PROCEDURAL FEATHER MODELLING DIGITAL ASSET

PERSONAL INQUIRY

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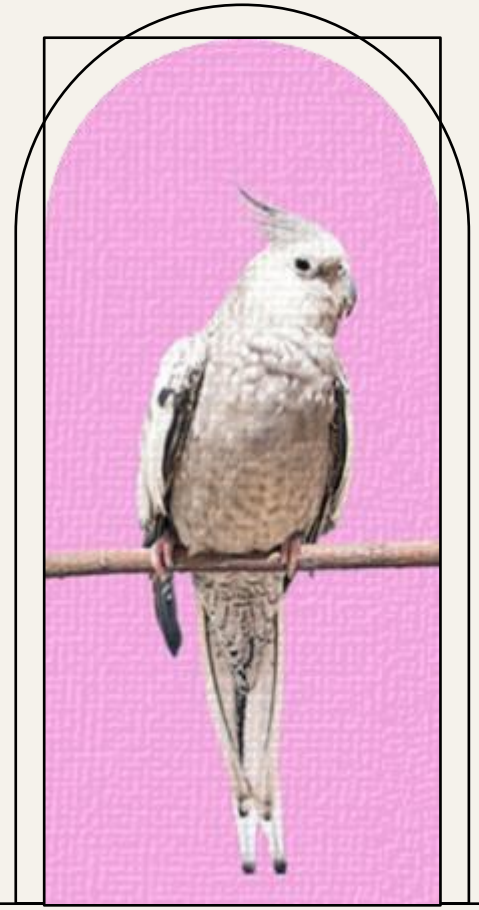
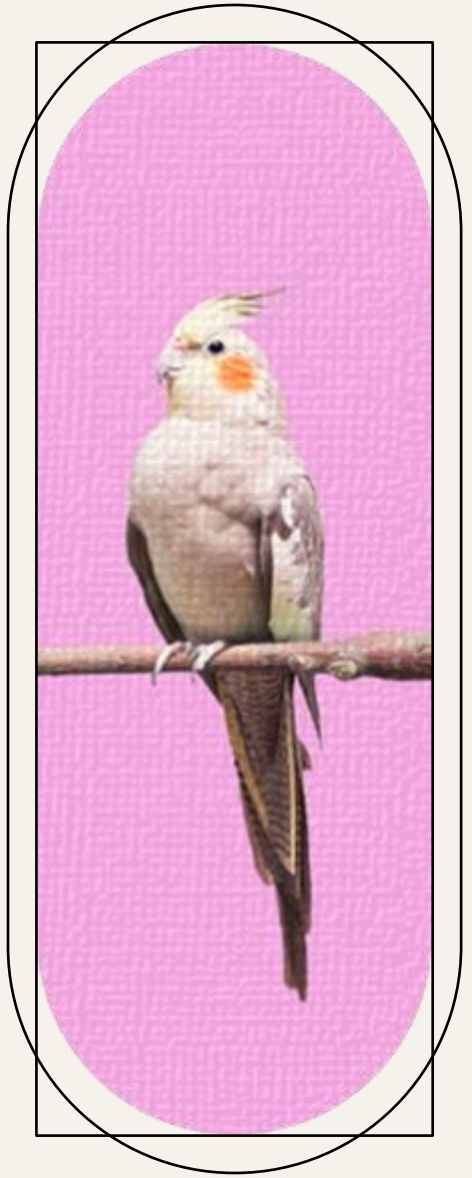
Objective

In this Personal Inquiry project, I am going to research about bird feathers and types of feathers , structures of a feather and its behavior's. Considering the research I did , I am going to create a procedural feather modelling digital asset using Houdini and compare the 3d feather to real world feather.

What is a Feather ?

- A feather is a type of exoskeleton found in all birds. Like our fingernails, feathers are formed of keratin, which is also waterproof, flexible, and lightweight. The bird can move each one around because it has muscles tied to the base of each one. Feathers are necessary for flight, insulation, and courtship behaviours. We can distinguish between different bird species and, in certain circumstances, between females and males based on the forms and colours of the feathers. They provide protection, colours that are utilised for communication, and insulation, which is crucial for maintaining body temperature. Although it may appear like a bird's feathers develop everywhere, they only do so in certain locations known as feather tracks. Although a feather may appear to have an easy structure to the naked eye, they actually have complex anatomy which indicates how birds use them. All feathers are made up of two main sections: the soft side branches known as barbs and the hard core shaft known as the rachis.
- A feather commonly weighs 0.0082 grammes or 0.000289 ounces.





Common types of feathers

There are 6 commonly recognized types of feathers:

Flight feathers - Flight feathers, a contrast to other bird feathers, are directly attached to the bird's bones. The primary purpose of a bird's flying feathers is to support flight. Flight feathers are primarily designed for aerodynamic purposes and play minimal role in insulation. The main purpose of the flight feathers is to help with the production of thrust and lift, which makes flight possible.

Contour feathers - The bright feathers you observe on a bird's exterior are its contour feathers. The colorful plumage that contour feathers provide both aids in distinguishing different bird species and helps the bird blend in with its surroundings. Against wind, rain, and temperature, contour feathers are the first line of defense. Like shingles on a roof, these feathers are organized in an overlapping pattern. They safeguard them from the wind, rain, and injury. Their barbules are not well developed.

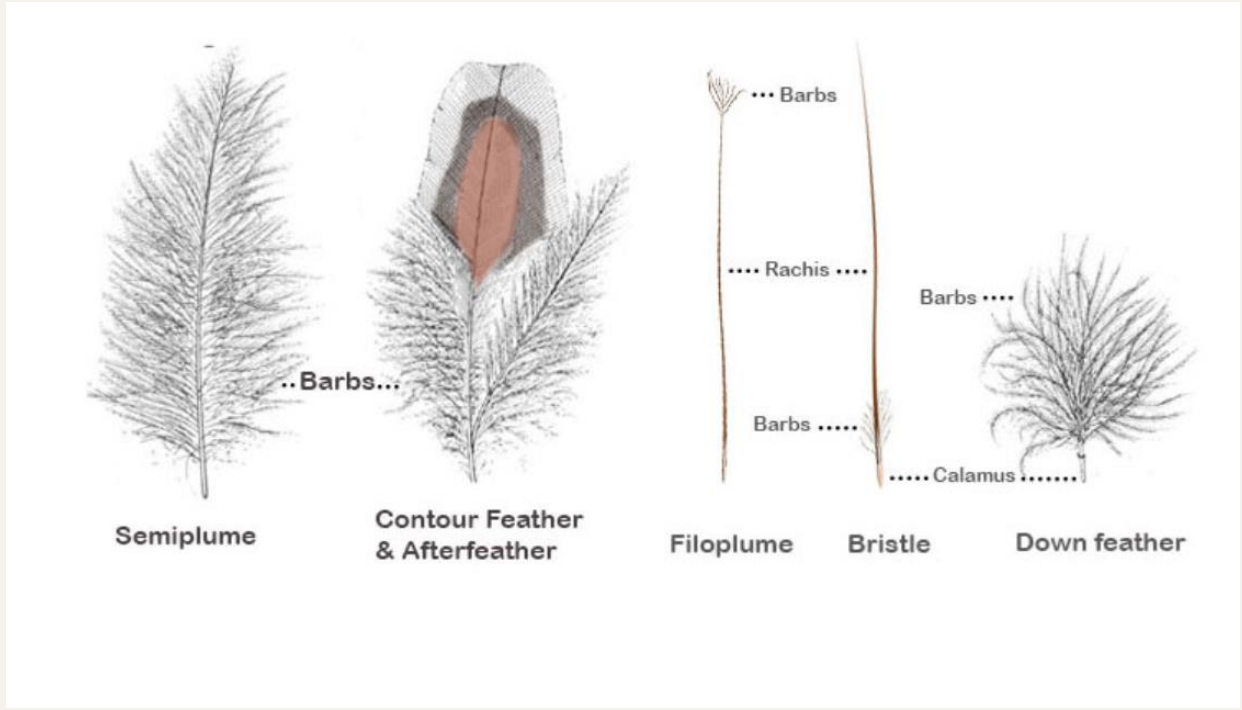
Down feathers - Feathers made of down are smaller, softer, and fluffier. Other feathers have rachises and hooked barbules, down feathers don't. Down feathers, which are found underneath the contour feathers, insulate the bird. Underneath the contour feathers is a layer of loosely structured feathers which serve to trap air close to the bird's body for warmth. The comfort of down is unmatched. Located mainly in the chest area.

