Next Steps: Procedural Animation

M02 - CHOPs Examples

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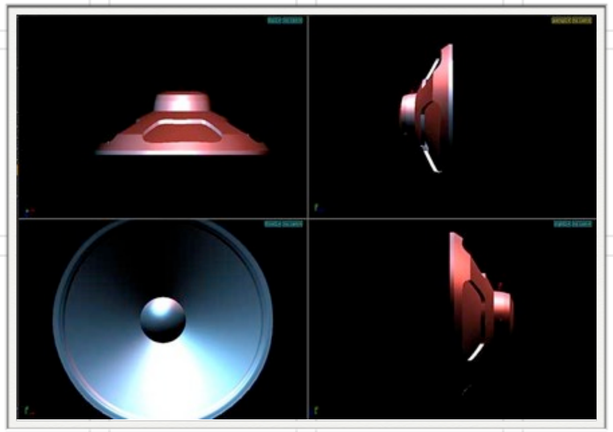
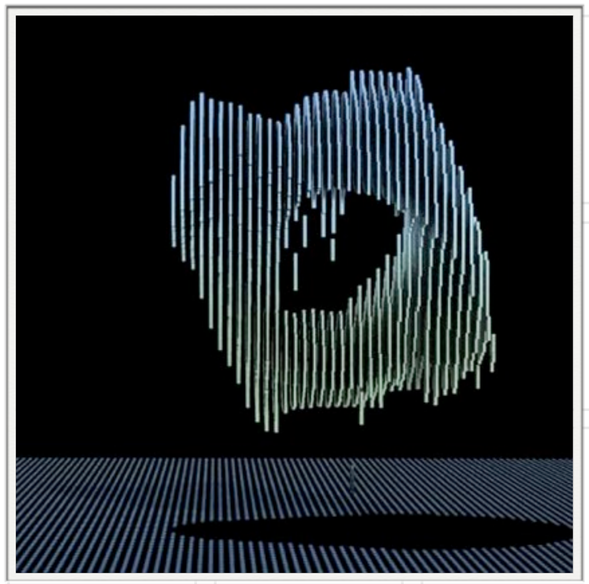
Agenda

Analyzing Incoming Data

Walk Through - Using Audio to Animate a Speaker

Pin Table Example





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Analyze Incoming Data

Generators and Filters

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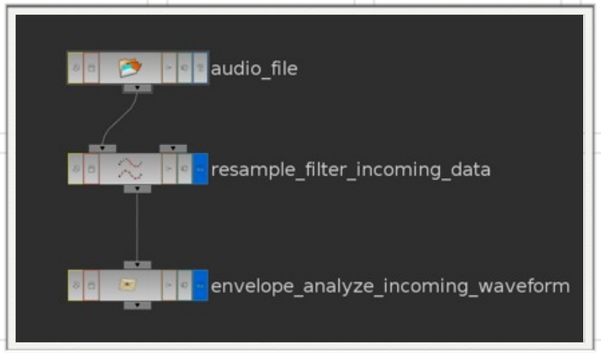
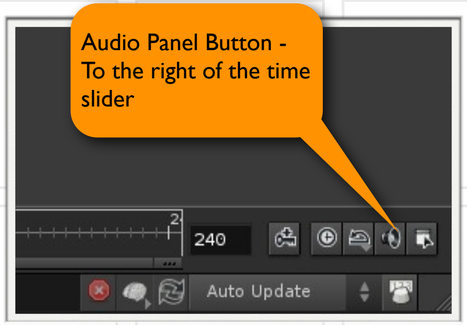
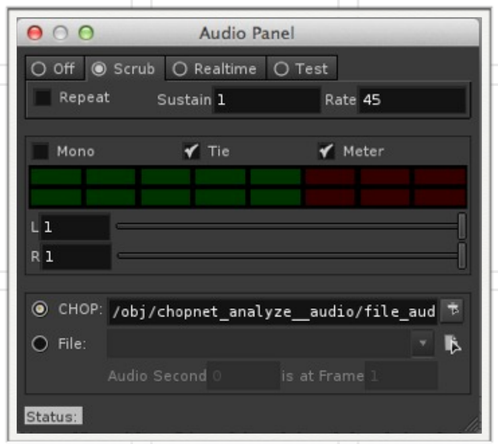
Envelopes







Let's analyze an audio file

Create a CHOPNET at the Obj level - Dive inside

Drop down a File CHOP

- Channel File - $HFS/houdini/config/Audio/Error.aiff

Open the Audio Panel

- Select the radio button - CHOP
- Point the parameter to the file node
- Set the Audio Panel Tab to Scrub

Notice in the play bar the waveform can be seen

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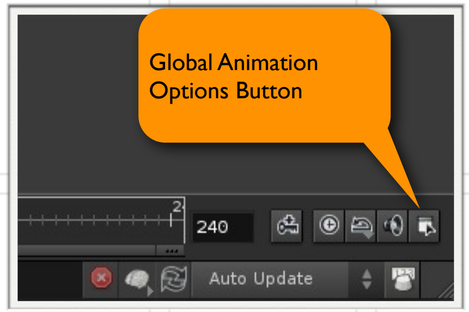
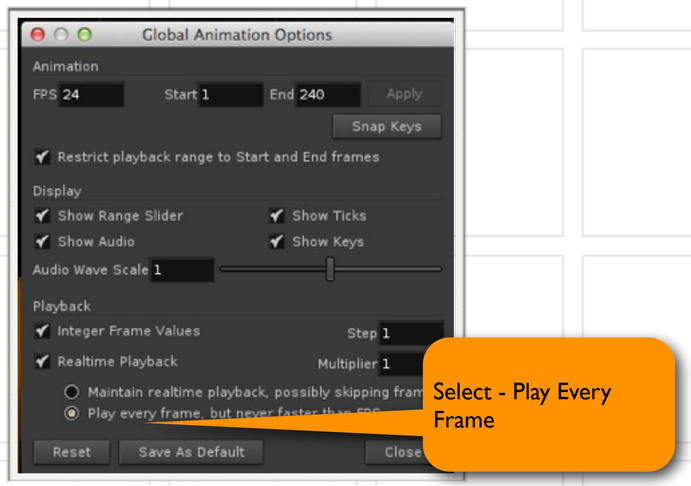
Just a reminder…





Not related to lecture

- If you open the Global Animation Options
- At the bottom there are two options for Realtime Playback
  - Maintain realtime playback, possibly skipping frames - This option is good for character animators needing to see if motion matches timing
  - Play every frame, but never faster than fps - This is what we want for simulation

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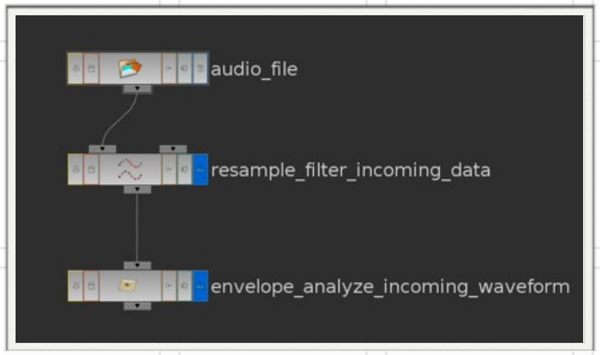
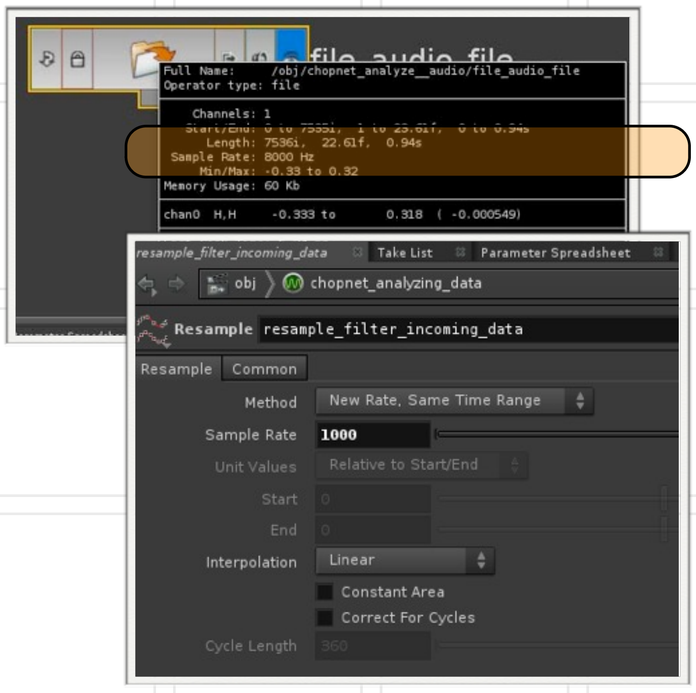
Envelopes





Let's analyze an audio file (continued)

Middle Click on the File CHOP

- Notice this Audio file is running at a sample rate of 8000 Hz
- We do not need so many samples for our animation

It is common to resample audio to a more reasonable frequency for animation

- Append a "Resample" CHOP
- Resample to 1000 - Remember most digital audio comes in 48 KHz or 44.1 KHz

Often we want to create Animation that is driven by beats of the audio

- Drop down a "Envelope CHOP", Look at the Waveform in the motion view
- Continued on Next Slide...

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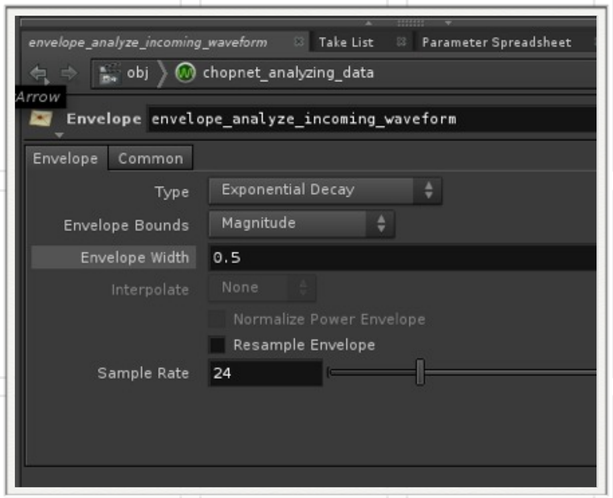
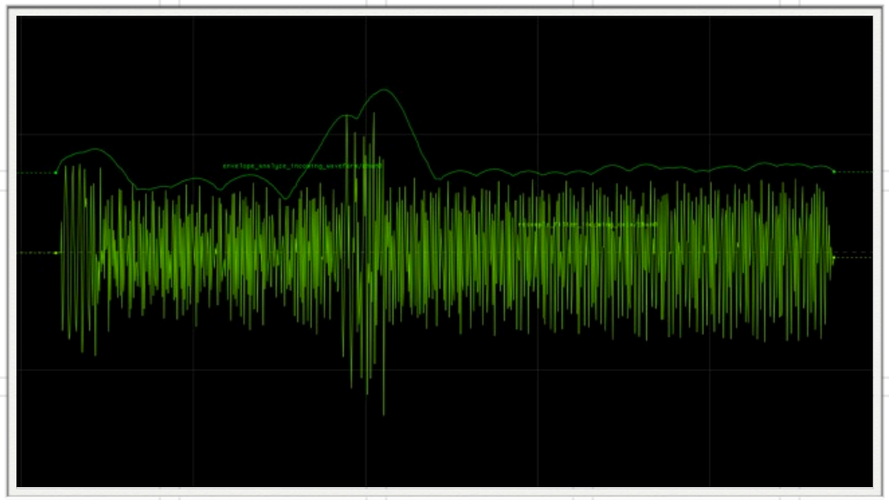
Envelopes (Cont.)

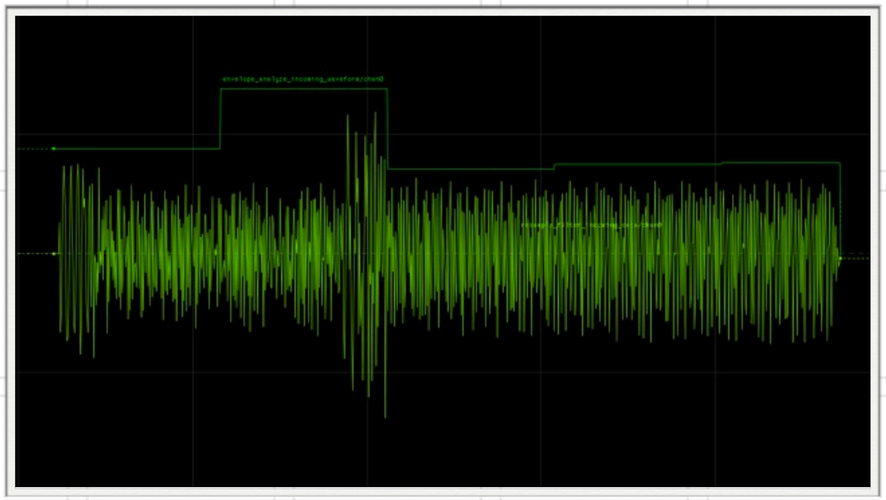
There are several different types of envelopes you can create based on your input waveform

- Type can either be Exponential Decay or Local Maximum Window





Type - Exponential Decay



Type - Local Maximum Window

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Envelope Definitions

Exponential Decay - For each sample, the value is compared to the previous sample. If it is greater than the previous, the value of the envelope is equal to the value of that sample, and that sample is stored as the current peak. If it is less than, the value of the envelope decays exponentially from the last peak to the current value (as more samples pass that are smaller than the peak, the envelope decays toward the waveform).

- Pros of this method: envelope always encloses the data.
- Cons: slope can be discontinuous, making the output look bumpy.

Local Maximum Window - The channel is separated into windows of N samples determined by the Envelope Width. In each window, the maximum amplitude is found. The maximum value of the window is used as the envelope value.

- Pros of this method: Good shape.
- Cons: signal sometimes jumps outside the envelope. The signal is quantized, so pulses can be off by as much as N/2.

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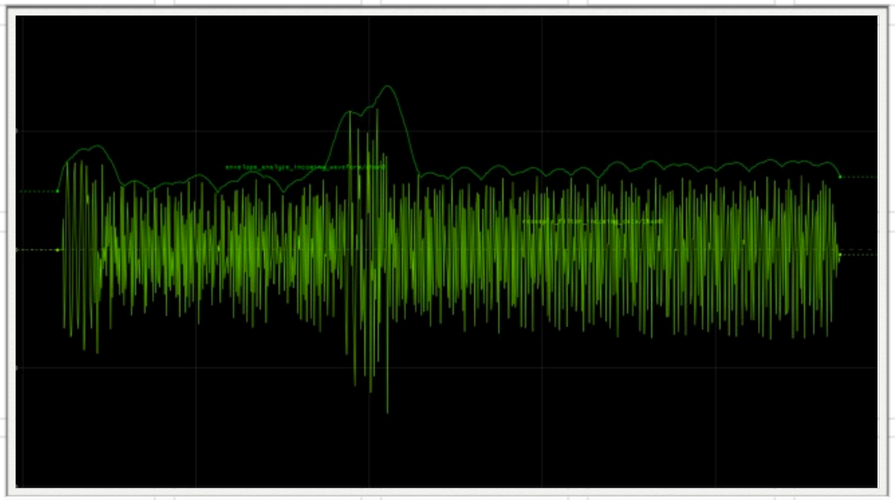
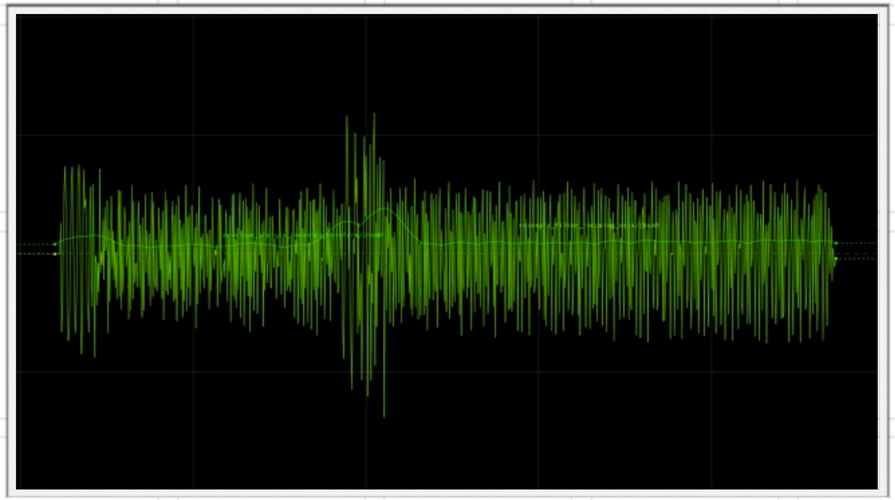
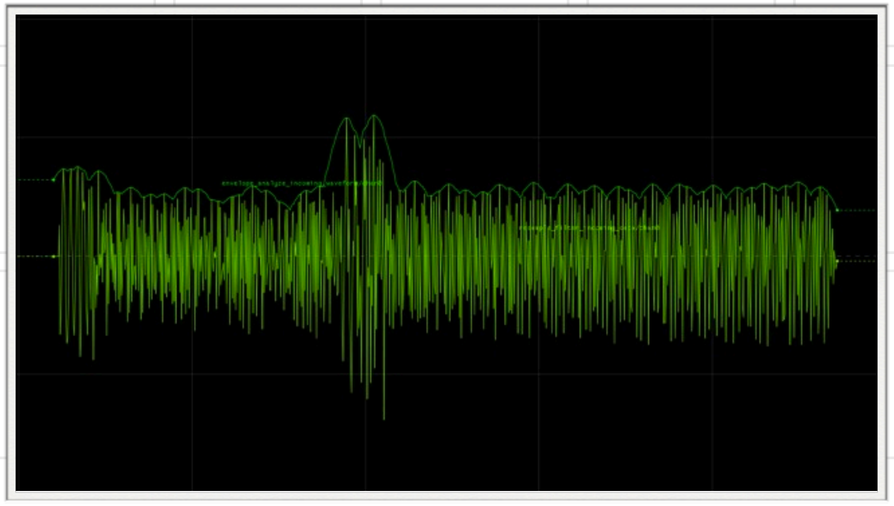
Envelopes (cont.)



