Amapi™

with

MicroScribe-3D

Tutorial

Introduction

Welcome to Amapi™, the most powerful and intuitive 3D modeling *and digitizing* software package available. Amapi features extensive built-in digitizing support exclusively for MicroScribe that allows you to create points, curves, and surfaces using data digitized directly from MicroScribe. Amapi has been used to create many of the fabulously realistic 3D models you have probably seen and wondered "How did they do that?". This tutorial will quickly get you started digitizing with Amapi and learning the techniques and art that go into creating professionally digitized models.

Amapi also has many very powerful modeling functions that are not described in this tutorial. To maximize your productivity with Amapi, it is recommended that you go through the Amapi exercise book and online tutorial as well.

As you go through these lessons, please keep the following in mind:

- **Learn all the techniques.** Some techniques may seem irrelevant to your current digitizing projects. However, the more you know the better you will understand how to best use Amapi.

- **Give yourself time.** Digitizing requires planning and precision and is both a technique and an art. Although you do not need to be an "artist" to digitize, remember you are working in an essentially new artistic medium, and it will take some time and effort to master it.

Lesson 1: Basic Concepts

This first lesson covers the basic background concepts you need to grasp before you actually start digitizing.

In this lesson you will learn:

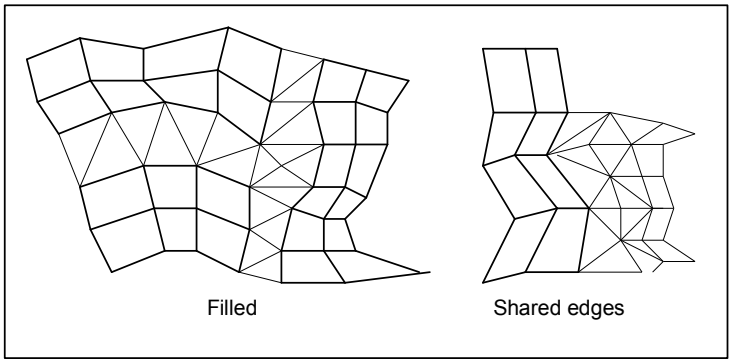
- How objects are digitized by building and connecting polygon meshes
- How to identify which meshes to digitize
- The critical role of planning and markup

Basic Digitizing: Build & Connect Meshes

You can digitize objects in Amapi one of two ways. The easier and quicker way involves digitizing different sections of your object as a separate meshes and leaving small gaps between sections. Then, you connect the separate meshes together by stitching them together. The second method is slightly more difficult and time-consuming but results in cleaner, more precise models. This method involves digitizing a section and then extracting boundary curves from that section for use in digitizing the adjacent sections. The resulting pieces form a seamless model without gaps needing stitching.

Building meshes. A mesh is a set of rows of polygons that share lines of vertices (points). With Amapi, you typically create the lines (by digitizing a series of points) and then fill in the polygons between the lines.

Connecting meshes. There are several techniques to connect meshes. The easiest way is to stretch edge points from one mesh to the edge points of the other. You can also create polygons that fill in the space between two meshes. Finally, you can extract a boundary curve from one mesh to use as a shared edge when you begin the next mesh.



Meshes can be connected with filler polygons or can share edge polygons

Connecting meshes requires careful planning. Usually, you will want similar point counts in the mesh edges you are connecting, so that the finished seam will look like a smooth transition.

Identifying Meshes

So how do you determine which parts of your object you should treat as separate meshes? The answer is part experience, part artistic vision, and part technique. Practice will give you experience. For artistic vision, study professionally-created models, such as those in the Viewpoint catalog.

One technique professional digitizers use is the "critical contours" technique. First, identify the "critical contours" of your object, i.e. the defining sharper curves of your object that give it its fundamental shape. Treat these critical contours as the edges of the patches to digitize.

Planning & Markup

Do not expect that you can just sit down, look at your object, and start digitizing. This is a common beginning digitizing mistake. The typical result is that the digitizing will start off deceptively well, but as you get towards the end you will find that things just don't seem to fit together or that a great deal of editing is needed to finish the model.

Planning and markup can be helpful for successful digitizing. Expect to spend a lot of time looking at your model and considering different ways to go about digitizing it. In essence, you should already know every patch and point that you intend to make, and how you are going to connect them, BEFORE you start digitizing. You will probably find that it is often easier and faster to start over than to try to "fix" a model at the end. It is also often a good idea to do a test pass to see how a particular digitizing approach will work.

One common technique is to actually mark the points or lines you intend to digitize directly on your object. You can use a pencil or pen, but it is often difficult to remove the marks when you are done. You can also use thin graphic or line tape (1 pt. wide is a good size), available at art supply stores, which is both flexible and removable. Another technique is to make small balls or lines with "sticky tack", a sticky clay sold at stationery and art supply stores to attach posters to walls without damaging the paint.

REMEMBER: Digitizing takes time. Be patient and precise.

Lesson 1 Summary

There are a few key points you should remember from this first lesson:

- You digitize by building polygon meshes, then connecting them.
- Amapi uses curves to construct meshes
- Identifying meshes involves experience, art and technique; look for critical contours.
- Planning and markup can be helpful to successful digitizing.

Lesson 2: Digitizing Basics

In this lesson, you will digitize perhaps the simplest possible object, a piece of paper.
While a piece of paper is only 2D, the purpose of this lesson is to familiarize yourself with the some of the basic digitizing tools and commands. You will learn how to:

Set up and enable your MicroScribe in Amapi
Digitize Polylines
Create a Ruled Surface (Lofting)
Use the Smooth Tool
Use AutoPlot

Setting Up and Enabling Your MicroScribe-3D In Amapi

The first time you start Amapi with MicroScribe-3D, you need to set up how the MicroScribe is to be used. These settings will be saved as the defaults the next time you use Amapi.

- Units

  The default units for Amapi after installation are cm. To change the units, choose Preferences from the Edit menu and select Units Settings. You can choose numeric inches if you want units reported in decimal (e.g. 7.125") or inches if you want the units reported in fractions (e.g. 7 1/8").

- MicroScribe Settings

  You can access the MicroScribe Settings Dialog Box from the Edit:Preferences Menu. You can also use the keyboard shortcut CTRL-2. All the keyboard shortcuts are summarized at the end of this document.

  1. Select the serial port number you are using for your MicroScribe-3D. On PCs, port 1 corresponds to COM1, and port 2 corresponds to COM2. On Macs, port 1 corresponds to the modem port, and port 2 corresponds to the printer port. If you are getting communications error messages, refer to the Troubleshooting Guide.
  2. If AutoPlot is checked, Amapi allows the user to hold the left footpedal down while tracing a curve with the stylus. Amapi will automatically plot points along the stylus path until the footpedal is released. The AutoPlot Distance setting specifies how far apart the points will be plotted. The units are set in Unit Settings. If you want precise control over the number and spacing of your digitized points, leave AutoPlot unchecked. For this tutorial, leave AutoPlot initially off.
  3. Amapi has a default Exact Scaling ratio of 1:1. This means a 1" long line digitized with the MicroScribe will appear in Amapi as 1". You can choose between several Amapi to MicroScribe Exact Scaling ratios (1:2, 1:5, 1:10). If Exact Scaling is not checked, the Amapi to MicroScribe scaling is determined by the distance between the first 2 of the 3 points digitized in the 3D Object Calibration. This distance represents the length of the front edge of the Amapi workbench (16"). Therefore, if the first 2 points digitized are 8" apart, the Amapi to MicroScribe scaling will be 16" to 8", or 2:1.

4. If MicroScribe Mouse is checked, the MicroScribe stylus overrides the standard mouse and controls the cursor in the drawing window. The user will be asked to digitize 3 points on the tabletop for 2D Mouse calibration. These 3 points define the borders of the screen, so moving the stylus around within those 3 points moves the screen cursor to the corresponding position on the screen. The right footpedal serves the same function as the standard mouse button. Note: The pulldown menus from the menu bar along the top of the screen can only be accessed with the standard mouse, even with MicroScribe Mouse enabled.

- Bounding Box Display (for Windows NT users only)
  If you are using Windows NT, you can improve the speed of the keyboard commands like rotate (arrow keys) and zoom ('-' and '+') by turning off the Bounding Box Display option. From the Edit Menu, choose Preferences:Amapi Settings. Make sure the Bounding Box Display checkbox is unchecked.

Click on OK to save these settings. You can now enable your MicroScribe in Amapi by choosing Use MicroScribe from the Edit menu. You can also use the keyboard shortcut CTRL-3. Selecting Use MicroScribe again disconnects the MicroScribe from Amapi so that no MicroScribe functions (digitizing, mouse, camera, etc.) are accessible. A checkmark next to the Use MicroScribe command indicates that the MicroScribe is enabled and can be used.

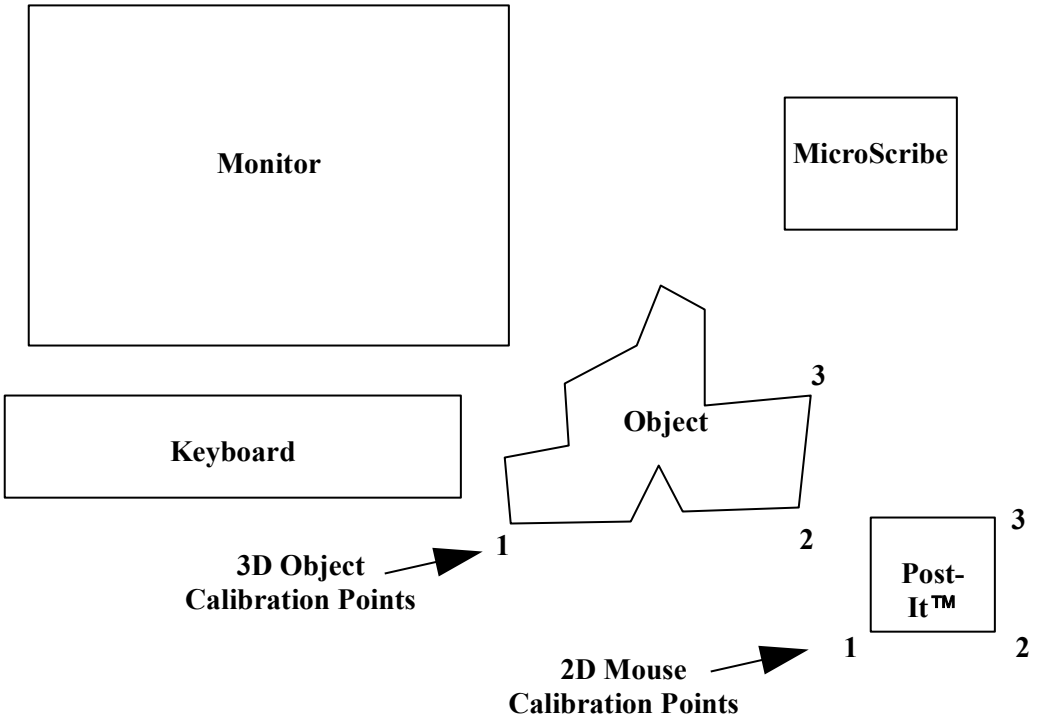
3D Object Calibration

After selecting Use MicroScribe, you will be prompted to digitize 3 object calibration points on your object to align the MicroScribe coordinate system with Amapi's coordinate system. These 3 points should be well-marked spots on the actual object that can be accurately digitized again later on. Small pencil or pen dots work well. The first point should be on the left front side of the model (with you facing the model, your left and closet to you). The second point should be on the right front side of the model, and the last point should be on the right rear corner of the model. These 3 points define a plane that will be aligned with the tabletop plane of the default Amapi workbench. Once these 3 points are digitized, you can save your model at any point and quit Amapi. If you start Amapi again and open that file, you can continue digitizing exactly where you left off provided you digitize *the same 3 object calibration points in the same order*. This is true even if the MicroScribe and the model are no longer in the same relative positions as before. You can move the model or even turn it upside down and pick up where you left off as long as you digitize the same 3 points in the same order the next time you start Amapi. If you wish to change your 3 object calibration points, you can recalibrate at any time from the MicroScribe Settings Dialog Box (CTRL-2). *Changing your 3D calibration points will not transform existing parts of your model to the new 3D calibration*. You will need to realign existing parts of your model with new parts of your model if you change your 3D calibration points. You can use the Assembly Tools to realign these parts. If you the exact relation of the new 3D calibration points to the old 3D calibration points, you can exactly realign the existing parts by explicitly entering the new coordinates and angles of rotation using the Move and Rotate Tools.

