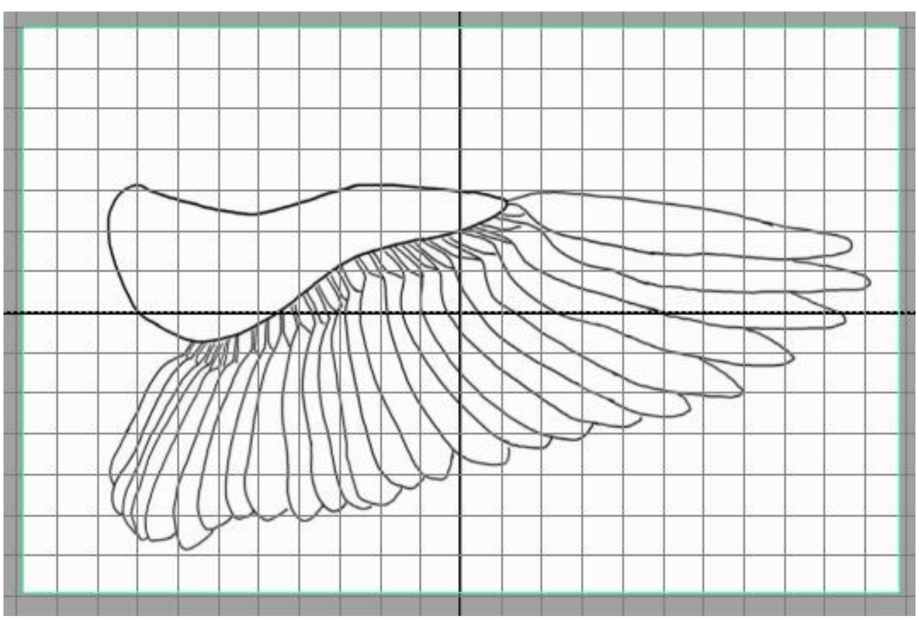
Modelling our Wings

There are many things we have to take into consideration when planning the wings. Although you can see there are various ways that major animation companies have tried and tested, this does not mean these are the ways that everyone should use. You need to structure the project around what is actually needed and what resources you have available. Students would not be expected to create a huge feather–code interface to use on their models that takes hours to render each frame as this is just not feasible within the lab resources and time constraints, and as my tutorials are focused towards students I will need to take this into consideration.

First draw the template of the wing. (See Fig 1) Divide the wing into:

- The main area containing the bones and muscles that is covered by the smaller covert feathers.
- The large primary and secondary feathers

Fig 1

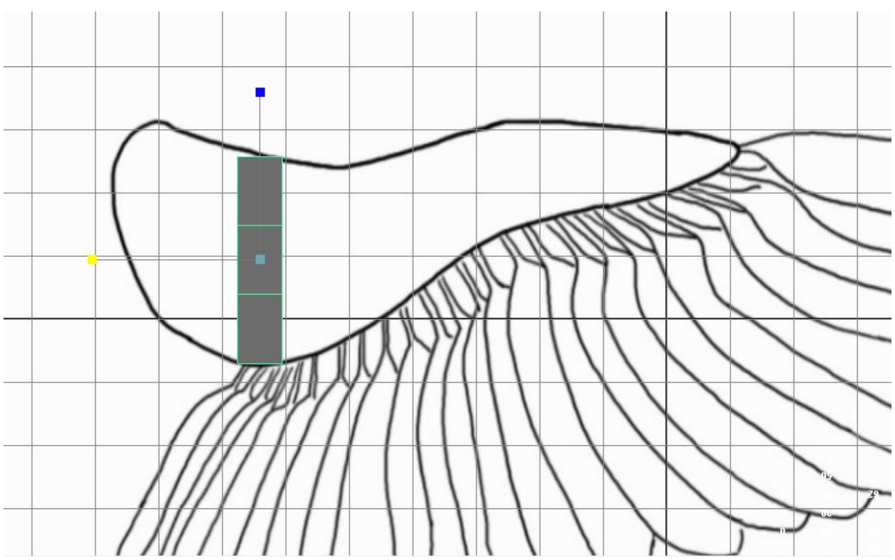


I have decided to do large broad wings suited to an eagle, but you may have to change the shape of the wing and feathers if you are doing a different type of bird, or to suit them to a specific type of creature. We will be using polygons to model the wings. Although nurbs are the favored technique for some film production work (Weta Digital with Gwailhir the Giant eagle for example) and polygons are for games, this is mainly based on their complexity and render time. In games everything has to render in a known, finite amount of time, therefore companies use polygons because they have a predictable complexity and render time. In film however, there is the luxury of long render times so you can use whatever suits your needs.

We will be using polygons in this example for several reasons. The first being that this tutorial is to hopefully help fellow students, and we don't have the luxury of allowing several hours to render a single frame. Secondly, polygons can be made to look as 'polygony' or as smooth as we might like, the render time increasing in proportion to the level of smoothness, which can allow us to come to a good compromise. Also that polygons are a lot easier to texture, which is good in this case as the feathers will be quite realistic.

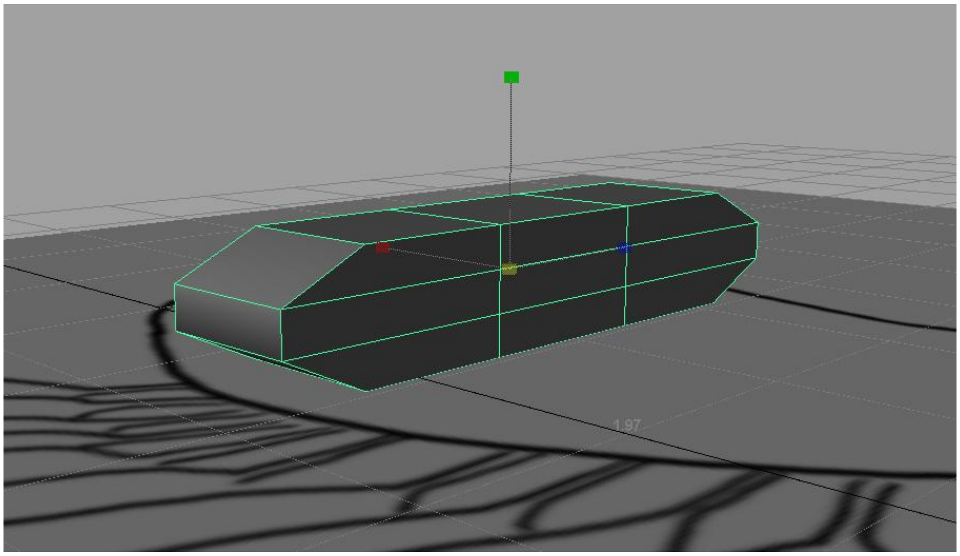
Begin modelling the main wing (Fig 2). I started using a cube divided into 3 width and 3 depth. The edges across the cube will be extended into planes for feathers later on.

Fig 2



Scale in the outside top and bottom vertices to create a rounder shape (fig 3).

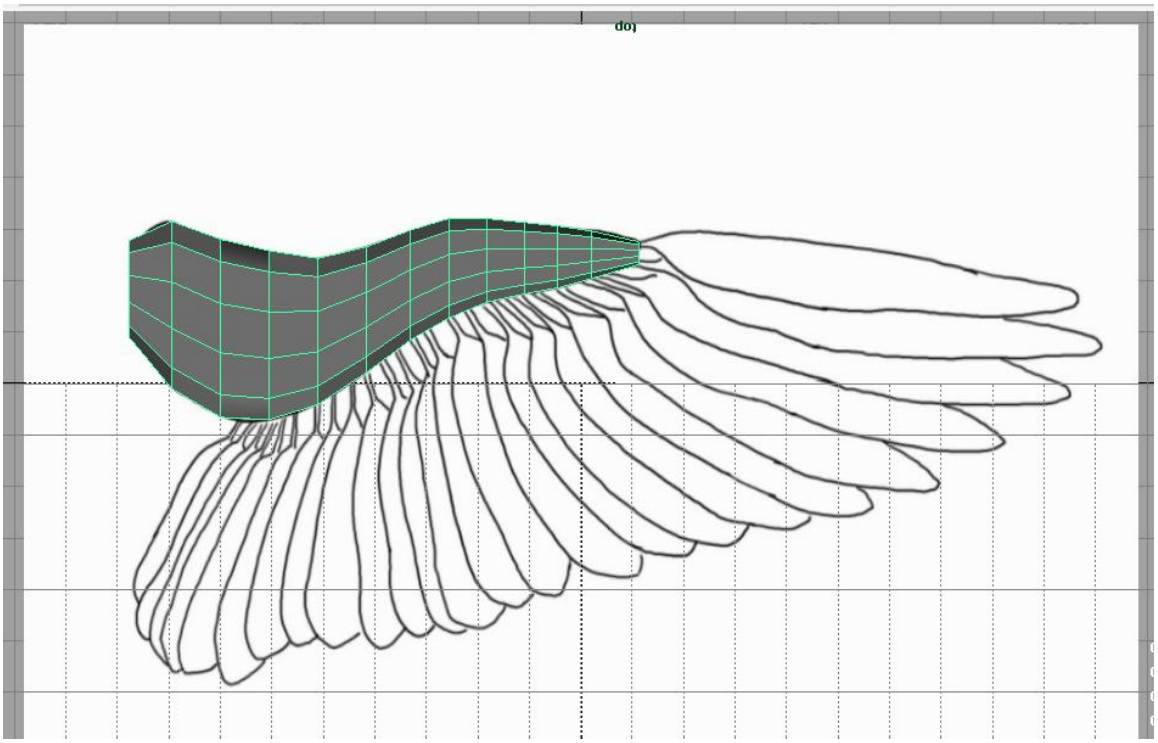
Fig 3.



