Enveloping in Softimage

● In the May 1999 issue of 3D Design (Animators Anonymous column: "Character Setup in Softimage," by David Gallagher, p. 49), we looked at the process of placing a skeleton inside a Softimage|3D charachter.

This web-only supplement covers the enveloping and vertex weighting process in Softimage, and the series continues in the June 1999 issue of 3D Design with a look at using controls, constraints, and expressions.

Now it's time to get our character to move with the skeleton using Softimage's "enveloping" tools. Enveloping is the process by which you attach the geometry to the skeleton and determine the influence the joints (or bones) have over each vertex.

This is an area where many people have difficulties. The character modeling may be finished, but now you're faced with the difficult task of essentially "modeling" the body correctly in every possible pose as it bends under sometimes extreme deformation. Even getting the vertices to behave at all can take lots of tedious work.

The basic process is simple. Gather together all character geometry that should bend with the joints of the skeleton under a single null. These don't have to be in descending order. For instance, a hand doesn't have to be parented to an arm but can be parented instead directly to the main null mentioned. For future reference, should you need to detach the arm, you won't lose weighting information for all its children as well.

Parts such as eyes, shoulder pads, and stiff armor can be left out of this hierarchy and parented later directly to the appropriate joint–eyes to the head joint, and so on. Don't do this yet, though! A bug in Softimage forces all objects parented to joints to become skeleton objects themselves when first mak-
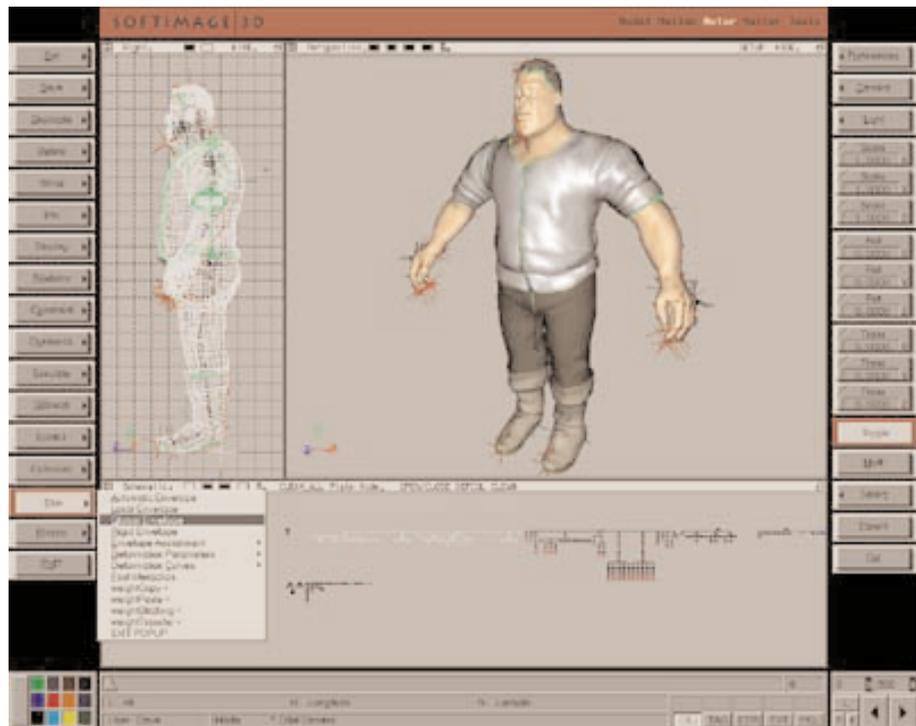
FIGURE 1. This character is ready to be attached to his skeleton. Afterwards, it will be called an "envelope" because it can be deformed by the joints and objects of the skeleton.The "Envelopes Initial Assignment" dialog box is displayed. Normally, you'll want to leave these options at their default values, and click OK

ing the envelope. This means the eyes, for example, would become just like any joint–when you rotate it, the eye would stretch and deform the face!

Start Your Envelopes I'll continue using my "Stuart" character (star of the May and June Animators Anonymous columns in 3D Design) as an enveloping example. With the character selected, choose Skin>Global Envelope. (See Figure 1.) Then pick each chain to be included into the skeleton. Since you have to wait between each click for Softimage to recalculate the weights, I often place all the joints as well under a single null so this can be done with one click only. I want this to go quickly since I may have to remake an envelope 10 or 20 times to reset the default state of the chains or to change their position without affecting the envelope.