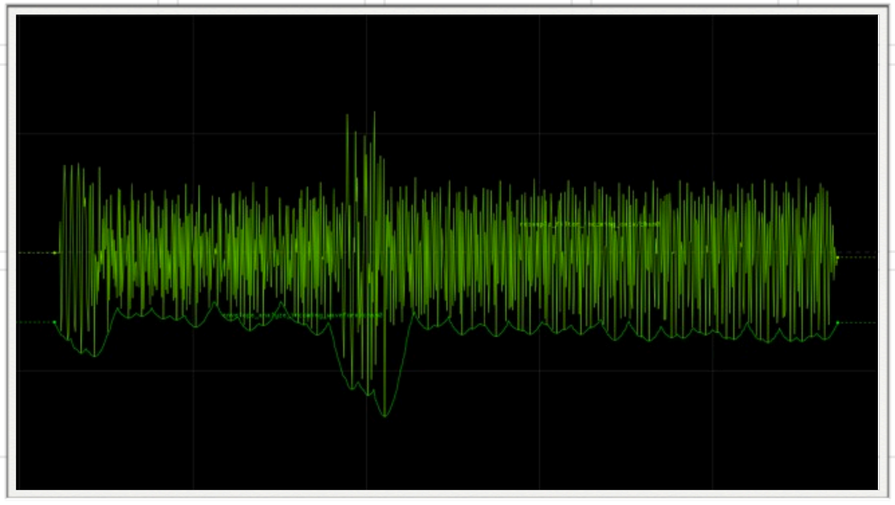
Type - Exponential Decay
Envelope Bounds - Magnitude



Type - Exponential Decay
Envelope Bounds - Signal Power



Type - Exponential Decay
Envelope Bounds - Maximum Values



Type - Exponential Decay
Envelope Bounds - Minimum Values

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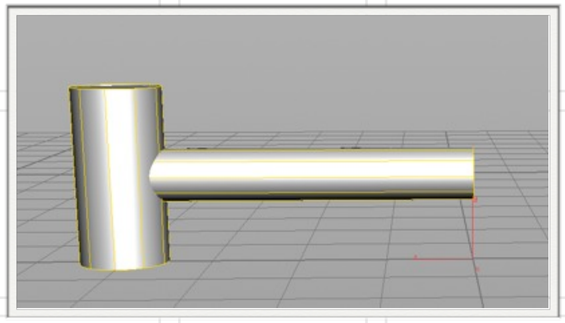
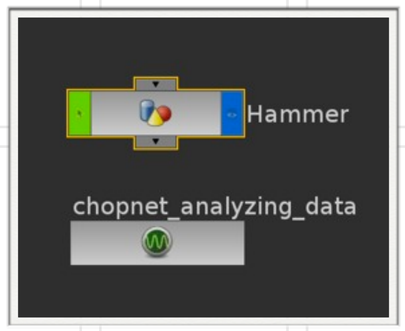
Using an Envelope to Drive Geometry





At the Object Level Create a Hammer

- Up to you to create
- Model on the z-axis
- Make Pivot of hammer at tip of handle on world (0,0,0)

We want the hammer to swing between -80 and 0 degrees rotation on the x-axis

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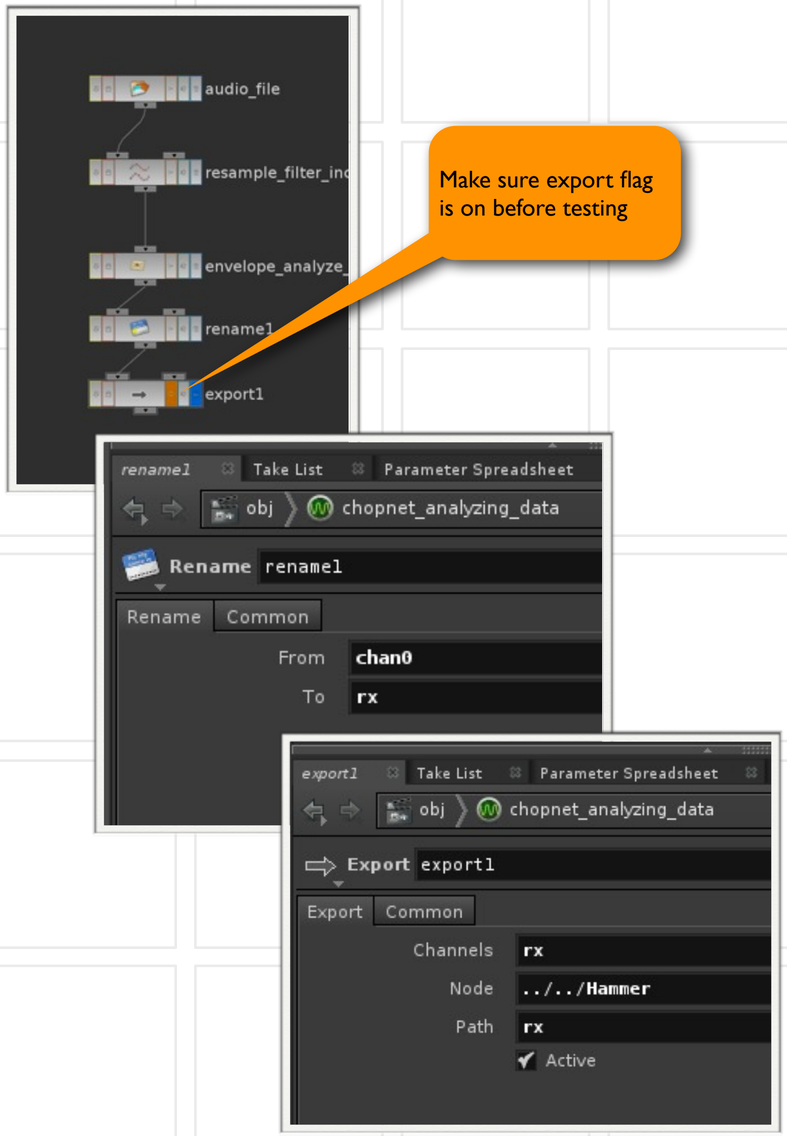
Using the Export CHOP



Append a Rename CHOP to the Envelope

- We will rename “chan0” to rx just to make are naming conventions more consistent
- How do we know it is chan0? Middle Click on the File Node

Append an Export CHOP to the Envelope

- Channel we want to use is rx (Chan0 before rename)
- The Node we want to effect is the Hammer object you created
- The path is the parameter in the Node you selected
  - In our case rx

Make sure the Export Flag is set on “export1”

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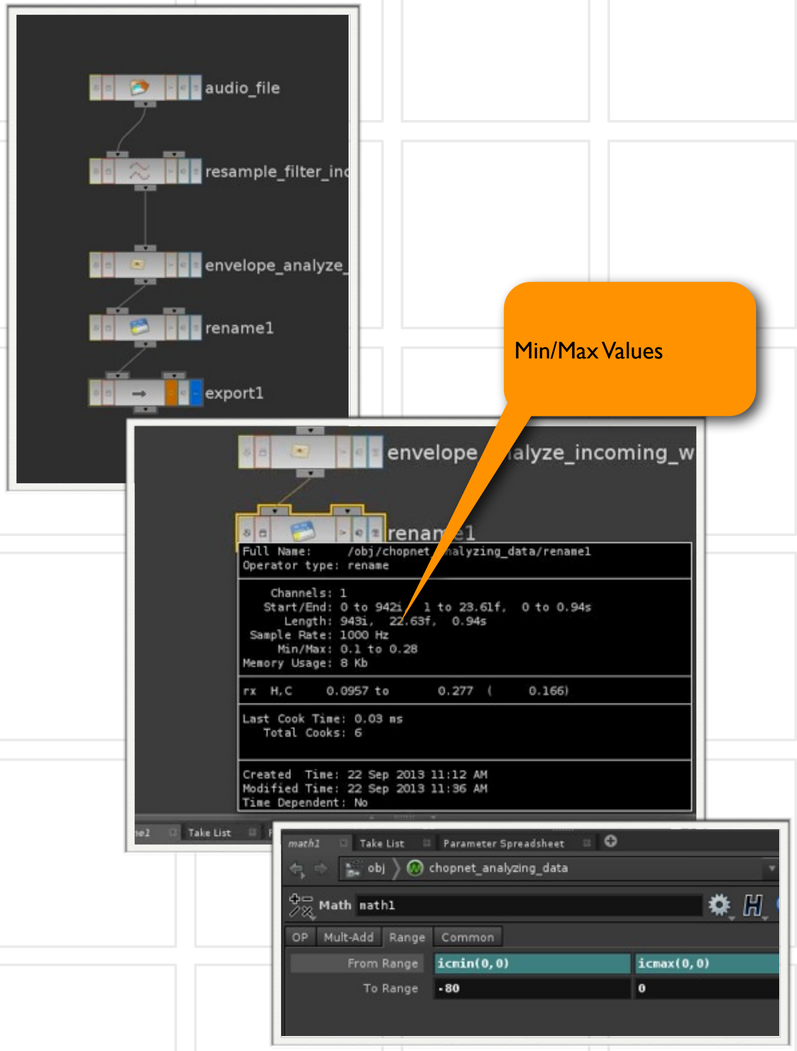
Using the Export CHOP (cont.)



Pretty Wimpy Animation

- We want the animation to swing the hammer 80 degrees but the waveforms amplitude is less then 1
- Make sure the envelope is set to
  - Type - Exponential Decay
  - Envelope Bounds - Magnitude

Export CHOP is a good approach if you only have one target you want to export data too. Other approaches are better for multiple targets

- Middle Click on the Rename CHOP to see the min and max values
- Append a Math CHOP after the Rename CHOP. In the Range Tab
  - From Range: 0.1, .28 - you can use the expression
  - icmin(0,0) and icmax(0,0) to automate process
  - To Range: -80, 0

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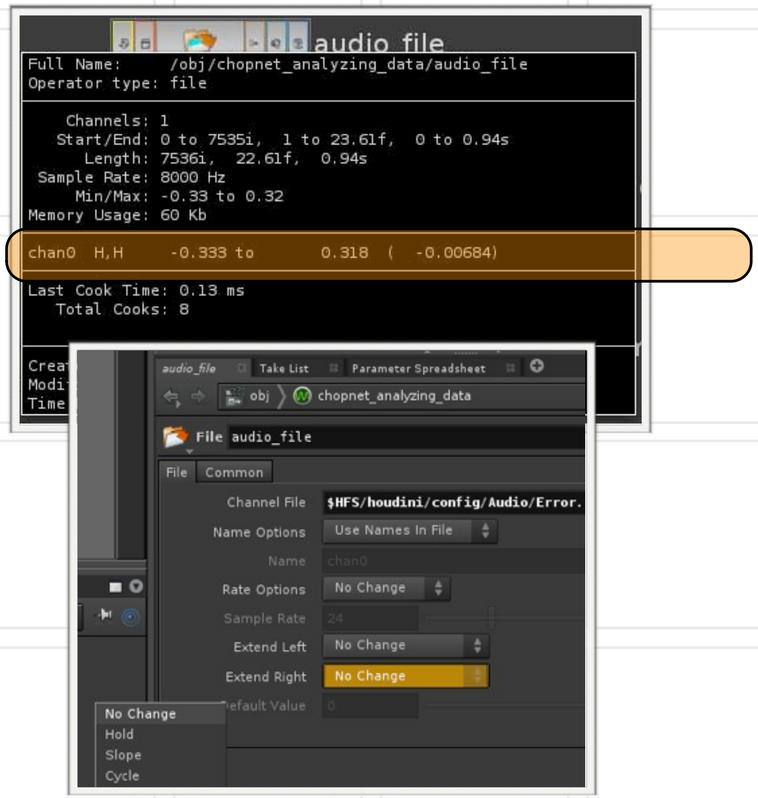
Making the Animation Cycle



If you select the File Node where we inputted the audio file and middle click

- You can see that the file is assigned to chanO
- Right after chanO is written H, H which stands for hold left and hold right
- In the Parameters for the File CHOP change Extend Right to - Cycle

Play the animation again and you will see the audio an animation repeat

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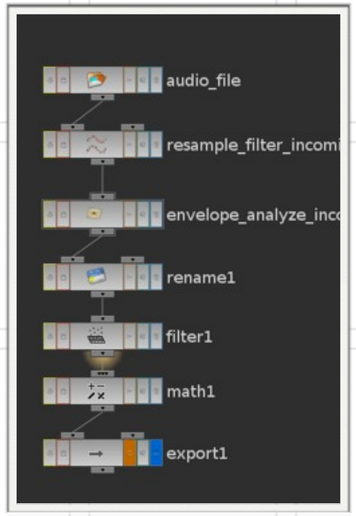
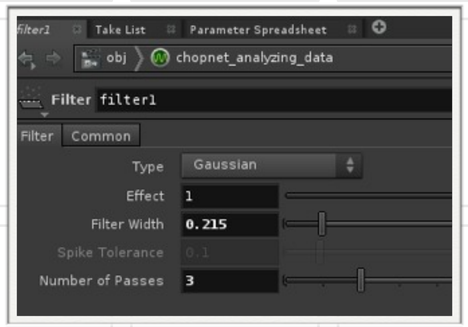
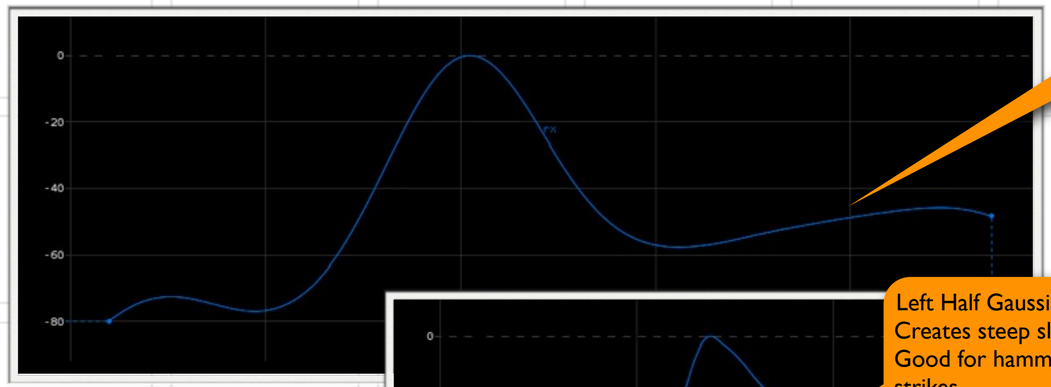
Smoothing Out the Animation





Right now the animation has too much noise. We want the hammer to drop in one swing.

Append a Filter CHOP to the Rename CHOP



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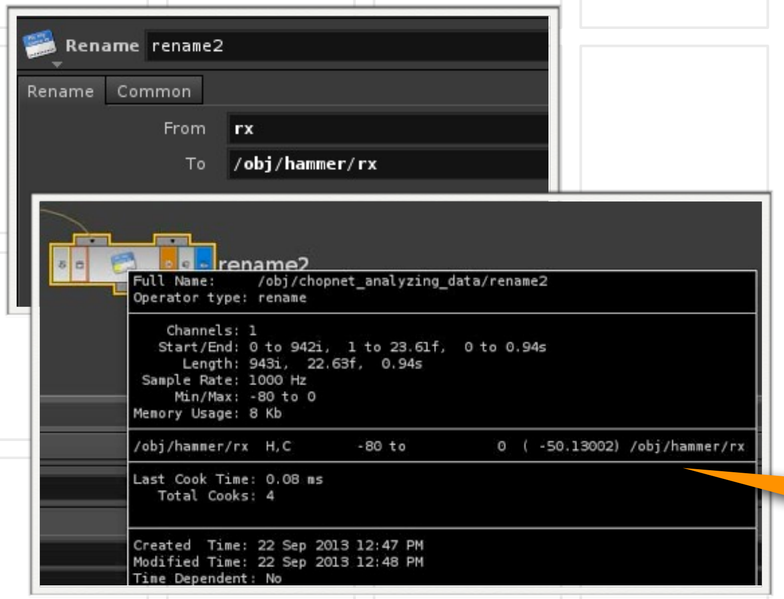
A Second Way to Export Channel Data



Shows channel data exported successfully

Instead of using a Export CHOP you can just use a Rename CHOP

- From - rx
- To - /obj/hammer/rx

If the channel data is exported correctly you will see the info if you middle click on the Rename CHOP

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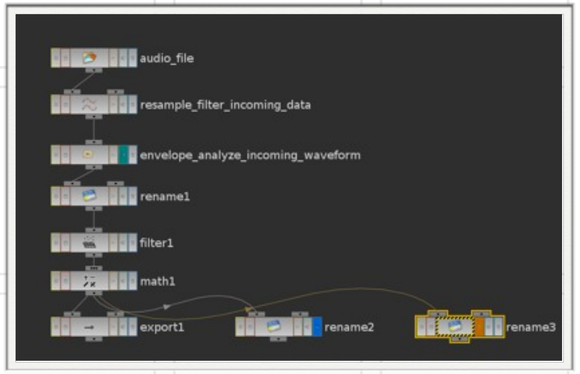
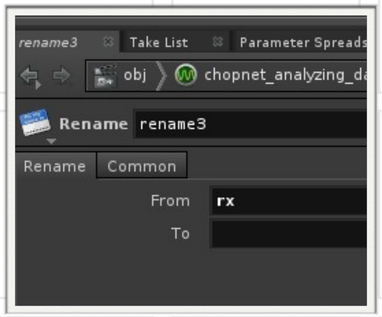
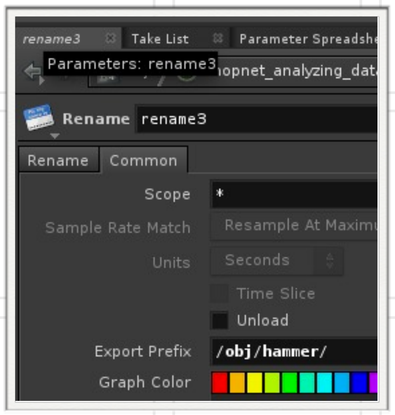
One Last Way to Export Channel Data







Again we will just use a rename CHOP

- From - rx

Switch to the Common Tab

- Export Prefix - /obj/hammer/

Remember to set the export flag

This approach is good if you want to target multiple objects with the same data

- An example would be multiple characters walking to the same beat

See example next slide

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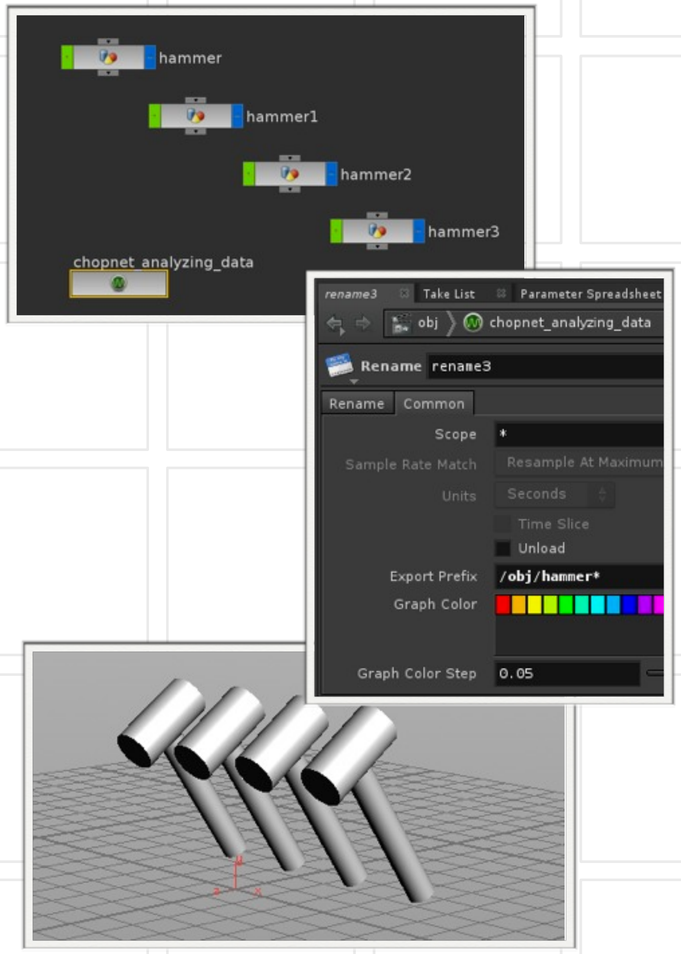
Multiple hammers in sync



