I  CHORD LENGTH OR UNIFORM PARAMETERIZATION

All of the better high end packages that implement Nurbs Modeling tools will offer the choice of constructing curves using either Uniform or Chord Length parameterization. If you are very new to NURBS modeling this can be somewhat confusing in terms of the pros and cons of each technique. The purpose of this exercise is to give you a better understanding of both of these techniques and help you to understand when to use each particular method. If I were to sum it up very briefly I would have to say that the biggest concern in making this decision is how will that surface be texture mapped as one will result in far less distortion of a texture map in many cases.

Most of your curve construction will likely be done by placing a Control Vertices to plot out the initial profile curves. By default, when using the Control Vertices, most systems will default to Uniform Parameterization as Houdini does. These curves tend to the easiest to control in the construction process and are well suited to curves that will have very irregular shapes and change direction many times along their length. While you are placing the control vertices that seldom if ever lie directly on the curve, the system is plotting a series of Break Points as well. These points do lie directly on the curve but are hidden unless you choose to toggle the display of such on.

Your other construction option is to construct a curve by plotting Break Points, often referred to as Edit Points in other systems. By Default when you build a curve with Break Points, the system constructs a curve using Chord Length parameterization. As you place the Break Points, the system will place the Control Vertices for you. This method is well suited to organic like surface and surfaces such as the car hood that you are going to build here that is basically made up of flowing curves where a high quality of curvature is desired.

Compare the parameterization on the two surfaces below.
1.1 GETTING STARTED

1. Launch Houdini and load the file *Model_param.hip*

2. Toggle the Sky Object and Ground Object’s display flags Off.

3. Pass the Curves Object into the SOP editor.

4. Place a Model SOP in the layout window.

5. Rename this Model SOP to be **Uniform Curves**.

6. Enter into Build Curve state and home the viewport window. Remember now that you are no longer in View state, to use the **h** keyboard command you will also have to hold down the **Space** bar.

7. Now select the Nurbs curve option from the icon set above the viewport window.

8. Now click on the **symbol to display the associated parameter window.**

9. Note that the default here is Chord Length Parameterization. Click on the Parameterization option and select Uniform as shown in the following illustration.
BUILDING A **UNIFORM** PARAMETERIZED CURVE WITH **BREAKPOINTS**

1. Toggle the Snap function On using the keyboard command \( \text{Alt}O \).

2. Toggle the display of Break Points On but don’t display actual Points at this time.

3. \( \text{Alt}O \) to toggle on the snap feature.

4. Draw a four point curve in the perspective window. Refer to the illustration below as reference. I simply left 3 grid space between each Break Point. Remember to end the construction, press the e key or right click to end.

5. Now draw a second curve, below the first one. Use 6 Break Points to create this curve. Once again, refer to the illustration below.

6. Switch back into the View State mode once again.

7. Append a Skin SOP to the Model SOP and toggle its display flag On.

As shown in the following illustration, note how the isoparms are spaced in the newly skinned surface due to the difference in the number of Break Points on each curve. Ideally when modeling you should try to keep the number of Break Points on each curve identical. But this is often easier said then done.
8. Append a **Texture SOP** to the Skin SOP and working with the Texture SOP parameters:
   - change the Texture Type option from Orthographic to *Uniform Spline*.
   - increase the Scale parameter to a value of 2

9. Append a **Material SOP** to the Texture SOP and toggle its Display and Render flags On. Now working with the parameters:
   - assign *Checker* as the material in the first Material field.

10. Toggle the viewport into Gouraud shading mode. You can use the $w$ key remember.
Chord Length or Uniform

Houdini Training 4.0 ©Side Effects Software 2000

Houdini does have a number of options to help out in situations like this. This is a Uniformly parameterized surface. You have also used Uniform Spline for the Texturing method in this example. So try this:

11. Working with the Texture SOP parameters once again:
   - change the Texture Type parameter to Arc Length Spline

Note the distortion of the checker patterns on the texture map due to the parameterization on the surface.

This is considerably better. Even though the surface is Uniform in its parameterization, Houdini has tried to do a Chord Length calculation for the mapping. This may be enough in many cases to get you out of a fix.

However you will now look at an actual Chord Length Parameterized surface.
BUILDING A CHORD LENGTH PARAMETERIZED CURVE WITH BREAKPOINTS

1. Place a second Model SOP in the layout window to the immediate right of the current Model SOP and toggle this SOP's display flag On.