The geometry is analyzed based on each point's distance from every joint then each vertex is assigned–or "weighted"–to several joints (based on the "default nb. of joints assigned joints" parameter in the dialog, normally set to 2). A vertex will be affected by the transformation of the joints in degrees–

one might be assigned, for instance, 4% to jointA and 57% to jointB and 39% to jointC. When jointA rotates, for instance, it changes the position of the vertex only slightly, but when jointB rotates, it will be greatly affected.

Deselect the hierarchy, then select one joint to test the envelope. I'll grab the upper leg joint and rotate it. In most cases, this initial assignment will not give very satisfactory results, with many vertices being partially assigned to the wrong joint. (See Figure 2.) Areas where the geometry is at all close to joints of other limbs or body parts may be partially assigned to those. Although a smooth gradual falloff in this initial assignment is desirable, the default result is often an over-assigning of vertices to places they shouldn't belong. Coincidentally, this also the hardest problem to solve–it's far more difficult to decrease the influence of a joint on vertices than it is to increase its influence.

Reassign Manually The most basic level of control is assigning vertices completely to a certain joint. This is done quickly and easily with Skin>Envelope Assignment>Reassign Manually. If you first pose your character you
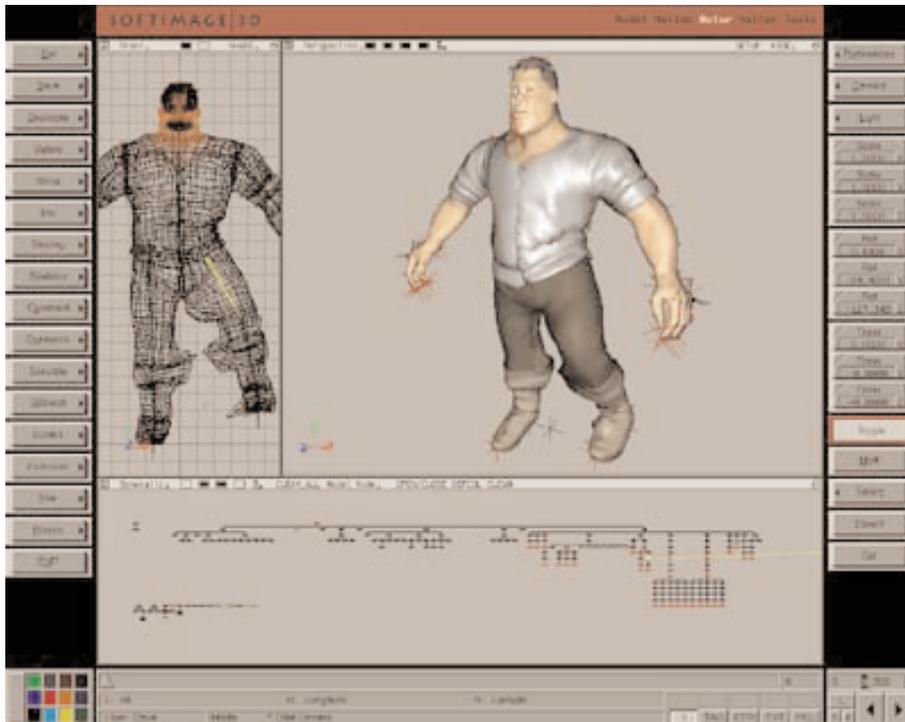
FIGURE 2. The default assigning of vertices to the joints is prone to make errors like this one. Vertices from the legs are partially assigned to the wrong leg or foot Fortunately, there are several ways to control the degree to which vertices are assigned to joints. You can avoid some of the problems by simply modeling your character "spread eagle" with all limbs and fingers spread to extents. You can see our example character, Stuart, was not modeled that way. His legs were modeled close together in a normal standing pose, which is more natural to model but harder to weight properly. The better pose would have helped minimize some of the troubles but there still would have been plenty of vertex weighting problems. Also, you can use bounding models (which we'll discuss shortly) to compensate for the slightly more difficult posing.

can tell which vertices need to be reassigned. With some of these errant vertices selected, choose the command then click on the joint or skeletal object you want to assign them to. The vertices are assigned 100% to that joint and jump to their new positions.