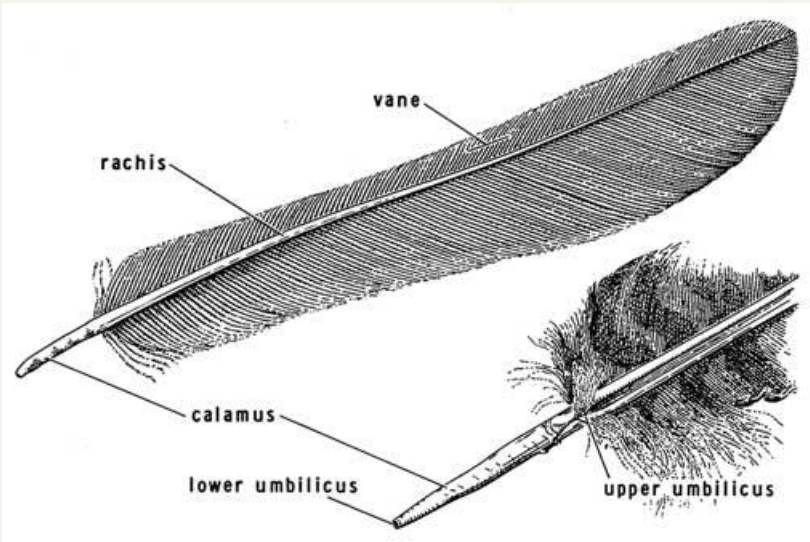
Semi plumes - Feathers that are loose and fluffy and resemble down feather; they insulate the body and make water birds more buoyancy. like down feathers and contour combined. Semi plumes have a developed central rachis but no hooks on the barbules, resulting in a fluffy insulating structure that is typically hidden behind other feathers on the body. There is a well-formed shaft on them. They are soft, yet, because to the lack of well-developed barbicels. Underneath contour feathers are semi plume feathers, which are used for insulation.

Filoplumes - The feathers on a filoplume are so tiny that they look like hair and are found all over the body. At the end of the shaft, they bear a tuft of barbs. Filoplume feathers are tied to nerve endings rather than muscles like other feathers, which allow for movement. The arrangement of feathers for flight, insulation, and preening is communicated to the brain via these feathers' messages. They are mostly found next to feathers that are physically active or movable, like a flight feather. Eight to twelve filoplumes may be connected to the calamus or quill of each flight feather. In ostriches and other non-flying birds, filoplumes are not present.

Bristle feathers - Most frequently found on the head, vaneless contour feathers have a short, firm rachis with only a few barbs at the base. They can develop around the eyes, nostrils, and mouth in flying insect-catching birds.
Another specific type of feather with sensory and defensive properties is a bristle.

Common Feather Types





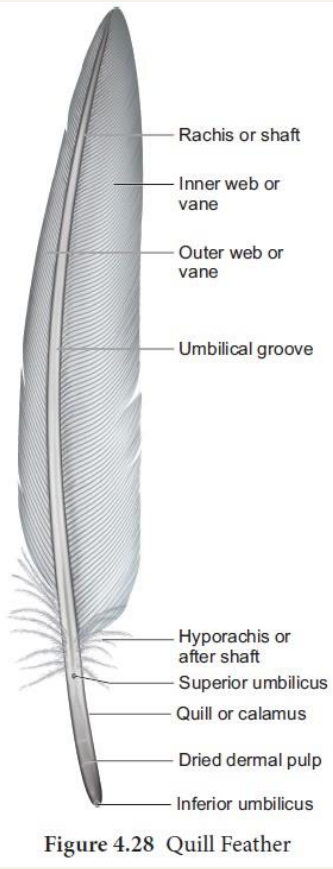


Figure 4.28 Quill Feather

Structure of feathers

Flight feathers – Flight feathers are made up of a stiff core shaft, called a rachis, to which barbs are attached to create a flat, aerodynamic (which is frequently asymmetrical) vane. The distal barbules on each barb feature hamuli, or tiny hooklets, which interlock with the filamentous proximal barbules to produce the vane. likely to be asymmetrical

Contour feathers - They are symmetrical, and the barbs do not contact.
The skin's follicle houses the basal calamus of the contour feathers that cover the body. This results in the formation of a flat feather with a centre rachis and two opposing, loose vanes.

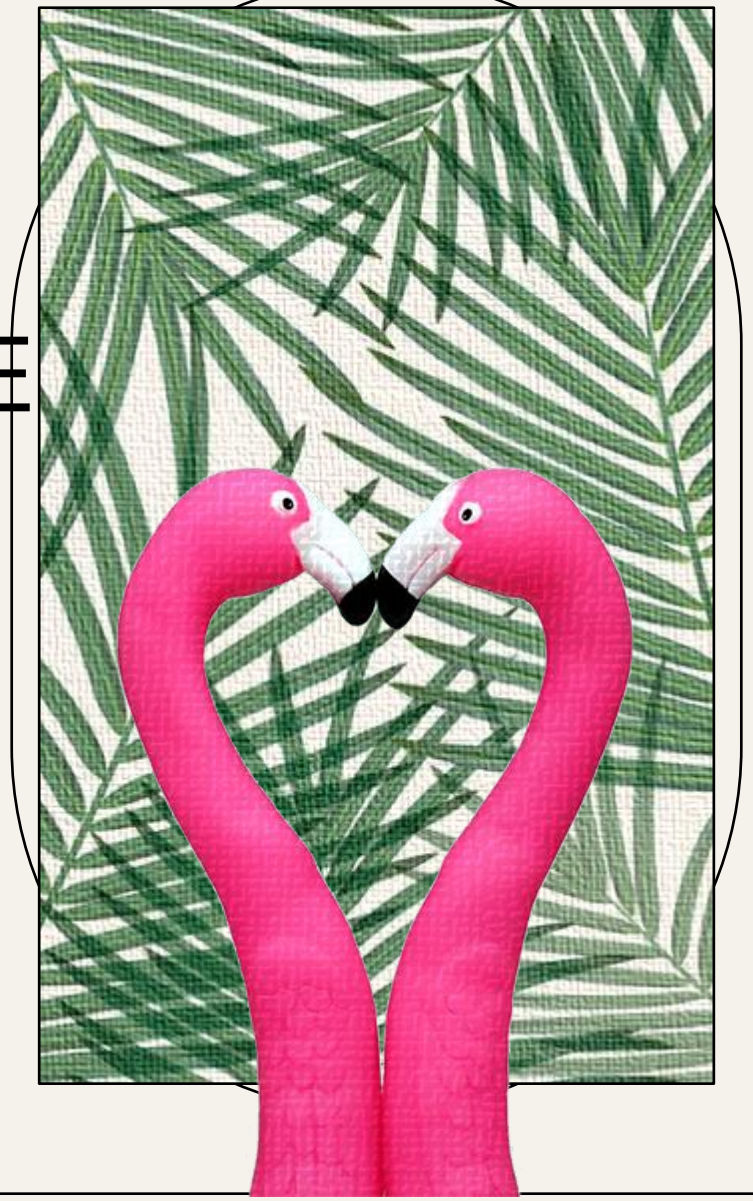
Down feathers - Down feathers, they normally don't have a rachis or form a vane

Semi plumes – Semiplumes, which are what egrets use as their display plumes during courting, are defined by having rachi that are longer than the barbs (which are frequently shortened), which fill out the body's outlines. Which have a rachis and side barbs with barbules that are smooth

Filoplumes - Filoplumes, which are small, hair-like feathers having some barbs and barbules on their tip, track the position of the flying feathers. They give sensory data for aerodynamic control and may even measure air speed.

Bristle feathers - Bristles are made up of a rachis with a minimal number of basal barbs and barbules. They provide sensory purposes and aid in collecting food by increasing the functional mouth hole (gape), which they can convert into eyelashes, nose covers, and, when situated around the mouth, rictal bristles. They are sensory and are usually found on the head.

I'M GOING TO CONCENTRATE ON PIGEONS' FEATHER IN THIS PERSONAL INQUIRY



TYPES OF PIEGONS

There are more than 300 species of wild pigeons and doves.
They exhibit a wide range of colors, patterns, and sizes.

Collared dove

Collared doves have a unique black neck collar, and they are a light, pinky-brown shade of grey. They have red feet and dark red eyes.
Length: 32 cm Wingspan: 51 cm Weight: 200 g

Rock dove/Feral pigeon

The domesticated rock dove was originally domesticated as a food source, and it is the wild ancestor of domestic pigeons today. Feral pigeons come in a variety of colors, some being bluer than others. Others are blacker. Some are a unique shade of dull red brick or cinnamon-brown. Some can be white, while others have the identical appearance of wild rock doves. In cities where their population is permitted to grow, they are occasionally viewed as an inconvenience.
Length: 31-34cm Wingspan: 63-70cm Weight: 230-370g

Stock dove

Stock doves look like rock doves/feral pigeons in size and color. They are generally blue-grey with a lovely bottle green band on the back of the neck and pink on the chest. In flight, they have black wing edges, and two partially black stripes close to their backs.
Length: 30-33cm Wingspan: 60-66cm Weight: 290-330g

Turtledove

Turtle dove is a delicate dove, bigger than a blackbird but a lot smaller and darker than the collared dove. Its tail is black, with a white edges, and its upperparts are particularly brown and black spotted.
Length: 26-28cm Wingspan: 47-53cm Weight: 130-180g

Woodpigeon

The woodpigeon, the biggest and most common pigeon in the UK, which has a white neck patch and white wing patches that can be recognized when it is in flight.
Length: 40-42cm Wingspan: 75-80cm Weight: 480-550g

PEGION COLOUR TYPES

Pigeons exist in a wide range of colours that we refer to as colour morphs. Seven different colour variants exist.