2D Mouse Calibration

If you have MicroScribe Mouse enabled, you will be prompted to digitize 3 mouse calibration points on your tabletop representing the lower left corner of your screen, the lower right corner of your screen, and a point somewhere near the top edge of the screen. These points delineate the

mouse working area. If the stylus is outside this working area, the cursor will not appear on the screen. Therefore, it is useful to place something like a Post-It™ note on your tabletop where you want the mouse working area to be. When prompted for the 3 mouse calibration points, digitize for the lower left corner, the lower right corner, and the top edge of the Post-It™ note. Now the Post-It™ note represents your screen, and whenever you place the stylus on the Post-It™ note your mouse cursor will appear in the corresponding position on your screen. Remember the right footpedal serves the same function as the standard mouse button. If you find your initial 2D Mouse calibration makes it difficult to navigate around the screen with the MicroScribe, you can recalibrate at any time with the keyboard shortcut CTRL-4 or from the MicroScribe Settings Dialog Box (CTRL-2).

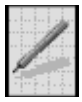


Recommended Setup for Digitizing with MicroScribe in Amapi: Top View

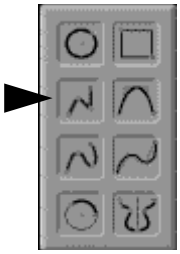
REMEMBER: To set up for digitizing:

Choose Proper MicroScribe Settings
Choose Use MicroScribe (CTRL-3)
Digitize 3D Calibration Points
Digitize 2D Calibration Points (if required)

Digitize A Piece of Paper



Set the Local Origin



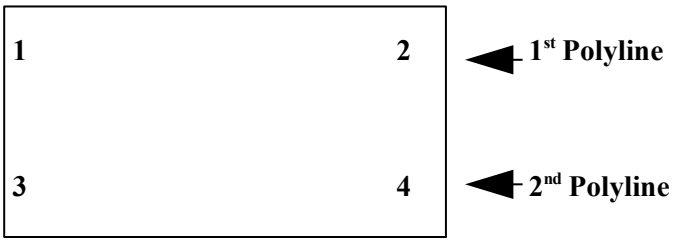
To become familiar with the digitizing tools and learn the basics of digitizing, let's begin with a simple object like a piece of paper. It is critical that you fixture the piece of paper firmly to your work area to prevent it from moving while you are digitizing. Silly Putty™, Handy Tack™, clay, and sometimes tape will work well. The following figure shows 4 points at the corners of the piece of paper. To digitize the paper, select the Drawing Tools icon, then the Polyline icon. If there is nothing else on the screen, the local origin will be set to the center of the workbench. A set of green and red axes indicate where the local origin is. If you have previously constructed objects on the screen already, you can place the local origin with the mouse by clicking exactly where you want it. If you are using MicroScribe Mouse, place the local origin using the MicroScribe and click the right pedal.

Once the origin has been placed, you will see 2 perpendicular yellow lines tracking the MicroScribe stylus endpoint. The current XYZ coordinates of the stylus tip are also displayed in real time in the lower left corner of the screen. These XYZ coordinates are referenced from the local origin you chose.

Create Polylines

To digitize the piece of paper, place the stylus tip on the corner labeled '1' and click on the left pedal. You will see a point appear on the screen. Place the stylus tip on the corner labeled '2' and click on the left pedal. Another point will appear on the screen with a polyline joining points '1' and '2'. Click on the right pedal once to end the polyline.

The polyline tool will remain active and the 2 perpendicular yellow lines should still be tracking the stylus tip. Place the stylus tip at point '3' and click on the left pedal. Do the same for point '4' then click on the right pedal twice. The first click will end the polyline, and the second click will put the polyline tool away. Now put aside the Drawing Tool by moving the mouse cursor to the right side of the screen.



Digitize a piece of paper as 2 polylines with 2 points each

Create a Ruled Surface (Lofting)

Click on the Ruled Surface tool icon. Your cursor will become a crosshair. Click on a point on each of the two polyline segments you digitized and hit Enter. This process, also known as lofting, will create a polygon Ruled Surface delineated by the two polylines. Generally, try to select the points on the ends of the curves and on the same side. Otherwise, your surface may appear twisted like a bowtie instead of flat. If you do get a twisted surface, you can undo the surface using Alt-Z. Hitting Alt-Z once will revert the surface back to the individual polylines. Keep hitting Alt-Z to unselect the endpoints denoted by stars, then hit Alt-T to refresh the screen. Now select a different set of endpoints (e.g., try the points on the opposite end of each polyline) and hit Enter.

Render and View your object

You can use the arrows keys to rotate your view of the object. Holding down the CTRL key with the arrow keys will pan or scroll your view instead of rotating it. Use the '3' and '.' keys on the Number Pad to zoom in and out. Center your object in the middle of the screen and hit Enter to render the object. Now select MicroScribe Camera from the Edit Menu or use the keyboard shortcut Ctrl-1. You should be able to "fly" around your object as you move the stylus. Use the '-' and '+' keys to zoom in and out and change the scaling of the stylus motion. Click on the footpedal to leave MicroScribe Camera Mode. Note: Other operations are disabled when MicroScribe Camera is active.

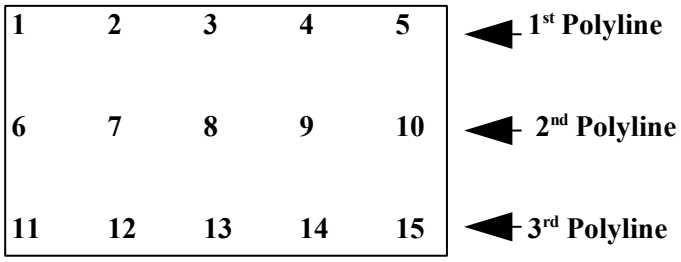
The Smooth Tool

The Ruled Surface you just generated is comprised of only a single polygon. While a single polygon is sufficient to represent a flat piece of paper, you usually will want multiple polygons to accurately represent your object. You can use the Smooth Tool to convert your simple and sparsely digitized model into a much smoother and more detailed surface.

First select the object by clicking on it on the screen. The object should turn light blue, and a small circle should appear at the center of the object to indicate that it is selected. Tap the right side of the screen with the mouse cursor to cycle through the 3 toolboxes until the Modeling Tools come up (there should be a hook, a lightning bolt, and a knife icon). Click on the Smooth Tool. A portion of the selected object will turn red and preview the smoothed model. Use the '+' and '-' keys to increase or decrease the number of polygon subdivisions and the resulting level of smoothness. Hit Alt-Z to undo the smoothing operation. To keep the smoothing, you can either hit the Enter key or put away the Smooth Tool by moving the mouse cursor to the right side of the screen. Hitting Enter will display the entire object in the smoothed wireframe. Putting away the Smooth Tool will keep the model smoothed for rendering and for file export but still display the unsmoothed, original wireframe to speed up redraw time. Try putting the Smooth Tool away. Confirm that the model is smoothed by hitting Enter to render the model. The rendered model should appear smoothed from the original wireframe. The smoothing effect will become very useful later in the tutorial when you digitize curved surfaces.

Create Denser Polylines

An alternative way of creating more polygons is to digitize your model with more points. To create more polygons in the piece of paper, you can digitize several points per polyline and more than two polylines. Hit Backspace to delete your current model. Using the same procedure you used earlier, digitize 3 polylines with 5 points each as shown in the figure below.



Digitize a piece of paper as 3 polylines with 5 points each

Use the Ruled Surface tool to loft the polylines and create a surface made up of multiple polygons.

AutoPlot your Polylines

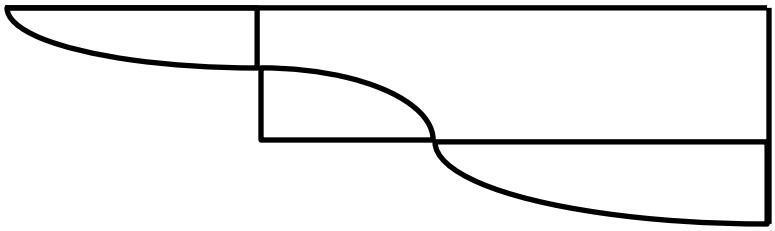
Instead of clicking on the footpedal each time you want to digitize a point, you can use AutoPlot to automate the process. Hit Backspace to delete your current model. Hit CTRL-2 to bring up the MicroScribe Settings Menu. Check the AutoPlot checkbox, and enter an AutoPlot Distance in the dialog box. Try using 2.0 (assuming units are set to numeric inches). Now when you go to digitize point '1', keep the left footpedal held down and trace the stylus through points '2' through '5'. Amapi should automatically digitize a point every 2.0 inches until you let the left footpedal up. If you let the left footpedal up, you can click on the right footpedal to end the current polyline or depress the left footpedal down again to continue the current polyline where you left off.

Lesson 2 Summary

You have learned how to use the Drawing Tools to create polylines and how to create Ruled Surfaces from those polylines. This lesson also taught you how to render your object and change your view either with the keyboard or with the MicroScribe. You have learned how to use a few, sparse digitized points and the Smooth Tool to create a smooth and detailed model. Finally, you learned how to use the AutoPlot feature to help automate the digitizing procedure. These basic digitizing functions will allow you to very quickly digitize any kind of object. The next lessons will introduce some advanced digitizing functions that give more precise control over how the pieces of your wireframe model will look and stitch together. It is important that you feel very comfortable with Lesson 2 before you move on, as the following lessons will build on this knowledge. Repeat Lesson 2 until you can quickly recognize the tool icons and recall the commands used in this lesson.

Lesson 3: Digitizing Simple Meshes

Now that you have learned some digitizing basics, it's time to digitize an actual object - the wing of a space shuttle. If you have a model jet airplane, that will do. Otherwise, cut out a piece of cardboard or mold a piece of clay roughly in the shape shown below. Fixture your wing firmly so that it will not move when you are digitizing.