This works for some areas, but for many of the problem zones a smooth gradual transition across many points is needed. Areas with scores of vertices will need to subtly transition between two or more joints, especially in regions like the shoulder and abdomen. Control over these gradual percentages is trickier. I'll cover first bounding models as a solution, then the Modify Weights dialog.

Bounding Models   I almost always use bounding models to control vertex assignment. Bounding models are used to define a region around the joints for the software to consider when reassigning vertices. You select a joint (which has already been defined

as a skeleton), choose the type of bounding model (Skin>Envelope Assignment>Bounding Model>), then resize and modify to define the region. Each of the three different kinds of bounding models has a unique effect on the process.

For the Exclusive type, vertices within these areas are kept from being assigned at all to the joint in question.

The Inclusive kind force all vertices within its boundaries to be assigned to the joint. When you overlap Inclusive bounding models from different joints, you can define smooth transition zones between joint influences.

Inclusive Limit bounding models define the limits of the joints influence. No vertices outside of the region can be assigned at all to the joint, but within the bounding model the vertices are weighted as they normally would. Inclusive Limit bounding models are the least intrusive to the process. They basically let the normal weighting process happen while allow-

ing you to define outside limits to the joints influence. As with the Inclusive type, Inclusive Limit bounding models can be overlapped to create smooth transition zones. This is slightly less effective though since if a bounding model defines an area too far away from the joint, it doesn't force those vertices to be assigned at all to the joint, and some more distant vertices may wind up not assigned at all. And since you've carefully overlapped the adjacent bounding model, you may be cutting its influence too early for a good transition–you can't tell until you reassign the points and try it out.

To do this, select the hierarchy defined as an envelope and choose Skin>Envelope Assignment>Reassign Automatically. This recalculates the vertex assignments again, this time taking into account any bounding models you've placed. Unfortunately, it also destroys any manual weighting you've done with the Reassign Manually command, or with Modify Weights.

I primarily use Inclusive Limit bounding models, but also use Inclusive at times. If you're willing to spend a bit more time with them, overlapping Inclusive bounding models is the most predictable.

Choosing Shapes   In addition to the three types, there are three shapes you can choose from: box, sphere and cylinder. Bounding boxes are useful because their vertices can be individually moved. You have to be careful, however, to keep the polygons planar–non-planar bounding boxes have unpredictable influences. The best way to avoid this is to always select two adjacent vertices then translate them in the plane perpendicular to the two. (See Figure 3.) They're also the only bounding model type that are visible in shaded mode. Bounding spheres have a more natural shape, of course, but since you can't visualize their intersection points with the body in shaded mode, bounding boxes tend to be more intuitive to use.

Bounding spheres and cylinders are certainly better shapes for organic forms, but since they can't be seen in shaded mode they are more difficult to position properly. Their points can't be edited unlike bounding boxes, but you can rotate and scale them into place as needed. I tend to use bounding boxes for most areas, and a small number of bounding spheres on top for areas that can't be defined well with the box shape.

Another advantage with bounding models is that once you've arranged them correctly on one side of the body, you can use Effect>Symmetry to mirror them onto the other side. Without the help of bounding models, after manually fixing one side of the body you would have just as much work to do on the other side!

You can test the weighting occasionally on the whole body as you work on the bounding models for one side. Simply multi-select the bounding models to mirror and choose Effect>Symmetry. Next parent each one to the appropriate joint. Choose "no" when it asks if you want them to become part of the skeleton. When they're all parented in, use Reassign Automatically to recompute the vertex weighting.

As mentioned earlier, if you use any bounding models at all it works best if you then put them on all the joints. Vertices outside the overlapping influence of two bounding models will attempt to be associated with the default number of joints–usually two–and can mistakenly become attached to distant joints. To keep this from happening, apply a bounding model to each joint.

Repeat the process of editing the bounding models, Reassigning Automatically, then moving some body parts to test the envelope. You may find it useful to create an animation of body parts rotating to extreme positions to test your changes quickly. Using bounding models alone will probably not solve all vertex weighting problems, but you can get most of the way there quickly. It provides some safety against those times when you discover some setup or hierarchy flaw, which will require you to cut the skeleton and recreate the envelope. Working with bounding models lets you reapply the work you had already done very quickly.

Bounding Models are only visible if Show>Controls is checked on. Be aware that when using some post process effects such as MB (post-process motion blur), you need to hide or delete all bounding boxes or you'll get artifacts in your renders.