Rename CHOP good approach for targeting multiple objects

In the Export Prefix just use a wild card

- /obj/hammer*

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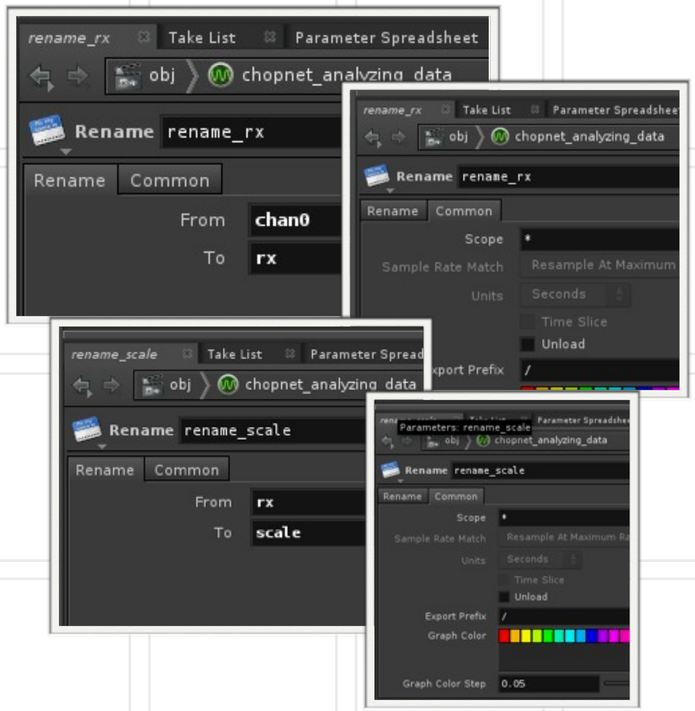
Exporting Multiple Channels



We will export rx and scale this time

In the rename for rx

- from - chan0
- to - rx
- In the common tab Export Prefix - /

Math2 - just sets the min/max range for scale to be 0.5 to 2

rename_scale

- from - rx
- to - scale
- In the common tab Export Prefix - /

In the Merge CHOP

- In the common tab Export Prefix - /obj/hammer*/

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A Couple New Filters

Jiggle & Trigger

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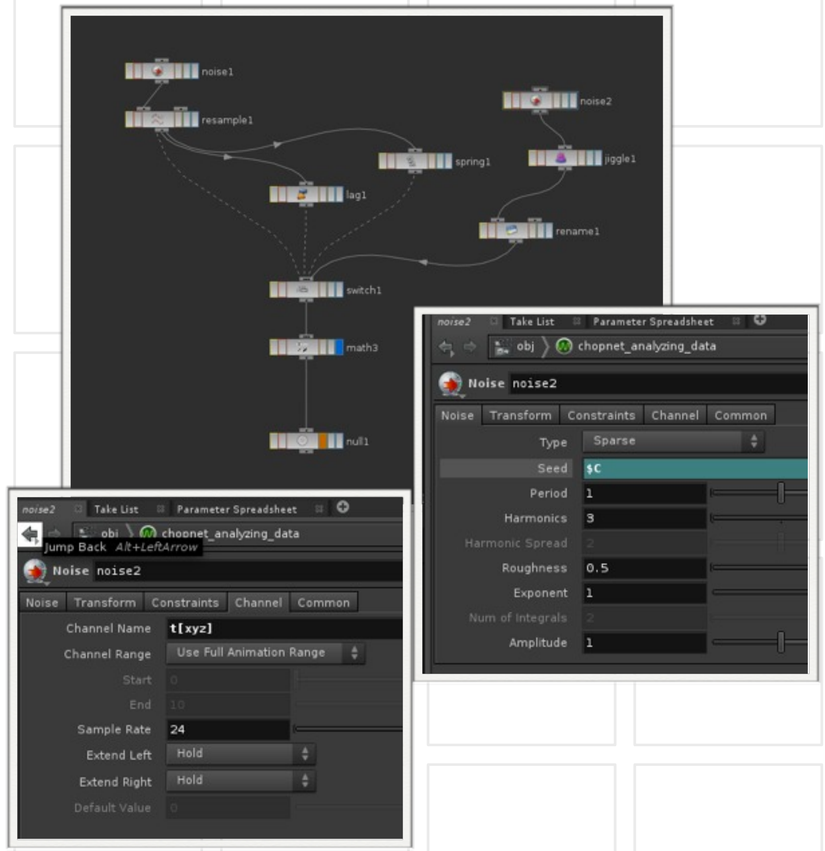
Different Filters to Play With - Jiggle



Lag, Spring - We used last week

Jiggle - requires tx,ty,tz (for jiggling jello)

- Noise
  - Seed - $C
  - Channel Name - t[xyz]
- Rename CHOP
  - From - t[xyz]
  - To - r[xyz]

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Jiggle

This CHOP creates a jiggling effect in the translate channels passed in. All channels ending in tx,ty, and tz are processed as a vector. If one of these translate vectors is missing a component, it is ignored

Stiffness - How tight the jiggle is. Values closer to zero will cause the translate values to stray more from their original values. Values closer to one will result in very close solutions.

Damping - The amount of damping on jiggle oscillations. More damping reduces oscillating around abrupt changes in direction.

Limit - This controls how far away the point is allowed to stray from the original value before it starts being pulled towards it.

Flex Amount - This controls the strength of the spring. Larger values will cause the translate values to stray more from their original values.

Multiplier - This controls a post-scaling effect on the values of the channel.

Reference - This gives an object path that the resulting values would be relative to. Note that the Multiplier is applied in the reference space.

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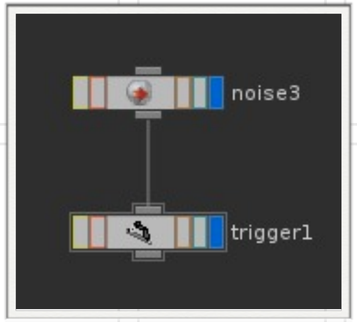
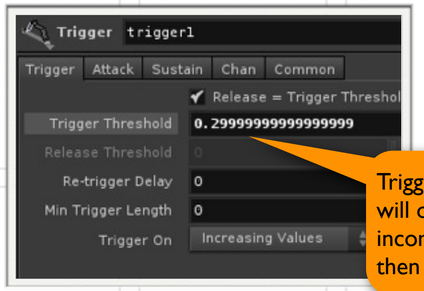
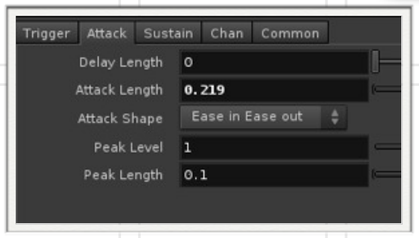
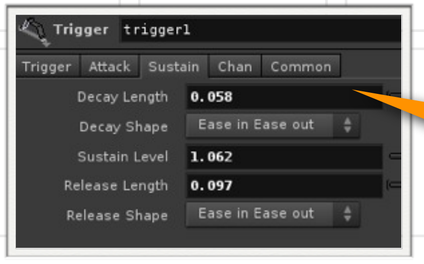
Different Filters to Play With - Trigger



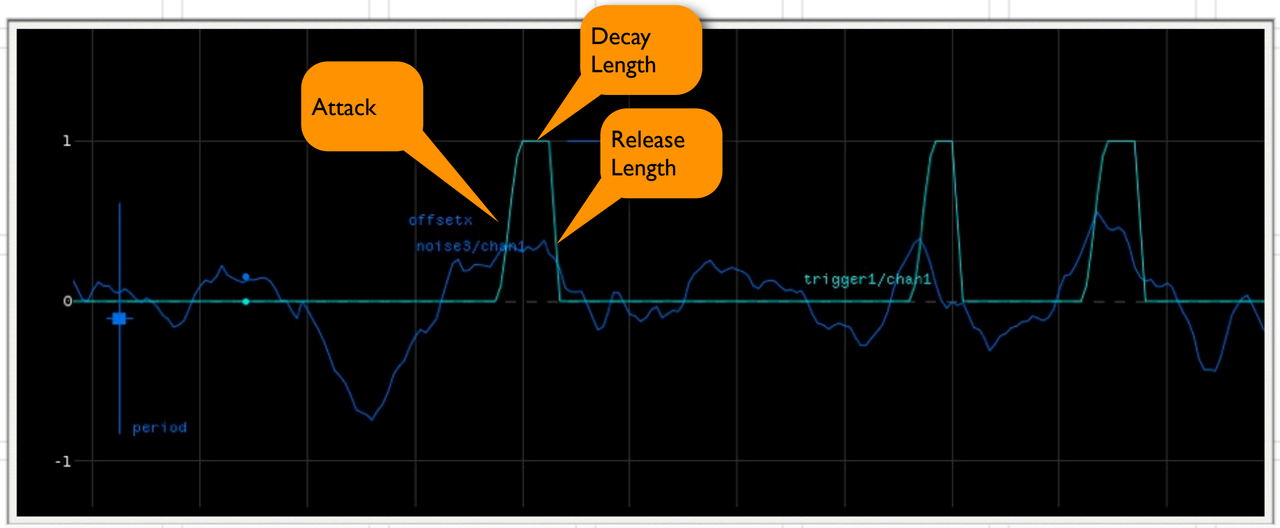


Trigger Threshold - a trigger will only be set when incoming channel is greater then this value





How steep or shallow is the decay



Trigger is another useful filter

Drop down a new Noise CHOP

Append a Trigger CHOP

Set both nodes to visible

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Driving a Speaker

A More Sophisticated Example

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Overview

In our last audio example we on drove the hammer by analyzing the amplitude of the waveform

This time we will drive the animation by the bass frequencies

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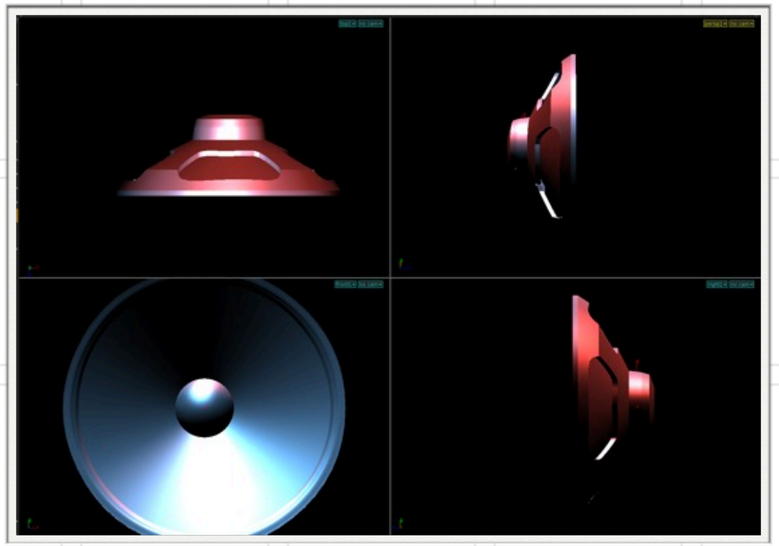
Scene Setup

The Speaker Geometry is Modeled as three separate objects:

- Passive Objects
  - Outer Cone
  - Speaker Basket
- Active Object (Will be driven by CHOPs)
  - Speaker Cone



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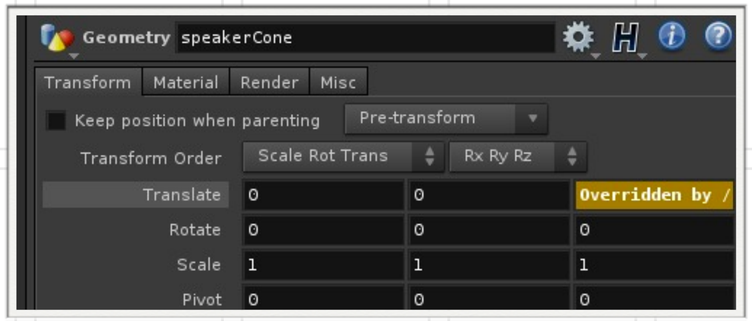
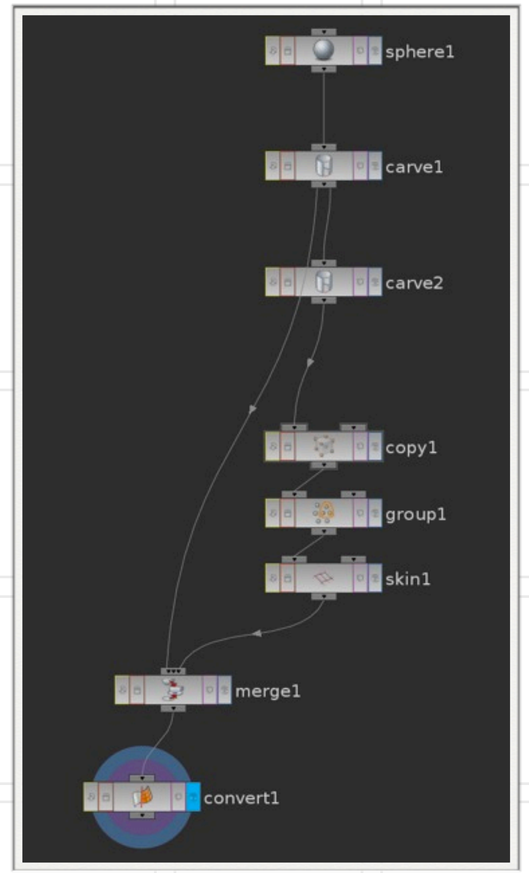
Speaker Cone





At the Object Level of the Speaker Cone CHOPs will drive tz

The rest of the geometry is just NURBs modeling

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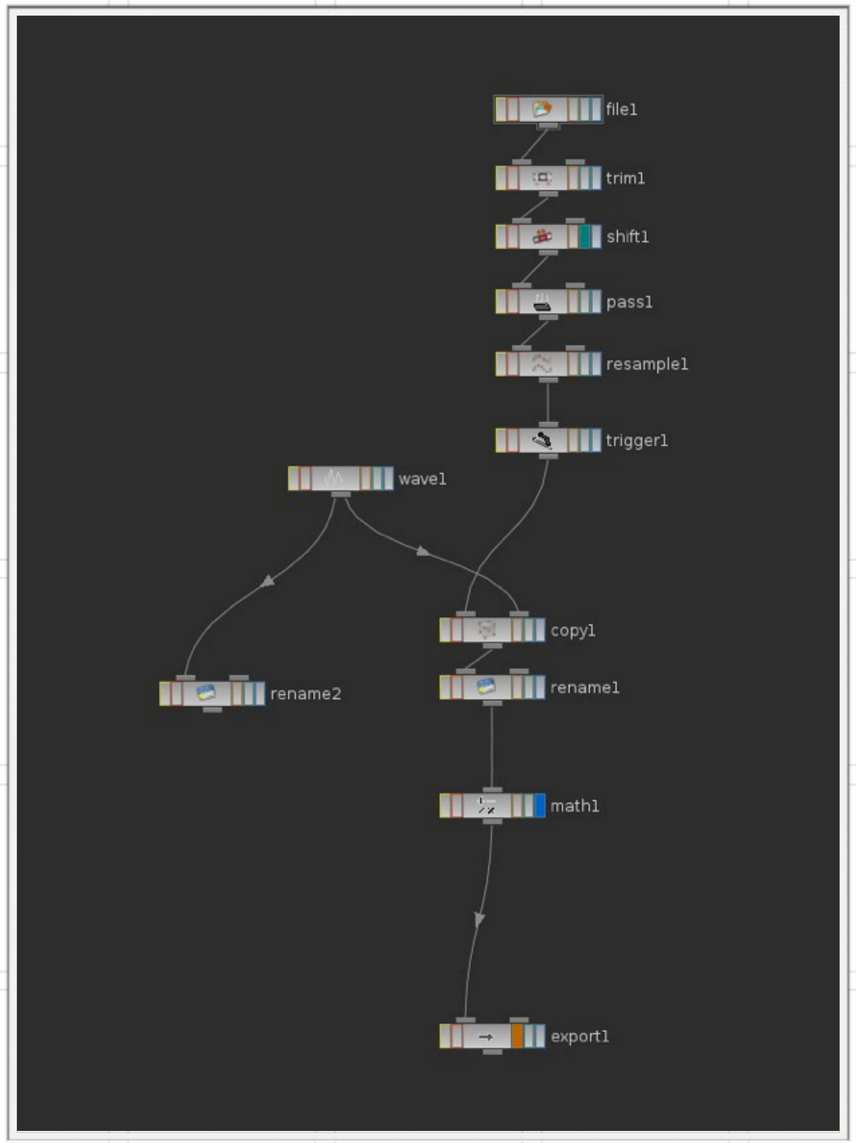
Overview of the CHOPNET