- Blue-barred: These have blue bars on their wings which are most common.
- Red-barred: The wings of these pigeons are marked with red bars.
- Red: The colour of these birds is a rusty red all throughout.
- Spread - Black-colored pigeons all over the place.
- White: The only colour on these pigeons is stark white.
- Checkered: These birds' wings are decorated in a checkerboard pattern.
- Pied: The coloration of these pigeons varies, with spots of colour appearing on various parts of their bodies.

TYPES OF FEATHERS IN PIGEON

1. Quills or Flight Feathers - These are pigeons thick, huge feathers. These feathers are used by the pigeon for flight.
These feathers have rachi that are strong. The three types of quills, often known as flight feathers, are remiges, rectrices, and coverts. categorized as
1) Remiges - Remiges are the term for a wing's flight feathers. Pigeon wings have 23 feathers per regime.
2) Rectrices - The tail's flight feathers are referred to as rectrices. In pigeons, there are 12 rectrices. These feathers aid the bird in controlling its flight and acting as a brake.
3) Coverts - Coverts are the quill feathers that protect the bases of the wing and tail quills. Although coverts are essentially the same as remiges and rectrices, they are smaller in size.

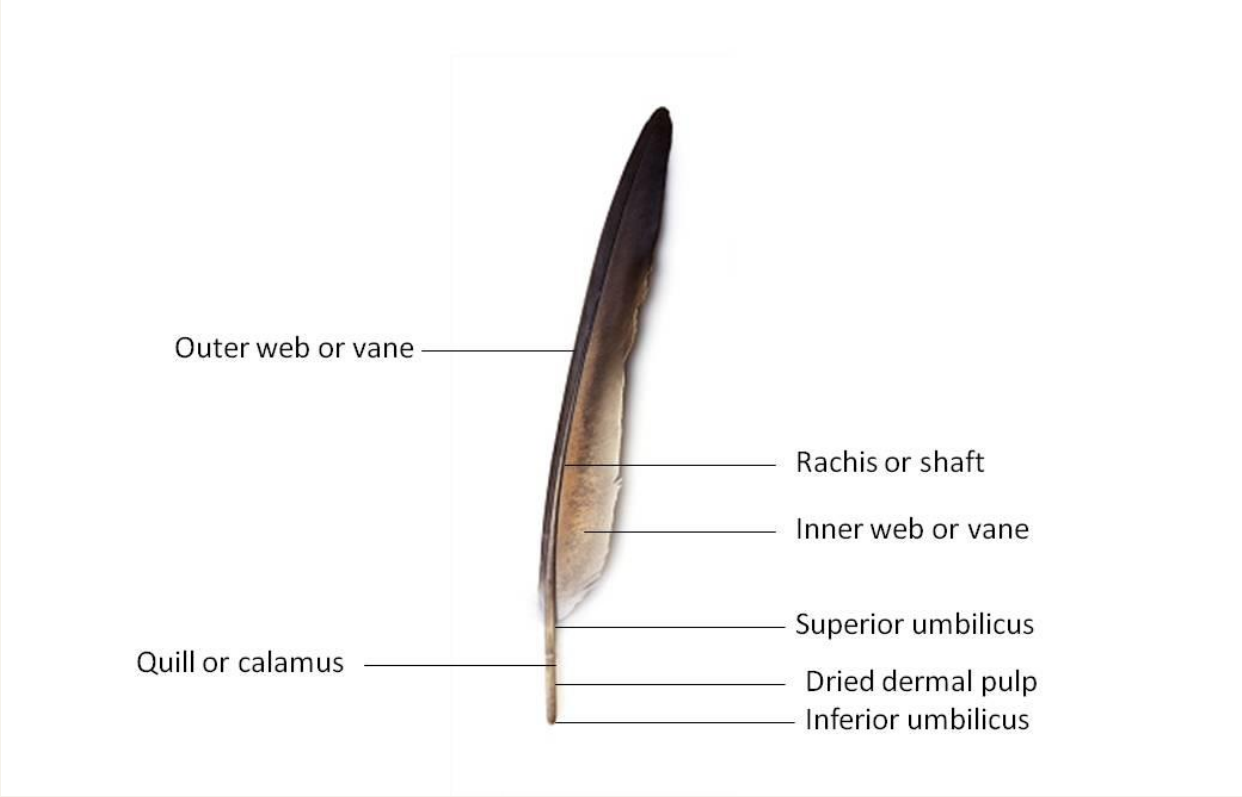
2. Contour Feathers - The majority of the body is covered by these feathers.They have smaller, woollier feathers that are easily differentiated from one another by their underdeveloped barbules. These offer warmth and turbulence-free, smooth airflow.

3. Filoplumes (Hair feathers or pin feathers) - These are the small, fragile feathers that look like hair.
They are made up of a long, thread-like rachis with a few fragile barbs and barbules at the free tip, and a short calamus.

4. Down Feathers (plumules) - The down feathers are small, delicate, and fuzzy; they don't have rachises, but they do have short calamuses. only to newborn babies. They lack rachises.
Down feathers are absent in adult pigeons. As the bird matures into an adult, the contour feathers take the place of the down feathers.

STRUCTURE OF FEATHERS IN PIGEON

- A typical pigeon feather has two parts. They are 1. The axis or main stem, and 2. The vane or vexillum.
- The axis - The feather's strong, hard center runs nearly the entire length of the feather. Once more, it is split into two parts. They are 1. Quill or Calamus and 2. Rachis or Shaft
- Quill - It is translucent, hollow, and tubular. It is the axis's proximal lower part. The quill's base is placed into a skin pit or epidermal follicle.
- Rachis - The rachis is the distal upper part of the axis. Transversely, it is solid, opaque, and about quadrangular.
- The Vane - It is the feather's enlarged membranous portion. It is split into two different parts by the rachis. The vane's proximal part is wider than its distal region.



PRIMARY RESEARCH

About the reference I used :

At the start I had no idea about making a feather procedural , so I did some research on to create a feather and I came across a youtuber user **Simon Houdini,** where I got some basic idea to model a feather.

And I also did explored for other resources related to feather modelling and I found that all shared similar approach in making of feather, were every method was from a Line and copy to points.

So, I thought I could make it procedural using similar approach and give it a try.

Following along the reference video:

First I followed the original tutorial to get a overview of the basic idea . While working I found some limitations.

1. The first limitation was **basic shape** of the VANE, which I couldn't make the shape which I desired for.

1. 2.The second thing I noticed was every real feather varies from each other, like from both side of feather can be **symmetric or asymmetric** .

3. The **centre shaft** also varies from shape to shape for different feathers.

4. Bending or **Bend angle** of the feather are also different.

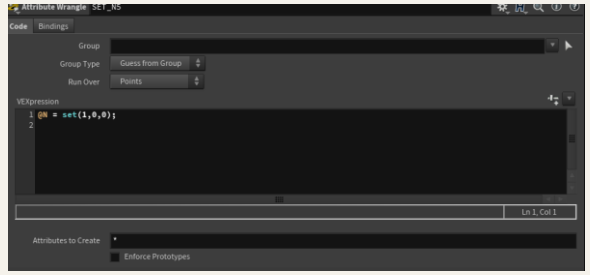
And Feather have also have **microscopic hairs** called Barbules, which was intresting , so I thought recreating this will make the feather more realistic.

These are the limitations and issues I found out on my starting stage.

To solve the problems, I thought Houdini has some inbuild attributes which might help.

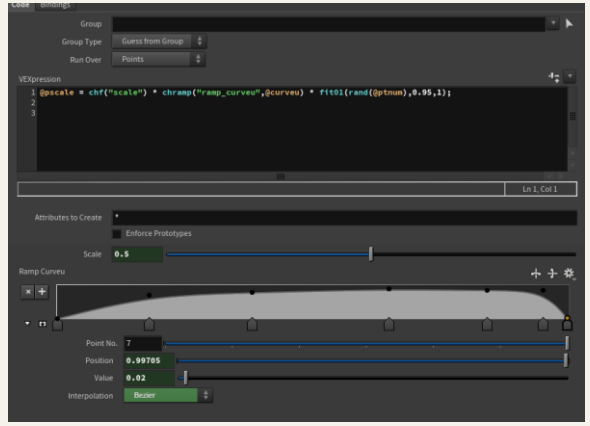
SHAPE

Considering the shape of feather I came across the Normals in Houdini .
So I took a line and set the normal to “X” direction and add another line on top of that using copy to point and I got the directions of the Barbs.



And I used a resample node to increase or decrease the points so I can get the number of barbs in the feather in a Procedural way.

In resample node there was a inbuild attribute “curve u” and Pscale I created a pscale as a channelfloat called it scale and multipled it with curve u . So I was able to change the shape in a procedural way .



In addition, I gave randomness to the lines as well.
In this way I solved the first issue.

For Creating variation on vane on both sides.