Extrude the faces of the side and extend the polygon at equal intervals to complete the shape (Fig 4). It is important to use good topology. Building a good topology based upon an understanding of the object makes the modeling task easier. The edges should flow with the contours of the object, which will allow it to deform better during animation.

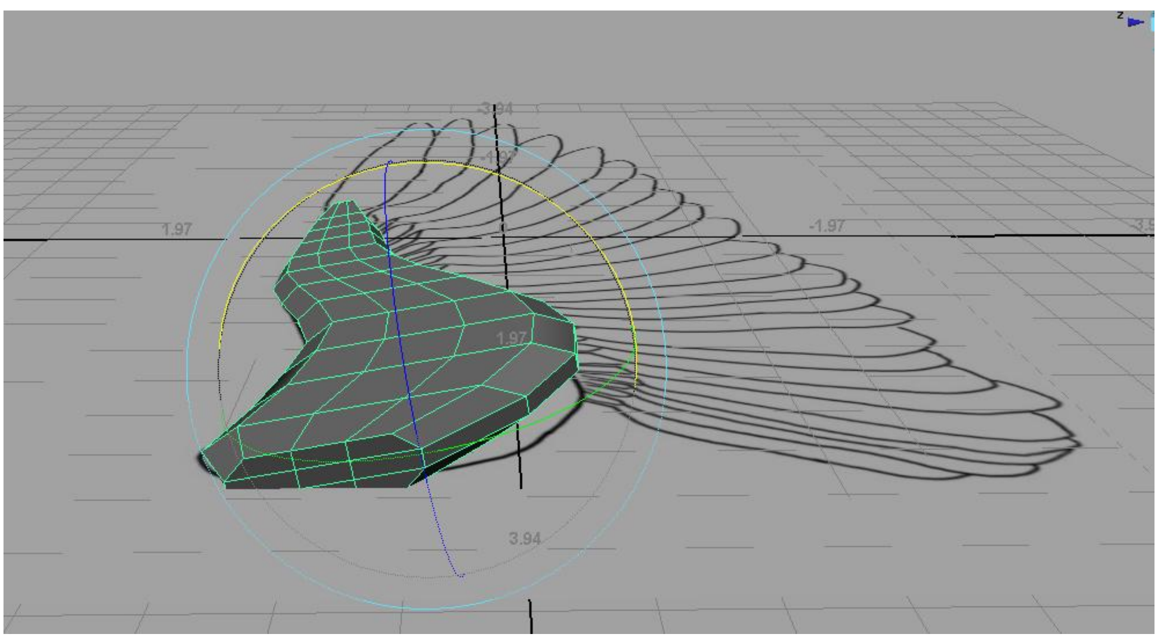
"Topology and edge loop theory are a big topic but essentially it boils down to a fairly simple concept, - that the placement and flow of edges of a surfaces is done in the most logical and efficient way to capture the detail of the surface and also fits the way the object will deform. A good topology will have edges that flow smoothly in an easily traceable pattern and appear to capture the form of the object in the most naturally optimal way possible. A bad topology will feature irregular shapes, edges which flow against details, smoothing errors, inappropriately high poly counts and often massive inconsistencies between the size of faces."
Matt Birkett-Smith, Innovations

Fig 4.



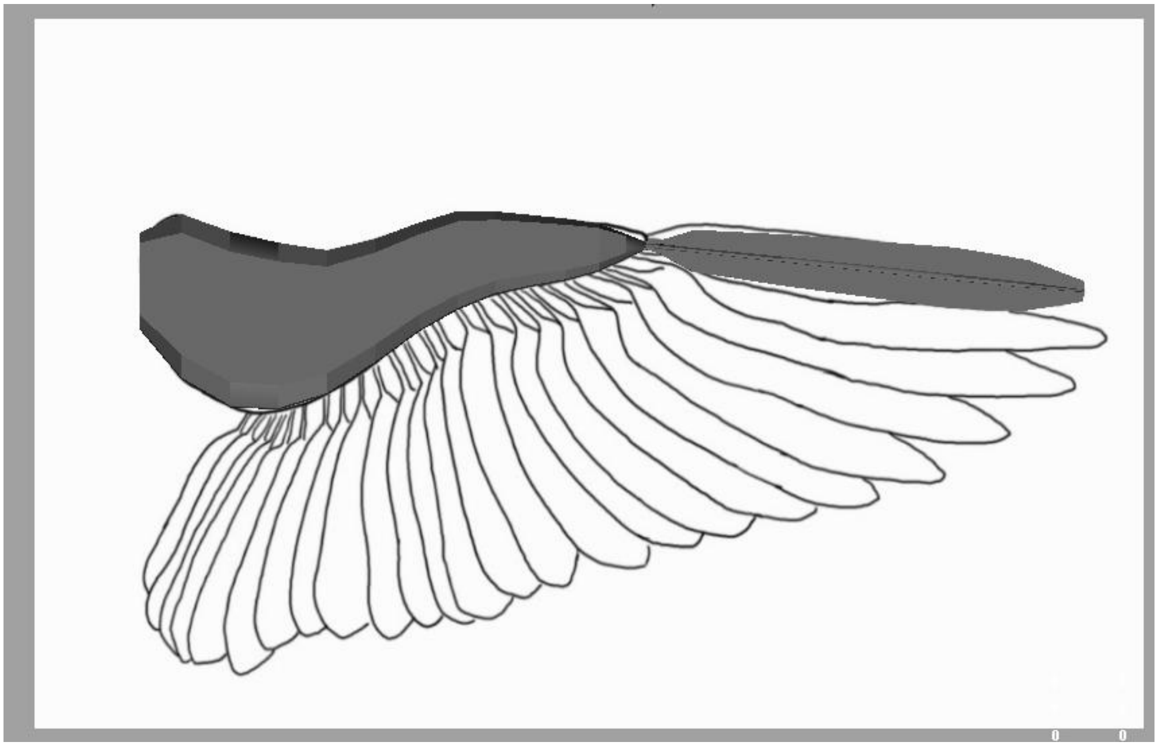
Next, tilt the wing shape by 10 degrees (fig 5). This will be the basis for the concave shape that wings have to generate lift.

Fig 5.



Now we can start modelling the feathers. I have modelled the basic shape of the feather, which will allow me to change its shape when I duplicate it to create other types of feathers (fig 6). You can model your feather as detailed as you want. However, you need to remember we will be smoothing it later, and we will have quite a lot of feathers to render at the end so you need to think about your render time.

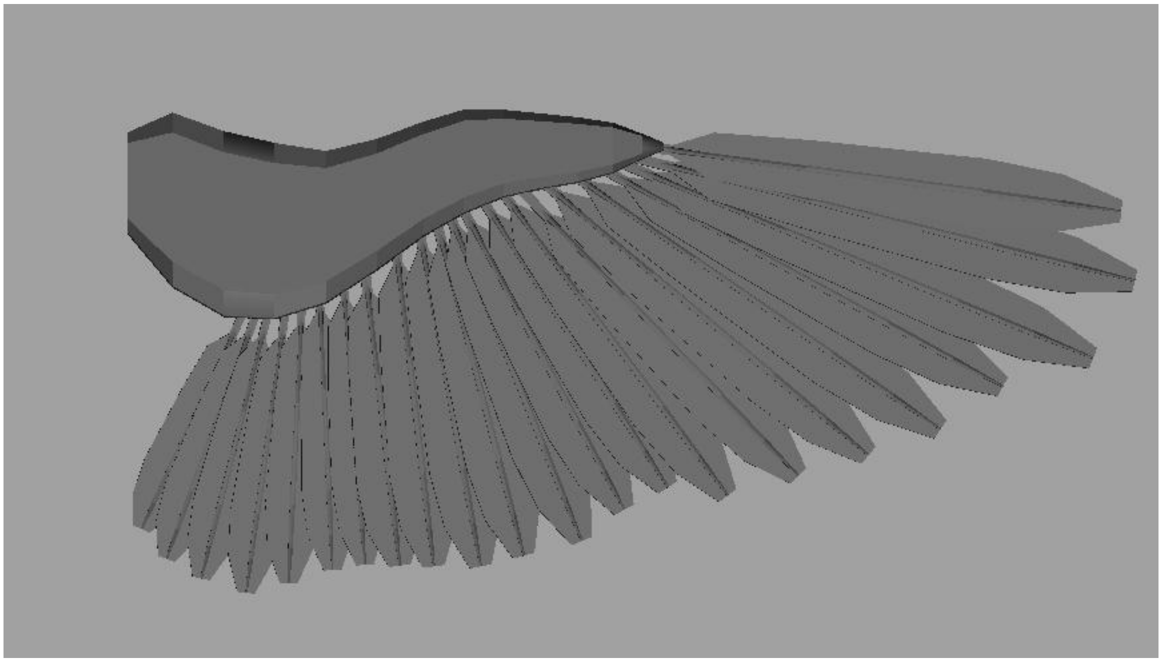
Fig 6.