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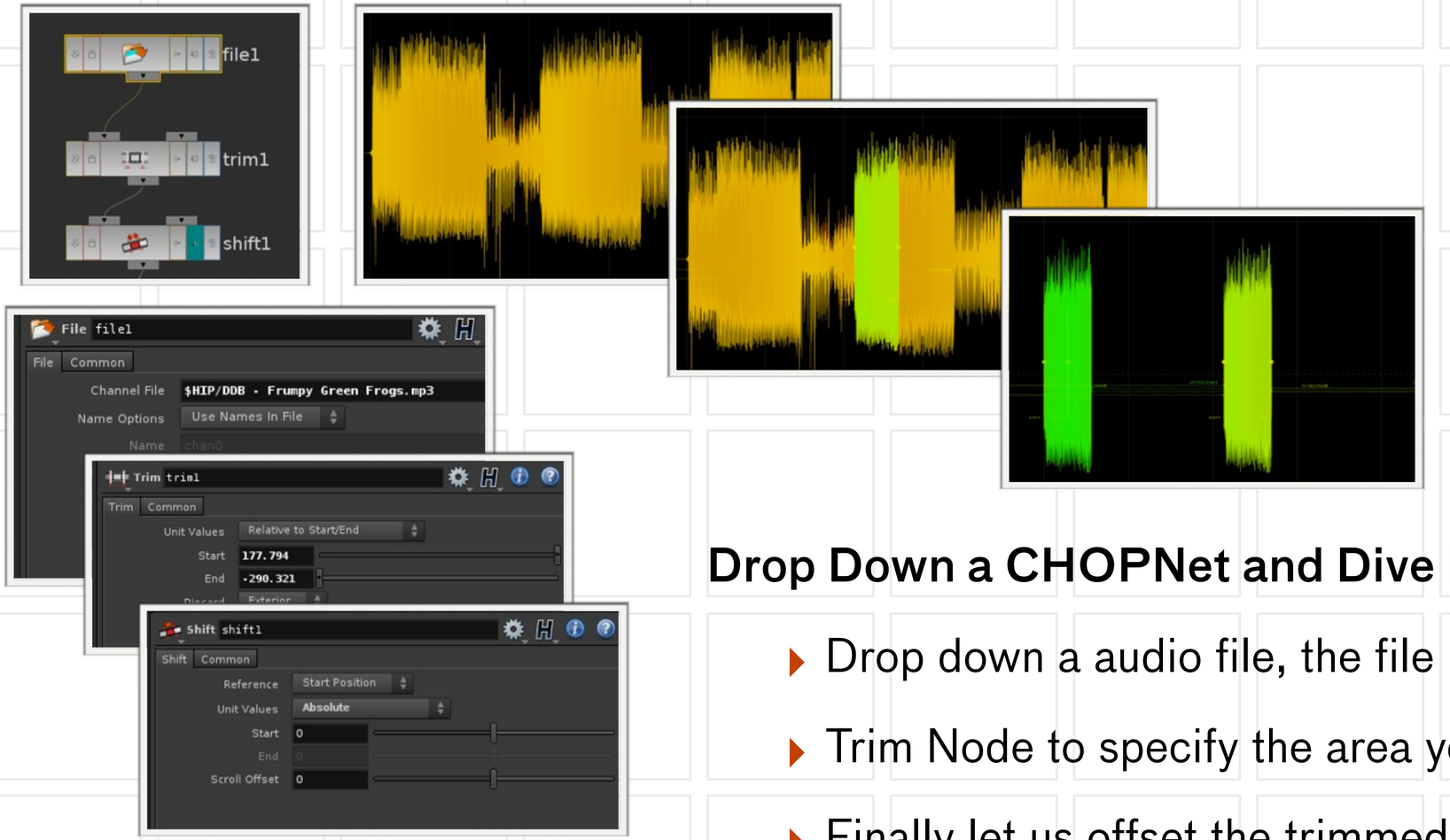
Reading the Audio File



Drop Down a CHOPNet and Dive Inside

- Drop down a audio file, the file is too long so use a...
- Trim Node to specify the area you want
- Finally let us offset the trimmed area in time back to O

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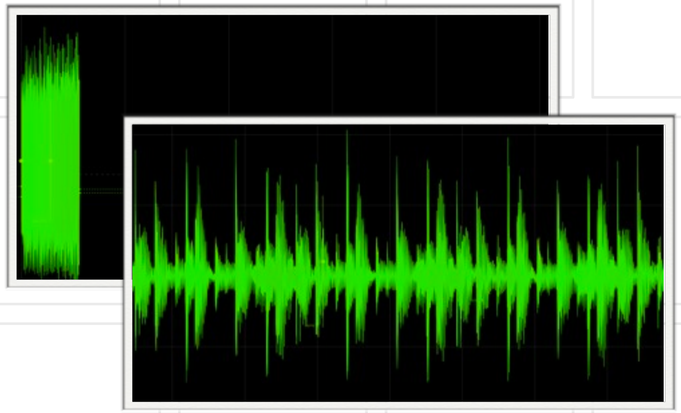
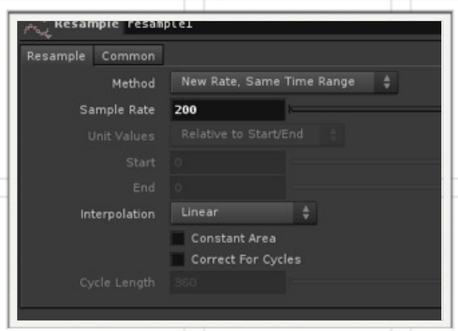
Filtering Out Everything Except for Bass





If we just look at the shifted dated there is not much frequency information. But once we zoom in we can see a pattern

Append a Pass Filter to the Shift we only want the Bass Frequencies

- Low Cut Off - 128, High Cut Off 145
- Let's add a gain of 10 to boost the signal

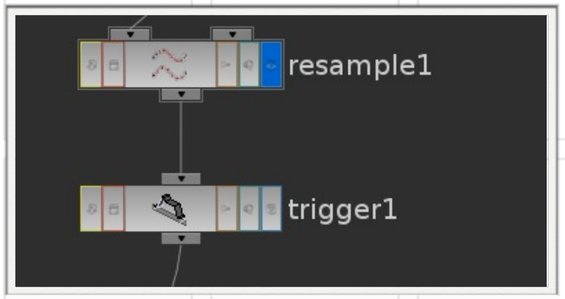
If you Middle Click on the file node you will see the sampling rate is 44.1 KHz. That is too high for animation

Append a resample node and set sample rate to 200

- Notice the amplitude of the waveform diminished

SIDE EFFECTS SOFTWARE

Isolating the Start of Speaker Movement



We will use a Trigger CHOP to isolate the areas where we want the speaker to be animated (thrown)

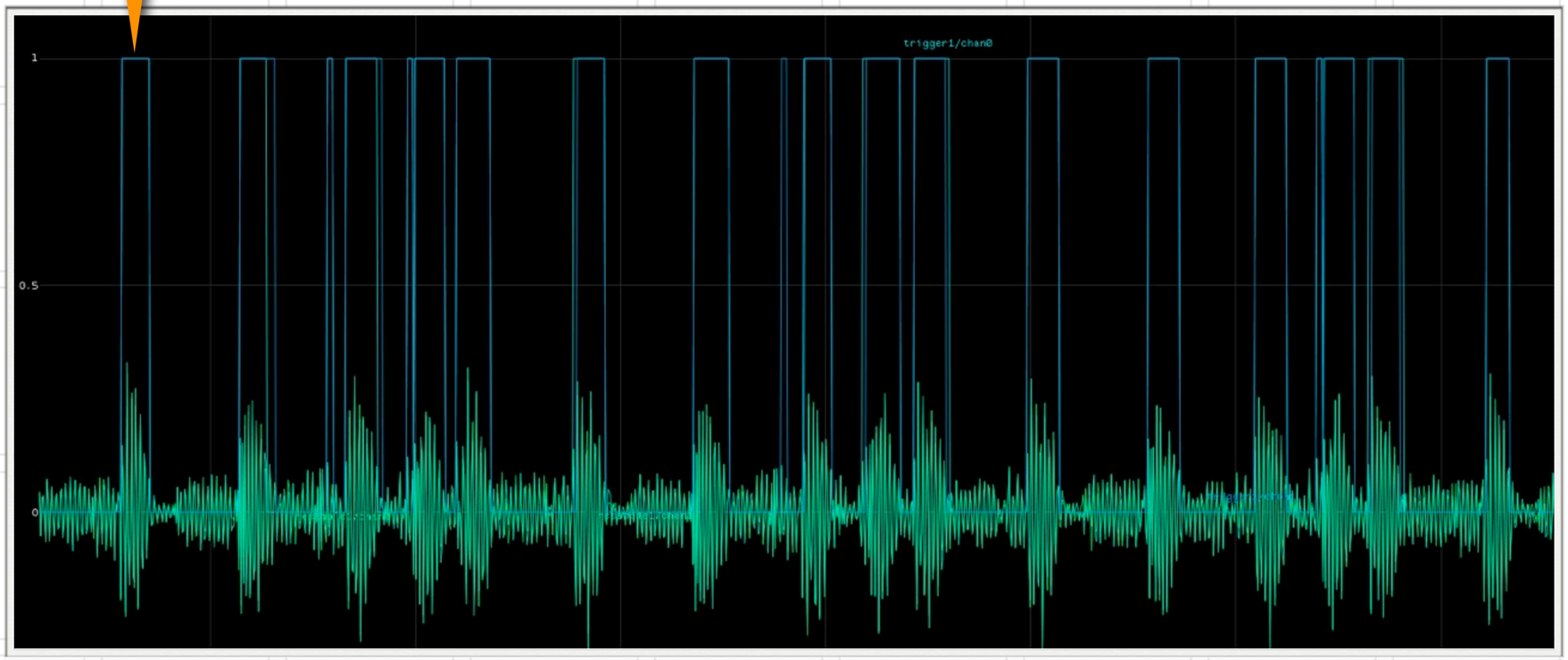
Append a Trigger CHOP

- Trigger Threshold 0.1
- We want an instantaneous attack
  - Delay Length - 0
  - Attack Length - 0
  - Peak Level - 1
  - Peak Length - 0.2
- And instantaneous decay
- Decay length - 0.001, Sustain and Release - 0

SIDE EFFECTS SOFTWARE

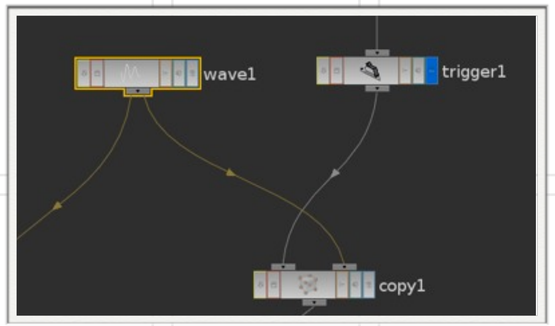
The Waveform from the Trigger CHOP

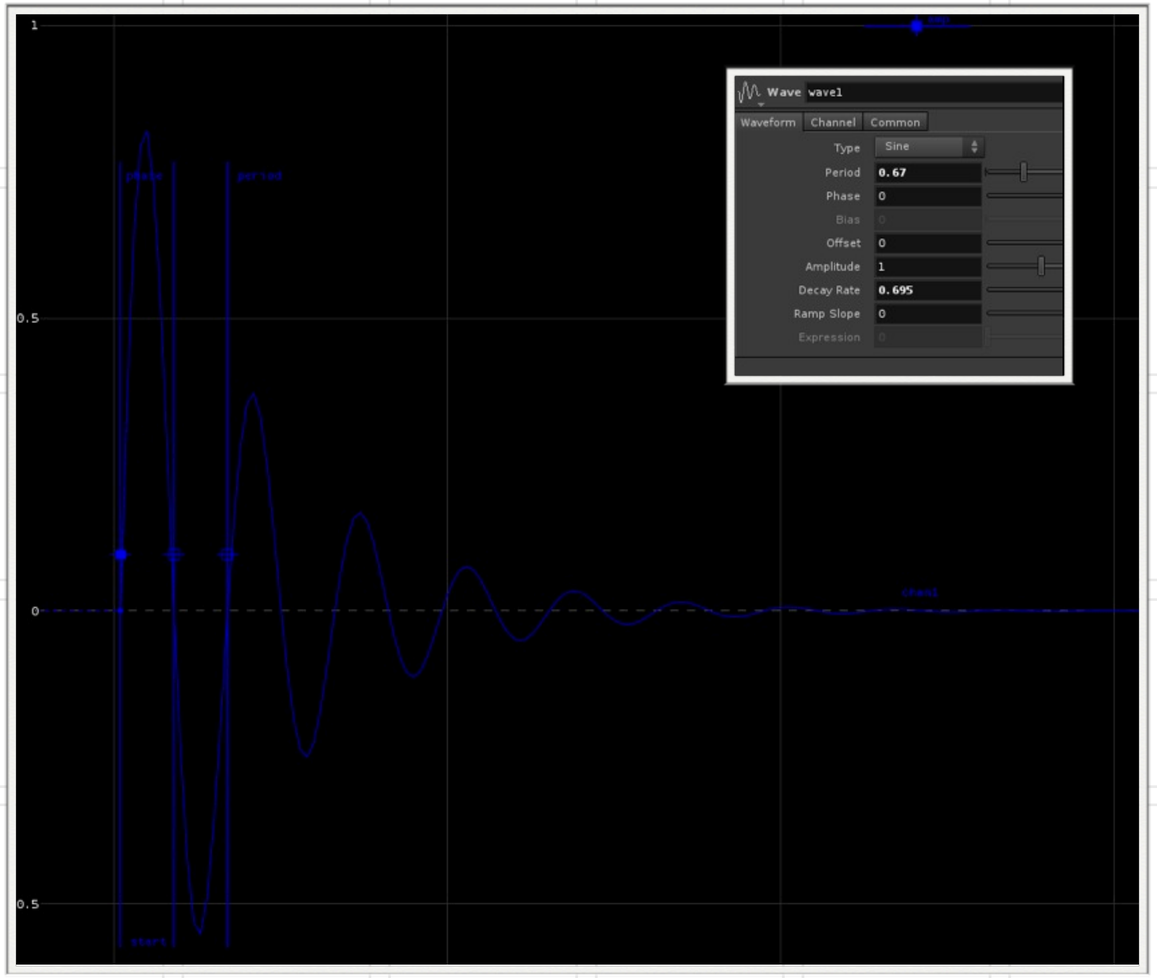
Peak Level - 1



SIDE EFFECTS SOFTWARE

Generating the Speaker Wave





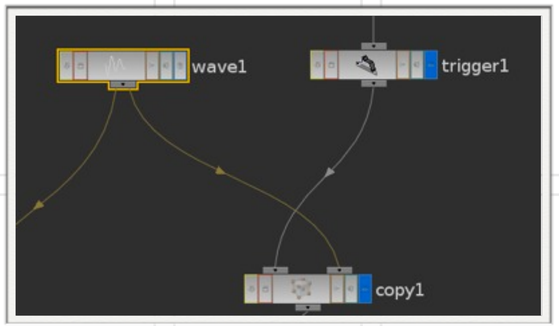
When a Trigger occurs we will animate the speaker cone using a Dampened Sinusoidal Wave form

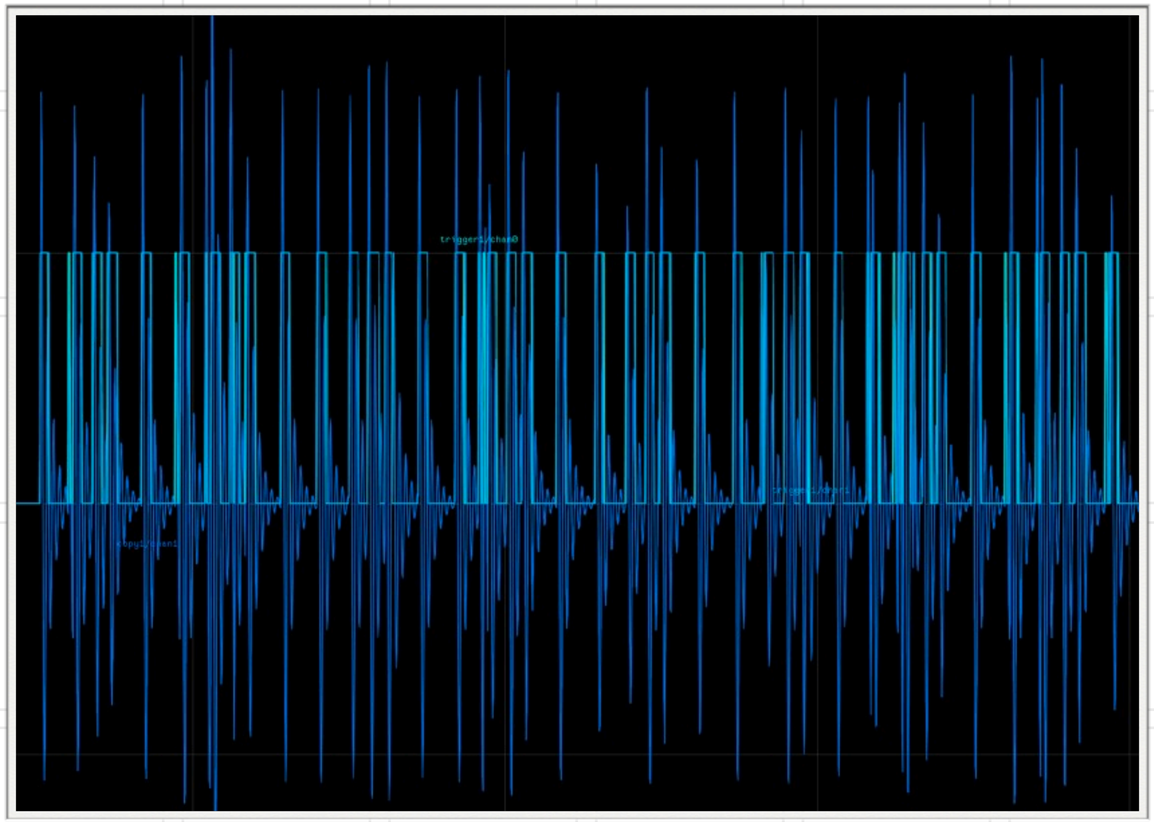
Drop down a Wave CHOP

- Use the parameters shown on the left
- Continued on Next Slide

SIDE EFFECTS SOFTWARE

Generating the Speaker Wave (cont.)