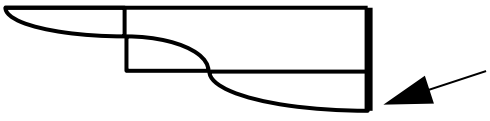
In this lesson, you will use several different techniques to digitize the wing. This is one of the strengths of Amapi: there is almost always more than one way to digitize something. Choosing the most appropriate way is a key to using Amapi effectively. By digitizing the wing several different ways, you should start to get a sense of the different approaches to a particular digitizing task and which of them will work best.

This lesson will cover:

- Creating a Ruled Surface
- Creating a Surface with Boundary Curves
- Extracting Boundary Curves

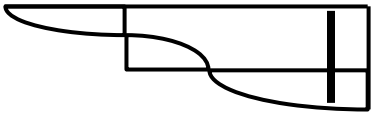
Creating a Ruled Surface

The first approach to digitizing the wing will be to use the Ruled Surface technique that you have already learned. After selecting the Polyline tool and setting the local origin, place the stylus at the rear corner of the wing. Trace the stylus along the back edge of the wing and

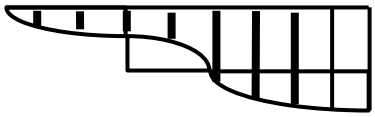


digitize a point roughly every 0.25" until you reach the inside corner of the wing. You can either depress the left footpedal once for each point, or you can use the AutoPlot feature described in Lesson 2. If you make a mistake, you can repeatedly undo the last digitized point with Alt-Z. To finish the polyline, depress the right footpedal.

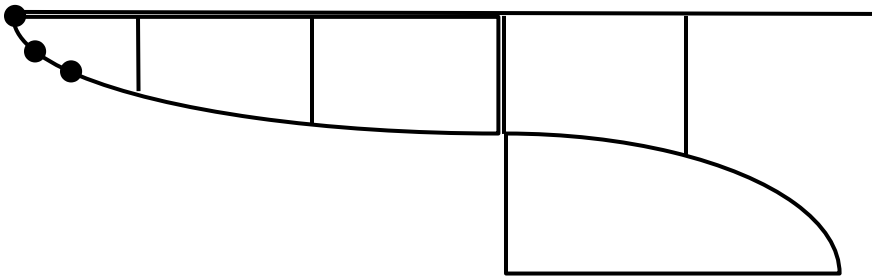
Now digitize another polyline from the outer edge to the inner edge of the wing about 0.5” over from the previous polyline. Try to space the points roughly 0.25” apart.

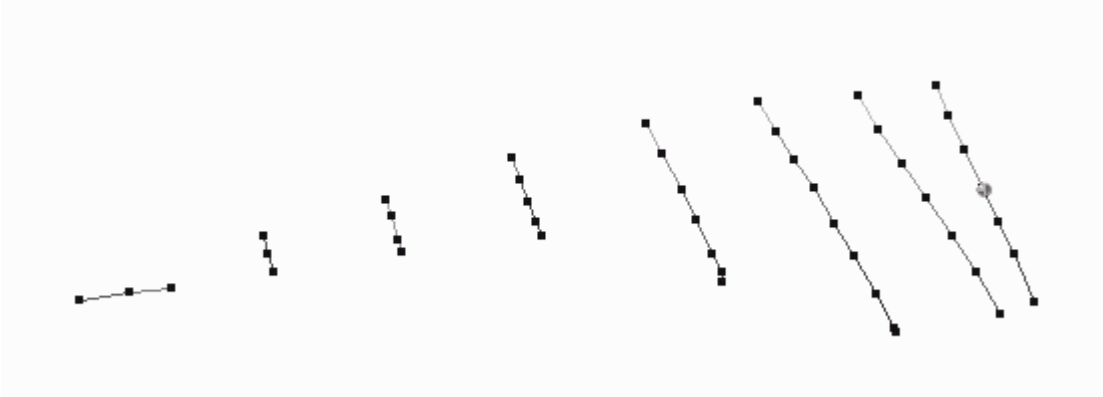


Continue digitizing additional polylines from the outer edge to the inner edge of the wing. Try to space the polylines about 0.5” apart.

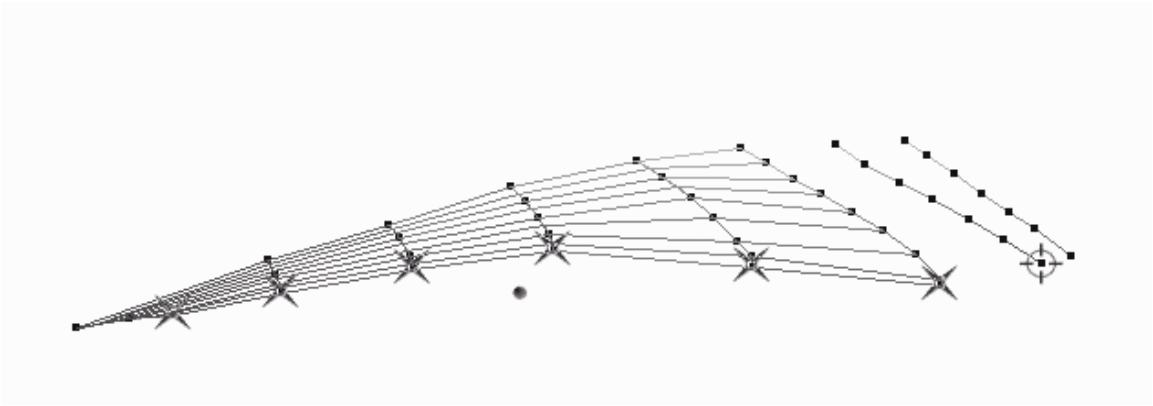


The front tip of the wing comes to a sharp point, but you need at least two points to create a polyline. Therefore, digitize the last polyline with a two or three points along the leading edge of the wing instead of parallel to the other polylines.





Your wing should look roughly like the figure above. Get the Ruled Surface Tool and click on an endpoint of each polyline to create a polygon mesh. Since the polyline on the front tip is not parallel with its adjacent polyline, you might get a bowtie effect with the surface twisted. Generally, the bowtie effect only happens you have if a polyline suddenly changes direction significantly from the preceding polylines. If this happens, try connecting the opposite endpoints of each polyline or change the direction you are going with the Ruled Surface Tool (e.g., left to right instead of right to left). In this example, since the polyline on the front tip of the wing changes direction significantly, starting with the Ruled Surface Tool on the left side will prevent the surface from twisting.

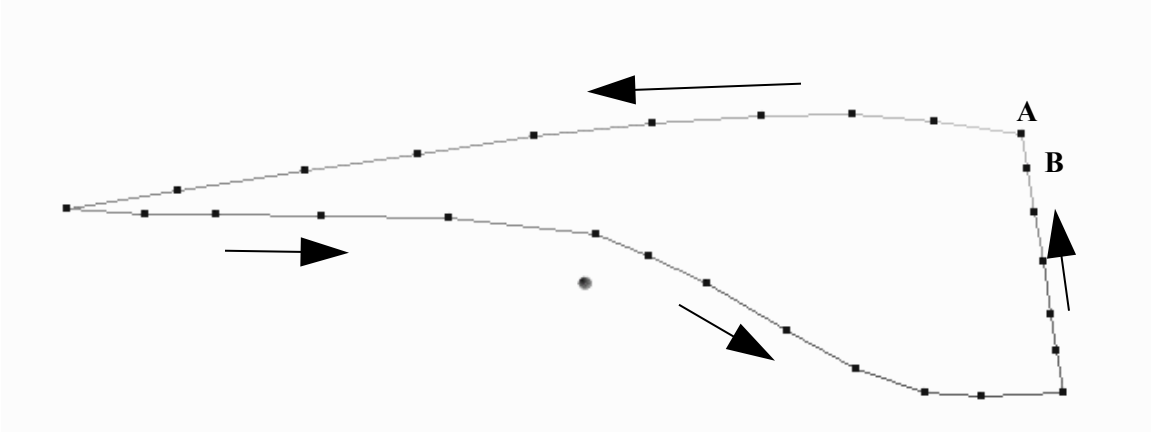


After selecting the endpoint of the last polyline with the Ruled Surface Tool crosshair, put the tool aside by moving the mouse to the right side of the screen. You can hit Enter to render the wing, or change your view either with the keyboard or the MicroScribe. Try using the Smooth Tool to create a smoother, more realistic wing mesh.

Creating a Surface with Boundary Curves

An alternative way of creating surfaces is to digitize only the boundary curves of a section and let Amapi fill in the intermediate curves and mesh for you. There are two tools that will perform this filling in function for you. One is the Hull Surface Tool, which requires four boundary curves and is ideal for rectangular shaped sections. The other is the Sweep Tool, which requires three boundary curves and is ideal for triangular shaped sections. Both will be used to construct the wing.

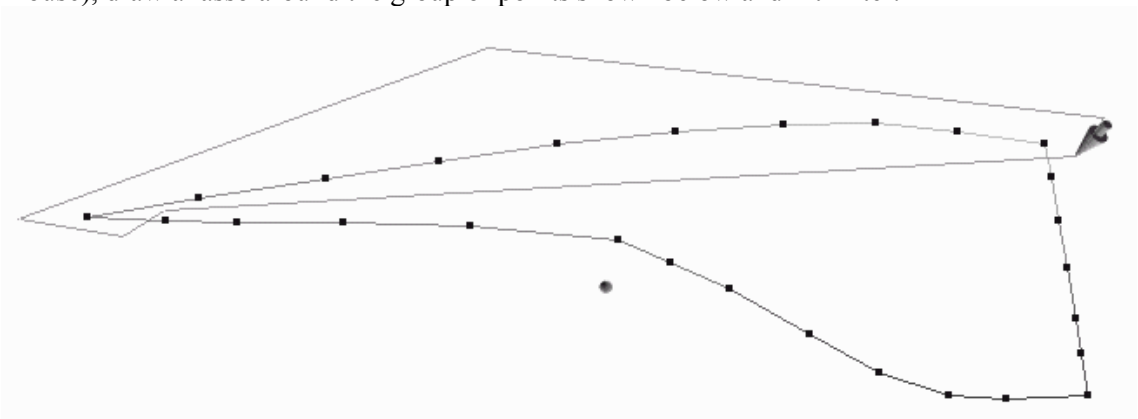
First digitize the outer boundary of the wing to define its shape. Make sure it a closed curve by digitizing the last point so that it coincides with the first point. In this example, digitize the point labeled 'A' first, followed by the points in the direction shown. After digitizing the point labeled 'B', hold the Shift key down. Your stylus coordinates will then "snap" to the nearest point already digitized. Put the stylus tip on point 'A' with Shift key held down and click the left footpedal. This will force your last point to be digitized coincident with the first point at 'A'.