2. Rename this Model SOP, Chord_length Curves

3. Enter into Build Curve state and home the viewport window. Remember now that you are no longer in View state, to use the $h$ keyboard command you will also have to hold down the $w$ bar.

4. Now select the Nurbs curve option from the icon set above the viewport window.

5. Now click on the $\bigcirc$ symbol to display the associated parameter window.

6. Change the Parameterization option from Uniform to Chord Length this time.

7. Now plot two curves once again the same way you did in the first example. Remember the upper curve is constructed with four Break Points and the lower curve with Six. Refer to the following illustration for the placement of the six points on the lower curve.

![Diagram showing Chord Length Parameterized Curve with Breakpoints](image-url)
8. Switch back into View State mode once again.

9. Append a Skin SOP to the Model SOP and toggle its Display flag On.

Note the difference in the parameterization on this surface. Even though the point count was different on each of the curves used in the construction Houdini cross inserted Edit Points to control the isoparms on the surface. But more importantly is how the parameterization is calculated on the surface when it comes to texturing as you will see in a moment.

10. Append a Texture SOP to the Skin SOP and working with the Texture SOPs parameters:
   - change the Texture Type option from Orthographic to *Average Spline*.
   - increase the Scale parameter to a value of 2

11. Append a Material SOP to the Texture SOP and toggle its Display and Render flags On. Now working with the parameters:
   - assign *Checker* as the material in the first Material field.

12. Toggle the viewport into Gouraud shading mode.

Note the lack of distortion in the mapping this time.

In the previous example where you used Uniform Parameterization but the Arc Length Spline option in the Texture SOP the mapping came close to this. However even in that example if you compare the illustrations you will note there was some stretching of the tiles in the middle area of the surface in that example. In this example there is not stretching.
THE CAR HOOD

In this portion of the exercise you will apply this modelling methodology to create a car hood, and apply textures to it.

1. Launch a new Houdini and load the file called *carhood.hip*

2. If the Training Desktop is not loaded then load it now.

3. Enter into the Car_hood’s SOP editor.

The curves have already been created for you. There are two different model SOPs included here. One is a set of curves modelled with *uniform* parameterization and the other the same set of curves modelled with *chord length* parameterization

When the curves were constructed in the modeler, we also created curve groups to make the skinning operations easier for you.

THE UNIFORM PARAMETERIZATION EXAMPLE

1. Ensure that the display flag is toggled on for the SOP named Uniform.

2. Append a Skin SOP to the File SOP called Uniform, toggle its display flag on and:
   - Click on the ▶ icon at the end of the U Cross Sections parameter field and select the group *hood_u*
   - Click on the ▶ icon at the end of the V Cross Sections parameter field and select the group *hood_v*
3. Toggle the viewport window in and out of Gouraud mode using the key whenever you want to view in either wireframe or Gouraud mode.

Take notice of the isoparms distribution on this surface.

4. Append another Skin SOP to the current Skin SOP, toggle its display flag On and:
   • select the fender_u group as the U Cross Sections
   • select the fender_v group as the V Cross Sections
   You now have the fender surface.

5. Append a third Skin SOP to the last Skin SOP, toggle its display flag On and:
   • select the w_well_u group as the U Cross Sections
   • select the w_well_v group as the V Cross Sections
   You now have the wheel well surface.

You now have 3 separated surfaces.

If you toggle the display of primitive numbers On, you will note the:

Hood is surface #0
Fender is surface #1
Wheel Well is surface #2
I decided to use a number of different techniques here to bring these surfaces together. Any or all of these could have been used but I wanted variety here to sure you a number of options.

**STITCHING**

You are going to use Stitch to stitch the hood and the fender edges together. Stitch does not create one single surface. As a result of the stitch the two surface edges will match but you will still have the ability to raise the hood for engine inspection without effecting the fender surfaces.

Remember that you always get the primitive numbers you want to use from the SOP immediately above the SOP you are about to use. The Hood is surface #0 and the Fender is surface #1.

1. Append a Stitch SOP to the final Skin SOP and toggle its display flag on.
2. Refer to the following illustration for the correct parameters:

   ![Stitch SOP illustration]

   1) Specify surfaces 0 1
   2) Stitch in the V parametric Direction
   3) Set the Left U parameter to 0
      Set the Left V parameter to 1
   4) Toggle the Stitch option On

   Note the change in the Primitive Numbering:
   - The Wheel Well is now surface #0
   - The Fender is now surface #2
   - The Hood is now surface #1
FILLETS

You are going to construct a Fillet surface between the Fender and the Wheel Well. As a result of the fillet you will have an additional surface. A fillet is a surface of its own.