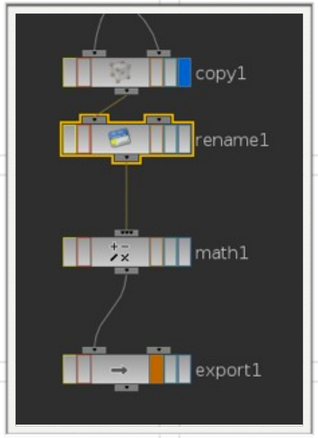
Now we will copy the wave into each trigger envelope

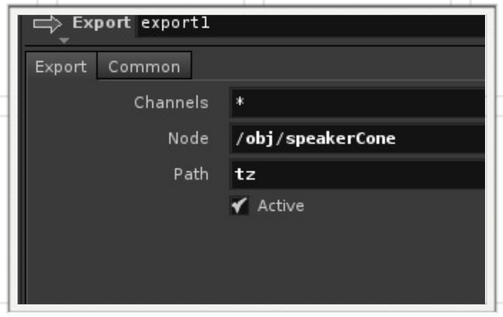
Append a COP CHOP to the Trigger

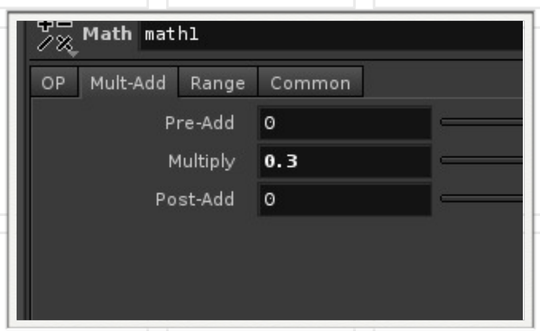
Wire the Wave into the Second Input of the Copy

SIDE EFFECTS SOFTWARE

Finishing the Network







Append a Rename CHOP to the Copy

- From - *
- To - bass

Append a Math CHOP

- Scale the amplitude to something reasonable for the animation

Export it

SIDE EFFECTS SOFTWARE

Pin Table Example

Major Project of the Week

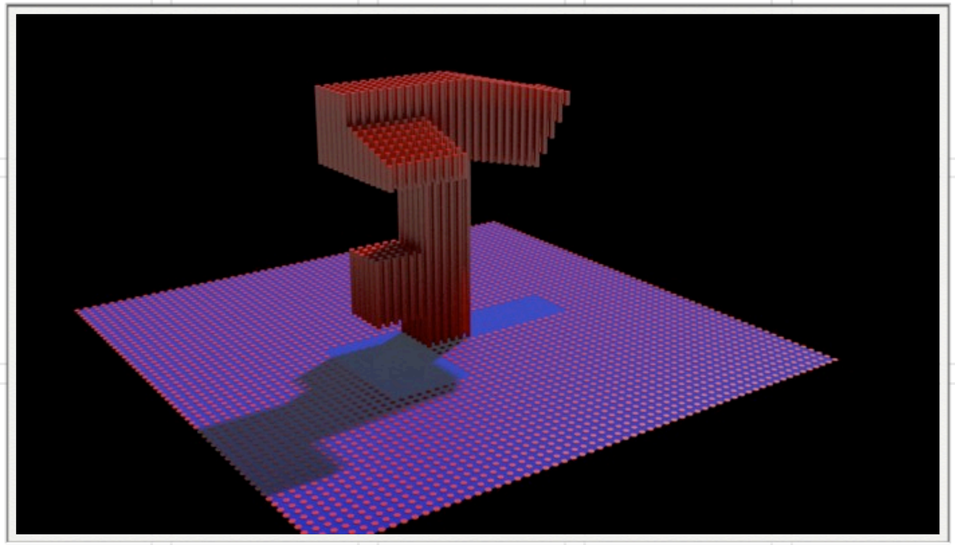
SIDE EFFECTS SOFTWARE

OBJECTIVES

Create a Pin Table that pulls pins up to fill any shape the artist wants filled with pins

Allow overhangs and multiple overhangs like the letter “F”

As the shape animates over the table to constantly pull pins to fill the new position and orientation of the shape



SIDE EFFECTS SOFTWARE

Setup

We will need two objects to create this animation

- A flat shape, such as a grid, to act as the table
  - The number of rows and columns in the grid will determine the number of pins
- A 3D shape to be filled by the pins

We will also need to create the pin generator

- Controls for lag and spring
- We will want each pin to have a slightly different weight so the lag and spring will be less mechanical
- A flag to determine when the animation should start

SIDE EFFECTS SOFTWARE

Table Shape

At the Object level drop down a Geometry Object and dive inside

Drop down a Grid

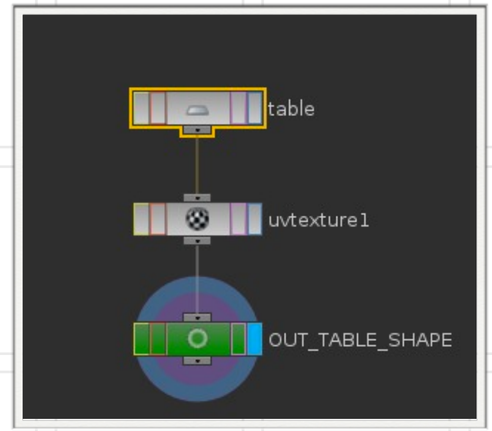
- While you are working on the network keep the grid resolution low. Rows, Columns - 25,25

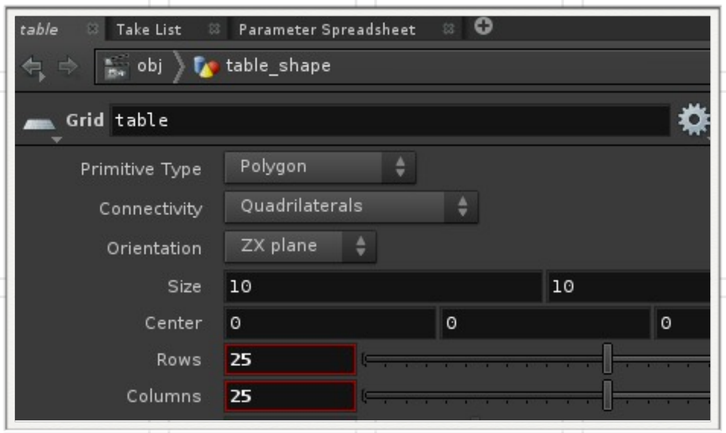
Append a UVTexture SOP

- This is important because we are going to use uv coordinates in a VOPSOP to assign weighting to each pin

Append a Null

- We will use Object Merges to import the geometry into the pin generator - Name it: OUT_TABLE_SHAPE



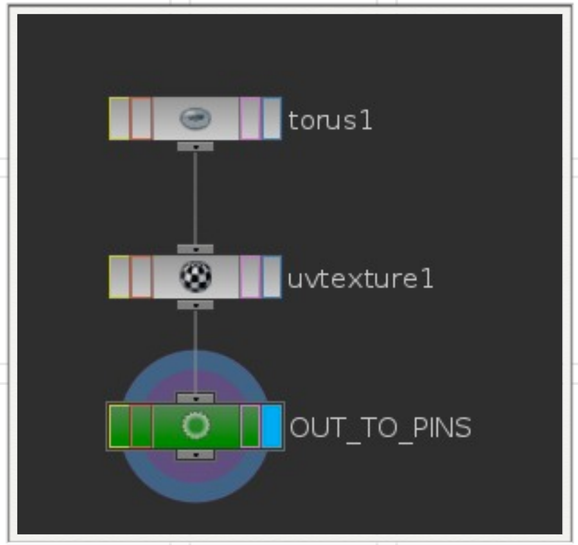


SIDE EFFECTS SOFTWARE

3D Shape

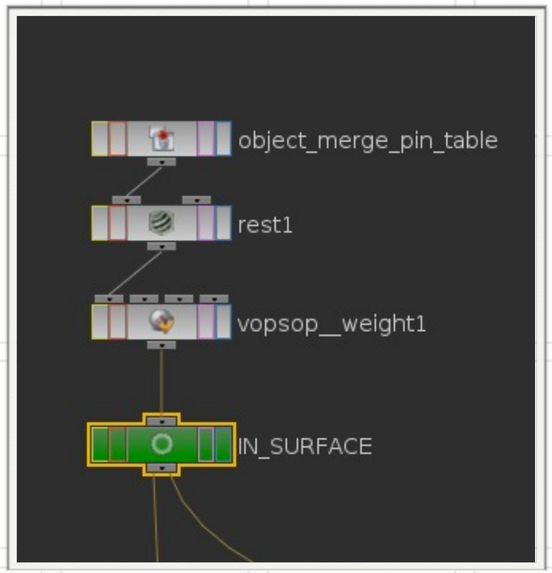
You can create any 3D Shape you like

- The size should be relative to pin table
- The entire geometry should be above the pin table with no intersections
- Remember the pin table will is too crude for fine shapes unless you create very small pins and very high density table. This will obviously take a long time to calculate
- Add a NULL to the end of the 3D Shape and call it OUT_TO_PINS



SIDE EFFECTS SOFTWARE

Pin Generator Setup - Table Creation



We will start by working on creating the table

At the Object level create a Geometry Object and dive inside. I named it pin_generator

Drop down a Object Merge and point it to:

- ../../table_shape/OUT_TABLE_SHAPE

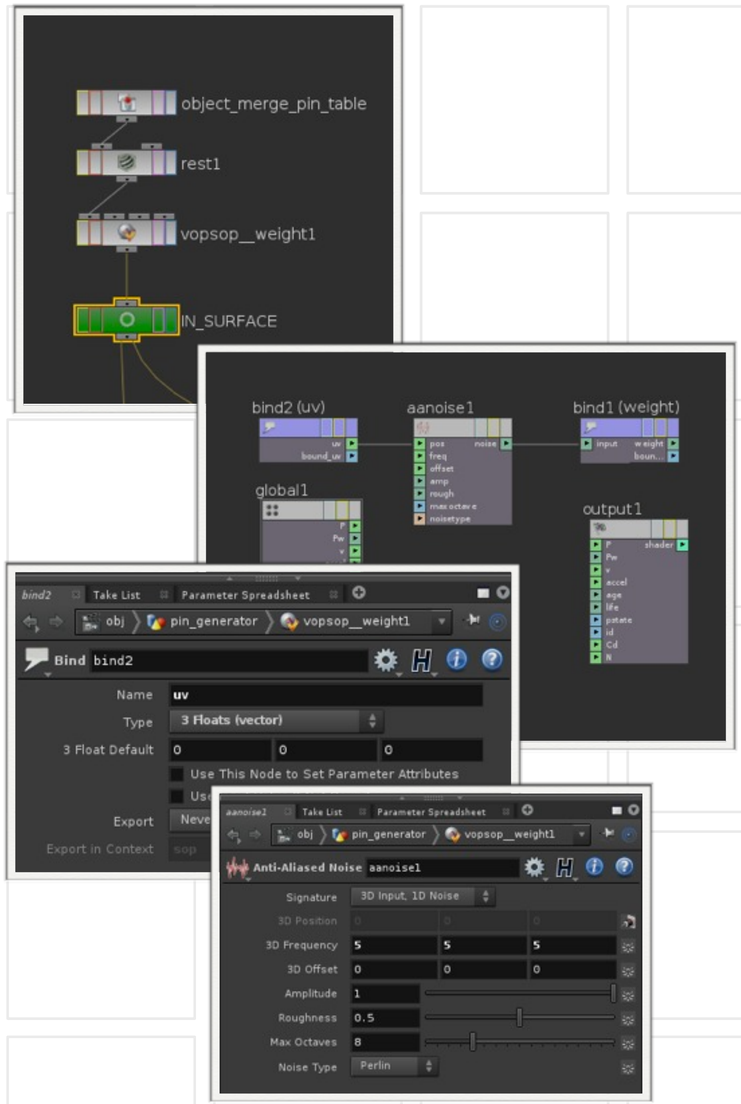
Append a REST SOP so materials will not swim

Append a VOPSOP - This will be used to create the point weight attribute “weight” that will give each pin a unique weight so lag and spring act differently on each pin

Continued on next slide...

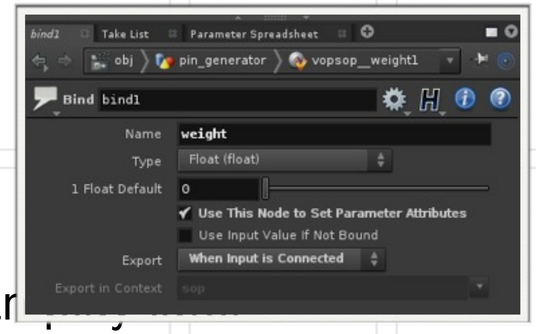
SIDE EFFECTS SOFTWARE

Pin Generator Setup - Table Creation



Drop down a bind VOP. We need to import the uvs

- Name - uv
- Type - 3 Floats (vector)



Wire the bind to a anti-alias nose VOP

- Keep amplitude to 1.
- 3D Frequency - Keep it simple. You ca

Wire the anti-alias noise to a bind export

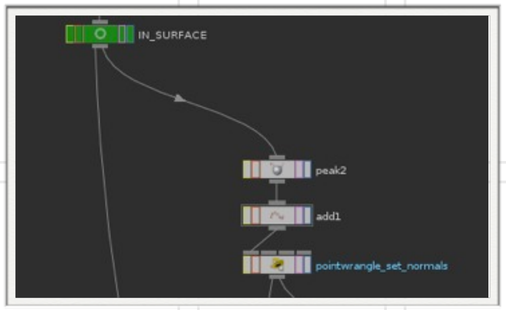
- Name - weight

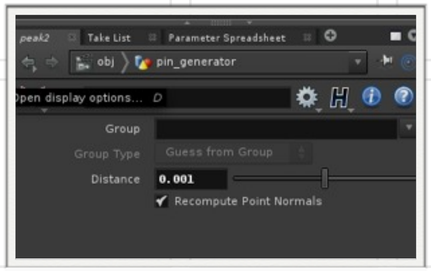
Go up to the Geometry level and append a NULL

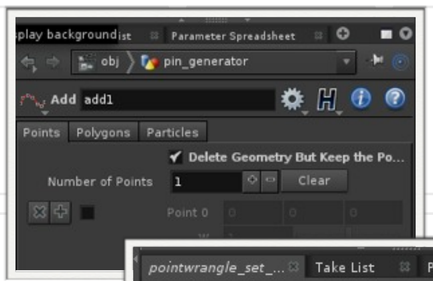
- Name it - IN_SURFACE

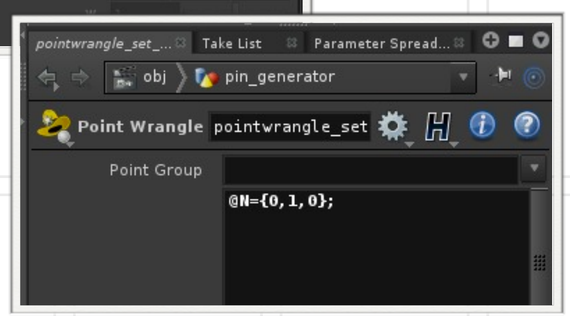
SIDE EFFECTS SOFTWARE

Extracting Pin Locations and Setting Normals









Append a Peak SOP to the IN_SURFACE NULL

- We want to allow the artist to determine if the pins will be flush, recessed, or raised slightly above the table
- In my case I wanted the pins to be just slightly raised over the table. Distance - 0.001

Append an Add SOP to the Peak

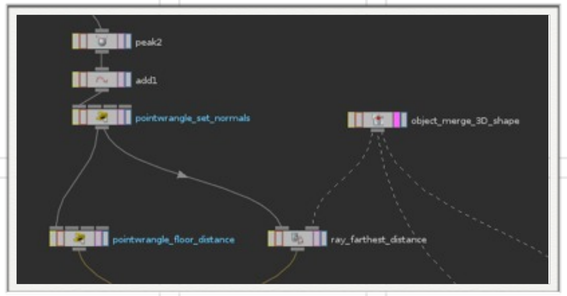
- We do not need the grids primitives, just the points to use to position the pins.
- Select Delete Geometry But keep Points

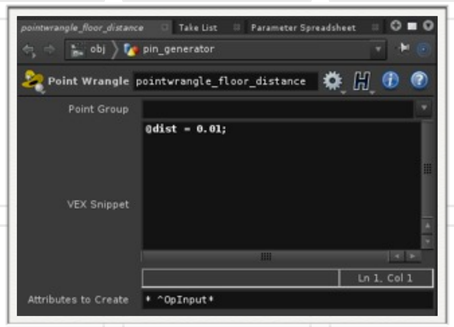
Append a Point Wrangle to set Normals to (0,1,0)

- @N = {0,1,0};

SIDE EFFECTS SOFTWARE

Importing the 3D Shape and Calculating Distances





Append another Point Wrangle. This time we want to create an attribute called dist. This will be a value just above the floor. We will use this value to keep the pins on the floor until the frame we determine to start the animation.

- @dist = 0.01;

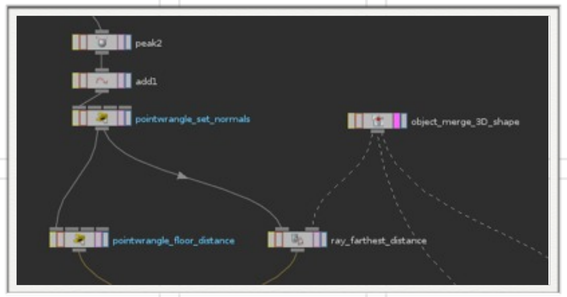
Drop down a Object Merge and name it object_merge_3D_shape

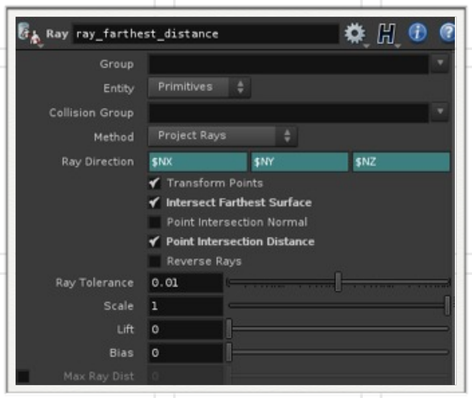
- Point to the OUT_NULL of your 3D Shape. In my case ../../3d_shape/OUT_to_pins

Continued on next slide...

SIDE EFFECTS SOFTWARE

Importing the 3D Shape and Calculating Distances (cont.)





Append a Ray SOP to the Point Wrangle that set the normals. We will use the Ray SOP to calculate the distances to the furthest surface from the table. Eventually the pins will travel from the floor to the farthest surface. Then it will calculate what is the next closest surface and that will be the length of the pin.