When you've exhausted the usefulness of the bounding model method (or even if you haven't used them at all), you'll need to turn to the more precise Modify Weights command.

Modify Weights   Modify Weights gives you per-vertex control over envelope weighting.
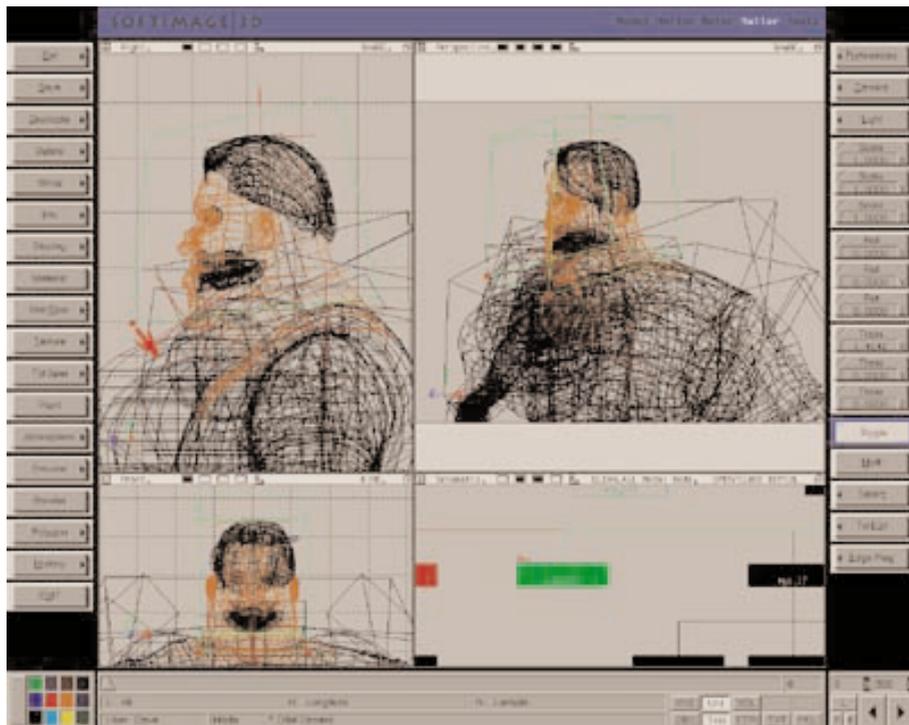
FIGURE 3. Bounding models can help improve initial vertex assignment. When editing bounding box points, select two adjacent points at a time and drag them in the view perpendicular to the selection to keep the associated polygons planar.

Select one or more vertices (often a row's worth of points), then choose Skin>Envelope Assignment>Modify Weights. The number ID of each tagged vertex is displayed in the Tagged Vertices section. You can select one or more to work on at a time with the Selected Vertices option, or modify them all at once with the All vertices option.

As you select a vertex, its weighting is displayed in the Joints section and it turns green in the view. For each joint, a percentage value is displayed representing the degree to which that vertex is weighted to the joint. Most will list 0.0, but one or several joints will list a non-zero number and these are the joints currently affecting that vertex. If you haven't named the joints properly these will show up with completely unhelpful names like jnt18_2–it's best if you name all the main joints in your character first (using Info>Selection, of course).

Weights can be modified using the slider or the numbers below "Weight." To change all the affected vertices to exactly the weight you choose, use the Absolute option. Often, though, you'll want to modify the weights not by overwriting the assignment of all the vertices, but adding to their current weight values. This way you leave all the subtlety of the automatic weighting while you modify it. For this, choose the Add option. Note that the Joints section only displays the value of one

of the selected vertices even though you can modify several at a time. Each vertex will likely have different weighting values, but these separate values are maintained if you choose the Add option. When you use the Add Percent option, the numbers you enter change the weights based on a percentage of the current value, not an absolute value.

To change the vertex weights, choose a joint then drag the slider to the right or type in a value and hit enter. If you're using Add mode, this can be any number (smaller numbers work better) but in Absolute mode, always enter a number greater than the displayed value. Note that although you can drag the slider to the left or decrease the shown amount, Softimage makes no attempt at redistributing the leftover value among the other joints. In other words, if you ever decrease values in Modify Weights you run the risk of leaving some vertices with a non-100% value in total. This can be difficult to detect afterwards, but means that when your character is moved in space, those vertices will lag behind ever so slightly. It may only be detectable when your character moves around quite a bit–at a time when it may be less convenient to be working on enveloping. As noted previously, it's easy to add weighting to a joint's influence over a vertex, but difficult to remove.

