Modeling with cages: How to make a hand

Making the middle finger

- Generate a rectangular extrusion, roughly as shown in 1. Next, working first in front and then in top view, move the points at one end to slightly converge it, as shown in 2.

We shall refer to this object as a finger cage and shall split it in half. Being symmetric we only need to construct one side. At the end we shall mirror it and stitch the two pieces.

- Working in top view, draw a line along the axis of the cage (3).

- With the Trim & Stitch tool active and Trim With Line selected in its dialog, click on the lower part of the cage and on the line. The cage is split in half, as shown in 3.

We shall next insert segments to the cage to articulate its topology so that smooth meshing works better. The new segments are inserted using trim and stitch operations.

- Working in front view, draw nine vertical lines, as in 4.

- With the Trim & Stitch tool and Split With Line selected in its dialog, click on the cage and on the first line. This splits the cage in two pieces. Repeat this operation once for each line. At the end, the cage is split to ten pieces, as shown in 5.

- With Stitch selected in its dialog and the Trim & Stitch tool active, click on the first two pieces to stitch them into one. Before executing the operation you may want to select Delete in the Status Of Objects dialog to avoid accumulating extra objects.

Repeat the operation eight more times. At the end, all pieces have been stitched back together into a single cage (6).

- Next draw a horizontal line, as in 6, and use it to split the cage horizontally. Then stitch it back together. The result is a single piece, as in 8 and 9. This has the same shape with the original cage, but its faces have been subdivided to a number of tiles.

Next we shall apply geometric transformations, that is, will move points, to better approximate the shape of our finger.

- Working in right view, which is looking from the tip of the finger cage, we shall slightly move the points in the circles, as in 10. Use the Pick tool and frame picking to select these groups of points. Recall that you will need to press shift to select the second and the third groups.

- With the Independent Scale tool, click on a, then b and c. The result is as shown.

- Next pre-select the four points at the tip of the finger cage, as shown in 11, and after switching to a front view move them the distance e-f, as shown in 12 and 13.

- Next, working in front view, slightly move points up and down to better simulate the shape of the finger (14).

How to make a hand

Material we shall be using. That is, how smooth meshing works. Keep in mind that it works best with meshes that consist of continuous and closed sequences of segments, which delineate four sided faces. Triangular faces should only be used when they can not be avoided.

We also recommend that, as you build the cage, every now and then you pause to derive a smooth mesh for checking how the cage works. If it does not adjustments should be made. This of course implies that, while we try to offer as specific instructions as possible, much will also rely on your own artistic intuition. ’Good luck!’

Articulating the nail

We shall next insert some additional segments to delineate and sculpt the area of the nail.

- Insert segment a-b, as in 16. Note that we inserted from point to point, using point snap, which allows more accuracy.

We shall continue this practice.

- To prepare for the next segment insertions, we first insert the points where the next segments will be inserted, as shown in 17. Two new points are inserted above and close to existing, in the areas shown with a circle.

- We next insert six new segments between the previously inserted points as shown in 18.

- More points are inserted where the circle is in 19, which is the middle of segments. Segments are inserted between them (20).

- Next we move points to improve the curvature of the nail area, as shown in 21. We shall do quite a bit more of such point moving a bit later.

- We insert a few more points (by snapping at mid-segment) and segments on the side, as shown in 22.

At this point, it is time to put the complete finger cage together by deriving a symmetric opposite and stitching the two pieces together.

- Working on top view (23), draw line b to use as the axis of reflection.

- With the Mirror tool active, About A Segment and Relative To Reference Plane selected in its dialog, and Self/Copy mode set to Copy, click on c then d. The result is as shown in 24.

- Next, stitch the two pieces together, which should produce the one piece cage shown in 25.

The final stage for completing the cage of the finger is “art” more than it is specific instructions we can offer. Look at your own finger and our example in 26 and shape the nail area by moving and/or scaling points to improve its curvature.

Note that the three “rings” of segments that delineate the area of the nail, the way they are close together will already have an affect on breaking the smoothness of the model. To make the break more distinct move the segments of the middle ring inwards to produce a little groove around the nail area.

For all these manipulations the ultimate test is seeing how smooth meshing works with your cage. If the resulting smooth model does not yet correspond to the shape you would like to produce, make a few adjustments and try again.
Making the other fingers

We shall next make four more fingers. Three will be copies of the one we just completed, properly sized. The fifth will be the thumb, which will also be based on a copy, but will require additional manipulations. We shall be constructing the fingers corresponding to a left hand and you can use your own hand as a model when you need to determine the relative sizes.

• Copy-move three more fingers and position them roughly as shown in 27.

• Using non-uniform scale, size the new fingers roughly as shown in 28. In each case you place the base (first click) of the scale at the bottom end of the finger (a), the second click at the top end of the finger (b), and moving the cursor along the axis of the finger you scale it up or down as appropriate for the respective finger.

• Using the Rotation tool and placing the centers of rotation where the bullets are, we rotate each finger as appropriate for the position it has on our hand, as shown in 29.

Next is the thumb. Note that the thumb is different in that it only has one knuckle.

• Make a copy of the largest of the four fingers just constructed. We shall next cut this finger to shorten it and also eliminate the lower knuckle.

• Draw a line where we need to cut it, as in 30.