Once you have modelled one feather, it is important to UV texture it before duplicating it. This will save you a lot of time later when you might have 100s of feathers to UV map! I used planar mapping which works fine with feathers, as they are very flat.

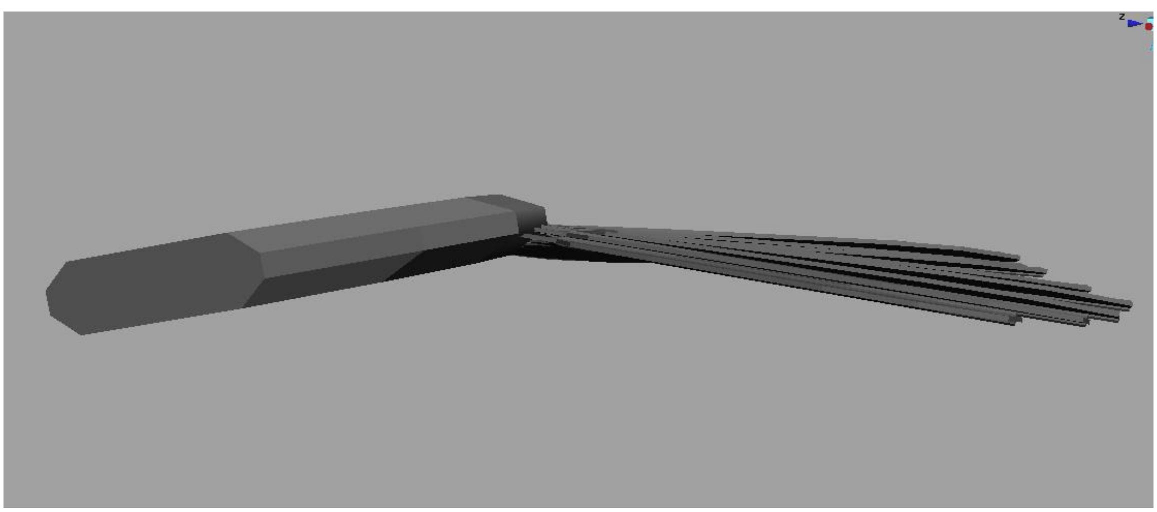
Duplicate the feather and move it around to follow the template (fig 7). You will need to tilt each feather slightly so that the feather on the right overlaps the feather on the left.

Fig 7.



You will also need to tilt the feathers so that the end of the feather is lower then the top (fig 8). This is to show the concave ‘aerofoil shape’ of the wing. Also, adjust the secondary feathers (the ones nearest the birds body) so they are rounder, and made the primaries slightly more pointed.

Fig 8



Now that the main flight feathers are laid out, we will begin texturing them. I decided on four different coloured feathers (fig 9) to make them look random and realistic, and not artificial and forced.

Fig 9.

1.2.

3.4.

You will also need to do a bump map, a transparency map, and a specular map (fig 10). The transparency map is important if you are adding ‘slots’ like feather 2.

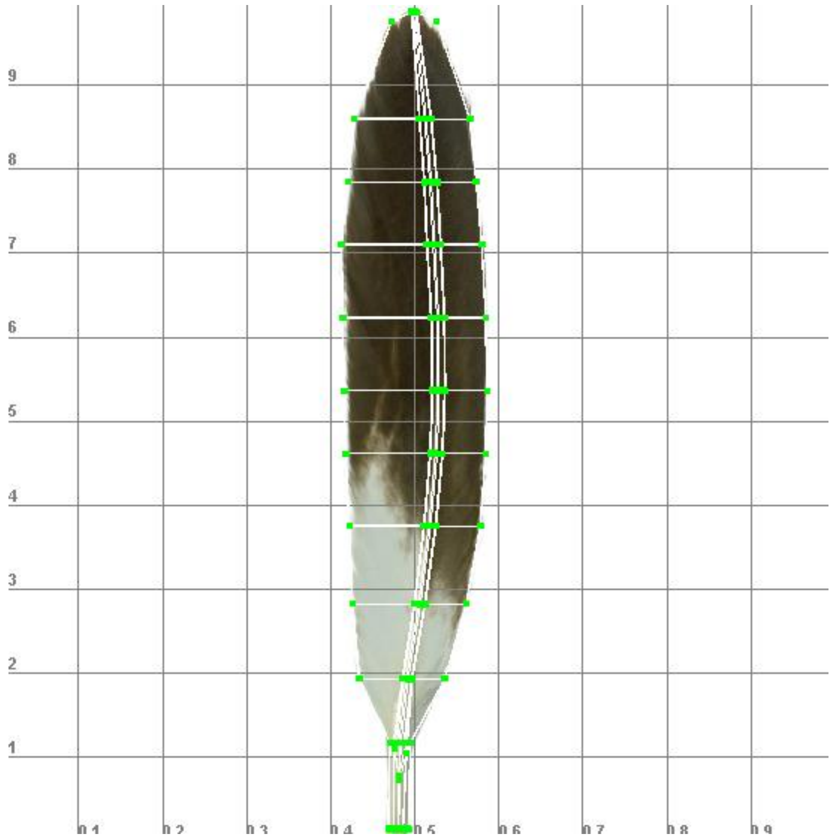
Fig 10.

5.6.

You can use the bump map (5) as the specular one if you wish. You may just have to add some white along the main shaft. Image 6 shows the transparency, white is opaque and the part of the image you want to see in the render.

Now, simply add these images into the specific nodes of your blinn shader and assign the shader to the first feather (fig 11 and 12).

Fig 11.



Here are the attributes for my feather nodes:

Blinn

Colour: file

Transparency: file

Ambient colour: 0

Incandescence: 0

Bump Mapping: file

Diffuse: 0.800

Translucence 0.2

Translucence Depth: 0.5

Translucence Focus: 0.5

Eccentricity: 0.450

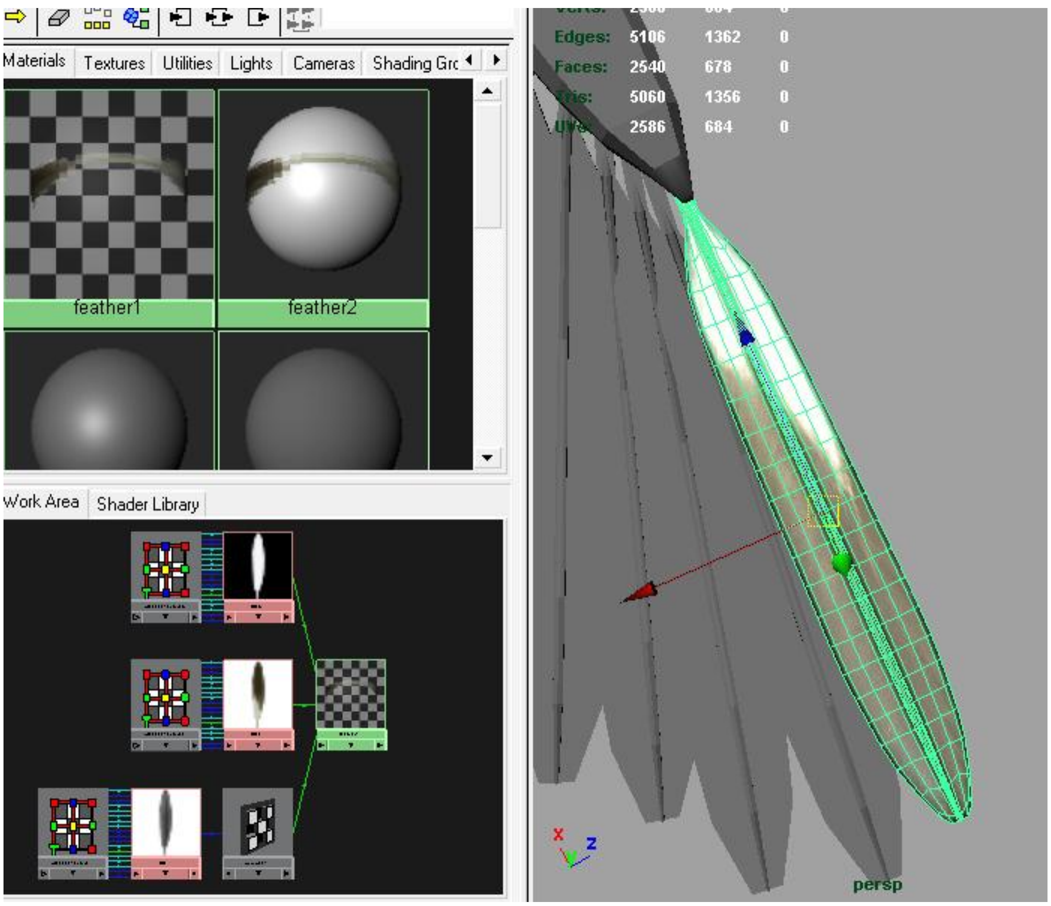
Specular Roll Off: File

Specular Colour: 0.5

Reflectivity: 0

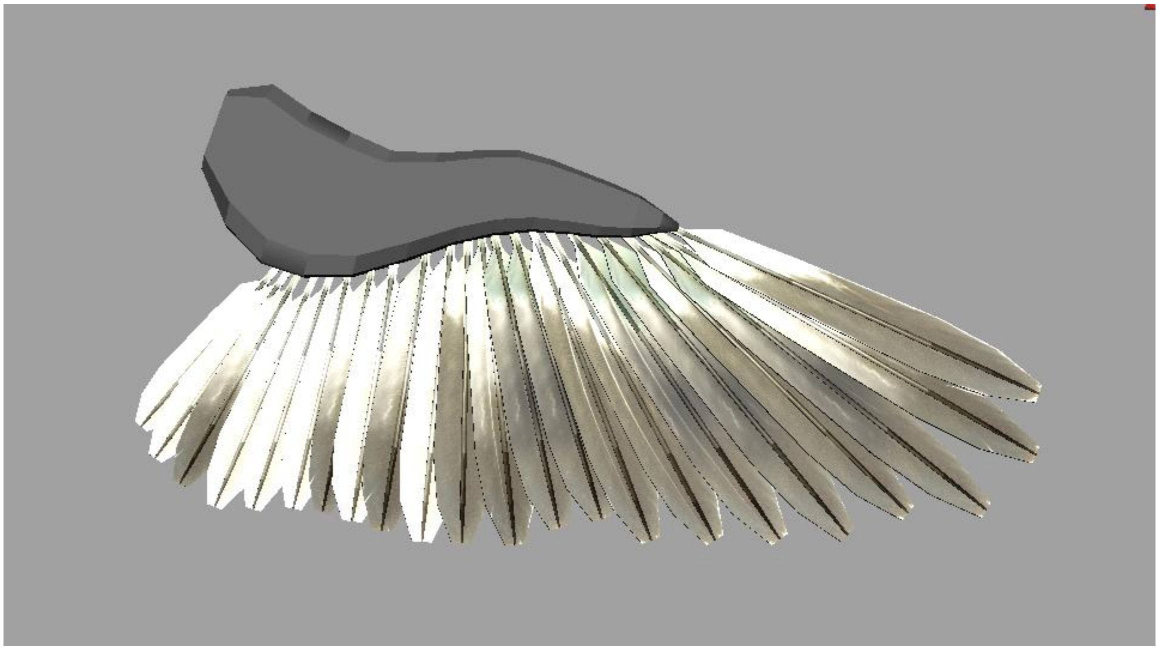
We may need to adjust translucence and specular later on depending on our light source.

Fig 12.

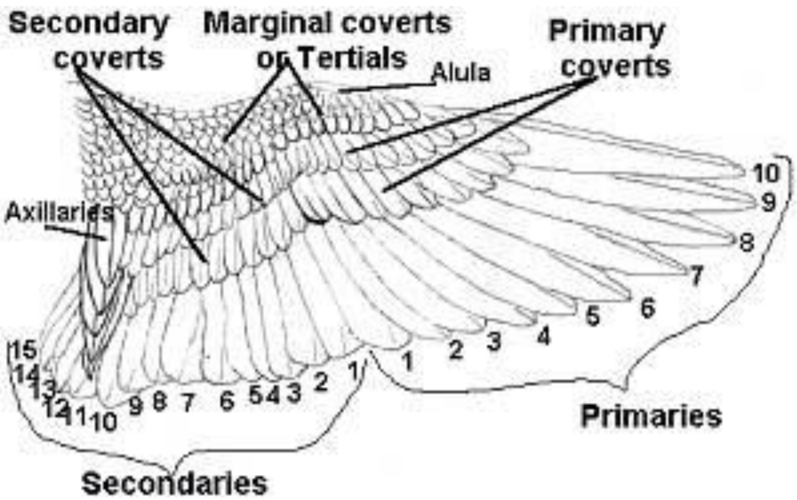


Now, create the shaders for the other 3 feathers and assign them to the rest of the main flight feathers (fig 13). I made my feathers darker on the right side of the wing (closer the body) and lighter on the left by varying the different shaders in a random order.

Fig 13.

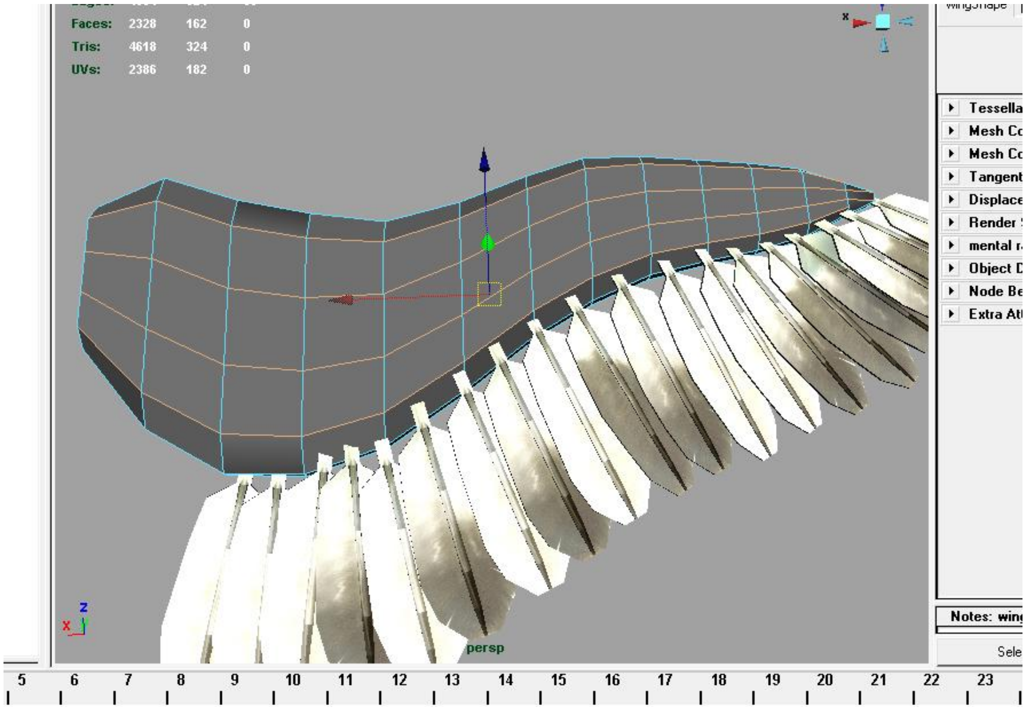


Now, using these feathers as a basis, create the first smaller row of primary coverts above it as you can see from the diagram below:



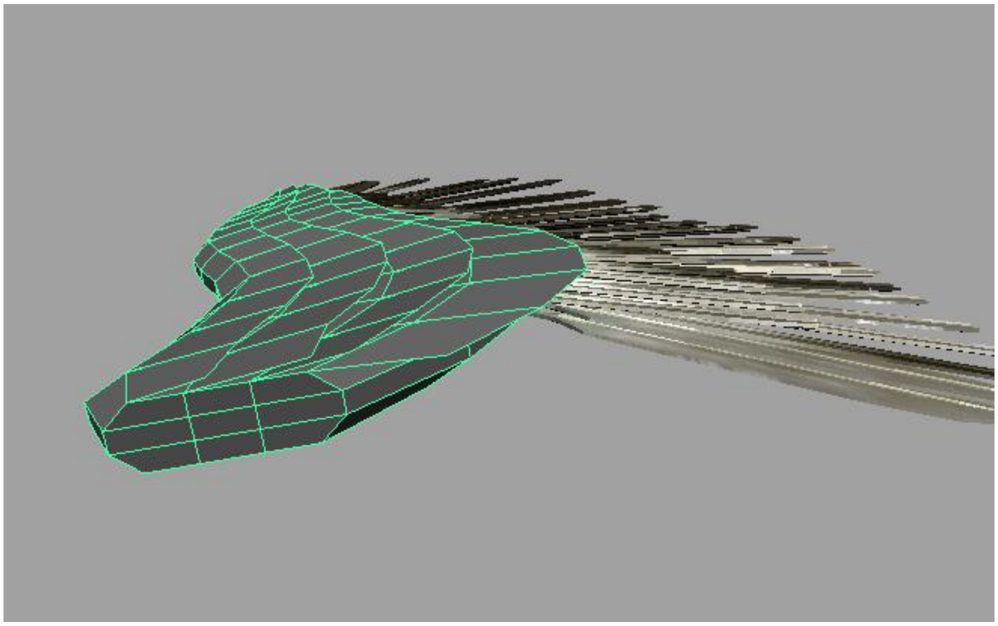
Now that we have the main polygonal feathers laid out, we can work on the main wing. First of all, select the four main edges running from one end of the wing to the other (fig 14). You can see them selected in orange in the image below.

Fig 14.



Extrude these edges to create the planes for the other feathers (fig 15). They will need to lie relatively flat and in the same direction as the other polygon feathers. Make the bottom plain slightly larger then the others as it will contain the second row of primary coverts, the other plains will only show the smaller tertials.

Fig 15.



UV map the main wing, keeping the last three plains separate (the primary coverts and the two above it) because of the overlapping geometry (fig 16).

Fig 16.