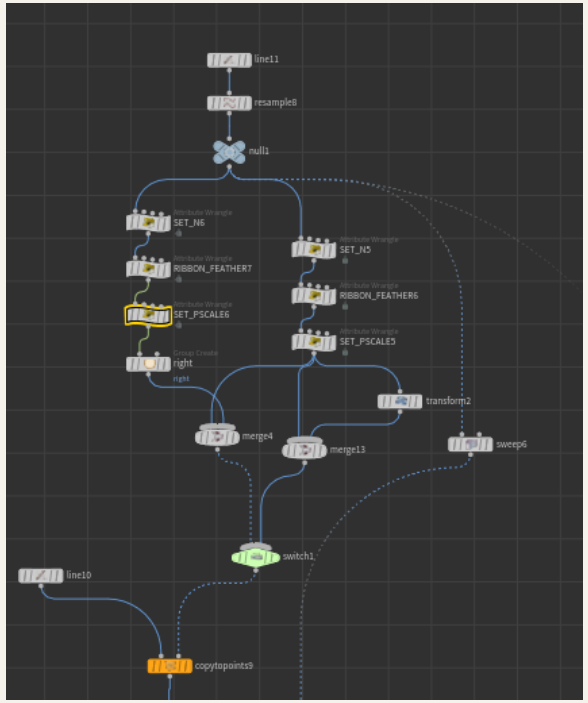
```
@N = set(-1,0,0);
```

```
@pscale = chf("scale") * chramp("ramp_curveu",@curveu) * fit01(rand(@ptnum),0.93,1);
```

I used the same method mentioned above to create this .
I changed the normal in negative direction and applied the same as expression , so it could be procedural.

In addition, I used switch node to merge these to make it turn on and off , as “symmetric or asymmetric”.

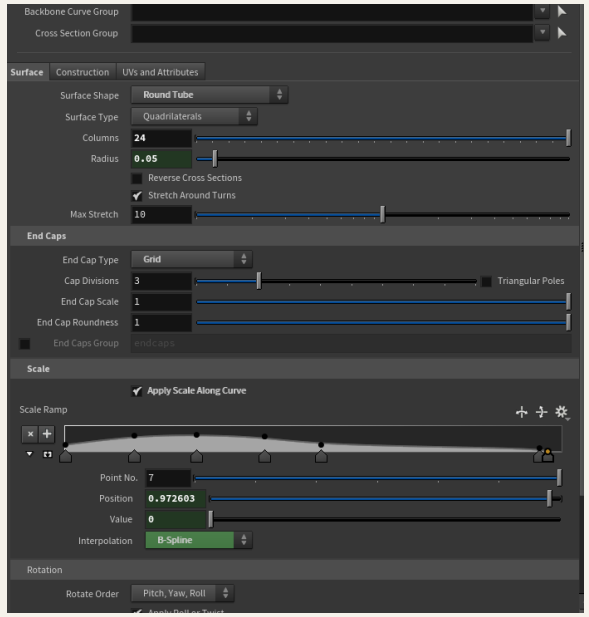
This way I solved the second issue I found.



Hollow shaft

I had no idea about creating this procedural so I tried different methods and I failed. Then I came to know scale ramp in sweep node where we can change shape of the shaft as per wish.

So I used scale ramp and radius as well so it might be handy.

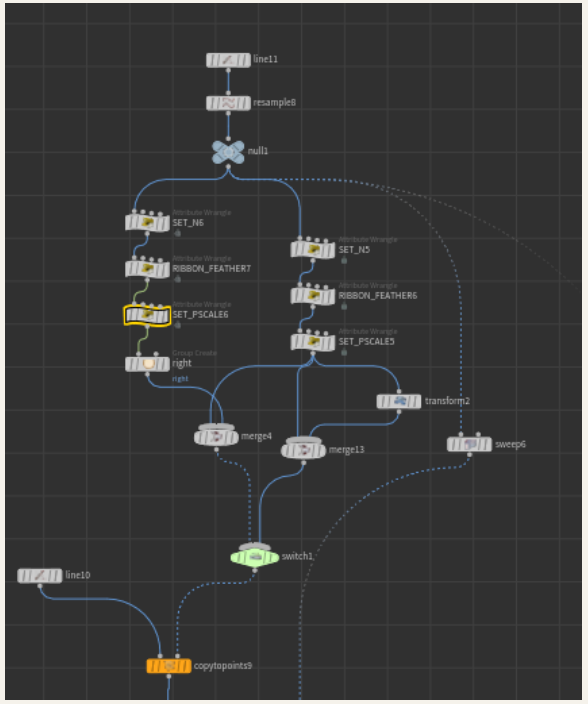


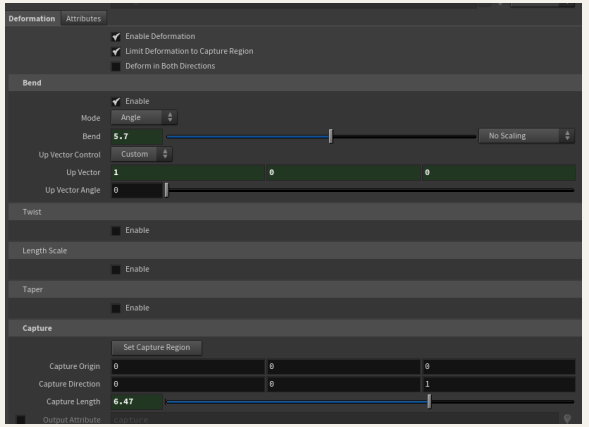
Giving the bend for the feather

For this , I thought I could use bend node tried to create the bending direction and I was able to achieve it at that time.

The best thing I thought was about “set capture region” tool in inbuild Houdini bend node and it worked at that time.

But later making it as a digital asset I faced some issues , I was not able to take add particular “set capture region” and could only solve bending an extend.



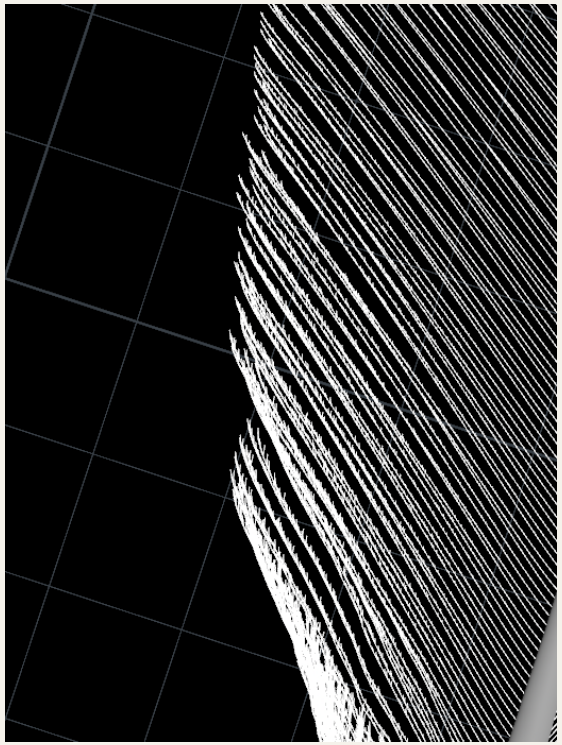


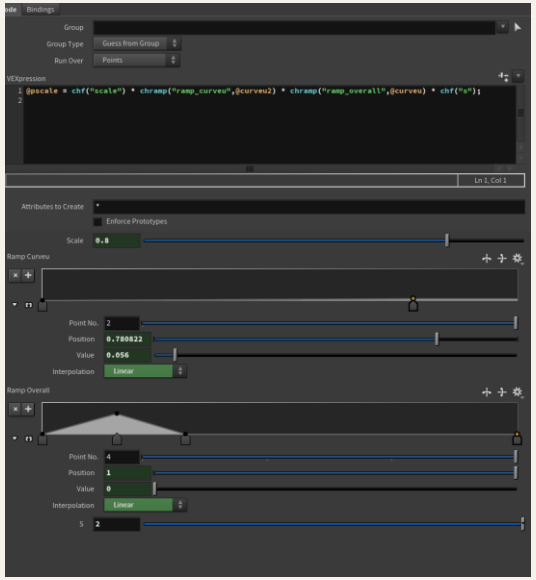
Creating Barbules

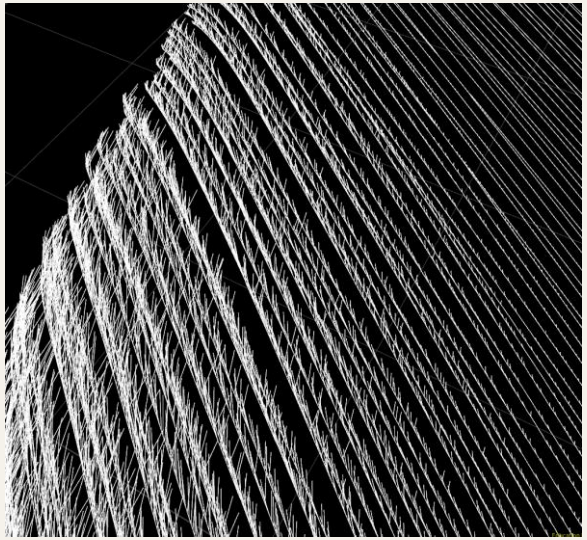
For creating the barbules ,I thought of the using the same method which I used for making vanes.
I Tried with to create it using same curve u, pscale but I found out some limitations while using and I tried with another resample node and created an second curve u attrib and named it curveu2.

Using pscale I multiped the both curve u attribs and made separate channels to control x and z axis . So I can make barbules as much length.

And I was able to solve this aswell.