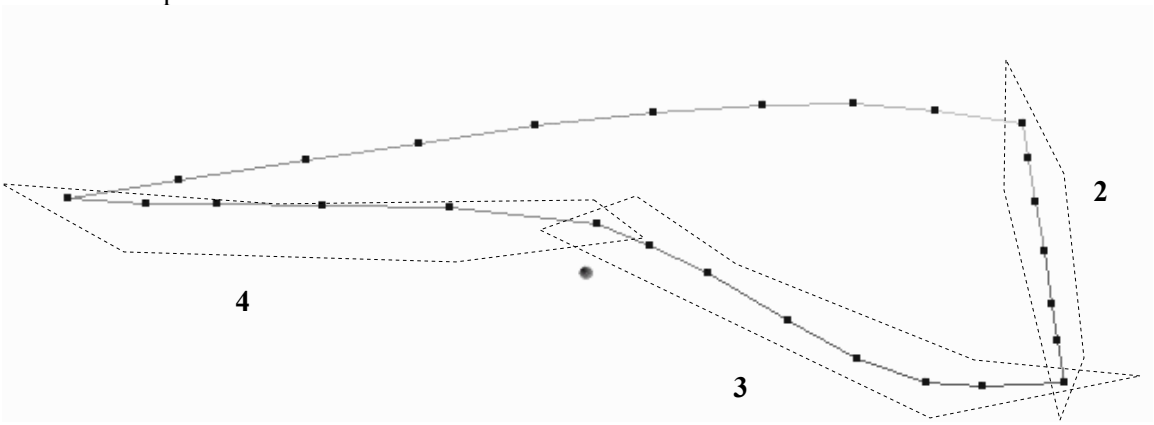
Remember: Holding the Shift key down will cause the digitized point to Snap to the nearest existing point (SGI version must use Stretch Tool - see Lesson 4)

Curve Extraction and Creating Hull Surfaces

Choose the Curve Extraction Tool from the Construction Toolbox. The default cursor is the Lasso Tool. By clicking on the mouse button (or the right footpedal if you are using MicroScribe Mouse), draw a lasso around the group of points shown below and hit Enter.



This will extract the surrounded points and make them into a curve shown in light blue. Extract the curves labeled ‘2’ and ‘3’ in the same manner. Make sure that the extracted curves overlap and share endpoints as shown.




The lasso tool will only extract a curve from a single existing curve. Another tool called the crosshair tool allows you to select points individually from multiple existing curves. For example, if we also had a sphere next to the wing, the crosshair tool would allow you to select points from both the wing and the sphere to create a new curve. Since the points making up curve labeled ‘4’ are all part of the wing curve, you could use the lasso tool to extract curve ‘4’ like you extracted curves ‘1’,‘2’, and ‘3’. However, we will learn to use the crosshair tool here instead.

> To use the crosshair tool, you will need to use the standard mouse. If you are using MicroScribe Mouse, hit CTRL-5 to turn it off and switch back to the standard mouse. Hitting CTRL-5 again will turn MicroScribe Mouse back on.

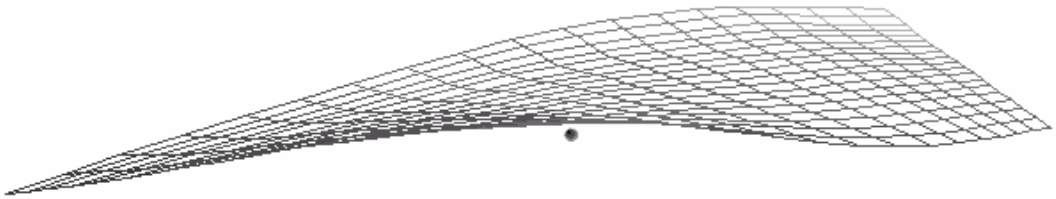
Click on the Curve Extract icon. The cursor should be the lasso tool. Click the right mouse button to change it to the crosshair tool. On a Macintosh, hold the Option key down and click the mouse button to change to the crosshair tool. Click on the points making up the curve labeled ‘4’ and hit Enter to extract the curve.

> REMEMBER: When extracting curves:
>
> The lasso tool will only select part of a single existing curve
>
> The crosshair tool can select points from multiple existing curves

You should now have 5 curves in your model: The original closed curve of the wing perimeter and 4 extracted curves. The original closed curve is probably hidden beneath the 4 extracted

curves. You can cycle among the 5 curves by hitting '+' or '-'. The selected curve will be light blue and have a small shaded sphere next to it. Cycle through the curves until the original closed curve is highlighted. Hit Backspace to delete it.

You should be left with the 4 extracted boundary curves. Click on the Hull Surface icon and hit the spacebar (this indicates you are creating a surface from four 3D curves). The icon in the upper left corner of the screen should change to the 4-cornered bowl. Click on the 4 boundary curves, and a mesh will be generated automatically. Experiment with the Smooth Tool to smooth the wing mesh. Remember you can Undo your changes. The figure below shows a smoothed Hull Surface mesh generated from the 4 boundary curves.



REMEMBER: When using the Hull Surface Tool with 4 boundary curves:

Hit the spacebar after selecting Hull Surface Tool

Use Curve Extraction to make Boundary Curves

Boundary Curves must share endpoints

Use the '+' and '-' keys to select different curves

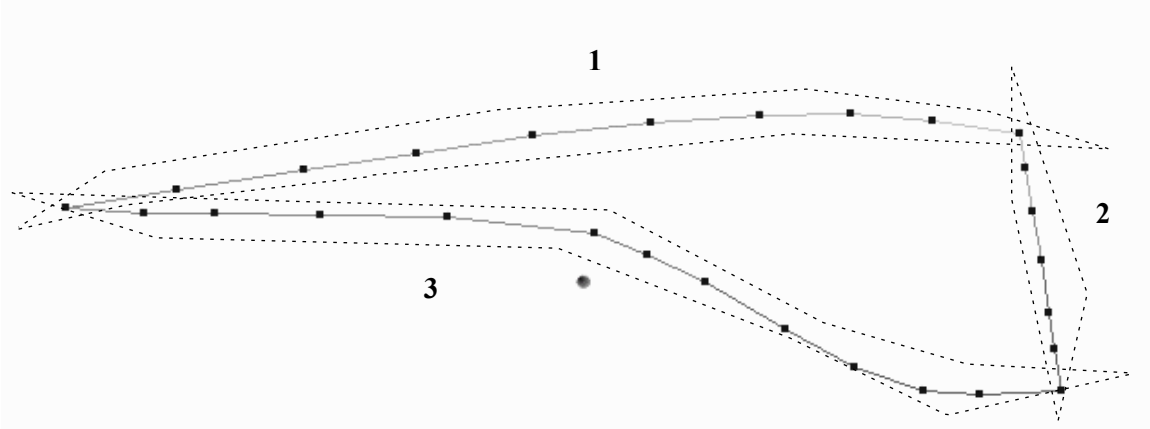
Undo operations with Alt-Z (or Cmd-Z on a Mac)

Showing and Hiding Objects

After creating the mesh, the boundary curves become hidden. To view them, you must select the Show Tool. Move the mouse to the bottom of the screen to bring up the Utilities Toolbox, and click on the Show Tool (the white ghost icon). The screen now displays all objects that are hidden from view, including the boundary curves of the wing. Click on a couple curves then put the Show Tool away by moving the mouse to the right side of the screen. The selected curves should now be visible. You can also hide objects with the Hide Tool (the gray ghost icon) in the Utilities Toolbox.

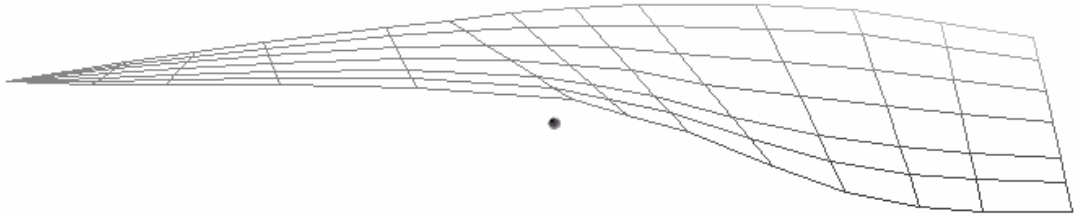
Creating Sweep Surfaces

Now we will create the wing mesh yet one more way using the Sweep Tool. First digitize the closed outer boundary curve of the wing as you did above. Extract the 3 boundary curves shown below with the Curve Extraction Tool.

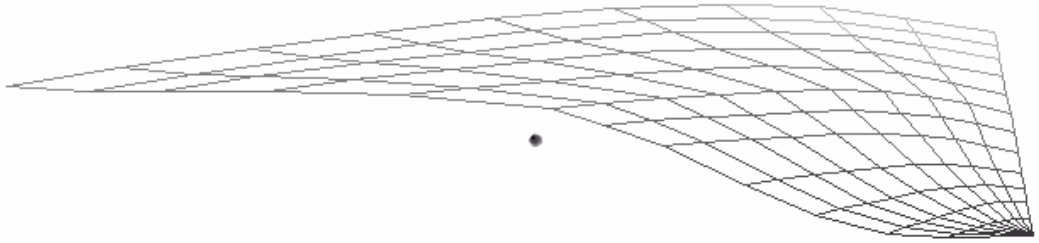


To use the Sweep Tool, you must first group 2 of the 3 boundary curves. Move the mouse to the bottom of the screen to bring up the Utilities Toolbox, and click on the Group Tool (the chain link icon). Click on curves '1' and '3' then put the Group Tool away.

Click on the curve '2' to select it. It should turn light blue and have a small shaded sphere next to it. Now click on the Sweep Tool, and then click the grouped curves. A mesh will automatically be generated like the one shown below.



Notice that the meshlines converge to the shared endpoint of the 2 grouped curves. Grouping 2 different curves will result in a different looking mesh like the one shown below.



REMEMBER: When using the Sweep Tool with 3 boundary curves:

Use Curve Extraction to make Boundary Curves

Use the '+' and '-' keys to select different curves

Boundary Curves must share endpoints

Undo operations with Alt-Z (or Cmd-Z on a Mac)

Group 2 of the curves and then select the 3rd curve before selecting the Sweep Tool

Grouping different curves changes the resulting mesh

Lesson 3 Summary

You have learned how to digitize meshes three different ways. The quickest way is to create a Ruled Surfaces from digitized curves. Sometimes, you can achieve better meshes using digitized boundary curves to create Hull Surfaces and Sweep Surfaces. Generally, the Hull Surface Tool is better for roughly rectangular patches since it requires 4 boundary curves, and the Sweep Tool is better for roughly triangular patches since it requires 3 boundary curves. You have also learned to use the Hide/Show Tool, the Group Tool, and the Curve Extract Tool to help you create the proper boundary curves.

While some objects turn out equally well using any of the three digitizing methods presented, you will inevitably run into an object or part of an object that really works best with only one of the three. Therefore, it is important that you understand and feel comfortable with all the Tools covered in this lesson.