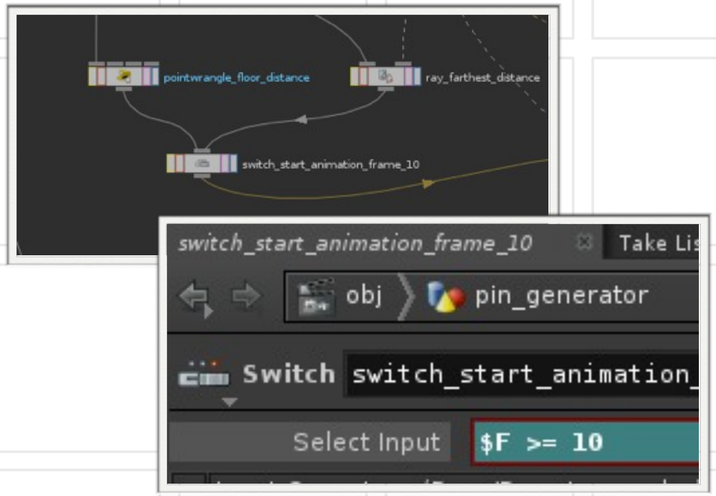
- Select - “Intersect Furthest Distance”
- Select - “ Point Intersection Distance”
  - This is real important since we need to create the attribute “dist” that shows the distance of the surface to the table

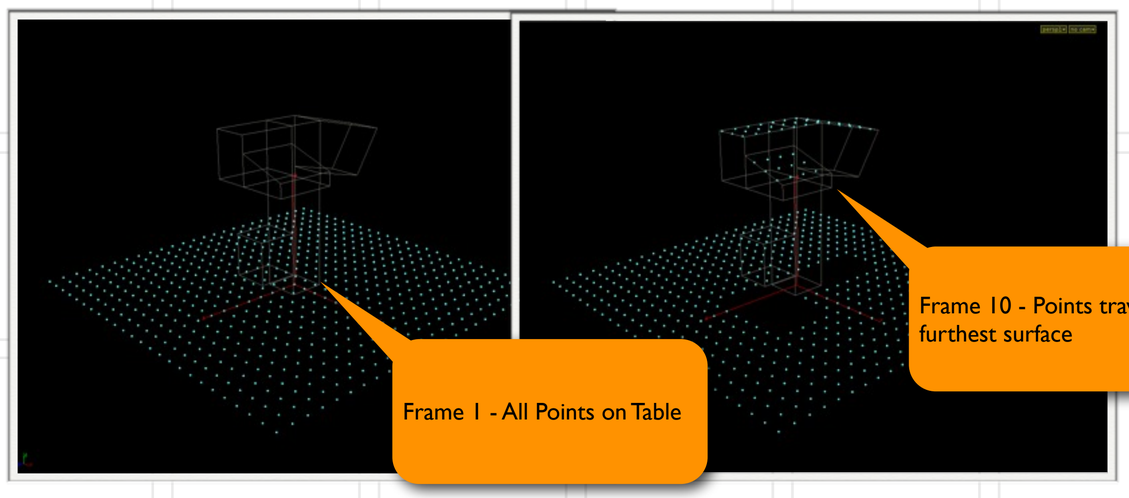
Wire the Object merge of the 3D shape into the second input of the Ray SOP

Continued on next slide...

SIDE EFFECTS SOFTWARE

Determining when the Animation will Start



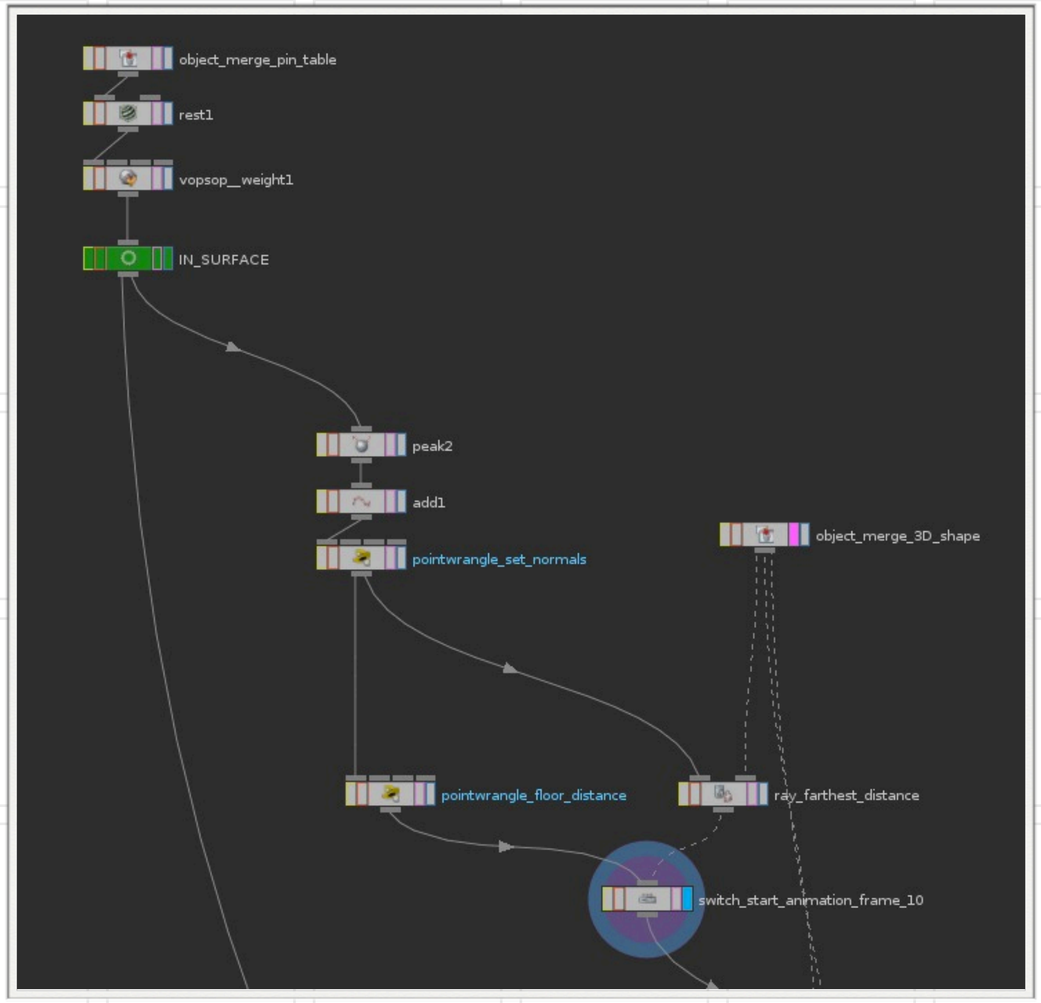


Append a Switch SOP to the Point Wrangle Floor Distance and Wire in the Ray Sop as the second option for the switch

- We want the switch to determine if the animation should start or not. If the Frame number is below 10 then keep the pins on the floor, if 10 or greater use the distances of the Ray SOP
  - $F >= 10

SIDE EFFECTS SOFTWARE

Network So Far...



SIDE EFFECTS SOFTWARE

A Small Problem Needs to be Solved

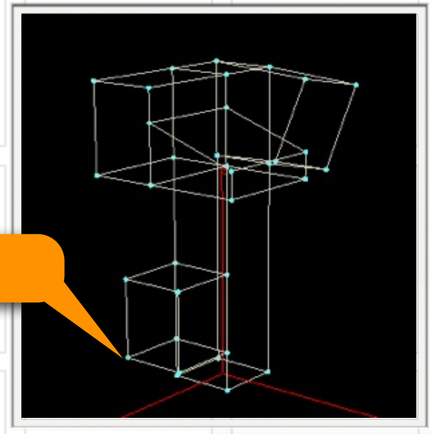
If you look at our 3D Shape it has to overhangs on one side

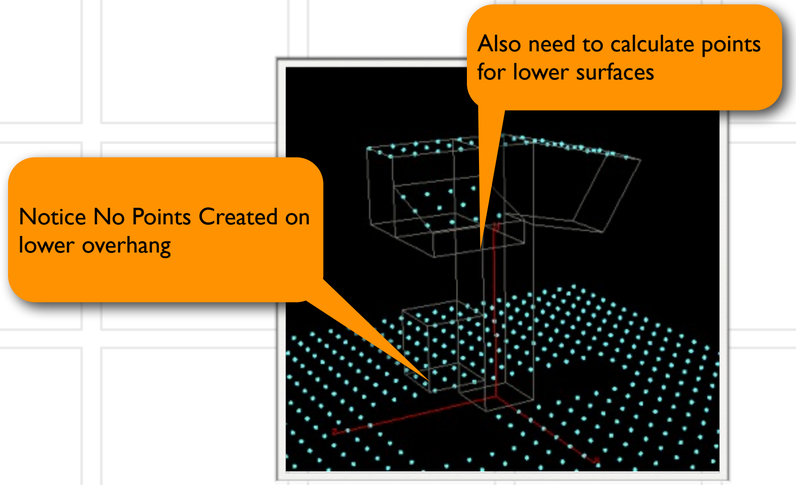
The Ray SOP only calculated the furthest points

We need to determine the distances of the closer overhang

We will use a VOPSOP to solve this

We also need to calculate points for the lower surfaces





SIDE EFFECTS SOFTWARE

Calculating Points for Lower Surface

Append a VOPSOP to the Switch we just created

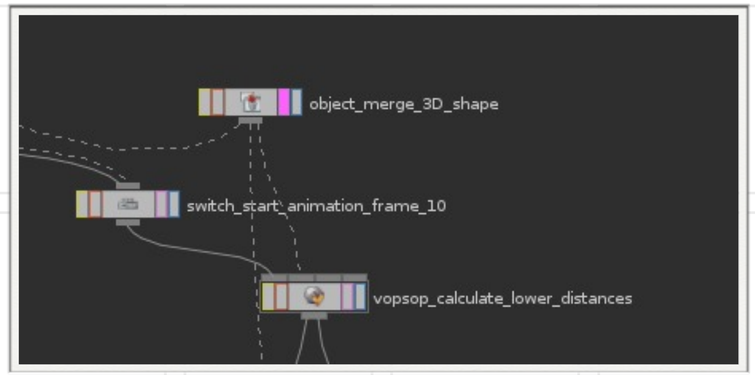
In the second context of the VOPSOP wire in the Object Merge 3D Shape. Dive Inside.

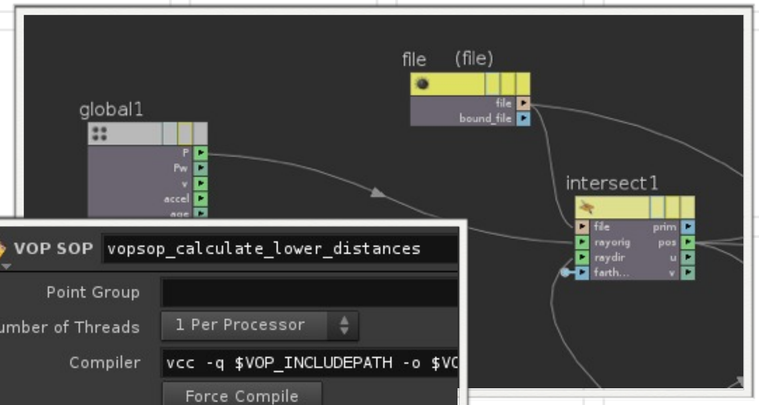
Drop down an Intersect VOP and expose the File input parameter

- This operator computes the intersection of the specified ray with the geometry, and returns the number of the hit primitive or -1. In the case of multiple intersections, the one closest to the ray origin will be used unless Farthest From Ray Origin is enabled, in which case the one farthest from the ray origin will be used.
- Promote the Furthest Surface Parameter

The File parameter takes a file. But we can also point to a node using the op syntax: op:`opinputpath(".",1)`

Go up one level and set the parameters





SIDE EFFECTS SOFTWARE

Calculating Points for Lower Surface (cont.)

op:`opinputpath(".",1)` - This states search in the current node the second input. Remember input contexts start at 0

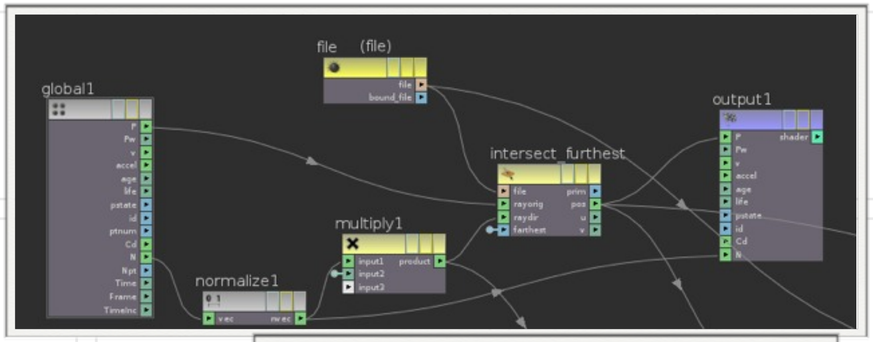
Select - Furthest from Ray Origin

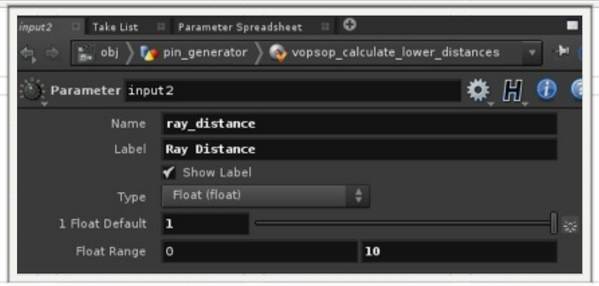
Dive back inside the VOPSOP

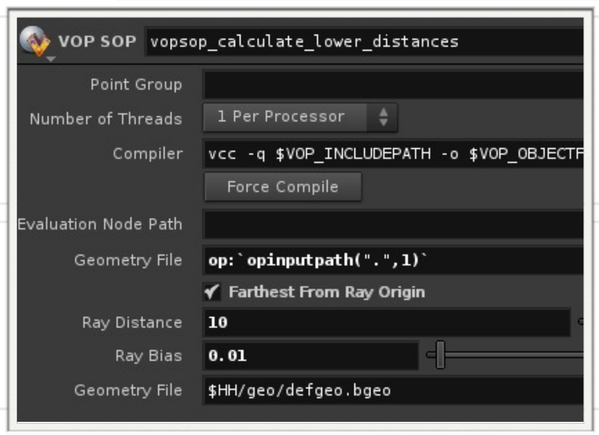
Wire the P output of the Intersect to Output P

For Ray Direction we need to do a couple of more calculations. Ray direction only searches as far as the magnitude of the normal. So we need to multiply the normal by a user defined value

- Append a Normalize VOP to Global N
- Append a Multiply to the Normalize and promote the second input
  - Name the promoted parameter “ray distance” , label - “Ray Distance”
  - Default - 1, Range 0,10
- Go up one level and set it to 10

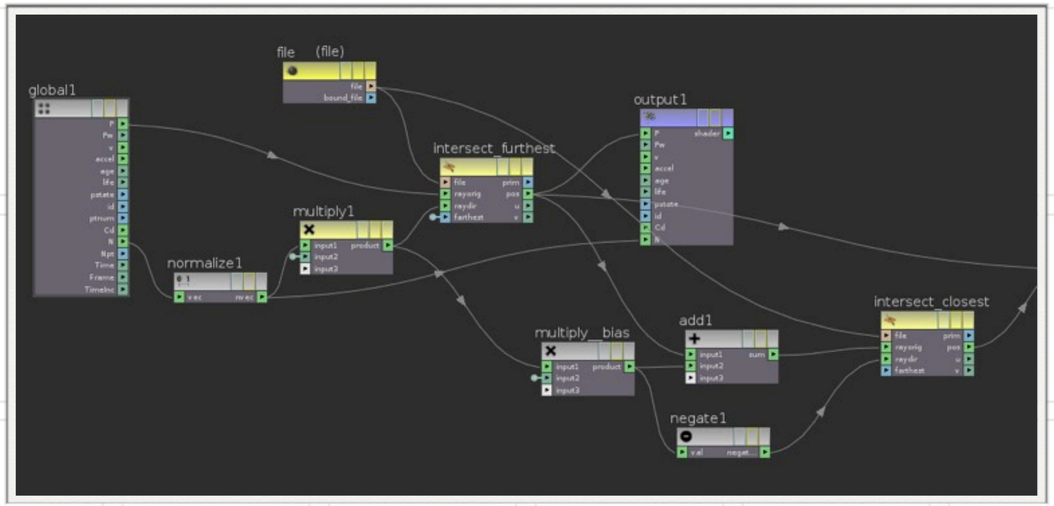






SIDE EFFECTS SOFTWARE

Calculating Points for Lower Surface (cont.)



So far we only calculated the furthest distances. We need to calculate the distance to the nearest surface. We can do that by using another intersect VOP and use the furthest distance as its starting point

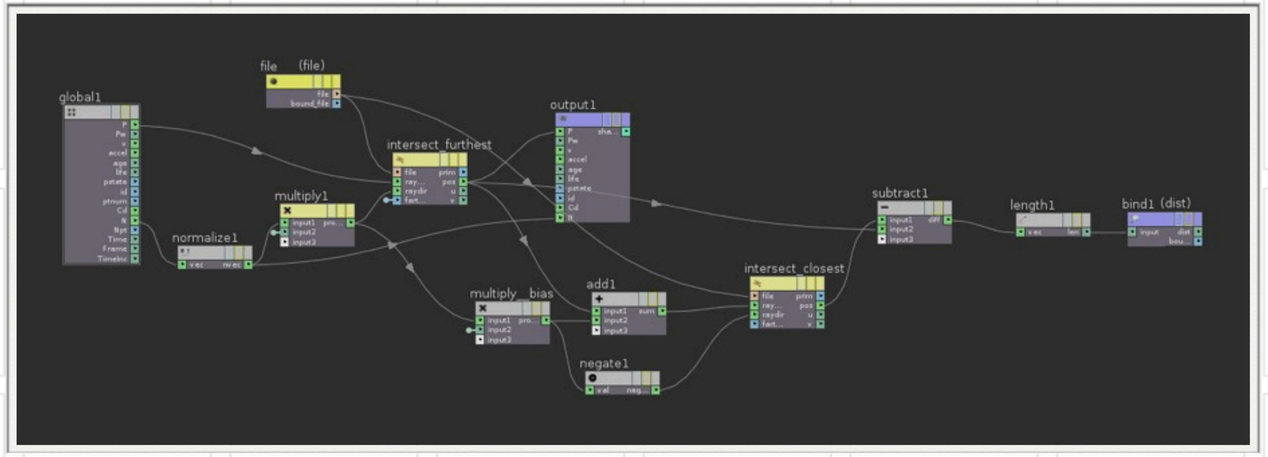
Drop down another intersect VOP and wire the File Parameter to it

We want to reverse the ray direction to search the opposite way so append a multiply bias and negate to the first multiply and wire it to the ray direction of the new intersect VOP

The bias is used to make sure it does not intersect the same surface as it started from

SIDE EFFECTS SOFTWARE

Calculating Points for Lower Surface (cont.)