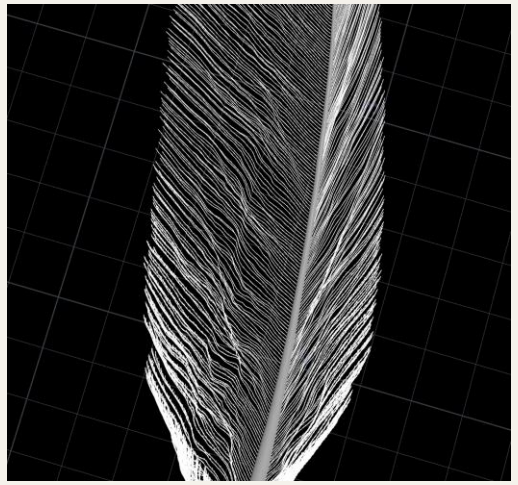


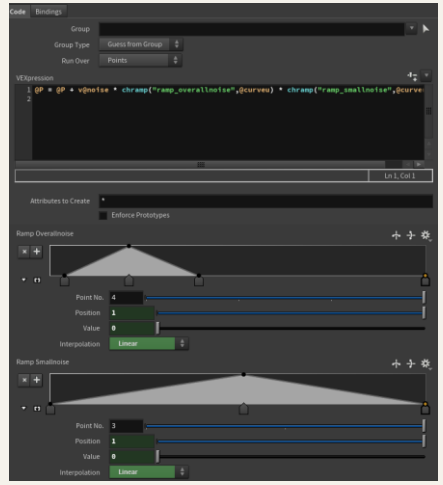
***Noise**
***Angle variation on vanes**
***Vane bend angle**

Real feathers as reference helped me to notice these minor details which was hidden from internet sources.
I found few more things while studying about feathers .
Some feathers might not look clean in real life reference.
There might be bends as well.

***Noise**

I used attrib noise and given some handles using ramps
So we can get some interesting noise patterns which
Gives a similar look as **Semiplume** feathertype.

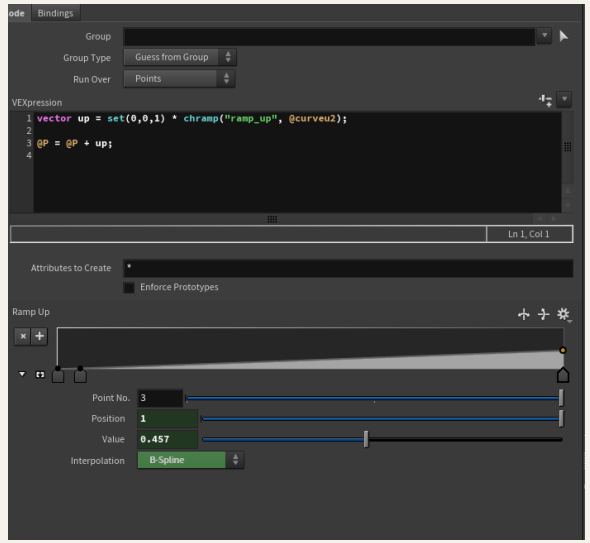


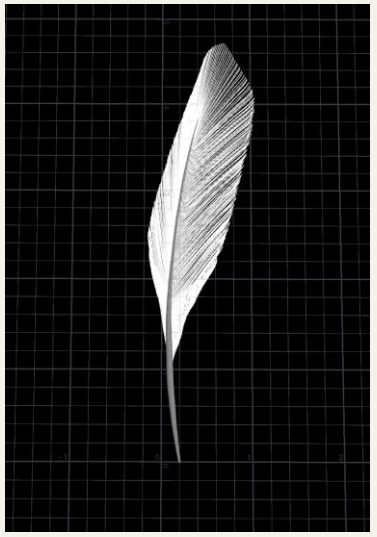


***Variation on vane**.

When I examined Flight feather and contour feathers closely , I found the upward growth direction of vanes was slightly different from each other.

So I was trying to solve this issue and I came up with “up vector”, so I can gave any direction as angle and assigned it to second curve u and In this way I created this minute variations , so I can achieve good results in feathers.

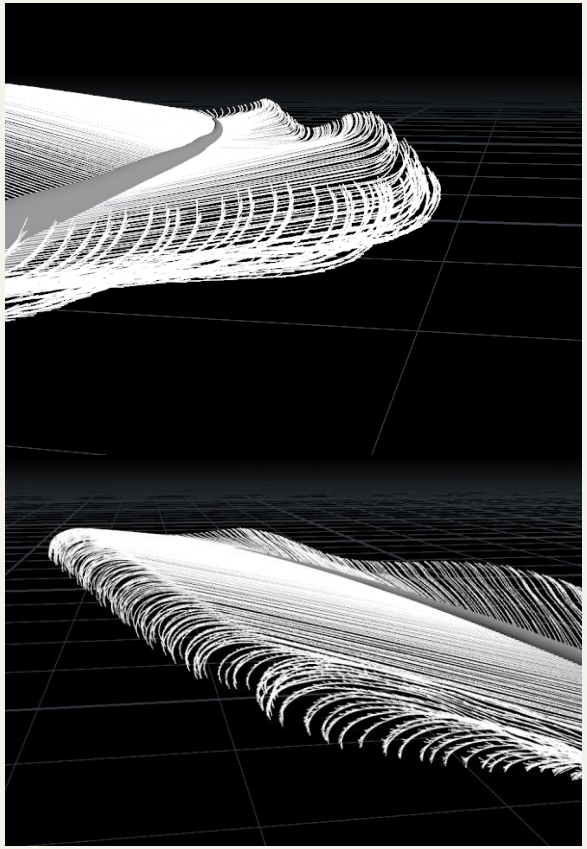




***Vane Bend Angle**

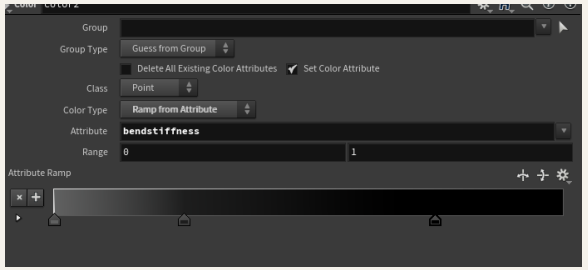
When I examined Flight feather and Tail feather or called Retrices closely I found the both side of the Vanes tips were facing in different angles like one facing positive and one facing negative direction.

For solving this issue need angle and axis , so I can apply the direction and angle according to feather. So, I created the channels ,which solved the problems.



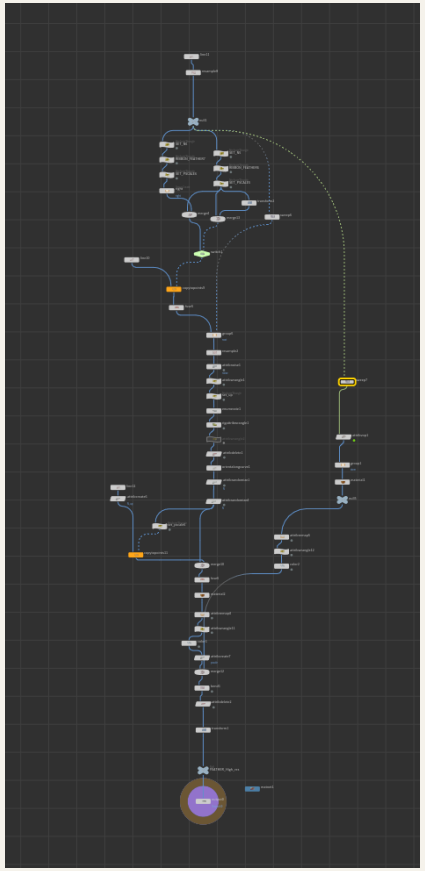
Texturing

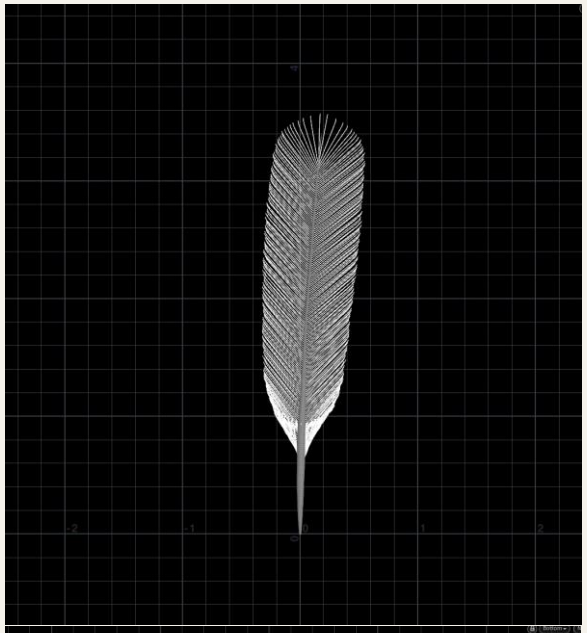
For texturing I used colour node but used a attribute ramp to derive the colour so we can assign texture as per ramp.