1. Append a Fillet SOP the Stitch SOP and toggle its display flag On. Do not work in Gouraud mode at this point. Do not toggle the Fillet SOPs display flag On just yet. Working with the Fillet SOP parameters:
   • enter 2 0 in the Group parameter field
   • toggle the Fillet SOPs display flag On
   • refer to the following illustration for the correct Fillet parameters:

Note the change in the Primitive Numbering:

• The Hood is now surface #0
• The Fender is now surface #2
• The Fillet is now surface #1
• The Wheel Well is now surface #3
JOIN

You will now copy these surfaces and mirror them over to make the other half of the car hood. These two surfaces will then be Joined together. When you join two or more surface together they become one continuous surface. No additional geometry is created.

1. Append a Copy SOP to the Fillet SOP.

2. Toggle the Copy SOPs display flag On and set the following parameters:
   • number of copies     2
   • scale on X axis only set to negative 1  (-1)

Note the numbering now:
   • the left hood surface is   # 4
   • the right hood surface is    # 0

In Gouraud mode you will see an obvious discontinuity problem between the two halves of the hood surface.

3. Append a Join SOP to the Copy SOP. You may choose to toggle the Join SOPs display flag on at this point although you will have a mess at this point.

4. Working with the Join SOP parameters:
   • set the Group field to  4  0
   • change the direction to be the V parametric direction

Note the numbering now:
   • the complete hood surface is   # 6
TEXTURING THE HOOD

1. Append a Texture SOP to the Join SOP and:
   • change the texture type to Uniform Spline

2. Append a Material SOP the Texture SOP, toggle its Display and Render flags On and:
   • Click on the ▶ icon at the end of the First Material parameter field and select the material *flames*.

3. View the hood in Gouraud mode.

![](image)

A couple of problems are quite obvious.

• First the map is being applied to each surface an on individual basis
• Second the orientation of the map is all wrong

4. Select the Texture SOP once again to display the associated parameter and change the Rotate parameter to negative 90 to rotate the texture negatively 90 degrees (-90).

![](image)

This is certainly better but it is still obvious that the map is being applied to each surface separately and it squashed and stretched to fit on each surface element.
**Concatenating the Surfaces with the Basis SOP**

The Basis SOP is a very powerful SOP which can alter the original parameterization of a surface or set of curves at any time. But one of the other features of this SOP is the ability to concatenate a series of surfaces so that Houdini see them as one continuous surface which by default will start at 0 and end at 1 in either parametric direction. As a result a texture map will flow over the multiple surfaces as if they were one continuous surface.

Here is how it works. It is pretty logical but there are a number of things you must watch closely. Also the concatenation must occur before the Texture SOP. The surface must be concatenated before the texture coordinates are applied by the Texture SOP.

1. Using the right mouse button, insert a Basis SOP between the Join SOP and the Texture SOP.

2. Display the Join SOP so that you can view the correct primitive numbering and parametric directions, but ensure that the Basis SOP is selected so that you can work with the Basis SOP parameters.

The first thing to do is to ensure that all surface elements are travelling in the same direction. In this example you will start by examining the surfaces from left to right and making sure they all travel in a clockwise direction.

To make this easier:

1. Toggle on the All/Selected option so that you will only be viewing the primitive hulls for the currently selected piece of geometry. Otherwise there is so much displayed on the screen it is hard to determine the direction of each surface. This option is the icon shown at the top of the list in the illustration to the right. When toggled to Selected mode the icon will display only to green cubes.

2. Now toggle on the option to display Primitive Hulls also shown in the illustration to the left.

The hulls will now be displayed for only currently selected geometry. Also when selecting a piece of geometry, ensure that you select it with the Right Mouse button not the left. This will ensure that you will not reposition the primitive you are selecting in any way. The right mouse button only selects geometry the left is select and transform.

3. Now move into Select/Transform state. And ensure that you are in select primitive mode.
4. Now using the Right mouse button, select each surface element and check the direction of the surface in the V parametric direction. I want all surface to travel in a clockwise direction. Keep track of all surface where the V parametric direction is not clockwise. Consider the following illustration:

Surface number 5 (the left wheel well), the V parametric direction is travelling in a counter clockwise direction. Note that number.