We now subtract the closest from the furthest distance to get the “pins” vector

Now append a length VOP to the subtract to get the floating point value of the length of the vector

Finally export the length as “dist”

SIDE EFFECTS SOFTWARE

Calculate Lower Points

This Network box should be much more straightforward

We blast the points on the floor - @dist<0.1

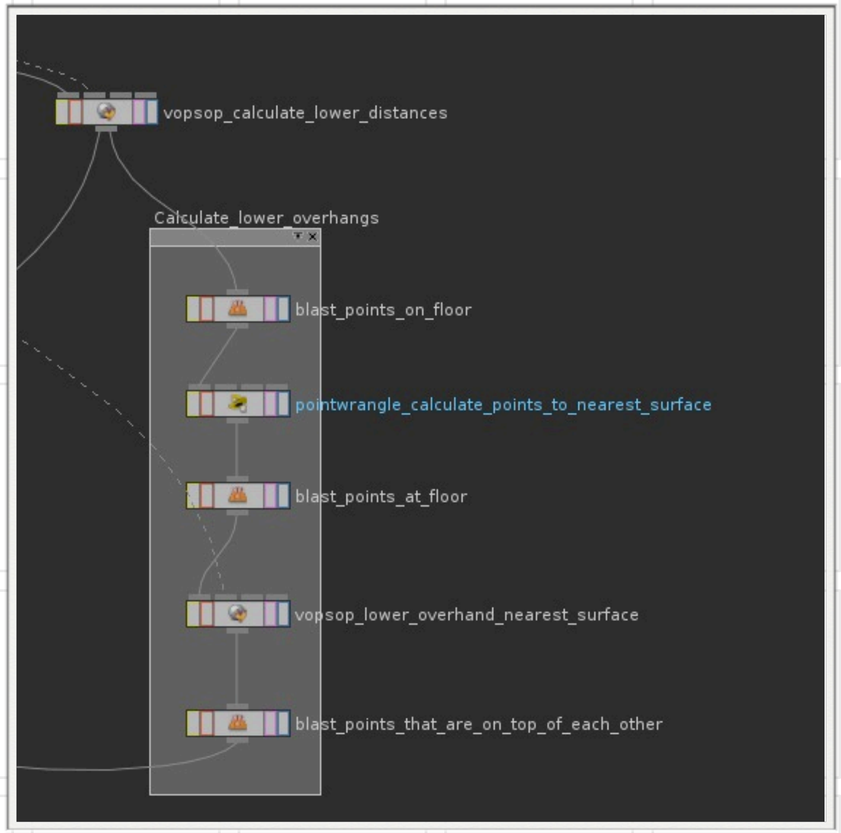
Calculate the nearest surface

- @P = @P - @N*@dist; //New Position of nearest surface
- @N = -@N; // reverse the normal so normal points up to furthest distance
- @dist = 0; // reset the dist attribute to 0 for future calculations

If there points at the base of the 3D Shape blast them since we do not need pins for them - @P.y<0.001

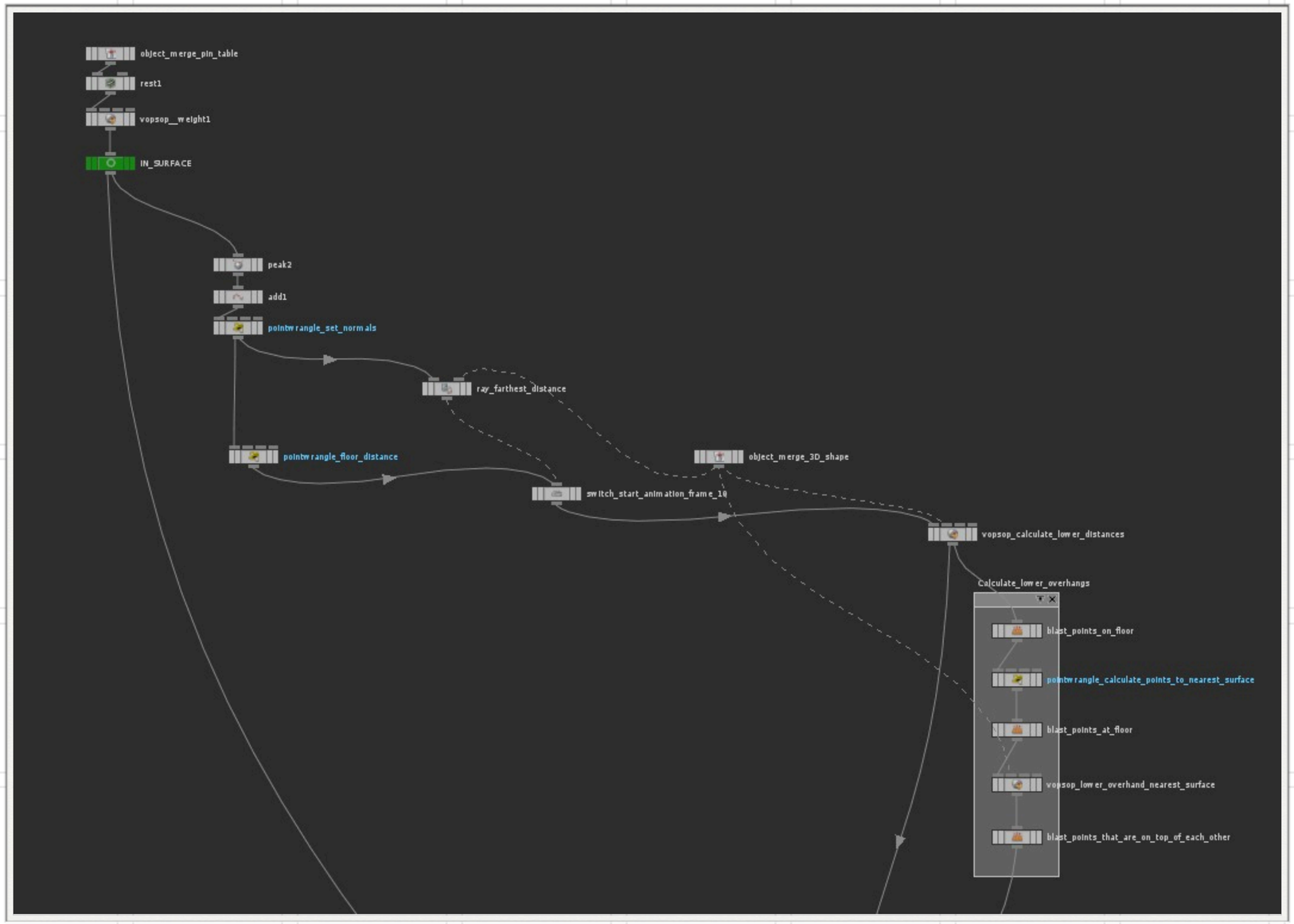
Do almost identical VOPSOP to calculate new nearest points

If the VOPSOP calculates points that are on top of previous points blast them since the pin length would be zero - @dist<0.001



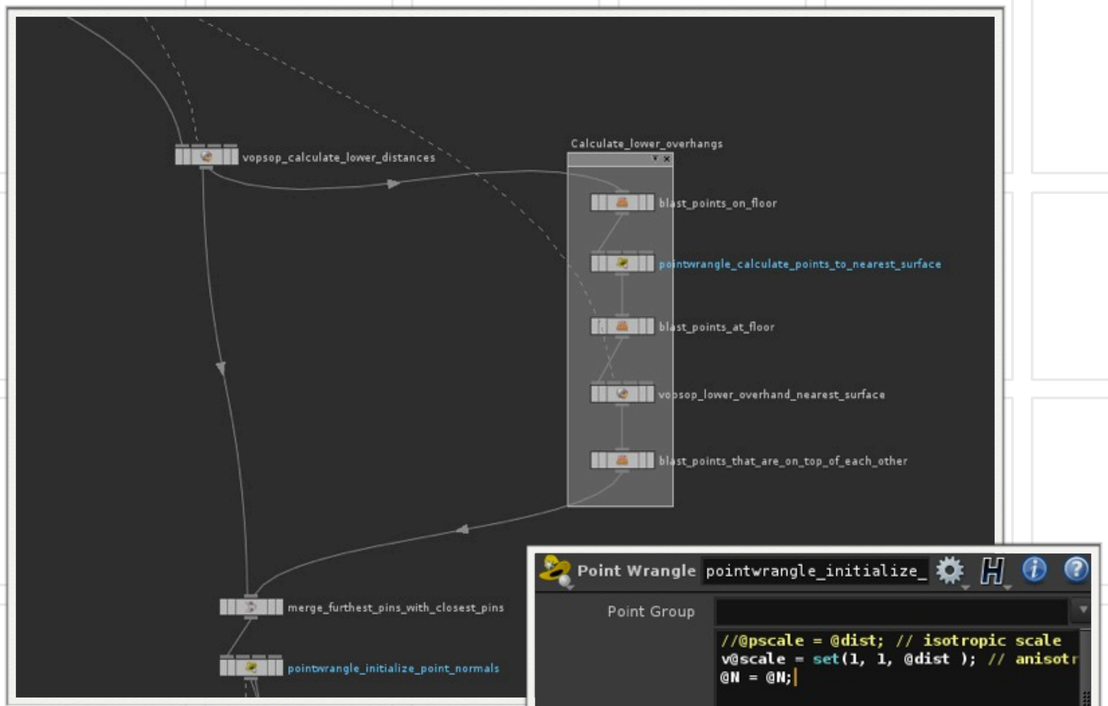
SIDE EFFECTS SOFTWARE

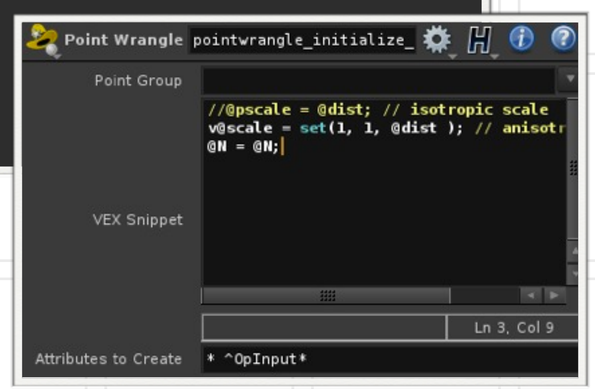
Network So Far...



SIDE EFFECTS SOFTWARE

Merge All Points Created and Initialize Normals





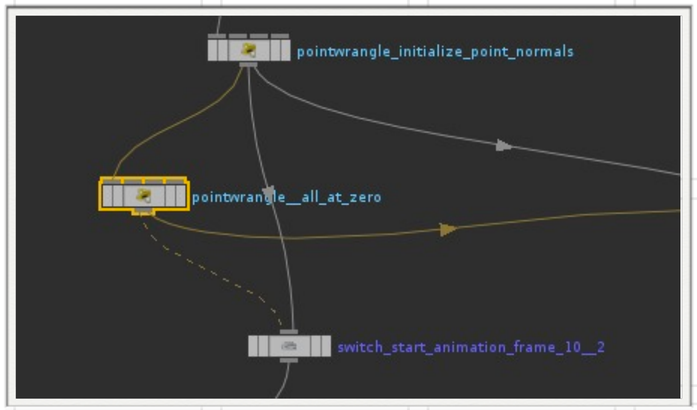
Append a Merge SOP to the last blast and wire in the output of “vopsop_calculate_lower_distances”

Append a Point Wrangle and initialize Normal and Scale attributes

- v@scale = set(1, 1, @dist); // anisotropic scale
- @N = @N;

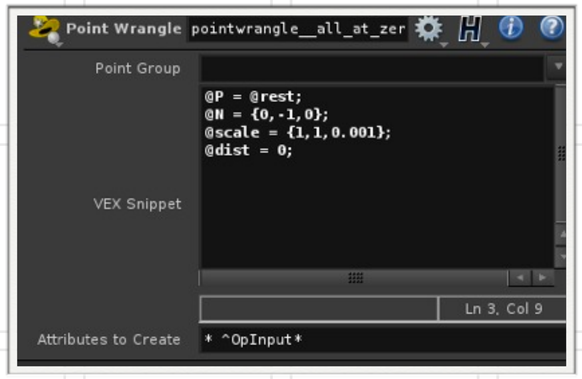
SIDE EFFECTS SOFTWARE

Setting Up the Pins for Animation



We want the pins to travel from the furthest surface to the nearest

- Append a point wrangle
  - @P = @rest; //set point position to rest position
  - @N = {0,-1,0}; // set the normal to travel downward
  - @dist = 0; // reset distance

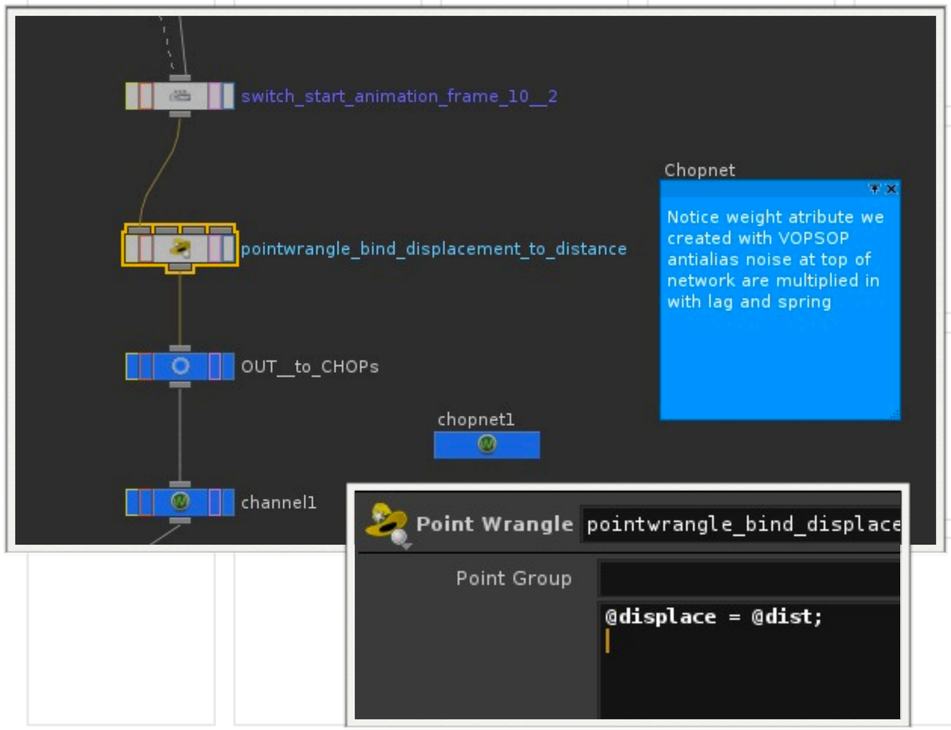


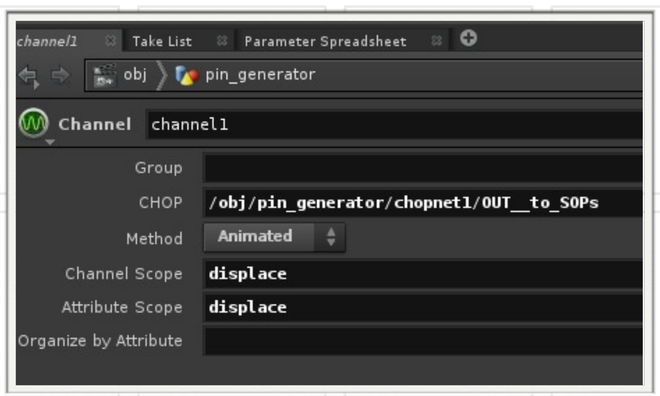
Append a switch to the pointwrangle_all at zero.

- I just did a reference copy of the previous switch - “switch_start_animation_frame_10”
  - $F<=10
- Wire into the switch the other point wrangle
- If Frame is less then 10 no animation else position points

SIDE EFFECTS SOFTWARE

Setting Up the Point for the CHOPNET





Append another point wrangle to set up the displacement of the pins

- All we are doing is using dist as displacement
- @displace = @dist;

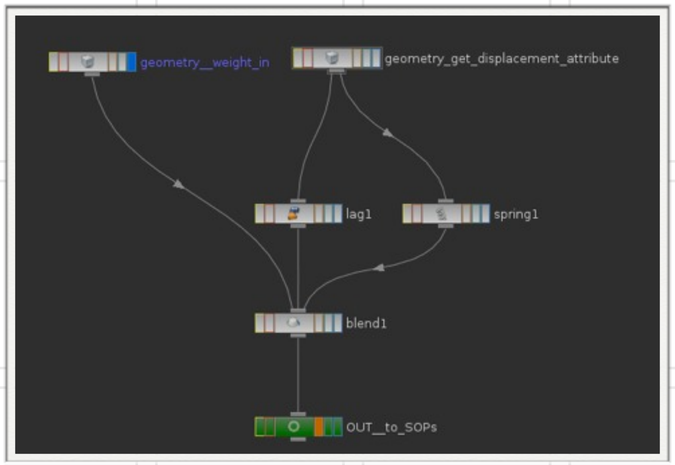
Append a Null for the CHOP Network

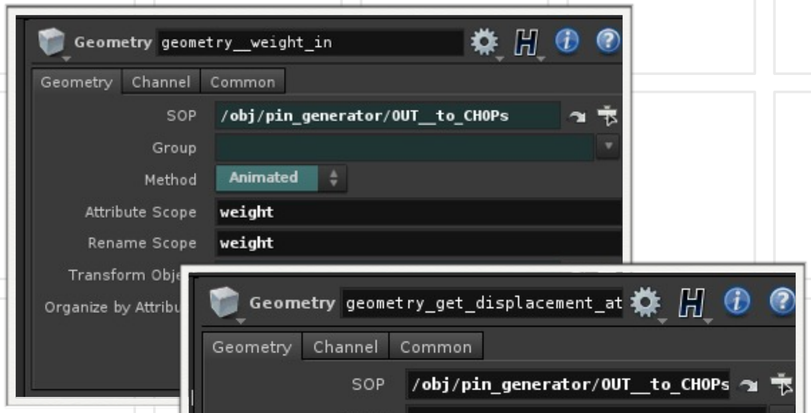
Append a Channel SOP to receive CHOP data

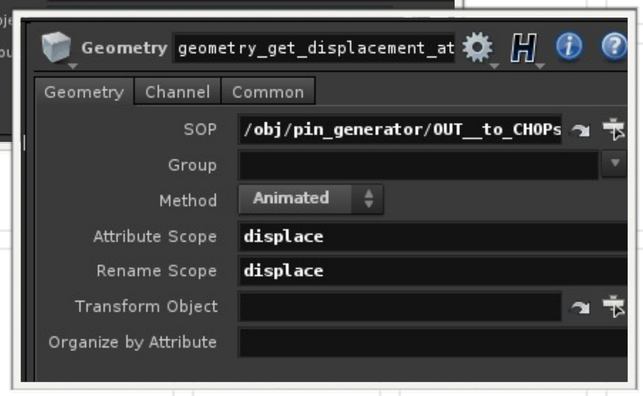
- fill in the parameters shown on the left

SIDE EFFECTS SOFTWARE

The CHOPNET







Drop down a Geometry CHOP. We need to import the weight attribute we created with antialiased noise at the top of the network

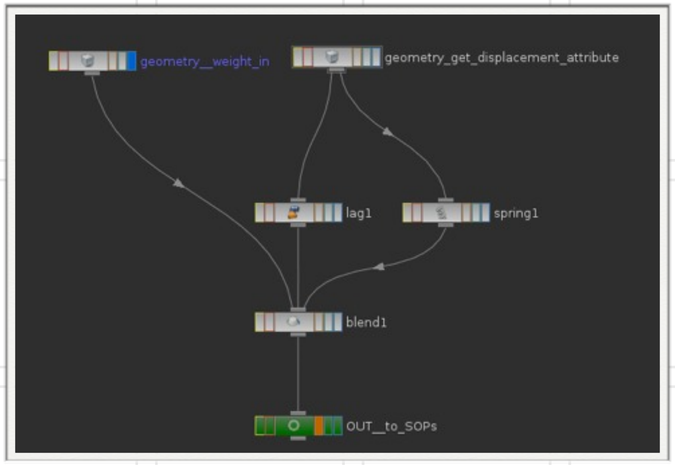
- SOP - /obj/pin_generator/OUT_to_CHOPs
- Method - Animated
- Attribute and Rename Scope - weight

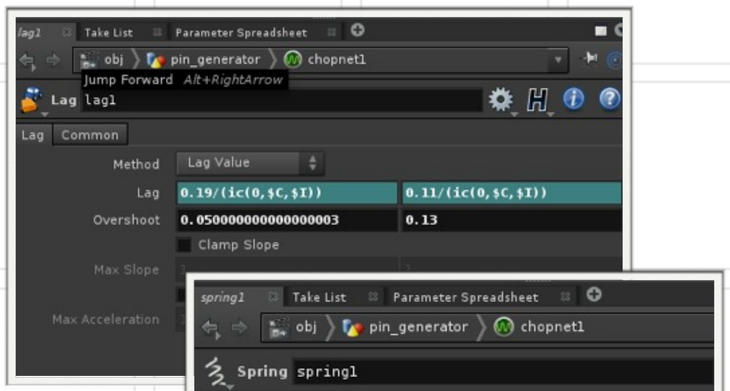
Drop down another Geometry CHOP. This time we will import the displacement attribute we just created

- SOP - /obj/pin_generator/OUT_to_CHOPs
- Attribute and Rename Scope - displace

SIDE EFFECTS SOFTWARE

The CHOPNET (cont.)