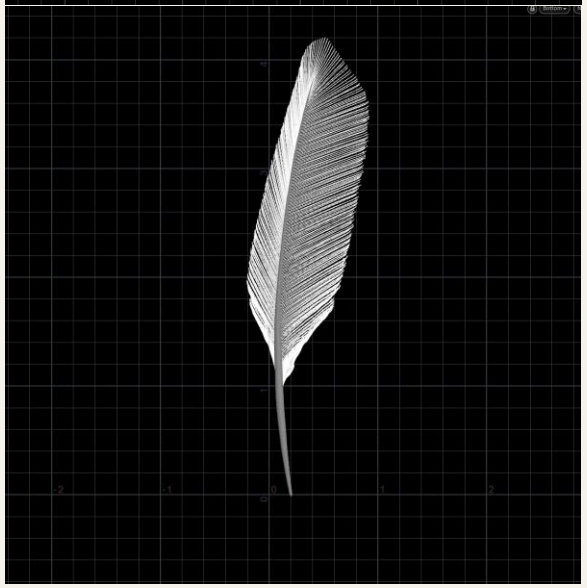


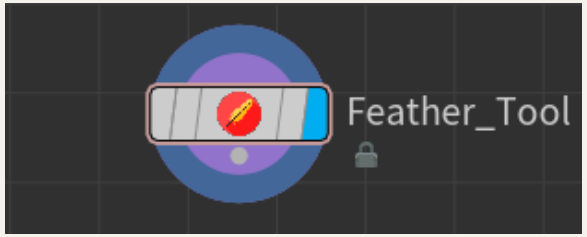
Conclusion

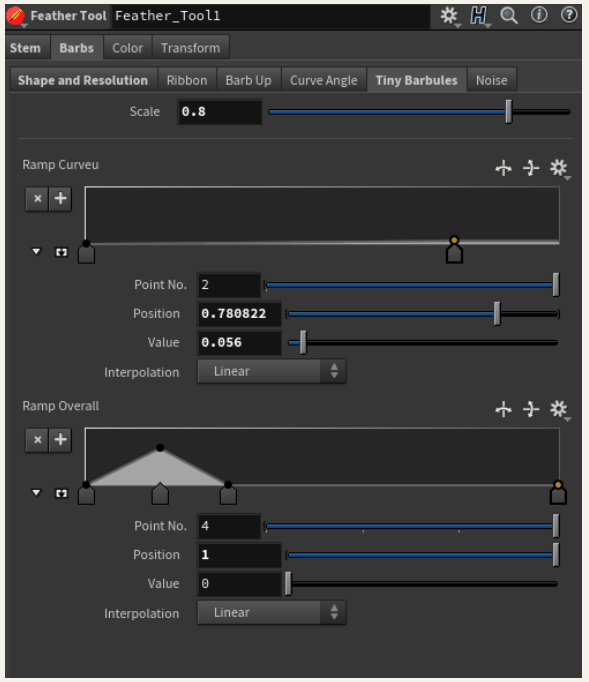
Combining everything thing together I was able to create a digital asset where I was able to create few feather variations.

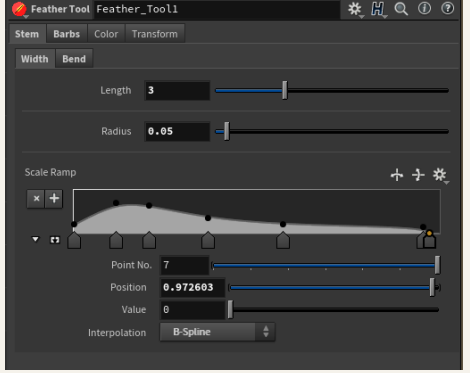




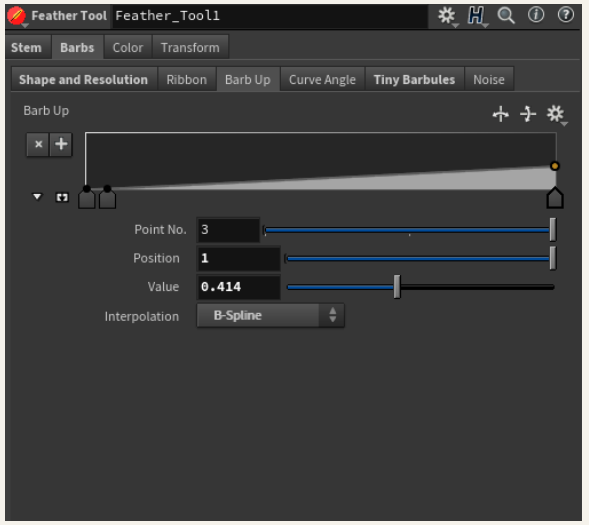



Feather_Tool


Feather Tool Feather_Tool1
Stem Barbs Color Transform
Shape and Resolution Ribbon Barb Up Curve Angle Tiny Barbules Noise
Scale 0.8
Ramp Curveu
Point No. 2
Position 0.780822
Value 0.056
Interpolation Linear
Ramp Overall
Point No. 4
Position 1
Value 0
Interpolation Linear


Feather Tool Feather_Tool1
Stem Barbs Color Transform
Width Bend
Length 3
Radius 0.05
Scale Ramp
Point No. 7
Position 0.972603
Value 0
Interpolation B-Spline


Feather Tool Feather_Tool1
Stem Barbs Color Transform
Barb Color
Stem Color


Feather Tool Feather_Tool1
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Barb Up
Point No. 3
Position 1
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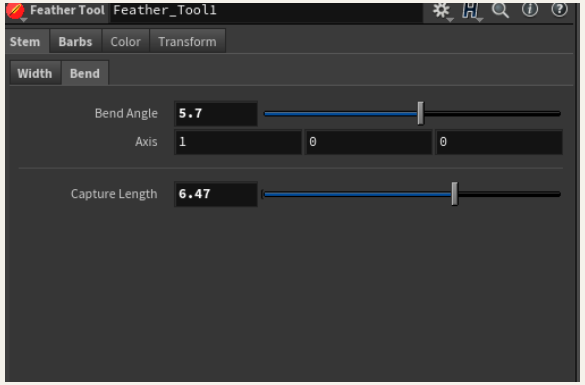
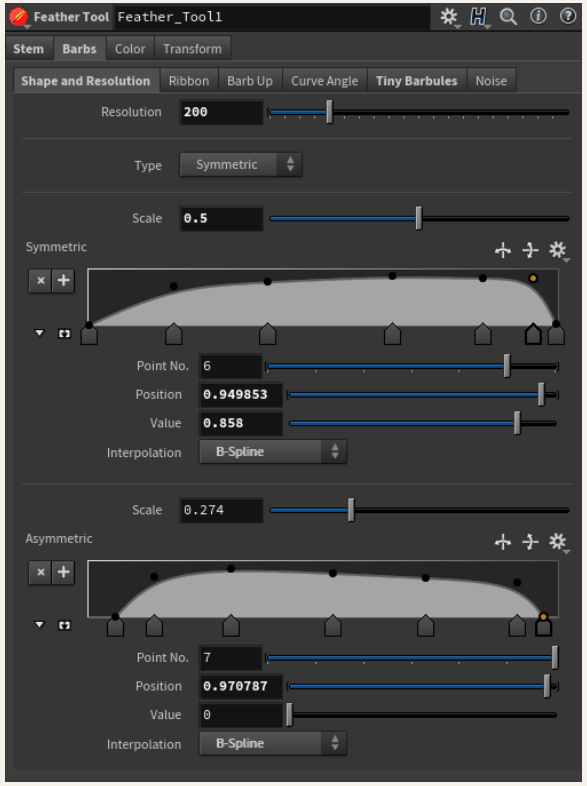
Interpolation B-Spline


Feather Tool Feather_Tool1
Stem Barbs Color Transform
Width Bend
Bend Angle 5.7
Axis 1 0 0
Capture Length 6.47


Feather Tool Feather_Tool1
Stem Barbs Color Transform
Shape and Resolution Ribbon Barb Up Curve Angle Tiny Barbules Noise
Resolution 200
Type Symmetric
Scale 0.5
Symmetric
Point No. 6
Position 0.949853
Value 0.858
Interpolation B-Spline
Scale 0.274
Asymmetric
Point No. 7
Position 0.970787
Value 0
Interpolation B-Spline