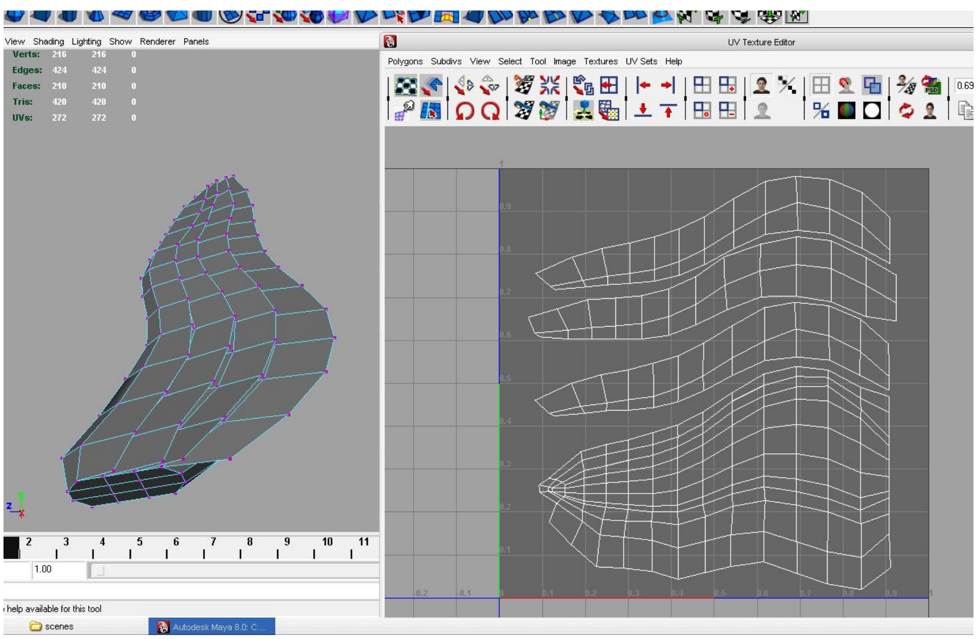


Fig 17.

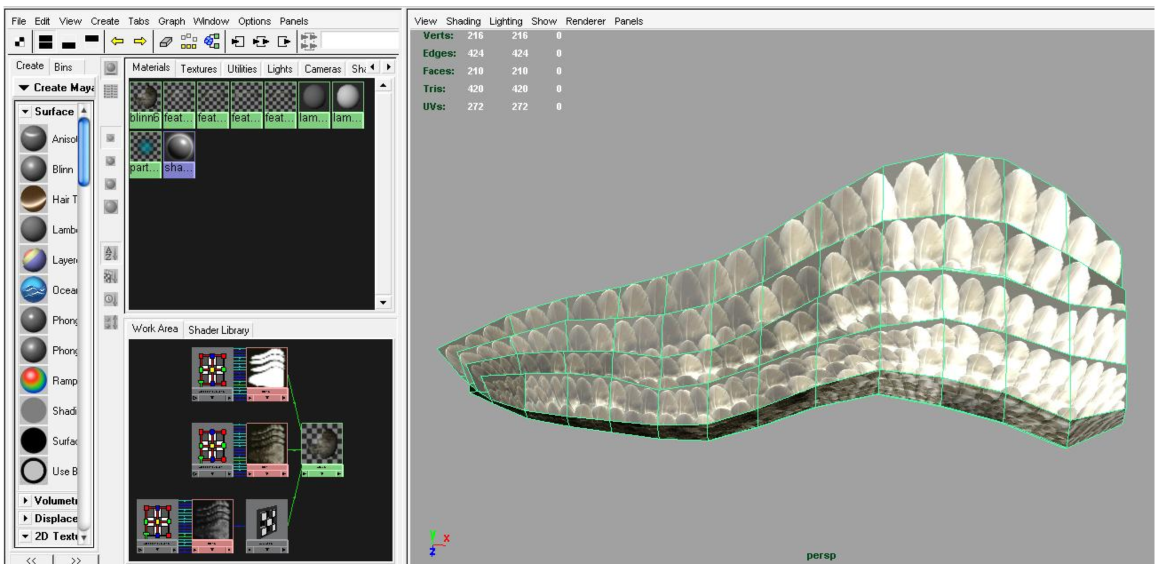
The image above (fig 17) is the final texture, however, we also need a bump map (fig 18) and most importantly a transparency map (fig 19) to go with it.

Fig 18. ***Fig 19.***

1.2.

Assign the maps to a blinn shader, and then assign the blinn shader to the wing (fig 20).

Fig 20.



The blinn shader has the same attributes as the one I described earlier, which of course you can change with regards to the light source and environment.

The wing is now modelled and textured. Smooth the wing and feathers to see the result.

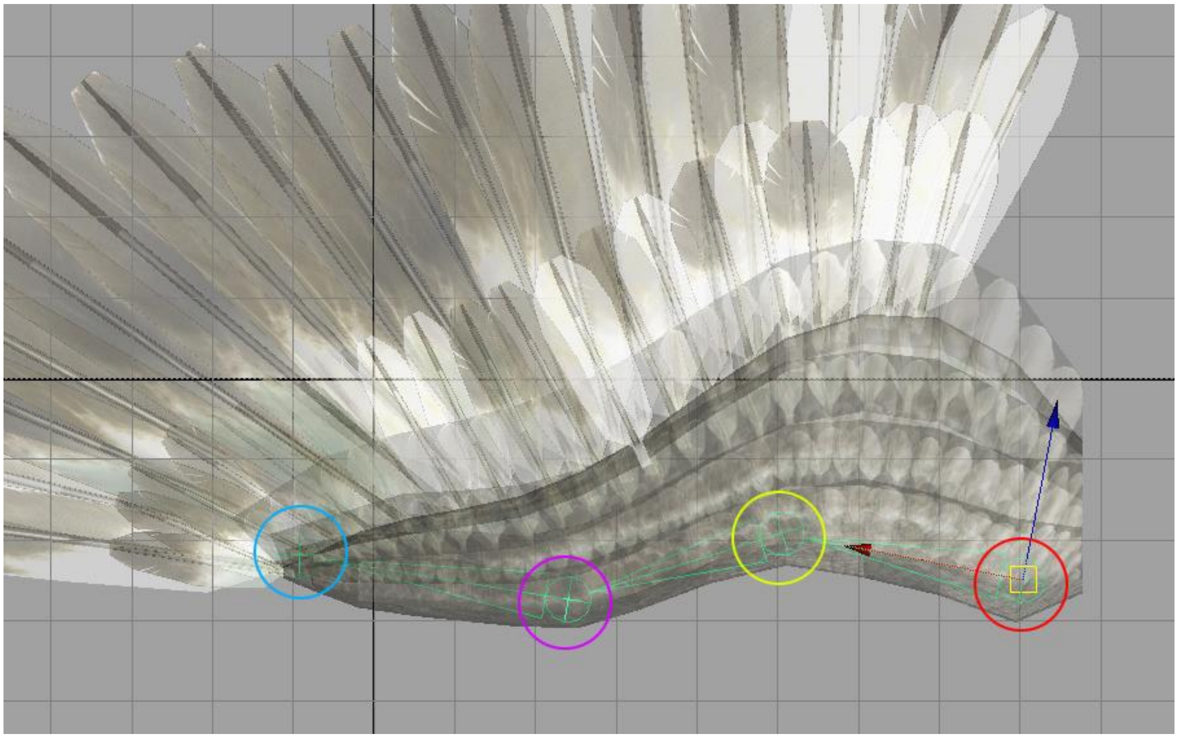
Rigging our Wings

In the past, companies modelling bird wings have had trouble when it came to rigging them. Because of the complexity of the wing structure and the different poses that it has to be able to do (i.e. A fully spread wing is completely different to a wing tucked away), rigging a wing that is flexible enough to accommodate this can be very tricky.

Many companies have used several different sets of wings for different shots, but ultimately, there is generally a shot where the wing comes from a tucked, or half-tucked position, to being spread. We need to take this into consideration when planning the underlying rig. The main polygon feather will need to be highly manageable – they will need to be able to tuck above or beneath each other, and also tilt in many directions.

The first few joints of the wing will be based on the skeletal structure of normal wings (fig 21).

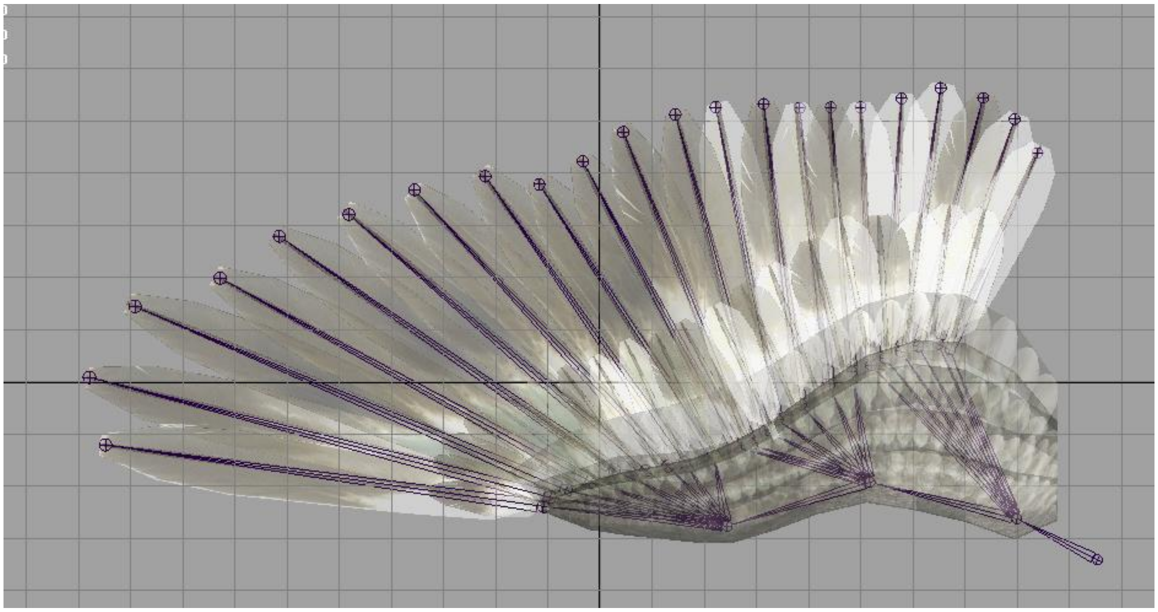
Fig 21.