Append a Lag and Spring CHOP to the Geometry that contains the displace attribute

Append a Blend CHOP to the Geometry_Weigh_In

- Wire into the Blend first the lag and then the Spring

Cont. on next slide...

SIDE EFFECTS SOFTWARE

ic()

We are going to use the ic() function in the lag chop

float ic (float input_index, float channel_index, float index)

REPLACED BY

hou.ChopNode

Evaluates a CHOP's input channel at a specific index.

EXAMPLES

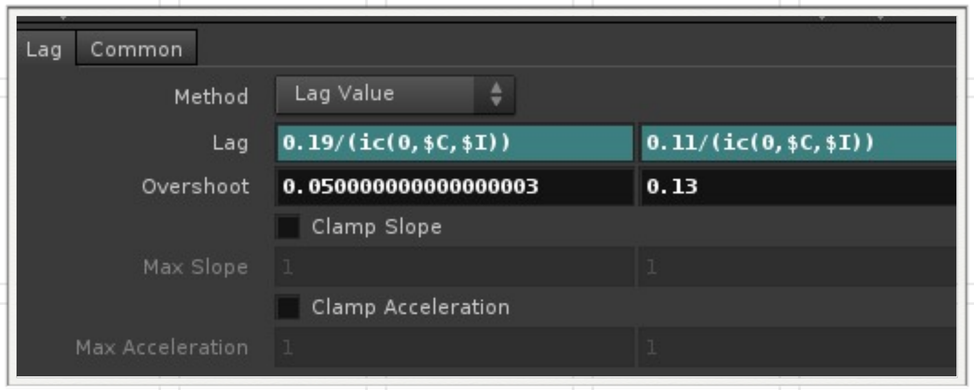
ic(0, 2, 10)

Local variables

- $I - Index
- $C - Channel

SIDE EFFECTS SOFTWARE

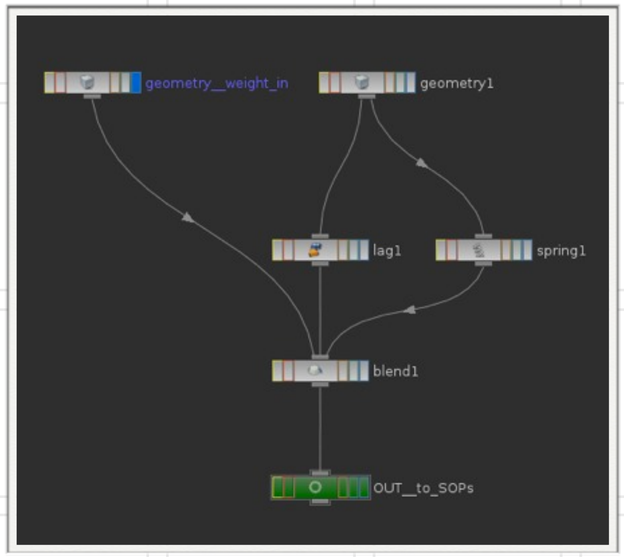
Lag CHOP

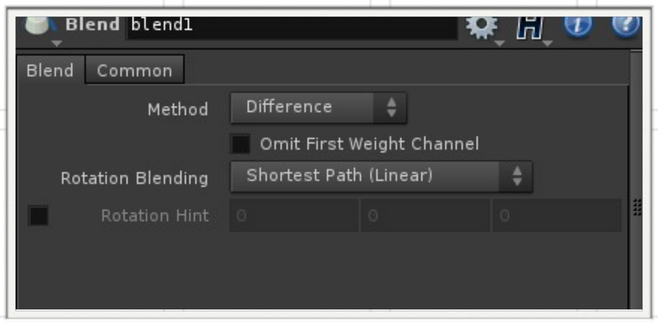


making the lag anisotropic and just varying it with the ic() function

SIDE EFFECTS SOFTWARE

Blend CHOP





The Blend CHOP combines two or more chops in input 2, 3 and so on, by using a set of blending channels in input 1. The blending channels cause different strengths of the chops to contribute to the output of the chop.

Here we use the noise we generated at the the top of the network to weigh the amount of lag and spring in each pin

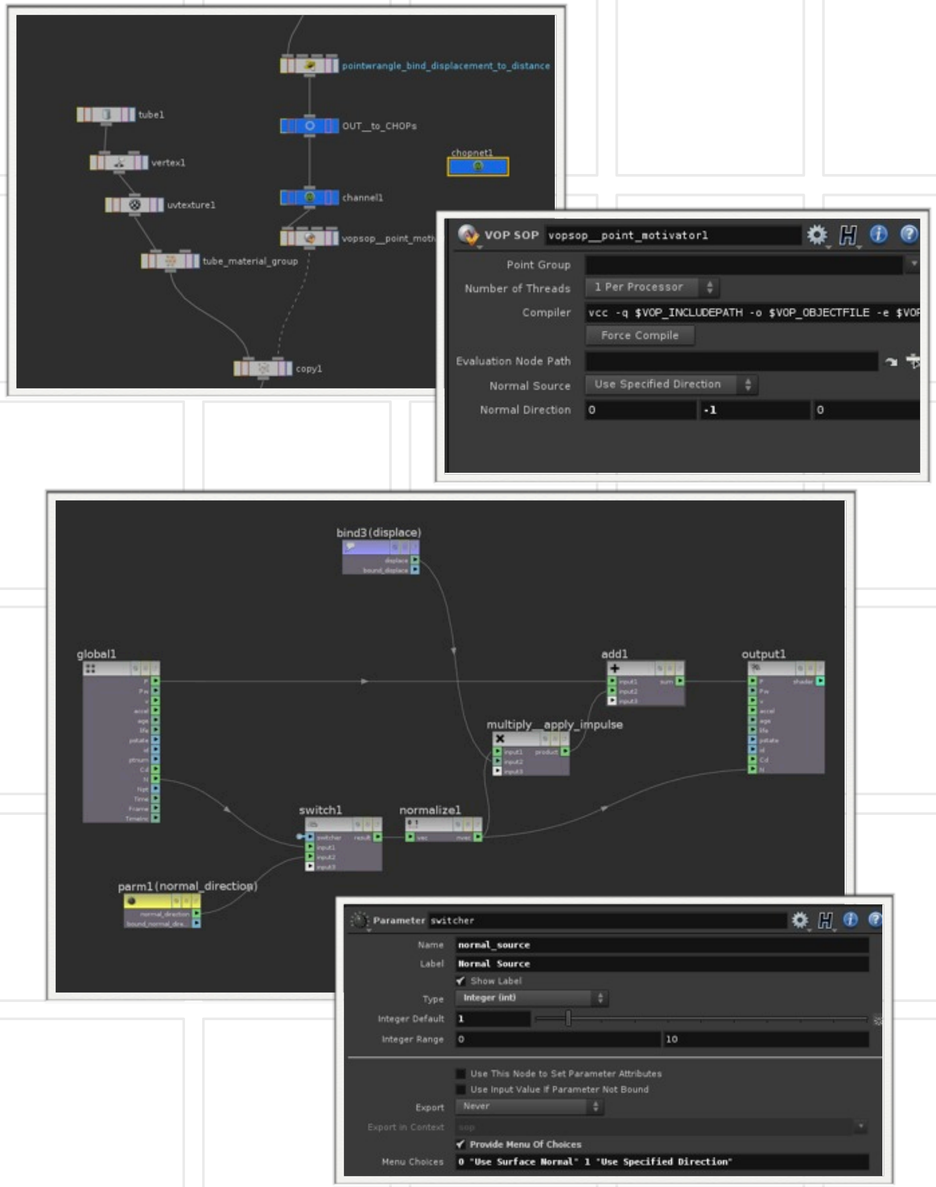
We set the Method to “Difference because

- Each blend input affects the result without reducing the effect of the others. You can exaggerate beyond each of the inputs by setting their Blend > 1, and you can also use negative values. When all blend channels are 0, you get smooth transitions as any of the blend channels ease out of zero.

Finally append a NULL CHOP and name it OUT_to_SOPs so the Channel SOP will fetch the data

SIDE EFFECTS SOFTWARE

One Last VOPSOP



We are going to now decide if we want to displace are points by a user defined normal or the surface normal

Append a VOPSOP to then Channel SOP

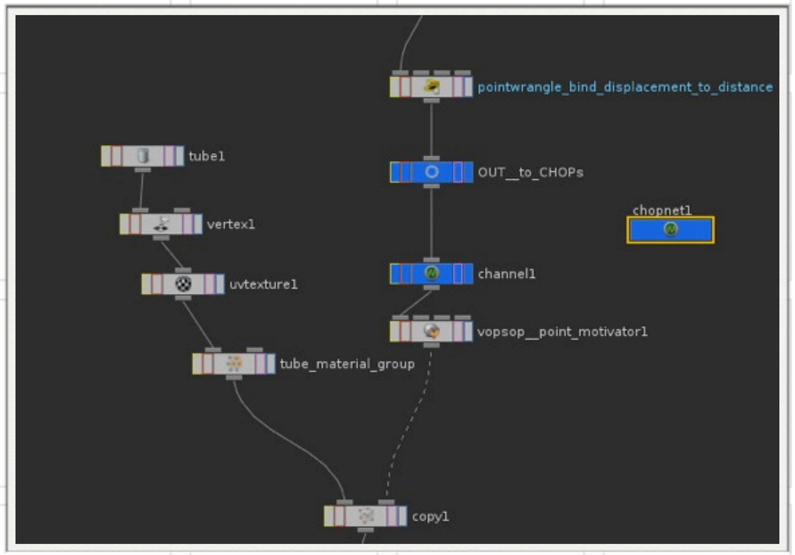
- Look at the Menu Choices on the switch
- We want to displace downward (0,-1,0)
- We will use the “User Specified Normal”

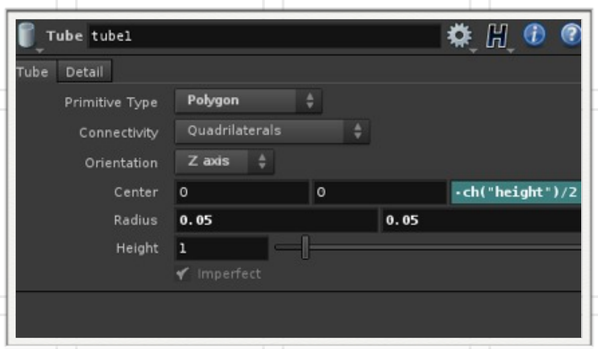
We multiply the user specified N by displacement and add it to the current position

Now we are ready to copy or tubes onto the points

SIDE EFFECTS SOFTWARE

Creating the Pins





Create a tube on the z axis with 1 as its length radius 0.05 and centered on the z channel

- -ch("height")/2

I made mine six sided and cusped the edges

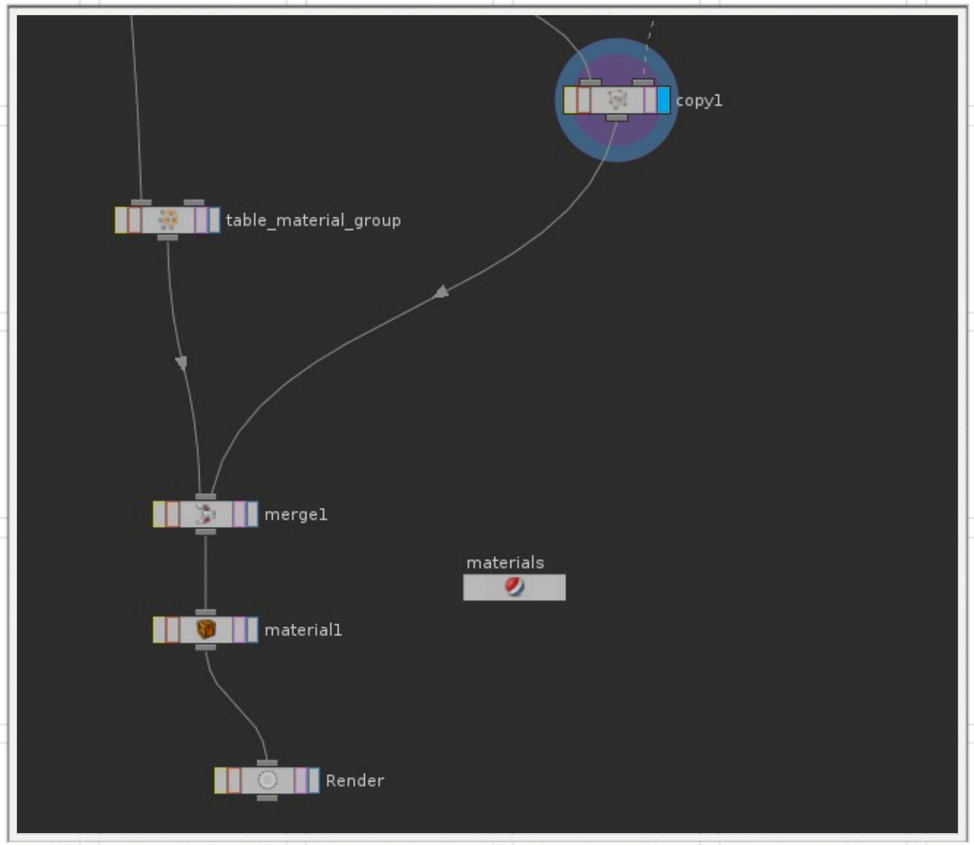
apply a uvtexture - I used faces

Group the tubes for materials

COPY the tubes onto the VOPSOP

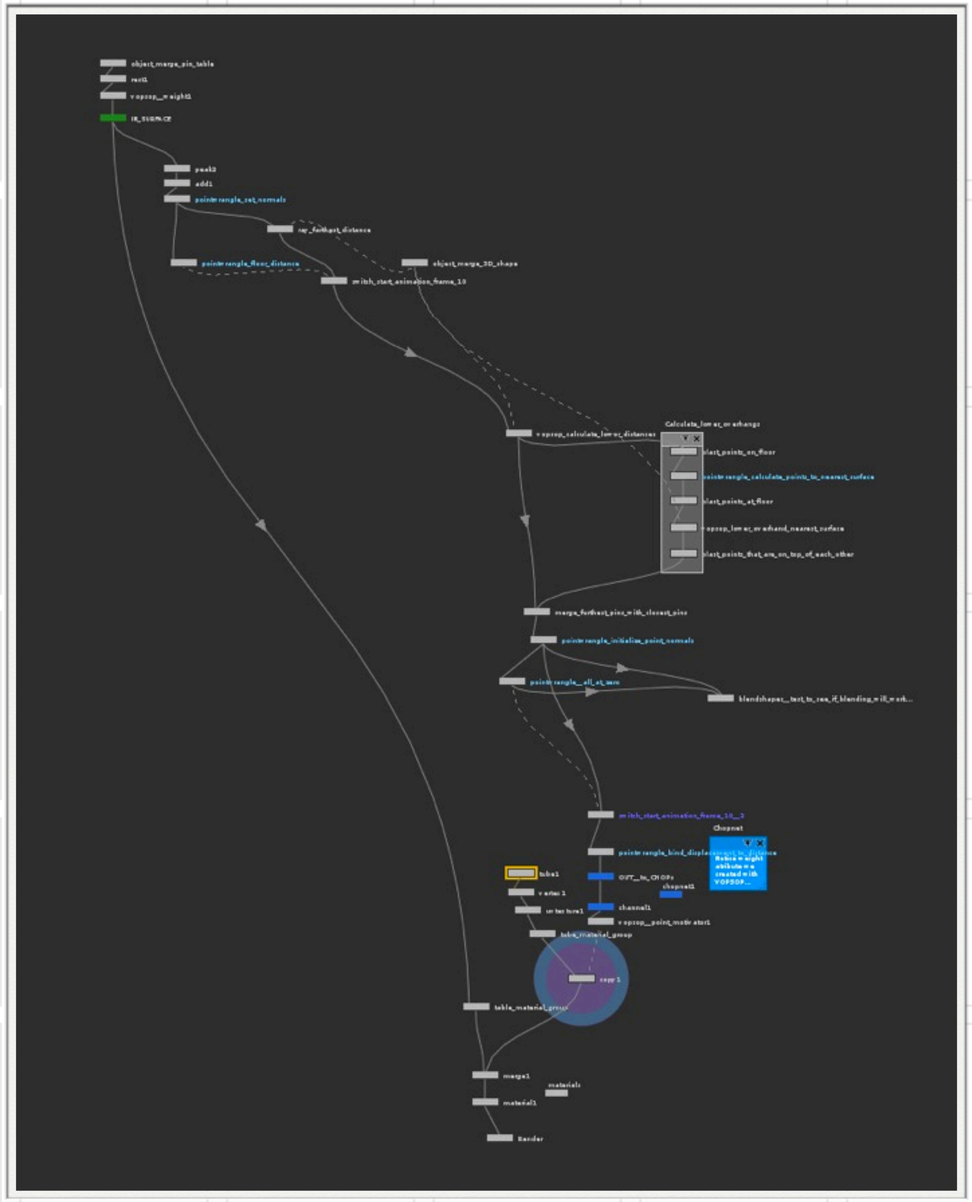
SIDE EFFECTS SOFTWARE

Apply Materials If You Like



SIDE EFFECTS SOFTWARE

Finished Network



SIDE EFFECTS SOFTWARE

End of Module 02

Procedural Animation

SIDE EFFECTS SOFTWARE