Lesson 4: Digitizing Advanced and Multiple Meshes

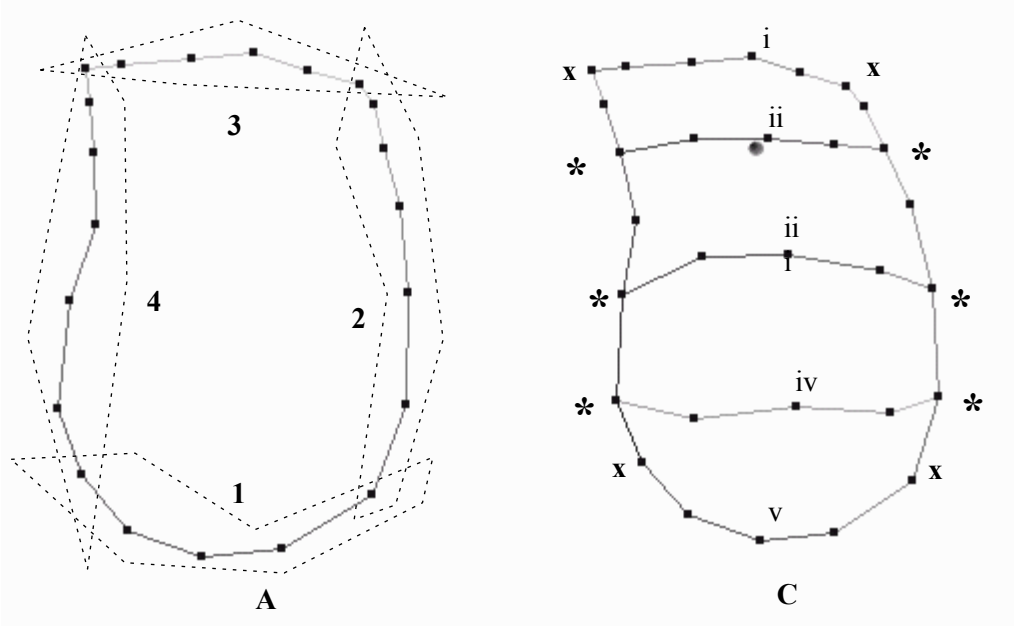
Lesson 3 covered three different methods of digitizing a mesh. The functionality of one of the methods, the Hull Surface Tool, can be greatly extended by adding contour curves. Also, once you have digitized several sections of your model, you will need to connect these meshes together. Lesson 4 will demonstrate these functions by digitizing a computer mouse.

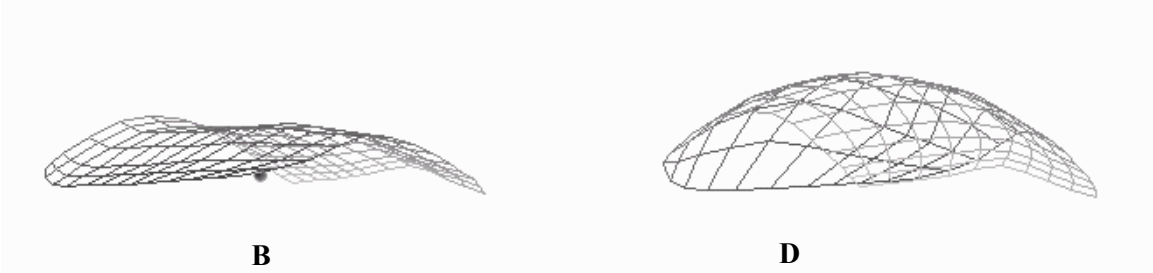
This lesson will cover:

- Creating a Gourand Surface using the Hull Surface Tool and Contour Curves
- Stitching adjacent meshes together
- Sharing Boundary Curves

Hull Surface Tool and Contour Lines

As mentioned earlier, generally the Hull Surface Tool is better for roughly rectangular patches since it requires 4 boundary curves, and the Sweep Tool is better for roughly triangular patches since it requires 3 boundary curves. The Hull Surface Tool also has the advantage of allowing contour lines within the 4 boundary curves. Contour lines are useful when just tracing the outer boundary curves of a section does not adequately capture the interior of the surface.





As an example, we will digitize the surface of a computer mouse. Using the same method we used for the space shuttle wing in Lesson 3, we digitized the outer boundary of the mouse and extracted the 4 curves shown in the figure A. With just those 4 boundary curves, the Hull Surface Tool created the mesh shown in figure B. You can see from figure B that the mesh is fairly flat; however, the actual mouse has a raised, rounded surface. The 4 boundary curves could not capture this geometry.

To get this added geometry, we digitized 3 intermediate contour lines shown in figure C. The endpoints of the contour lines marked with asterisks '*' were Snapped to boundary curves '2' and '4'. Endpoints of the contour lines must be Snapped to points on opposite boundary curves (e.g. curves '1' and '3', or curves '2' and '4'). Also, the Snapped points must not be endpoints of the boundary curves (e.g., points marked 'x'). You can Snap the contour line endpoints when you digitize them by holding the Shift key down at the same time you click on the footpedal. You can also Snap these endpoints with the Stretch Tool after you digitize the entire contour curve. To Snap points using the Stretch Tool, click on the curve with the point you wish to Snap. The selected curve should turn light blue and have a shaded sphere next to it. Click on the Stretch Tool icon, and click on the point you wish to Snap. Now you can relocate that point with the mouse. If you hold the Shift key down, the point will Snap to the nearest existing point. Click the mouse button when you have placed the point where you want it.

You can have contour curves connecting both sets of boundary curves. For instance, in figure C, an additional contour curve connecting boundary curves '1' and '3' could have been made using the points labeled Roman numeral 'i' though 'v'. In this example, this additional set of contour curves was omitted.

After the contour curves were digitized, we used the Hull Surface Tool again, but this time included the interior contour curves. This type of surface is called a Gourand Surface. After selecting the Hull Surface Tool and hitting the spacebar, we clicked on boundary curve '1', the 3 contour curves, and finally boundary curve '3'. This set of roughly parallel curves turned white to indicate they were selected, then we hit Enter. Next, we clicked on the other set of parallel curves, boundary curves '2' and '4', and hit Enter. Amapi generated the mesh shown in figure D. Since the mesh goes through the contour lines, you can clearly see that it more accurately represents the mouse than the mesh in figure C.

REMEMBER: When using the Hull Surface Tool with interior contour curves:

Contour curves must Snap to opposite boundary curves

Contour curves must not Snap to boundary curve endpoints

You can have a two sets of contour curves for both pairs of opposite boundary curves

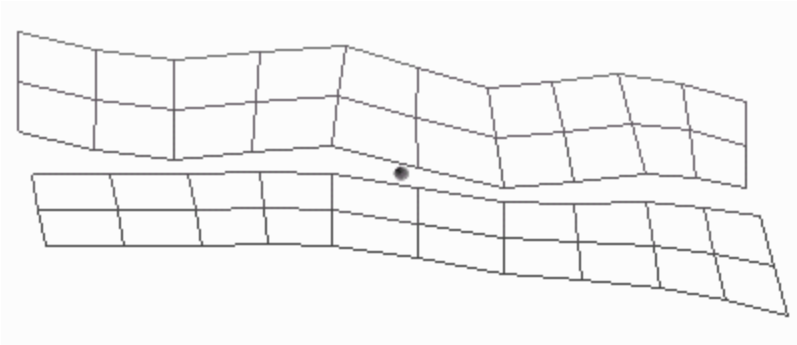
Hit Enter after selecting each set of parallel curves

Connecting Adjacent Meshes

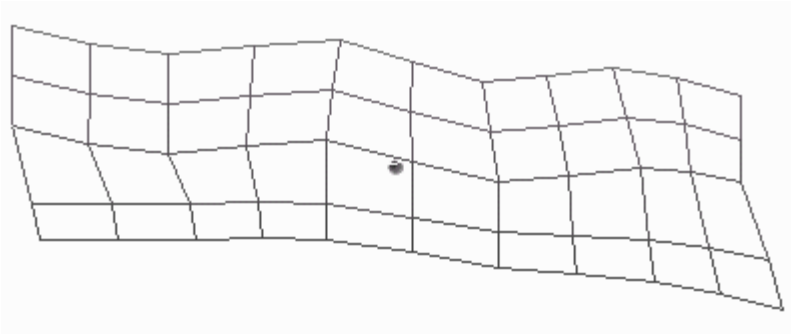
You have learned how to digitize a section of a model several different ways. You can use these methods to digitize adjacent sections of the model, but you must also connect these meshes together. Connecting meshes generally requires careful planning. It helps to have similar point counts in the mesh edges you are connecting so that the finished seam will look smooth.

Using the Stretch Tool

If the two meshes you wish to connect are separated by a small gap, the easiest and quickest way to connect them is with the Stretch Tool.

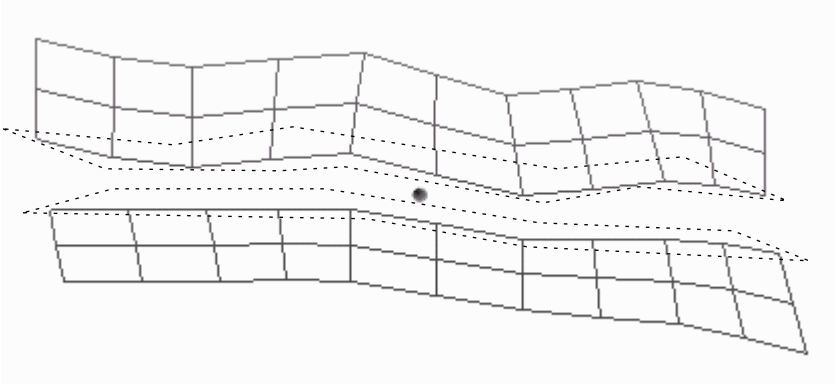


Grab each point on the border of one of the meshes and Snap it to the corresponding point on the border of the other mesh by holding the Shift key down.

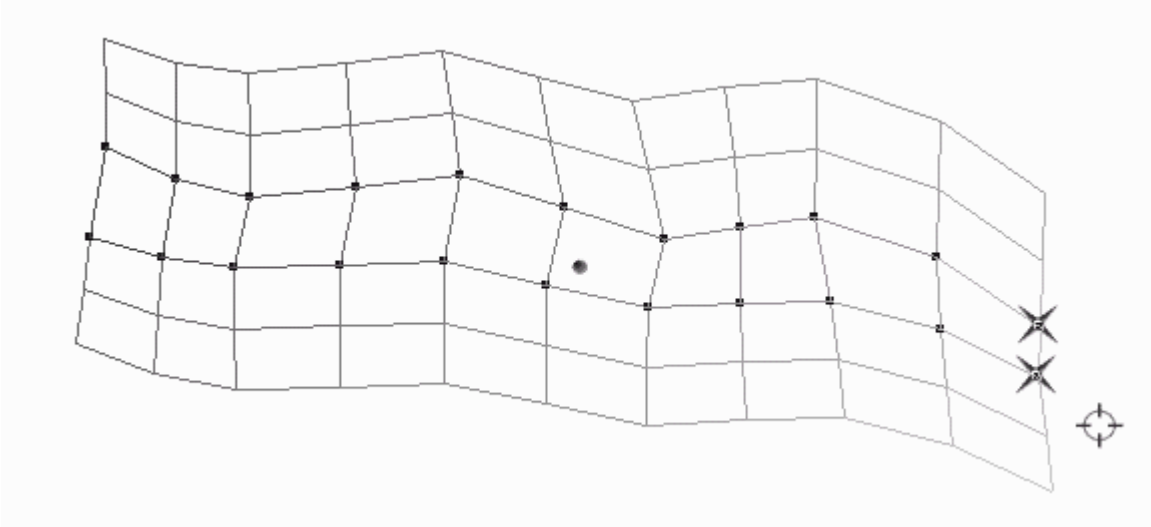


Filling Gaps with Polygons

If the two meshes you wish to connect are separated by a larger gap, you can fill in the gap with a row of polygons. First extract the borders of the two meshes.