The red circle represents the shoulder joint, the yellow circle represents the elbow, the pink circle is the wrist, and the blue is the first finger.

We are going to need to control each feather, so each feather is going to need it's own joint so it can rotate, tilt and be moved enough for the wing to open and close. From each joint – shoulder, elbow and wrist will stem 5 – 7 more joints that will then extend to the end of each main primary and secondary feather to control them. Each feather will then be parented under each joint (fig 22). Regarding the primary covert feather polygons, they will be parented to whatever joint is closest – the optimum being one covert and one primary or secondary feather per joint.

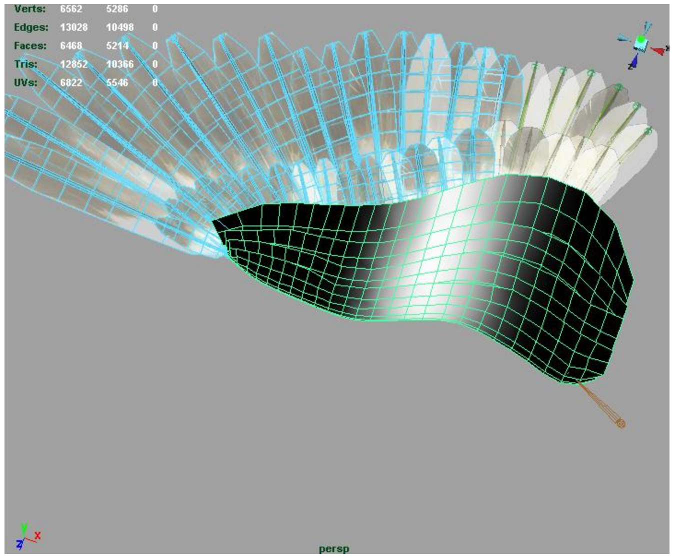
Fig 22.



We are parenting them under each joint as this will save time on weight painting. Feathers cannot be stretched like skin, so weight painting is not necessary in this case. I have only one joint per feather, which means the feathers cannot bend. I did this because in real life, feathers cannot bend and I am attempting to make a realistic wing. However, if your character is cartoony, or you wish your feathers to bend, you will need to add an extra joint in the middle and paint weights on it so it functions properly.

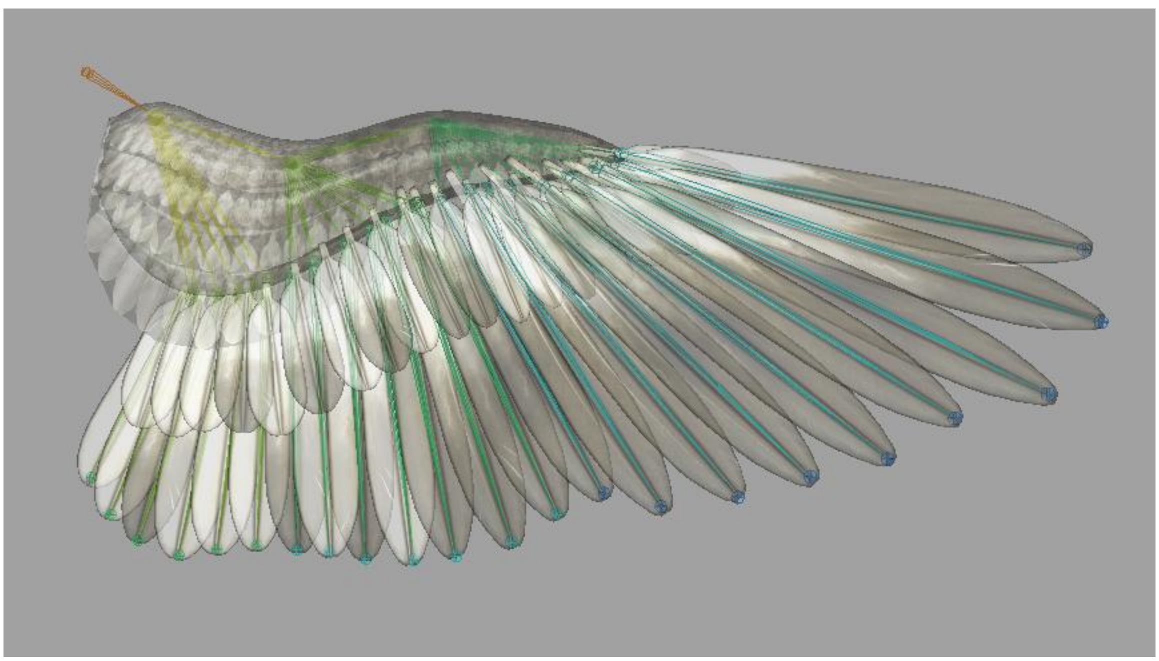
Once all your feathers are under the ROOT hierarchy, it is time to skin the main part of the wing. Select the ROOT and the main wing geometry and skin them using a smooth-bind. (Make sure your geometry has been smoothed first).

Fig 23.



Painting the weights should be pretty straightforward. There are only three joints to paint, just do some tests by bending the wing so that you can be sure it can bend enough to open and close (fig 23). Now we just need to smooth the feathers (fig 24).

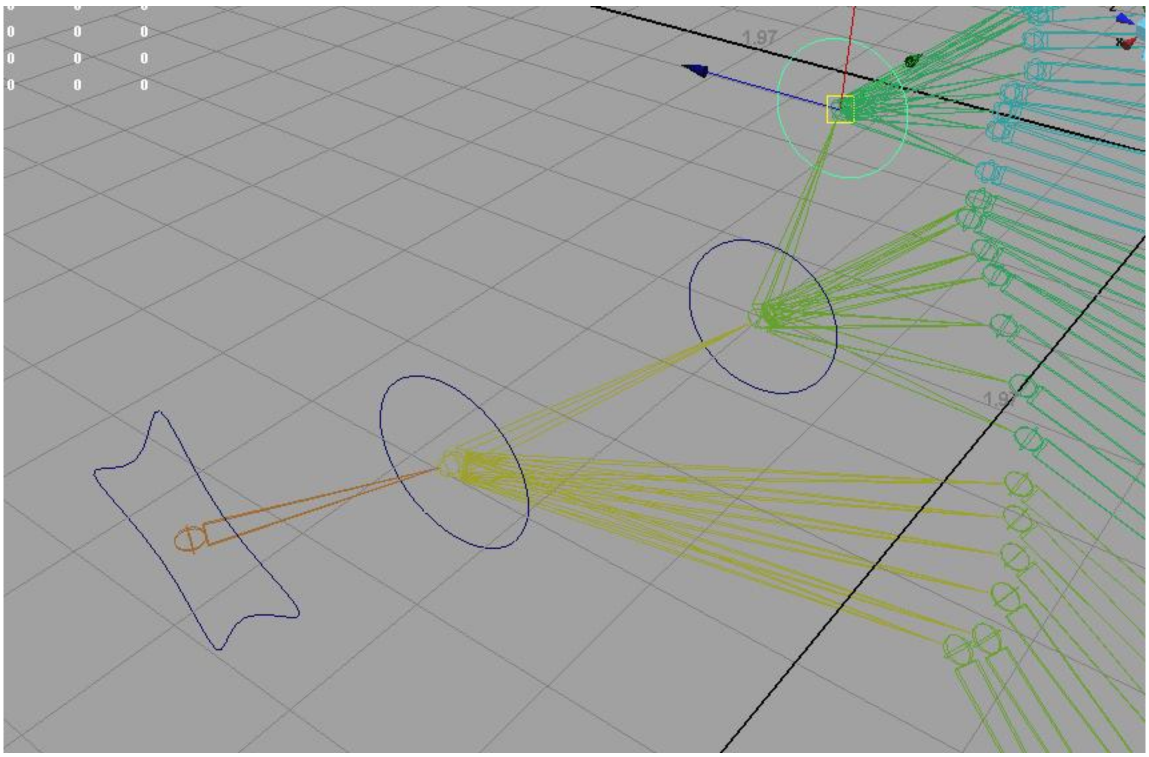
Fig 24.



Animating the Wing

We are now going to create some controls for the wing so it will be easier to animate it. First, hide the polygon geometry so you can only see the skeleton. Create a circle curve, rotate it 90 degrees in the **z** and snap it to the ROOT joint (hold down shift and v). Rename it ‘COG’. Duplicate the curve three times and snap one to the shoulder joint, one to the elbow joint, and one to the wrist joint (fig 25). Freeze transformations on all four curves and rename each one appropriately.

Fig 25.