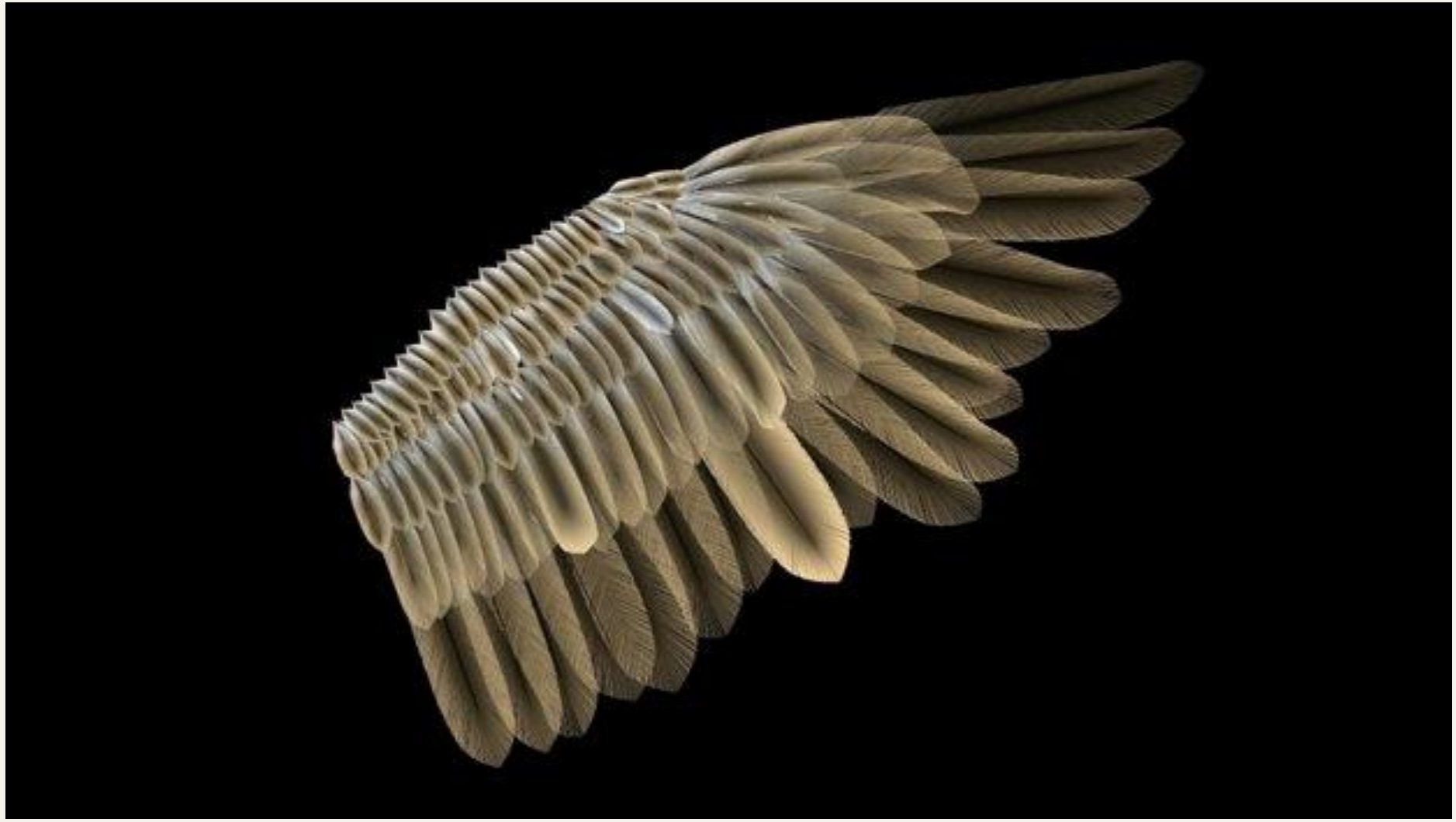
RENDER

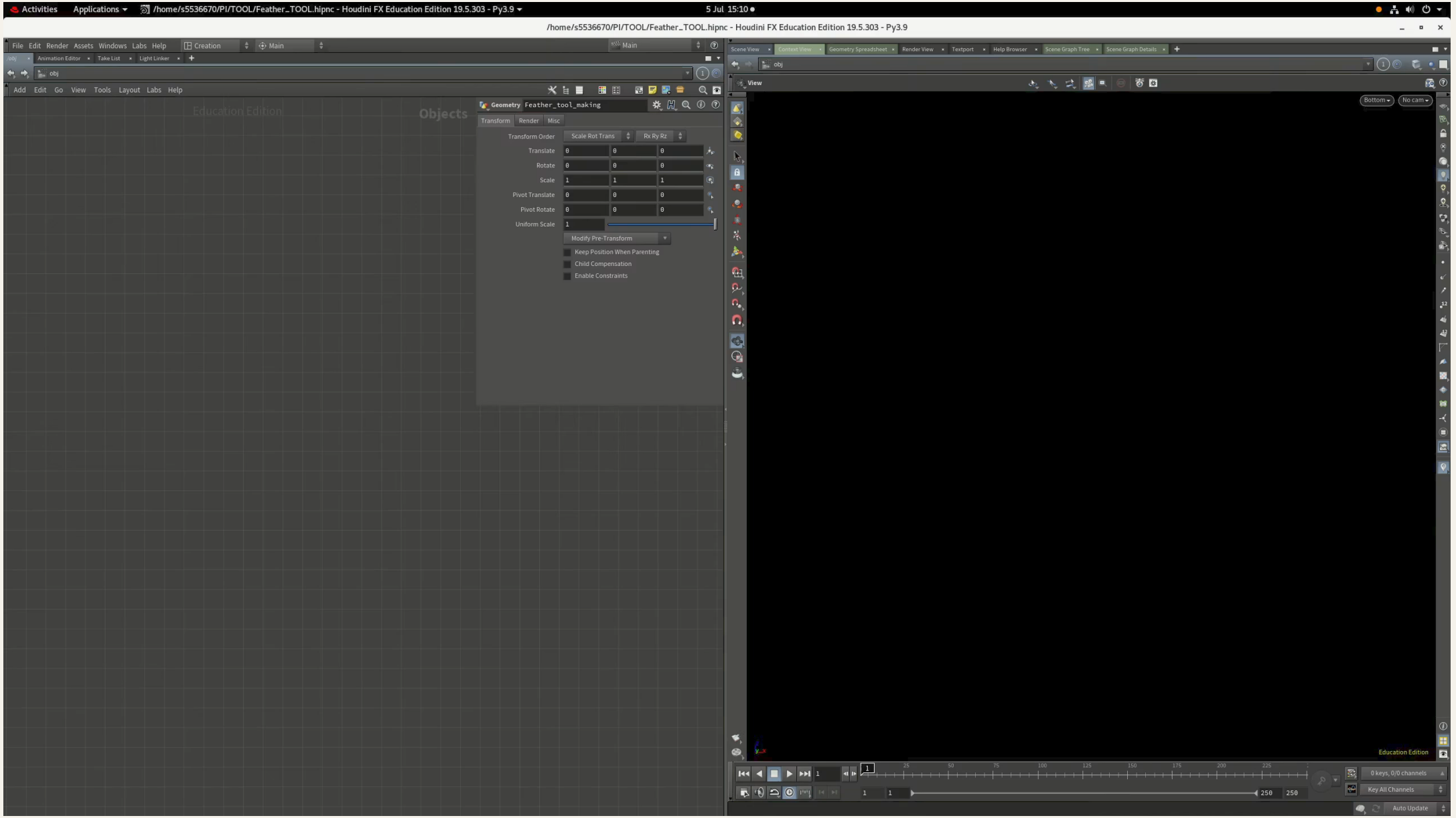
REFERENCE

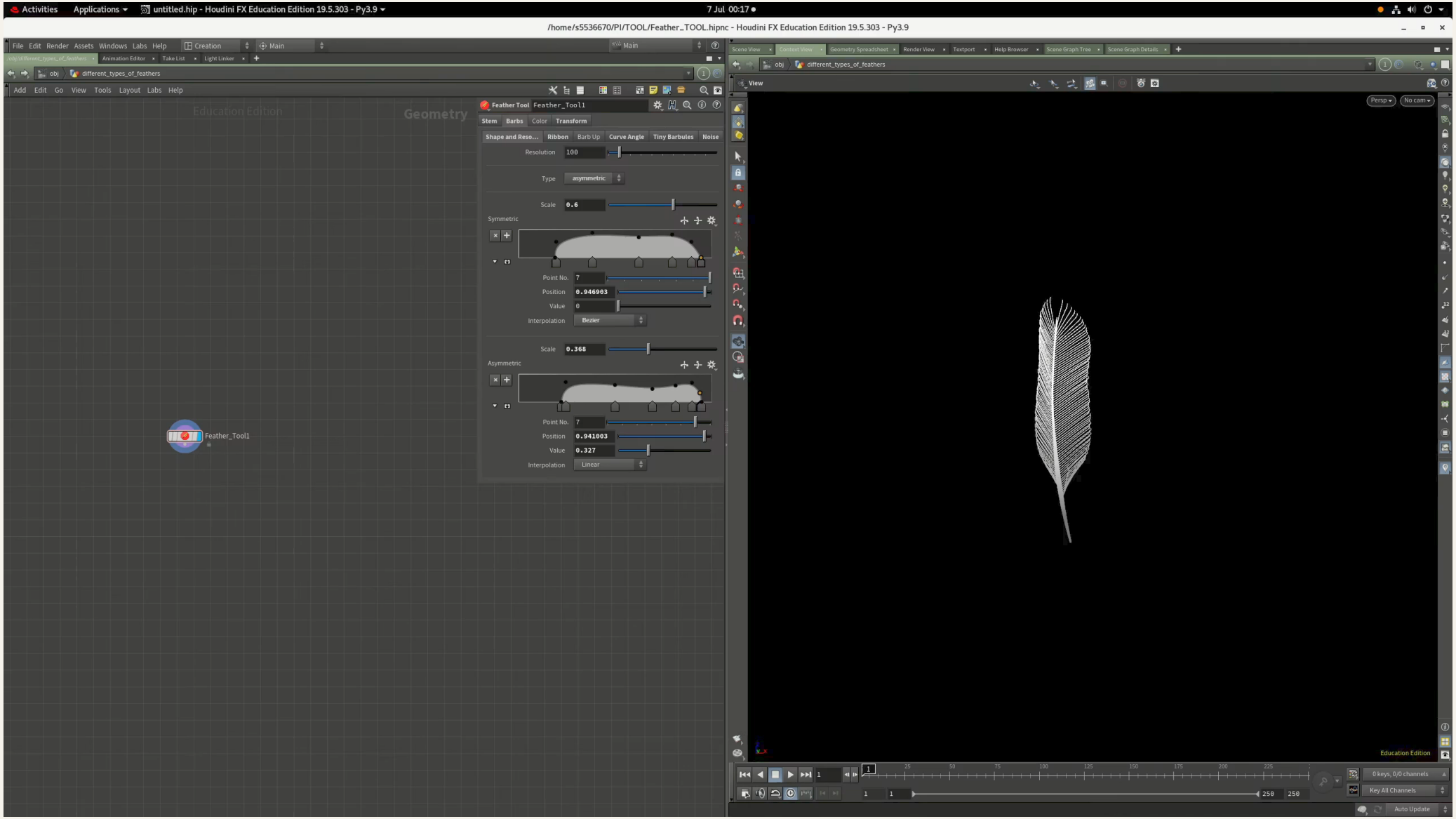
Renders

Reference

Wing render




Activities
Applications
/home/s5536670/PI/TOOL/Feather_TOOL.hipnc - Houdini FX Education Edition 19.5.303 - Py3.9
5 Jul 15:10
/home/s5536670/PI/TOOL/Feather_TOOL.hipnc - Houdini FX Education Edition 19.5.303 - Py3.9
File Edit Render Assets Windows Labs Help
Creation
Main
Add Edit Go View Tools Layout Labs Help
Education Edition
Objects
Geometry Feather_tool_making
Transform Render Misc
Transform Order
Scale Rot Trans
Rx Ry Rz
Translate
Rotate
Scale
Pivot Translate
Pivot Rotate
Uniform Scale
Modify Pre-Transform
Keep Position When Parenting
Child Compensation
Enable Constraints
Scene View
Context View
Geometry Spreadsheet
Render View
Textport
Help Browser
Scene Graph Tree
Scene Graph Details
View
Bottom
No cam
Education Edition
0 keys, 0/0 channels
Key All Channels
Auto Update


Activities
Applications
untitled.hip - Houdini FX Education Edition 19.5.303 - Py3.9
7 Jul 00:17
/home/s5536670/PI/TOOL/Feather_TOOL.hipnc - Houdini FX Education Edition 19.5.303 - Py3.9
File Edit Render Assets Windows Labs Help
Creation
Main
Animation Editor
Take List
Light Linker
obj
different_types_of_feathers
Add Edit Go View Tools Layout Labs Help
Education Edition
Geometry
Feather_Tool1
Feather Tool Feather_Tool1
Stem Barbs Color Transform
Shape and Reso... Ribbon Barb Up Curve Angle Tiny Barbules Noise
Resolution 100
Type asymmetric
Scale 0.6
Symmetric
Point No. 7
Position 0.946903
Value 0
Interpolation Bezier
Scale 0.368
Asymmetric
Point No. 7
Position 0.941003
Value 0.327
Interpolation Linear
Scene View
Context View
Geometry Spreadsheet
Render View
Textport
Help Browser
Scene Graph Tree
Scene Graph Details
View
Persp
No cam
Education Edition
0 keys, 0/0 channels
Key All Channels
Auto Update

REFERENCES

- BrainKart. (n.d.). *Pigeon (Columba livia) - Classification, External features, Exoskeleton, Endoskeleton, Anatomy Structure*. [online] Available at: https://www.brainkart.com/article/Pigeon-(Columba-livia)_33185/.

- The RSPB. (n.d.). *Pigeons and Doves | Bird Family Overview*. [online] Available at: https://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/pigeons-and-doves/.

- Anon, (n.d.). *Types of pigeons* -. [online] Available at: https://www.pigeonrescue.org/resources/types-of-pigeons/.Types of pigeons -Types of Pigeons There are more than 300 species of wild pigeons and doves. (Dodos were pigeons! The largest flocks ever recorded were of Passenger pigeons- both species that humans drove to extinc...

- birdsofseabrook.app.clemson.edu. (n.d.). *Feathers*. [online] Available at: https://birdsofseabrook.app.clemson.edu/topics/feather_structure.html.

- Study.com. (2022). Available at: https://study.com/learn/lesson/bird-feathers-types-parts.html.

- Villa, A.L.V., Aragão, M.R.S., dos Santos, E.P., Mazotto, A.M., Zingali, R.B., de Souza, E.P. and Vermelho, A.B. (2013). Feather keratin hydrolysates obtained from microbial keratinases: effect on hair fiber. *BMC Biotechnology*, 13(1). doi:https://doi.org/10.1186/1472-6750-13-15.

REFERENCES

•Science Learning Hub (2011). *Feathers and flight*. [online] Science Learning Hub. Available at: https://www.sciencelearn.org.nz/resources/308-feathers-and-flight.

•academy.allaboutbirds.org. (2013). *Everything You Need To Know About Feathers | Bird Academy • The Cornell Lab*. [online] Available at: https://academy.allaboutbirds.org/feathers-article/#:~:text=Bristle [Accessed 7 Jul. 2023].