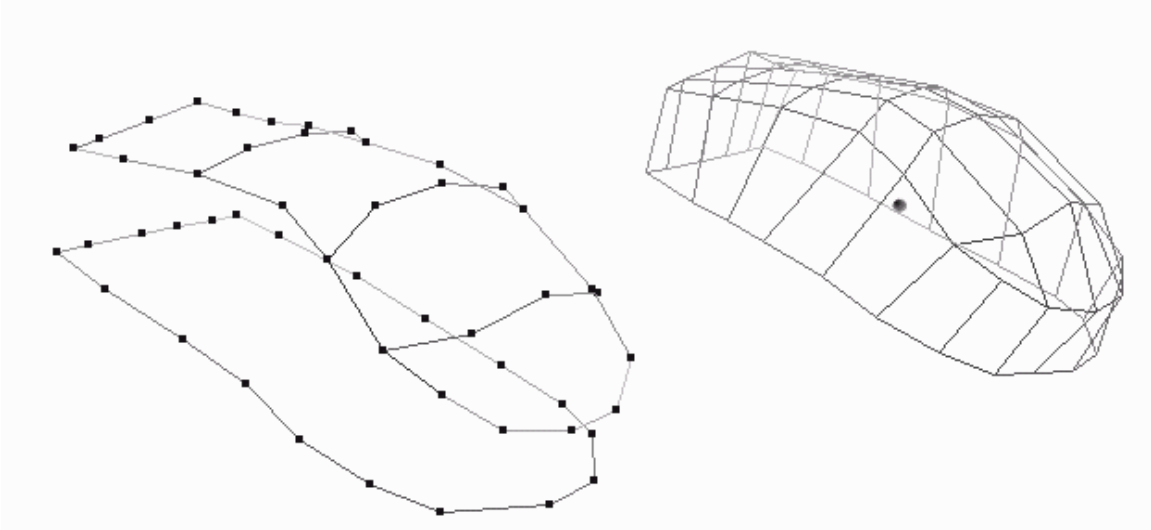


Next, use the Ruled Surface Tool to create a row of polygons between the extracted curves.



Sharing Boundary Curves

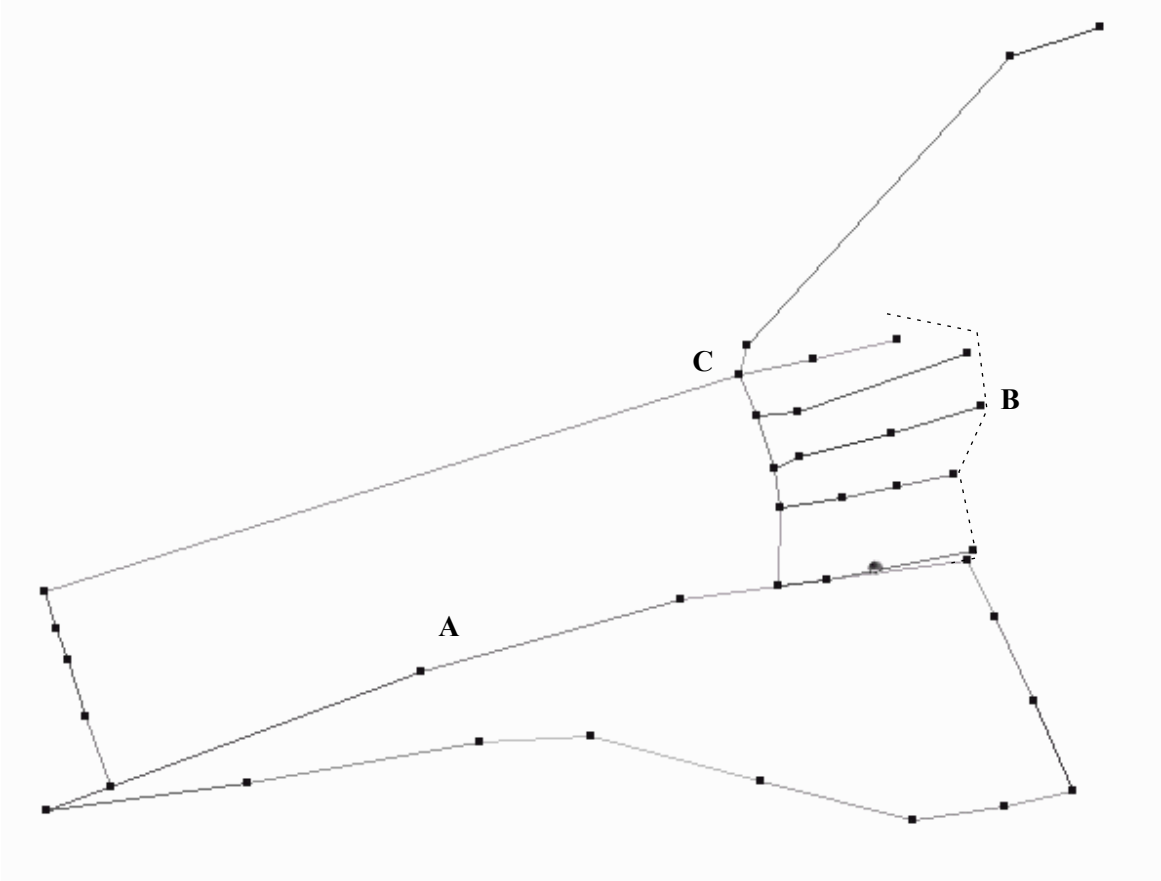
The final method for connecting meshes involves slightly more planning than the Stretch Tool and Filler Polygon methods. However, this method often results in the most accurate models. The key is for one or more adjacent meshes to share boundary curves. In the case of the digitized computer mouse, we can create the sides of the mouse with a Ruled Surface between the outer boundary of the mouse we digitized earlier and another closed curve representing the bottom of the mouse.



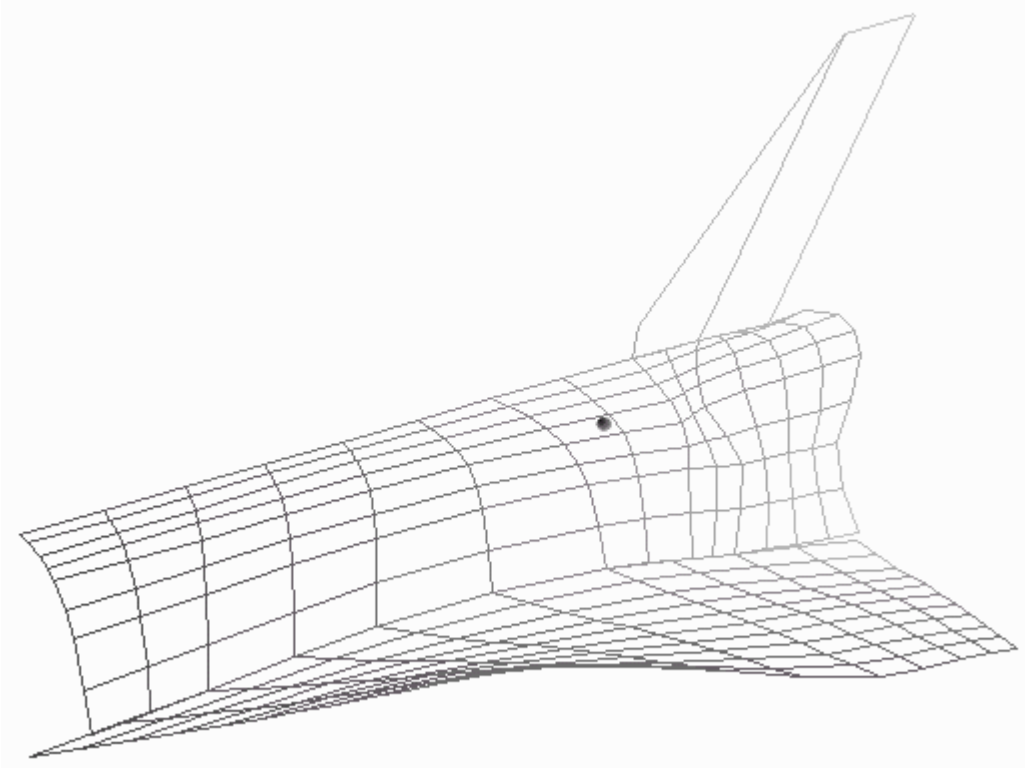
Since we used the outer boundary of the mouse both as one of the ends of the Ruled Surface representing the side of the mouse and as the boundary curves for the Gourand Surface on top, the resulting wireframe model has no gaps between the sections. The seam between the top and the sides of the mouse is smooth and continuous.

Examples: A Space Shuttle, a Cat, and a Human Face

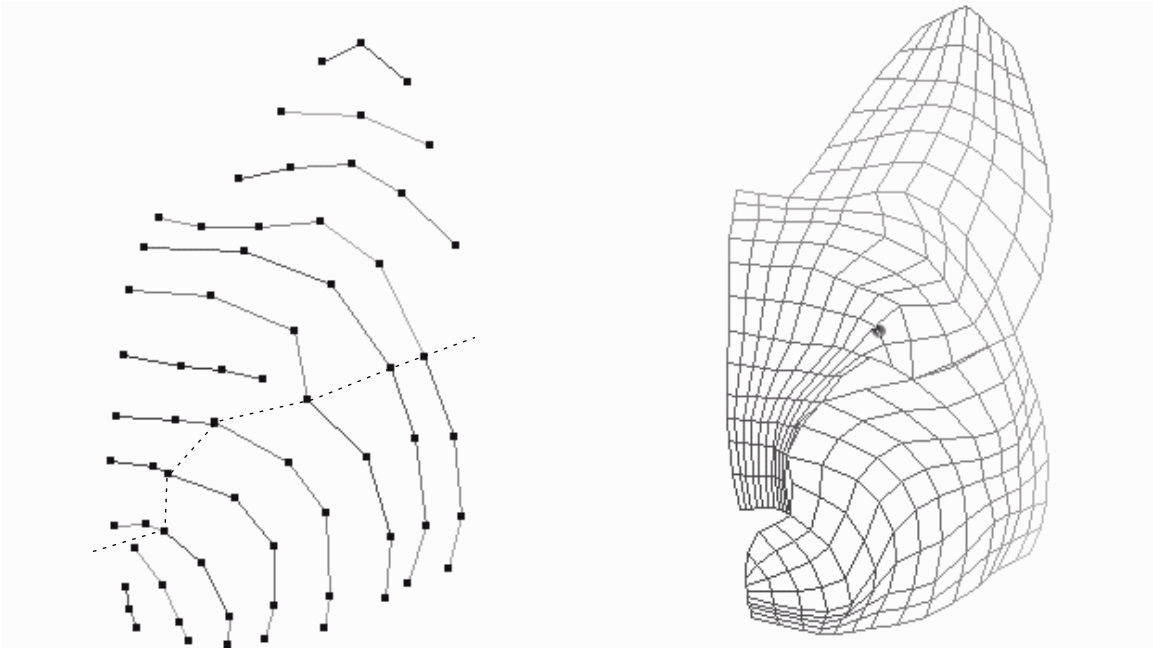
The figure below shows the space shuttle digitized using several of the methods you have learned so far. After digitizing the wing, the cargo bay was digitized as a Hull Surface with 4 boundary curves. The cargo bay boundary curve labeled 'A' was extracted from the wing boundary curve to get a smooth seam between the two sections. The rear section including the engine is a Ruled Surface made from the 5 digitized curves labeled 'B'. When the 5 curves were digitized, the leftmost point was Snapped to the rear of the cargo bay by holding the Shift key down when the point was taken. Snapping these points provided a smooth, gapless seam between the cargo bay and the rear section. The tailfin was created as a Ruled Surface using just 2 curves. The 1st curve just reused the 5th and topmost curve from the rear section. The 2nd curve was digitized by Snapping the first point labeled 'C' to the rear corner of the cargo bay and then taking a 3 more points following the upper edge of the tailfin.