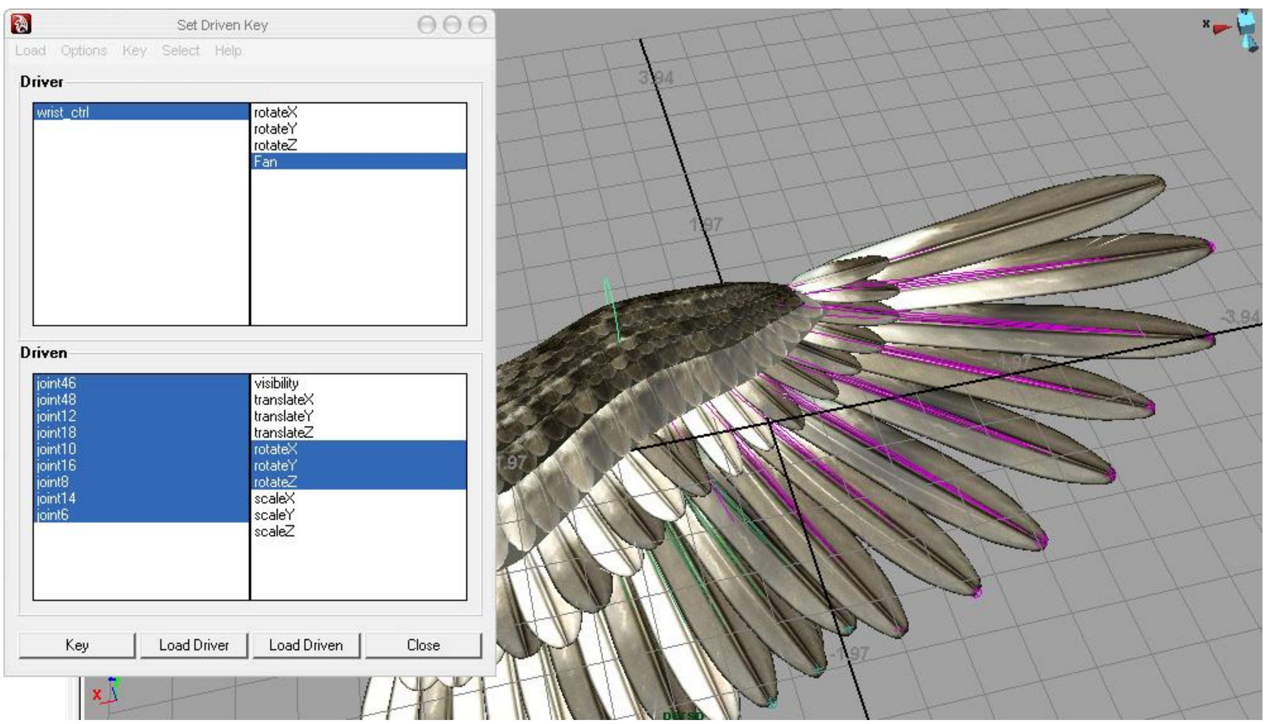
You may wish to change the shape of the controls as I have, but I will leave this up to you.

Parent the ROOT joint (this should include all the joints in the hierarchy within it) under the COG curve. This will mean that the whole wing can move, translate, rotate etc when you move the COG control, and not interfere with the current pose the wing may be holding.

Clean up the channel box by locking and hiding the translates, scales and visibility of the shoulder, elbow and wrist controls. Now select the shoulder control and shift select the shoulder joint, and parent constrain them. Do this for the elbow control and elbow joint, and wrist control and wrist joint.

Open the outliner, and parent the wrist control under the elbow control, the elbow control under the shoulder control, and the shoulder control under the COG. Then, in the channel box for the wrist, shoulder and elbow controls, add an attribute called 'fan' with a minimum of -10 and a maximum of 10. This will be the driver for fanning the feathers when the wings are flapping.

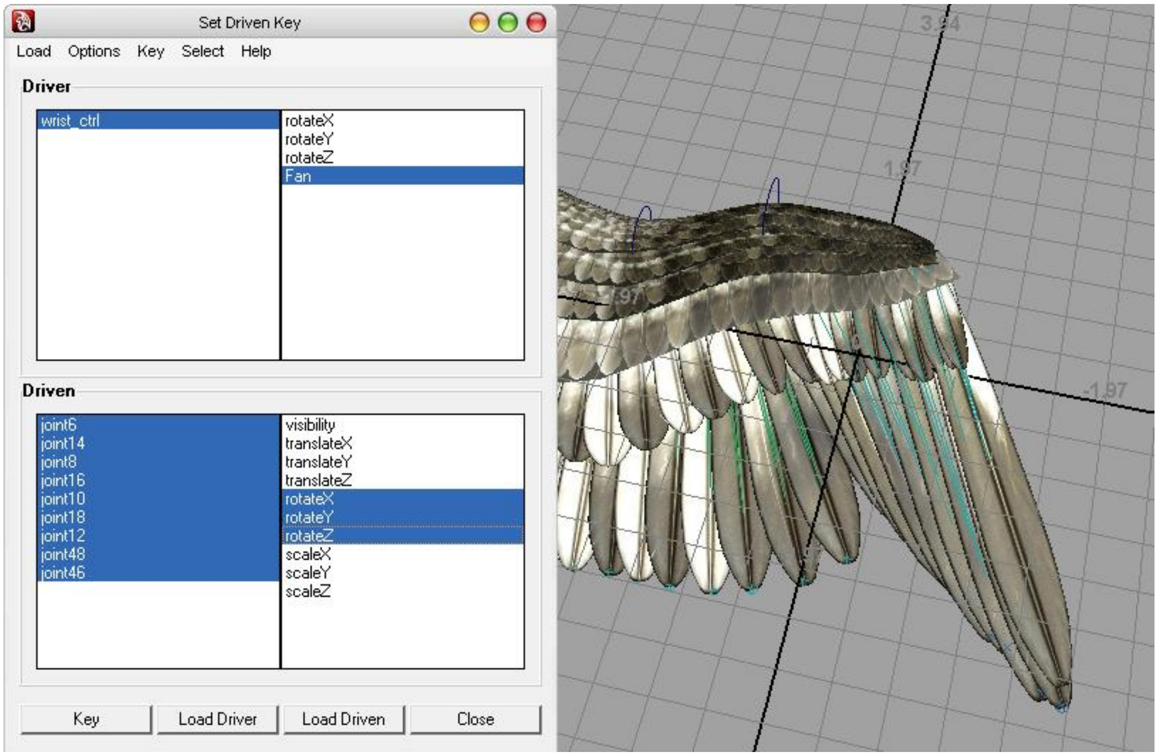
Fig 26.



Select the wrist control and go to *animate* -> *set driven key* -> *set* and click the load driver. Now select the feather joints under the wrist joint hierarchy and load them in as driven (fig 26). With 'fan' selected in driver, and the rotates selected in driven, press 'key'.

Set the fan to 10 and rotate each feather joint in the y direction to spread them out. You may need to display the feathers to make sure that the feathers overlap and do not intersect. Key it.

Fig 27.



Set ‘fan’ to -10 and rotate the feathers so that they close up together (fig 27). Key it.

Do the same for the elbow and shoulder joints, and then test the wing by opening and spreading it (fig 28), and closing it (fig 29).

Fig 28.