•kidwings.com. (n.d.). *3. Bird Feathers | Kidwings*. [online] Available at: https://kidwings.com/project/bird-feathers/#:~:text=Semiplume%20feathers%20are%20a%20cross [Accessed 7 Jul. 2023].
•3. Bird Feathers | Kidwings
•A post from Chris Anderson on Kidwings provided by: https://kidwings.com

•www.youtube.com. (n.d.). *Basic Procedural Feather || Houdini Tutorial*. [online] Available at: https://youtu.be/jNj9o9g04pA [Accessed 7 Jul. 2023].

•www.olympiadgenius.com. (n.d.). *Types of feathers*. [online] Available at: https://www.olympiadgenius.com/study-material/grade-4-Science-Types-of-feathers/?_id=367 [Accessed 7 Jul. 2023].

•M. S., A.E. and B. S., B. and C. (n.d.). *Understanding Feather Types and Structure*. [online] ThoughtCo. Available at: https://www.thoughtco.com/feather-anatomy-and-function-129577.

REFERENCE

Report, A. (2021). *A Guide To Bird Feathers*. [online] Avian Report. Available at: https://avianreport.com/bird-feathers/.
A Guide To Bird Feathers - Avian Report
Bird feathers are one of the most distinctive features of avian anatomy. Feathers are fundamental to many aspects of a bird's existence. They provide

Birdwatching-Bliss.com. (n.d.). *Bird Feathers - ID, Structure, Types, Colors*. [online] Available at: https://www.birdwatching-bliss.com/bird-feathers.html.

Bird, C. (2018). *Different Types of Bird Feathers*. [online] Bird Watching Academy. Available at: https://www.birdwatchingacademy.com/different-types-of-bird-feathers/.
Different Types of Bird Feathers - Bird Watching Academy
Feathers emerged from the scales of reptiles and kept birds apart from all other creatures. Feathers are essential for insulation, flight, and courtship displays. Feather shapes and colors help us …

Feather | zoology. (2019). In: *Encyclopædia Britannica*. [online] Available at: https://www.britannica.com/science/feather.

The RSPB. (n.d.). *Bird Feathers | How Feathers Work?* [online] Available at: https://www.rspb.org.uk/birds-and-wildlife/natures-home-magazine/birds-and-wildlife-articles/how-do-birds-survive/adapted-for-flight/how-do-feathers-work/#:~:text=Feathers%20are%20made%20of%20lightweight.

Reference

kidwings.com. (n.d.). *3. Bird Feathers | Kidwings*. [online] Available at: https://kidwings.com/project/bird-feathers/.
3. Bird Feathers | Kidwings
A post from Chris Anderson on Kidwings provided by: https://kidwings.com

KINDS OF FEATHERS OF COLUMBA LIVIA. (n.d.). Available at: https://maharajacollege.ac.in/fileupload/uploads/60dd3370b8beb20210701031600KINDS%20OF%20FEATHERS%20IN%20COLUMBA%20LIVIA.pdf [Accessed 7 Jul. 2023].

Anon, (2022). *Feathers in Pigeon | Columba livia | Diagram | Swarborno*. [online] Available at: https://swarborno.com/feathers-in-pigeon-columba-livia-diagram/#Feather [Accessed 7 Jul. 2023].
Feathers in Pigeon | Columba livia | Diagram | Swarborno
In this article on pigeons, we will learn about the structure, types, development, and uses of feathers in pigeons (Columba livia).
BrainKart. (n.d.). *Pigeon (Columba livia) - Classification, External features, Exoskeleton, Endoskeleton, Anatomy Structure*. [online] Available at: https://www.brainkart.com/article/Pigeon-(Columba-livia)_33185/.

Weigh, W.T. (2018). *Weight Of Feather*. [online] What Things Weigh. Available at: https://whatthingsweigh.com/how-much-does-a-feather-weigh/.

Audubon. (2020). *Pigeon Watch: Get to Know (and Love) Our Amazing City Birds*. [online] Available at: https://www.audubon.org/news/pigeon-watch-get-know-and-love-our-amazing-city-birds.