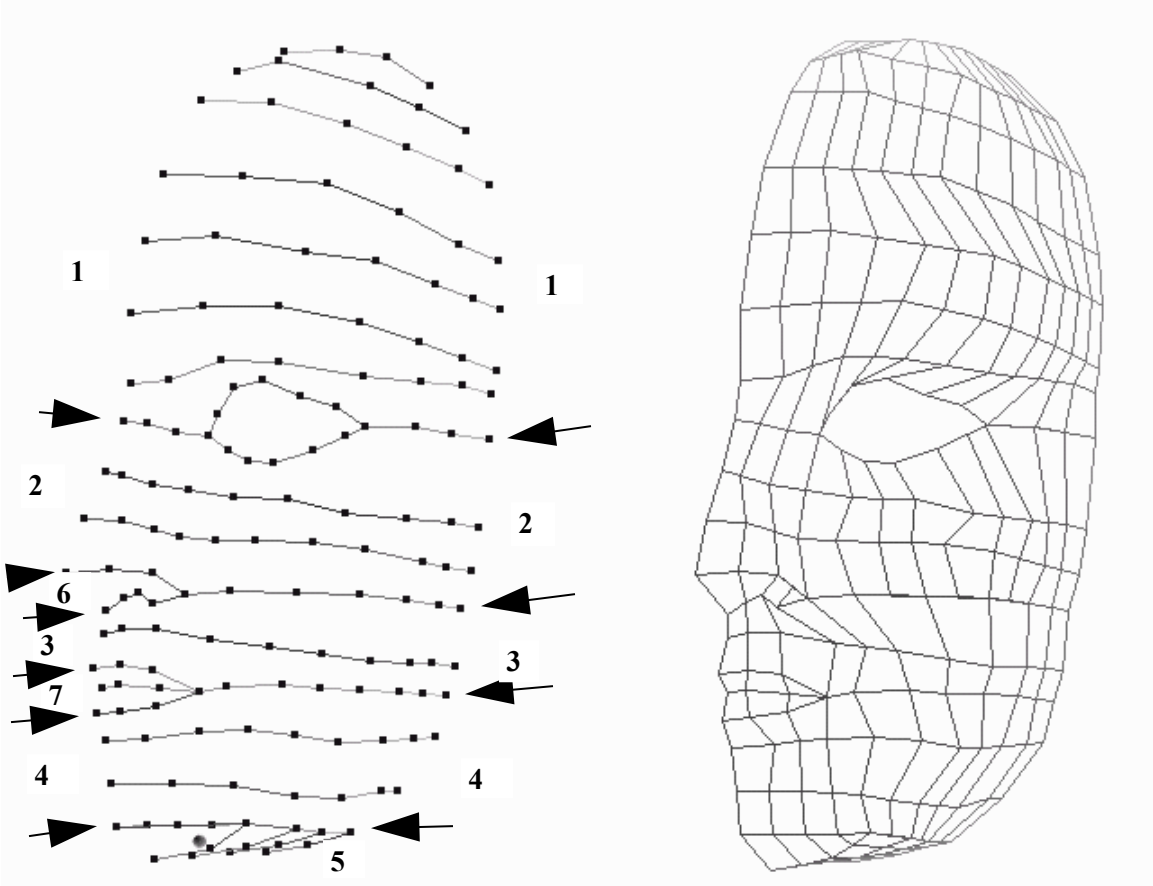
Notice that the model was digitized with a relatively sparse number of points. Even with the low number of points, you can get a very detailed model in Amapi using the Smooth Tool. The separate meshes were Smoothed and Grouped together, resulting in the wireframe model shown below.



The left side of the figure below shows the lines digitized to create the wireframe model of the cat shown on the right. The Ruled Surface Tool was used to create 3 meshes: one for the ear, and two for the face. The two face meshes are separated by the dotted line and shared the points along the dotted line using the Snap feature. The ear mesh extracted part of the face mesh for the bottom-most line. The two face meshes were joined together into a single mesh using the Weld tool, then the whole model was Smoothed.



The left side of the figure below shows the lines digitized to create the wireframe model of the face shown on the right. The Ruled Surface Tool was used to create 7 meshes. The different meshes are numbered, and arrows mark the borders between meshes. The eye was made by leaving a hole between meshes '1' and '2'. The lower boundary curve of mesh '1' was digitized with 4 points from the nose to the eye, 5 points along the top of the eye, then 4 points from the eye to the side of the head. To make sure meshes '1' and '2' joined smoothly and created the eye, the upper boundary curve of mesh '2' was digitized with 4 Snapped points on the mesh '1' boundary from the nose to the eye, 5 points along the bottom of the eye, then 4 more Snapped points on the mesh '1' boundary from the eye to the side of the head. The lower boundary curve of mesh '2' was digitized with 4 points down the nose and then 6 points from the nose to the side of the head. To make sure meshes '2' and '3' joined smoothly, the upper boundary curve of mesh '3' was digitized with 4 points under of the nose and then 7 Snapped points on the mesh '2' boundary from the nose to the side of the head. The leftmost 4 points of the lower boundary of mesh '2' and the leftmost 5 points of the upper boundary of mesh '3' were extracted and used to create a Ruled Surface representing the underside of the nose (mesh '6'). The mouth and lips (mesh '7') were constructed in a similar fashion using the boundaries of meshes '3' and '4'. All 7 meshes were joined together into a single mesh using the Weld tool.



REMEMBER: When digitizing complex meshes and connecting them together:

Use the Shift key to Snap digitized points to existing points

Sometimes you will need to create curves from a combination of extracted or Snapped points and newly digitized points

Use the Weld Tool to join several meshes into a single mesh

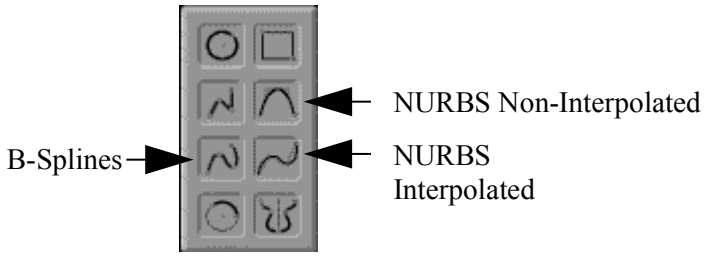
Use the Group Tool to join several meshes into a single group of several meshes

Lesson 4 Summary

You have learned how to use the Hull Surface Tool with interior contour curves to create Gourand Surfaces that better represent complex surfaces. You have also learned to join adjacent meshes together by stitching them together, filling in the gaps with a row of polygons, and sharing boundary curves. Finally, through some examples, you have learned how to best use the Snap feature and Curve Extraction.

Lesson 5: B-Splines and NURBS

Lessons 1 through 4 showed you how to create polygon meshes using polylines. You can just as easily create B-Splines and NURBS curves by simply choosing those tools instead of Polylines from the Drawing Tools.



B-Splines

B-Splines are similar to Polylines except that they fit intermediate points between your digitized points to create a smoother curve. Therefore, B-Splines are sometimes better suited for digitizing very organic and curvy surfaces. If you are using B-Splines, you can use the '+' and '-' keys to increase and decrease the smoothness of each curve after you digitize it. If you use B-Splines with the Ruled Surface Tool, the Hull Surface tool, or the Sweep Tool, you will still get a polygon mesh. Note that the same level of mesh smoothness can be achieved using digitized Polylines and the Smoothing Tool to smooth the polygon mesh.

NURBS

There are two choices for NURBS curves: Non-Interpolated and Interpolated. A Non-Interpolated NURBS curve is a best fit of the digitized points that may not pass exactly through all the points. An Interpolated NURBS curve both fits and is forced to pass exactly through all the digitized points. If you are using NURBS curves with the Ruled Surface Tool, the Hull Surface tool, or the Sweep Tool, you will get a NURBS mesh instead of a polygon mesh. However, if you are using the Hull Surface Tool with interior contour curves (Gourand Surface), you will only get a polygon mesh, even if your boundary and contour curves are NURBS curves. Refer to the Amapi Manual for more information about using NURBS in Amapi.

The Smooth Tool

The Smooth Tool behaves on B-Splines exactly the way it does for Polylines. You can increase the number of points on a B-Spline curve or increase the number of polygons in a mesh created from B-Splines. On NURBS curves or NURBS meshes, the Smooth Tool brings up the current U and V Range values in the lower left hand corner of the screen for the selected object. You can increase or decrease the point density of a NURBS curve or the mesh density of a NURBS mesh by changing these U and V values.

Quick Digitizing Overview

This section is a brief summary of the basic digitizing methods presented in the previous lessons. It does not cover many of the nuances of digitizing taught in the lessons and only serves as a quick reference.

Creating A Polygon Model From Digitized Polylines

1. Make sure MicroScribe has been enabled using either the Use MicroScribe command or the keyboard shortcut CTRL-3. A checkmark next to the Use MicroScribe command indicates that the MicroScribe has been enabled. Remember: If you are using MicroScribe Mouse, use the stylus to move the screen cursor and the right footpedal to perform mouse clicks.
2. Click on the 2D Drawing Tools icon in the Construction Toolbox. While normally only for 2D shapes, the 2D Drawing Tools allows construction of 3D shapes if used with the MicroScribe.
3. If a the 2D Drawing Tools palette does not appear, you must first choose a reference point. This reference point servers as a local origin. Any point on the physical object serves as a good reference point. Position the MicroScribe stylus where you want the reference point and depress the right footpedal.
4. Click on the Polyline icon in the 2D Drawing Tools palette
5. Place the MicroScribe stylus on the object where you want your first Polyline to begin and depress the ***left*** footpedal. If you have AutoPlot on, keep the left footpedal held down, drag the stylus over the object to where you want the Polyline to end, and release the footpedal. If you do not have AutoPlot on, you must position the stylus and click the left footpedal wherever you want a digitized point.
6. If you want to put away the Polyline tool, click the ***right*** footpedal ***twice***. If you want to end the current Polyline and begin another one, click on the ***right*** footpedal ***once***. You can now begin the next Polyline by repeating step 5.
7. To create a polygon surface patch from the digitized Polylines, click on the Ruled Surface icon from the Construction Toolbox. Click on the endpoint of each of the digitized Polylines.
8. You can use the Smoothing Tool to create a finer mesh from the surface patch created in step 7.

Creating Spline and NURBS Models From Digitized Curves

For B-Spline and NURBS models, the procedure is the same as for Polygon models except that you click on the B-Spline, NURBS, or NURBS Interpolated icon instead of the Polyline icon in step 4. If you are using B-Splines, you can use the '+' and '-' keys to increase and decrease the number of points in each curve after you digitize it. If you are using NURBS curves, the Ruled Surface tool will create a NURBS surface patch instead of a polygon surface patch.

Creating Patches From 4 Digitized Boundary Curves

You can also use 4 digitized boundary curves and the Hull Surface tool instead of the Ruled Surface tool to create surface patches.