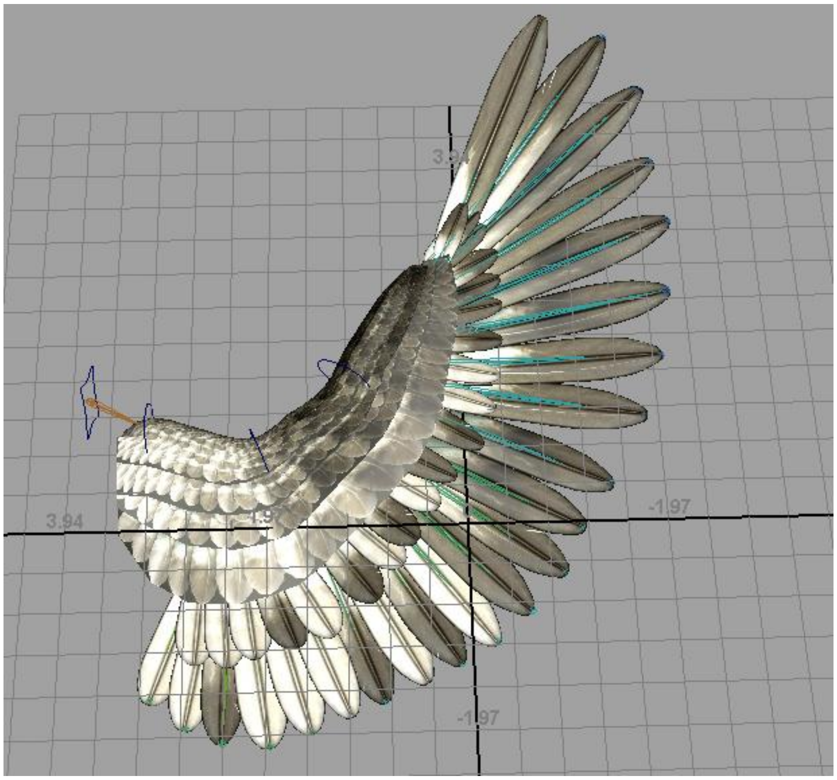
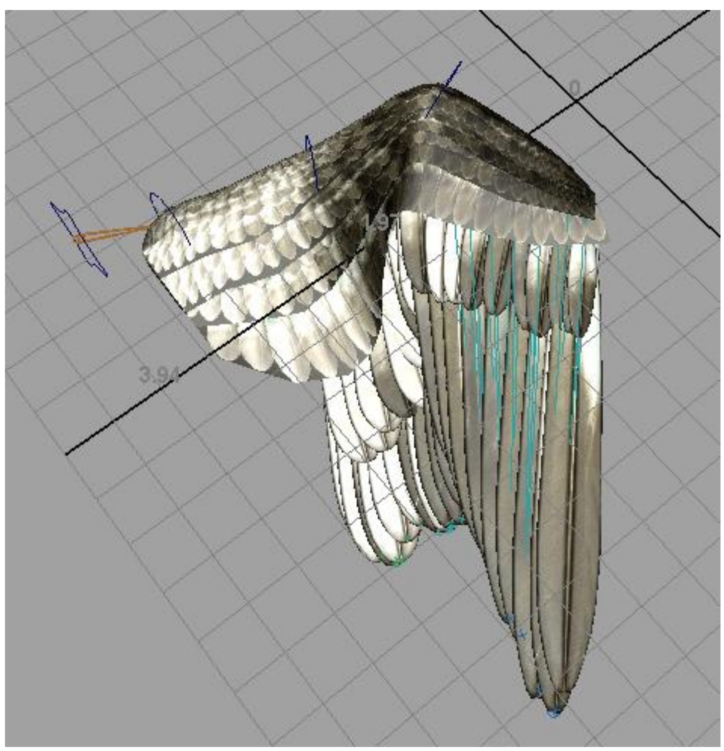
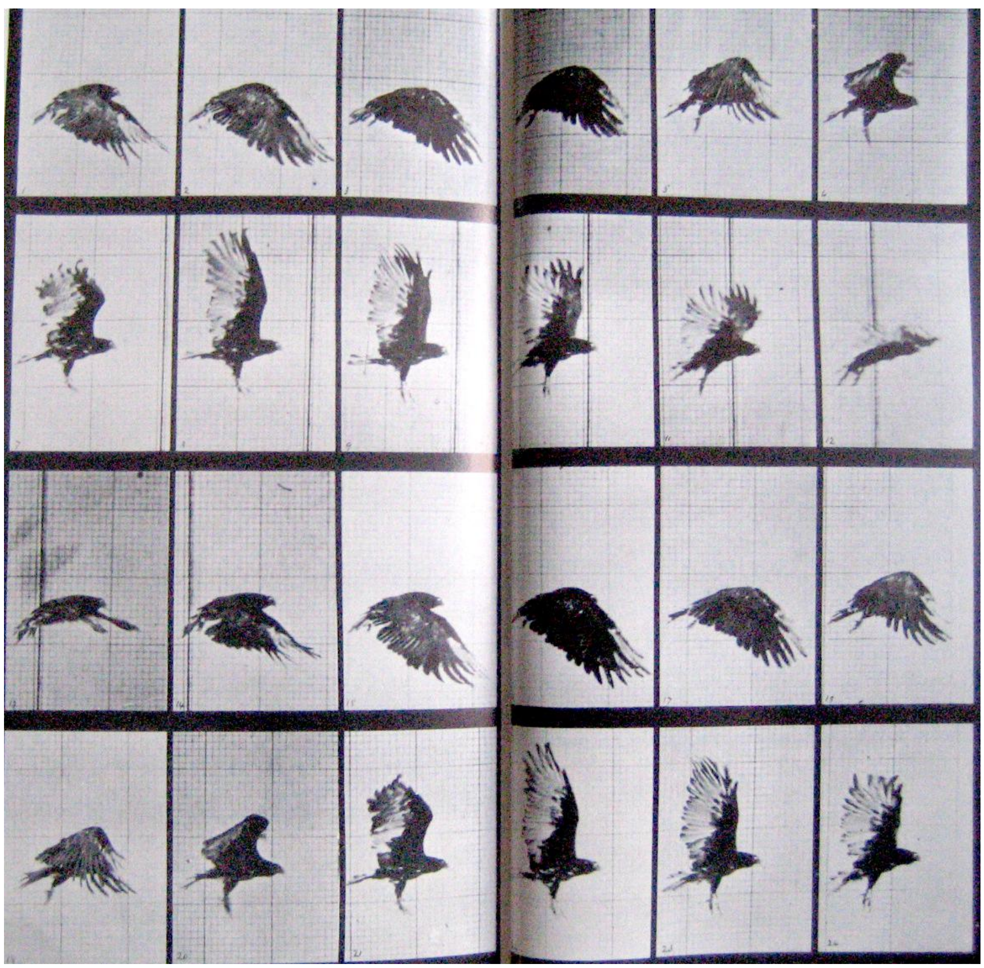


Fig 29.



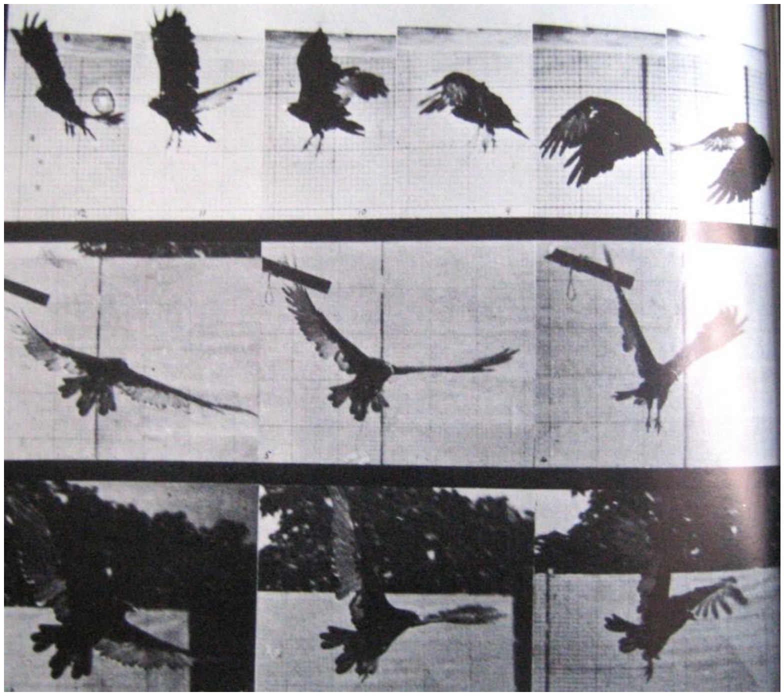
Animating a wing cycle

When it comes to animating a wing cycle, you will need to know how the specific wings that you have chosen function in the air, i.e. hummingbird wings flap very fast as they hover, whereas an albatross's wings soar, and flap relatively slowly. I suggest collecting as much motion reference as possible.



Source: Animals in Motion, Muybridge Dover publications Inc.

My wing is similar to an eagles, so my wing cycle will be quite slow and smooth. I looked at the vulture in the 'Animals in Motion' book by Muybridge as their wing shape is very similar to an eagles.



Source: Animals in Motion, Muybridge Dover publications Inc.

I have made several test animations including two different views (a side and a top) of a slow flap of the wing, and then a close and an open, that you can see in the mp2.

Conclusion

Since this was a project primarily focused towards extending my knowledge into an area I had never ventured, I feel that I have succeeded in what I set out to do. A bird wing is multi functional – it needs to bend and flex in a completely different way to a human arm, and it also has hundreds of feathers to control. The first main hurdle was to investigate how film and game production companies overcame this in their modeling and rigging techniques. Unfortunately, companies are very secretive about their methods and may only give you a vague outline of how they did it. I had to take these clues to build up my own idea of the best way to create a bird wing.

Many films used separate models for when the wing is closed, and when it is spread, and after modeling my own wing I believe that this is probably the best way. However, my plan was to create a wing that could close and open for the shots of the bird/creature getting ready to take off and fly. This left me some leverage as the wing did not have to be perfect when it was shut, but as long as it could open and spread and flap like a wing, then I would have fulfilled my brief.

I decided to model my wing in polygons for the reasons I stated at the time. I used polygons for the main feathers instead of plains, because of the degree of shaft thickness and the fact that feathers are not that thin. However, I would have liked to have tried to model the main primary feathers out of plains to see the difference, but perhaps this is something I could look into if extended the project.

Figuring out the best way to rig the wing was tricky. From researching I discovered that some people use deformers to move the wing which means that the feathers and wing bend in a cartoony fashion. However, I wanted mine to be realistic so I began with the wing skeletal structure (which is always the best starting point). Then I wondered how I could control and rig the feathers. I thought about 'For the Birds' where they grouped 10 or so feathers underneath a controller, but since I didn't have half as many feathers I could do one for each feather. I knew I wanted the feathers to be rigid so I just parented them underneath the correct joint in the rig (a flash-back from rigging in the first year of university). This meant that I could control each main feather so I could close or fan the wing easily.

If I could extend this project I would like to experiment with other wing shapes and sizes, as I would find it very interesting to model and then rig them, as they would all be very different. I would also like to make the main wing feathers out of single plains, instead of extending the edges of the main body to create 4 large plains. This would mean that I could better control these feathers and create effects like wind brushing through them. However, I would need to optimize the number of feathers for the Maya and the computer to handle it.

When it came to animating I found it slightly tricky due the fact that there was no body on the end of the wing. I had decided to only model the wing for this project as that was the part I was to concentrate on and making a body would have just been a waste of time. However, if I were able to extend this project I would like to model a body – bird, human, or mythical creature to investigate how each one would work with the wings in a CG environment, this would also help me further in my major project.

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