Surface number 3 and surface number 4, the fillet and the left fender in my example are also travelling in a counter clockwise direction.

All other surfaces in my case are travelling in a clockwise direction. So lets assume yours are the same, they should be. If not note the correct surface numbers for your case.

5. Using the Right mouse button insert a Primitive SOP between the Join SOP and the Basis SOP. Working with the Primitive SOP parameters:
   - set the Group field to read 5 3 4 (the surfaces that need reversed)
   - enter into the Face/Hull folder
   - change the Vertex option to Reverse V

Now all the primitives are travelling clockwise in the V parametric direction.

6. Deselect any currently active primitives and switch back into View state.
Now you are ready to Concatenate the surfaces. You only want to do this in the V parametric direction.

It is also important that you concatenate in an order where the first V parameter begins but does not contact with any other surface you are using in the concatenation. Remember you reversed the direction of the left wheel well so that surface starts with an edge value of 0 which does not align with any other surface you are concatenating with. Therefore that is the start point for the concatenation. The V direction on the right fender also travels in clockwise direction so its start point does align with another surface that you are concatenating with, so don’t use that one as the start of the process.

7. Refer to the following illustration to set the Basis SOP parameters:

1) Concatenate in this order.
2) Ensure the Edit U Basis option is toggle Off. You are not concatenating in the U direction.
3) Toggle the Edit V Basis option on. This is the direction in which you are concatenating.
4) Toggle the Concatenate, Origin and Length options On
8. Toggle the Gouraud shaded mode on at this point and it is obvious that the map is now being used as though this were one continuous surface with parameterization beginning at 0 and travelling through to a value of 1 at the other edge of the surfaces. The problem here of course is that the map is now stretched out to cover the entire set of surfaces.

9. Working with the Texture SOP parameters once again:
   • increase the scale parameter for the V direction to a value of 5
   • increase the offset parameter for the V direction to a value of 0.28
THE CHORD LENGTH PARAMETERIZATION EXAMPLE

1. Ensure that the display flag is toggled on for the SOP named Chordlength_curves.

2. Append a Skin SOP to the File SOP called Chordlength_curves, toggle its display flag on and:
   • Click on the ▸ icon at the end of the U Cross Sections parameter field and select the group chrd_hood_u
   • Click on the ▸ icon at the end of the V Cross Sections parameter field and select the group chrd_hood_v

3. Append another Skin SOP to the current Skin SOP, toggle its display flag On and:
   • select the chrd_fender_u group as the U Cross Sections
   • select the chrd_fender_v group as the V Cross Sections

4. Append a third Skin SOP to the last Skin SOP, toggle its display flag On and:
   • select the chrd_well_u group as the U Cross Sections
   • select the chrd_well_v group as the U Cross Sections

5. Append a Transform SOP to the last Skin SOP, toggle its display flag On and:
   • set the translate parameter for the Y axis only to a value of negative 2 (-2)

6. Toggle the template flag on for the Skin3 SOP (this sop is in the first network) and compare the flow of the isoparms on the two surfaces.
7. Now toggle the template flag Off again.

Now you will save yourself a lot of work by simply copying the rest of the SOPs from the previous network and using them for this network. To do so:

8. Select the Stitch1 SOP ensuring that it is currently active and then using your right mouse button click directly on the centre of the SOP tile to display the associated pull down menu and select the option Select Outputs.

All SOPs from the Stitch1 SOP through to and including the Material1 SOP should now be active.

9. Copy the active SOPs using (Ctrl+C) and then paste them using (Ctrl+V).

10. Place the newly pasted SOP network under the Transform1 SOP and connect the output of the Transform1 SOP into the left hand input node of the Stitch2 SOP.

11. Toggle the Material2 SOPs display flag On and there you have it the new surface.

The illustration below shows the two surfaces once again.

12. Select the Texture2 SOP to display the display the associated parameters and:

   - set the Texture Type parameter to **Arc Length Spline**

13. Using a Merge SOP, merge the output of the two SOP networks together and toggle on the Merge SOPs display and render flags.
14. Toggle the viewport window into Gouraud shaded mode and compare the two texture mapping results.

Although the mapping is not really to bad on the surface constructed with Uniform Parameterized curves, you can see how the Chord Length parameterization has less stretching when the two maps are compared in this manner.