1. Digitize 4 boundary curves for the surface you would like to patch. The endpoints of each of the 4 curves must coincide with an endpoint of one of the other 3 curves so that together, the 4 curves form a closed curve outlining the surface. You can use the Stretch tool with the Shift key to Snap the endpoints together after you have digitized the 4 curves (Do not use the Snap tool to join the endpoints, as this will displace the entire curve instead of just the endpoint). Alternatively, you can use the Snap function when digitizing the endpoints of the curves by holding down the Shift key. This action will cause the cursor to snap to the closest existing point in the model. Make sure the cursor is snapped to the endpoint of one of the other curves, then click the left footpedal. A new curve will begin exactly where the previous curve ended, even if your hand placement of the stylus is slightly off.
2. Click on the Hull Surface tool and hit the spacebar to indicate you are using 4 curves to create the surface.
3. Use the mouse cursor to select the 4 curves. A patch will be created.
4. You can use the Smoothing Tool to create a finer mesh from the surface patch created in step 3.

Note: You can use Polylines, B-Splines, or NURBS to create the boundary curves. Like the Ruled Surface tool, the Hull Surface tool will create a polygon patch from Polyline or B-Spline boundary curves and a NURBS patch from NURBS boundary curves.

Creating Patches From Digitized Boundary and Contour Curves

In order to accurately digitize a complex surface using the Hull Surface tool, sometimes it may be necessary to digitize one or more intermediate contour curves inside the 4 boundary curves.

1. First digitize the 4 boundary curves as in step 1 above.
2. Digitize as many contour lines as needed. Each boundary curve has two adjacent boundary curves and one opposite boundary curve. The contour curves should be roughly parallel and span from one boundary curve to the opposite boundary curve. Use the Shift key either with the Stretch tool or when digitizing the contour curves to ensure the contour curve endpoints are connected to the boundary curves (Do not use the Snap tool to join the endpoints, as this will displace the entire curve instead of just the endpoint).
3. Click on the Hull Surface tool and hit the spacebar to indicate you are using 4 or more curves to create the surface
4. Use the mouse cursor to select the 2 opposite boundary curves to which the contour curve endpoints are connected and hit Enter.
5. Use the mouse cursor to select the remaining 2 boundary curves and all the contour curves and hit Enter. A patch will be created.
6. You can use the Smoothing Tool to create a finer mesh from the surface patch created in step 5.

Note: You can use Polylines, B-Splines, or NURBS to create the boundary and contour curves. However, the Hull Surface tool will only create a polygon patch, regardless of what kind of curves were used for the boundary and contour curves.

Creating Patches From 3 Digitized Boundary Curves

You can also use 3 digitized boundary curves and the Sweep tool instead of the Hull Surface tool to create surface patches.

1. First digitize the 3 boundary curves. One curve should be the profile curve that will be swept through the path defined by the other 2 curves. Again, the endpoints of each of the curves must coincide with an endpoint of one of the other curves so that together, the curves form a closed curve outlining the surface.
2. Group the two curves that define the path together.
3. Click on the profile curve to select it.
4. Click on the Sweep tool.
5. Click on the path curves. A patch will be created.
    6. You can use the Smoothing Tool to create a finer mesh from the surface patch created in step 5.

Note: You can use Polylines, B-Splines, or NURBS to create the boundary curves. Like the Ruled Surface tool, the Sweep tool will create a polygon patch from Polyline or B-Spline boundary curves and a NURBS patch from NURBS boundary curves.

Keyboard Shortcuts For Using MicroScribe In Amapi

The following keyboard commands and shortcuts are very helpful when using the MicroScribe in Amapi. For Mac users, use the Apple Command key instead of the Alt key.

- **ALT-Z** Undo. Works on just about any operation. Number of undos is set in Amapi Preferences. If you are using a tool, the Backspace key also performs Undo.
- **ALT-R** Redo. Reverses the last undo.
- **ALT-T** Redraw. Redraws the entire screen and erases remnant lines.
- **ARROW KEYS** Rotate the view. Useful for getting the best view of the model while digitizing.
- **CTRL-ARROW KEYS** Holding down the CTRL key while using the arrow keys pans the view left/right/up/down instead of rotating it. Useful for centering the digitized model on screen.
- **SHIFT KEY** Holding down the SHIFT key while digitizing causes the sampled point to be Snapped to the nearest existing point. Useful for closing curves or creating shared points and boundary curves.
- **'3'** Zoom in. Useful for closely examining small parts of the digitized model.
- **'.'** Zoom out.
- **'+'** and **'-'** Select next/previous curve or object. Useful for selecting curve or object hidden behind other curves and objects.

Make sure **Num Lock** is on to use these shortcuts. Note to PC and SGI users: The following keyboard shortcuts work only with the number pad section of your keyboard. Both the number pad and the standard number keys will work on Macintosh computers.

- **CTRL-1** Enables MicroScribe Camera
  Allows you to change the view of the model by "flying" the stylus around the model. Use the '-' and '+' on the number pad to zoom the camera in and out. Click on the footpedal to leave MicroScribe Camera Mode. This command can also be activated from the Edit menu. Note: Other operations are disabled when MicroScribe Camera is active.

- **CTRL-2** MicroScribe Settings Dialog Box
  Allows you to change the default MicroScribe settings (Port Number, AutoPlot, MicroScribe Mouse, etc.) and perform 3D Object and 2D Mouse recalibration. This command can also be activated from the Edit:Preferences menu.

- **CTRL-3** Enables/Disables MicroScribe
  This shortcut performs the same function as selecting Use MicroScribe from the Edit menu. Selecting it once enables all MicroScribe functions. Selecting it again disables all MicroScribe functions (digitizing, mouse, camera, etc.). A checkmark next to the Use MicroScribe command indicates that the MicroScribe is enabled and can be used..

- **CTRL-4** 2D MicroScribe Mouse Recalibration

Prompts you to digitize 3 points on your tabletop representing the lower left corner of your screen, the lower right corner of your screen, and a point somewhere near the top edge of the screen. These points delineate the mouse working area if you are using the MicroScribe stylus in place of the standard mouse. If you find your initial 2D Mouse calibration makes it difficult to navigate around the screen with the MicroScribe, you can recalibrate at any time with this shortcut. This command can also be activated from the MicroScribe Settings Dialog Box (CTRL-2).

- **CTRL-5** Enables/Disables MicroScribe Mouse
  This shortcut performs the same function as selecting the MicroScribe Mouse checkbox in the MicroScribe Settings Dialog Box (CTRL-2). If MicroScribe Mouse is checked, the MicroScribe stylus overrides the standard mouse and controls the cursor in the drawing window.

Troubleshooting Common Problems

When I select Use MicroScribe either from the Edit Menu or using the CTRL-3 shortcut, I get a "Check Communications Parameters and Host Hardware" Error

Make sure the MicroScribe is powered on and the serial cable is firmly plugged into the jack labeled 'serial' on the MicroScribe. On a PC, the other end of the serial cable should be plugged into one of the two serial ports, COM1 or COM2. If you have additional connectors for COM3 and COM4, you can also use these as long as they use the standard addresses and interrupts. On a Mac, it should be plugged into either the modem port (port 1) or the printer port (port 2). On an SGI, it should be plugged into one of the two mini-din-8 (circular 8-pin) serial port connectors (labeled 1 and 2). If your SGI has a DB9 (trapezoidal 9-pin) serial port connector (e.g., Onyx), you need a special serial cable. Contact Immersion for further details.

Select MicroScribe settings from the Edit: Preferences Menu or using the CTRL-2 shortcut. Make sure the correct serial port number is selected. If the correct port number is selected, try reducing the baud rate to 9600.

Note to PC users: If your mouse plugs into a COM port, you can not unplug your mouse once you are in Windows and plug in the MicroScribe serial connector in its place. The MicroScribe must be plugged into a different COM port than your mouse.

Note to PC users: A COM port may be unavailable even if nothing is physically plugged into that connector on the outside of your computer. An internal modem or other internal serial device may already be using the COM port you want to use for the MicroScribe. If this is the case, you will have to: 1) change the device's settings to another COM port (refer to the device's owner's manual), or 2) remove the device from your computer. Also make sure to change the settings of any software that use the device.

Note to PC users: If the COM port you want to use for the MicroScribe has a male DB25 (trapezoidal 25-pin) connector, you will need to standard female DB25 to male DB9 adapter. These adapters can be purchased at any computer accessory store.

Note to Mac users: If your Mac is using AppleTalk over the printer port, you can not use the printer port for the MicroScribe. To turn off AppleTalk or to select the ethernet connection for AppleTalk instead of the printer port, go to the Chooser and select AppleShare.

Note to Mac/SGI users: The Mac and mini-din-8 SGI serial cables are standard Mac printer cables and can be purchased at any computer accessory store.

If none of the above steps fix the problem, try cycling the MicroScribe power (turn it off then back on) and try connecting again.

When I select Use MicroScribe either from the Edit Menu or using the CTRL-3 shortcut, I get an "Error in macro: mCalibration macro" message on the PC or SGI, or a hard exit to the text console shell on the Mac.

The first version of Amapi for MicroScribe required the default workbench and background grid to be present when the MicroScribe was used. If you turned these off in the Amapi Settings from the Edit:Preferences Menu, you will get an error when you choose Use MicroScribe. If you do not wish to have the workbench and background grid on-screen when using the MicroScribe, use the hide tool (the ghost icon) to hide them instead of turning them off. The latest version of Amapi does allow you to turn the workbench and background grid off. Contact Immersion if you wish to receive this newest version.

When I use the Hull Surface Tool, I get an "Alert: Curves must lie on different planes" message.

You must hit the spacebar after clicking on the Hull Surface Tool to indicate you will be using at least 4 boundary curves to create the mesh.

When I use the Hull Surface Tool, I get an "Alert: All curves must be connected" message.

One or more of your boundary curves do not share endpoints, or one or more of the endpoints of your interior contour curves are not Snapped to opposite boundary curves. If you have two sets of crisscrossing contour curves, these must also share common interior points. Use the Stretch Tool to Snap the points of your curves to the correct locations.

When I use the Hull Surface Tool, I get an "Alert: Memory failed" message.

One or more of the endpoints of your interior contour curves are connected to boundary curve endpoints. Use the Stretch Tool to Snap the contour curve endpoint to a different boundary curve point.

When I select the Drawing Tools and choose a tool (e.g. Polyline), I do not see the yellow perpendicular lines tracking the stylus tip and the cursor seems to hang.

Amapi stores the 3D calibration data for the MicroScribe in a file called prefs.dv. Your prefs.dv file may have become corrupted. Try deleting the prefs.dv file and restarting Amapi. The newest version of Amapi should fix this problem. Contact Immersion if you wish to receive this newest version.

SGI Users: When I start Amapi, I get an "Internal Error in module garbymgr.c: line 638."

Amapi needs to store your preferences and the 3D calibration data for the MicroScribe in the prefs.dv file in the RSRC directory of you Amapi directory. You do not have write permission to the RSRC. Change the permissions with something like "chmod a+w -R RSRC".

SGI Users: The screen goes blank when I use the pulldown menu and some of the submenus do not work.

Yonowat has fixed these problems in the newest version. Contact Yonowat or Immersion if you wish to receive this newest version.