• With the Trim & Stitch tool active and Trim With Line selected in its dialog, click on the upper part of the finger and then on the line. The finger is trimmed as shown in 31.

Next we put the thumb into position, relative to the other fingers. However, prior to moving and rotating it we create a 4-sided polygon around it, roughly as shown in 32.

We shall always transform the polygon with the thumb cage. We may even want to group it with the thumb cage to make sure they move together. This polygon will later be used to create a reference plane that will facilitate the manipulation of the thumb.

We shall next construct a cage for the palm.

• Working at top view, draw a polygon by placing points between the fingers, as in 33.

• Extrude the polygon to a height slightly bigger than the diameter of the largest finger (34).

Next we extend the thumb to intersect the palm.

• With the Pick tool and topological level set to Point, pre-select the points at the base of the thumb. With the Move tool move them along its axis far enough to cross the palm cage (35).

Next, the five fingers will have to be attached to the palm, using trim and stitch operations.

• With the Trim & Stitch tool active and Trim & Stitch First Object selected in its dialog, click on c and d, as in 35.

Repeat the operation for all the other fingers. This trims and stitches all the fingers to the palm, which are now a single piece (36).

Articulating the cage of the palm

Next, we shall be meshing the palm cage by inserting new segments. We shall be using the Vector Line Draw tool with the Insert Segment modifier on.

• Where the segments are inserted is shown in the illustrations of group 37. Follow these drawings and insert the segments.

When a segment is not inserted on existing points, we recommend that the points at the ends of the segments be inserted first. Then the segments are always inserted from point to point.

This allows for better control of the positions of the insertions. Also, note that all the point insertions are at the middle of segments and are executed using mid-segment snaps.

This makes the job a lot easier. Finally, recall that smooth meshing works best with continuous segment sequences, which you should be doing.

The hand cage should now be as in 38.

Next we need to move some parts of the hand to shape it better.

• Using whatever pick options are appropriate (lasso or single point pick) and the Pick tool, pre-select all the points of the four fingers. This includes the points at their bases but not the points of the palm that surround the bases of the fingers (39).

• With the Move tool move the points a bit up, as shown in 40.

• Pre-select the points of the thumb (as for the other fingers) and move them a bit to the right, as shown in 41.

We shall adjust the positions of the fingers, which is done in two steps: the four fingers are moved first and then the thumb.

• Using whatever pick options are appropriate (lasso or single point pick) and the Pick tool, pre-select all the points of the four fingers. This includes the points at their bases but not the points of the palm that surround the bases of the fingers (39).

• With the Move tool move the points a bit up, as shown in 40.

• Pre-select the points of the thumb (as for the other fingers) and move them a bit to the right, as shown in 41.
Shaping the cage

Observing your own hand, you notice that the thumb is rotated relative to the palm, which we shall also do next. We shall use the rectangle we earlier attached to the thumb to generate a reference plane.

- Set the topological level to Point and with the Define Arbitrary Plane tool active click on points a, b, and c, in this order (42).
- While on top view, pre-select the points of the thumb, as you did earlier.
- Set view to Plane Projection: Front (43).
- Select Rotate, place the axis of rotation (first click) at the center of the thumb (d), and rotate counterclockwise about 55 degrees. The thumb should now look as in 44. Note that we also slightly adjusted the points right after the base and rotated them a bit (about 30° clockwise).

We shall next move some more points to improve the curvature of our shape.

- Pre-select points e, f, g, and h, marked with bullets in 45, and move them up.
- Pre-select the corresponding points at the lower part of the hand and move them down. The result should be as in 46.
- Pre-select points i, j, and k in the vertical middle between the four fingers (47) and move them outwards. The result should be as in 49.

Building a forearm and joint

This is the last step for completing this tutorial. The forearm is essentially constructed using the open end of the hand as an initial profile.

- In the Derivative Surface Options dialog select Boundary Of Surface Object.
- With the 2D Derivative Surface Object tool click on a segment of the open end of the hand cage. This produces a closed profile which is a copy of the end of the hand, as shown in 51. We shall next extrude this.
- In the Extrusion/Convergence Options dialog select Perpendicular To Surface and from the Heights menu select Graphic/Keyed.
  - With the Derivative Extrude tool active click on the profile you created a bit ago and dynamically rubber band it to the desired position. Its size should be roughly as in 52.
  - After selecting Topology for Faces in the Delete Options dialog, use the Delete tool to delete the two faces at the ends of the extruded object you just created.
  - Next insert three lines at the upper end of the of the forearm, using the trim and stitch methods we used at the beginning of this tutorial. Their position is roughly as shown in 53.
  - At the end also stitch the forearm to the hand and move some points of the recently inserted lines to shape this part like a joint.

The very last step is the smooth meshing of the cage. If throughout this model building process you have been testing your results by smooth meshing the partially built cages, you are ready to just do it again.

If you need some help with the parameters to apply, here is what we used:

Maximum # Of Subdivisions = 2;
Maximum Segment Length = off;
Maximum Face Angle = 1°;
Curvature = 80%.

Next, continue to move points to improve the roundness of the cage. This is really “art” and we shall not describe the process in exact terms. Use your own hand and the shapes we display below (50) as examples. If your model of the hand is a bit different than ours, it does not really matter.