The "weighted" switch makes your Add

weighting changes affect vertices less which are farther away from the selected joint. This is very useful at times for making smooth transition zones.

Again, to see the best way to detect problems in the weighting, first pose the modein an extreme pose, or create an animation to test the various problem areas. While in the Modify Weights dialog box, you can scrub the timeline to test your changes as you work. (See Figure 4.) Unfortunately, you can't change the scene any other way while you work in Modify Weights, such as orbiting the camera or switching to wireframe.

If your model is made of NURBS or patches, use Tag>Points>Row in U and V to select the rows for Modify Weights. For some troublesome areas, selecting and editing in rows may not suffice. In these cases, take a brute force approach. Select all the vertices in that area and use Modify Weights in Selected Vertices mode–one point at a time. Select each point that looks like it's positioned wrong. Unfortunately, you have to select them by numerical ID, so keep clicking on the vertex list until the right one highlights. This is easier with NURBS and patch objects, since their points are neatly arranged in rows. With polygons, it's anyone's guess which point is next in the list. Transparent Ghosting Shaded mode can help you to see the selected green points around the backside. Also, if you find all the red tagged points distracting while you work, remember you can turn off their visibility with Show>Tag.

Move from one point to the next, changing the weights in absolute mode until you get the smooth weighting you want. Of course, this is far easier with characters that have fewer points, so NURBS or patches and Metamesh objects are preferable.

A high number of joints can also make this process tougher. Each skeletal object in the character hierarchy shows up in the Joints list–making it much harder to find a particular joint quickly.

Those are the three main tools Softimage offers for refining envelopes: bounding models, Reassign Manually, and Modify Weights. In addition you have some control over bending areas and bulges for multi-joint chains with Skin>Deformation Parameters.
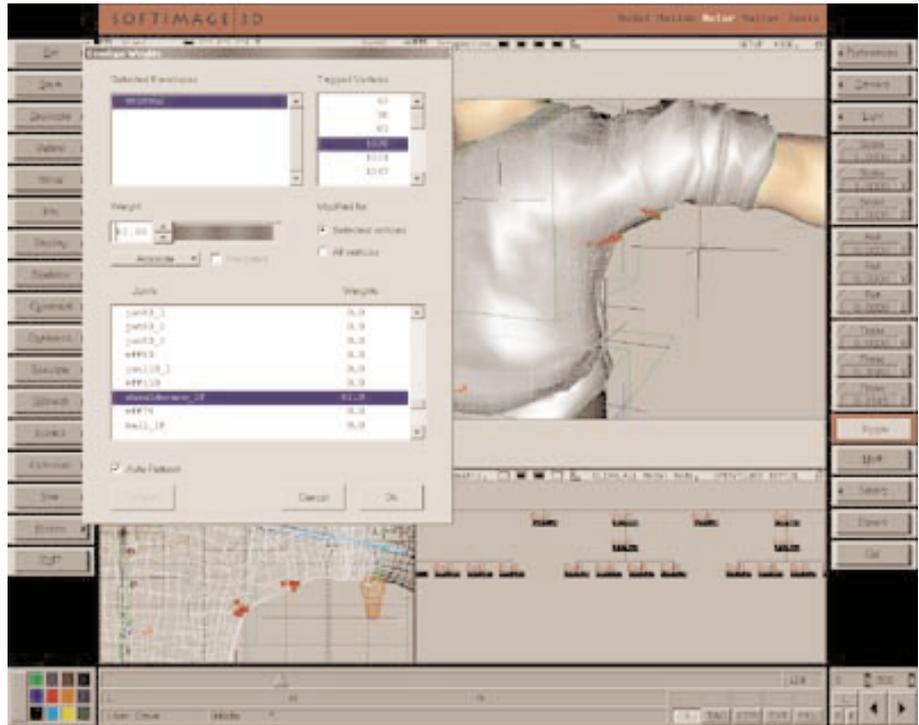
FIGURE 4. Transparent Ghosting Shaded mode is helpful when using Modify Weights. Points obscured by the surface are shown as X's. Note though, how the selected joint (light blue) is only highlighted in the wireframe window–unfortunately these aren't visible when obscured in the shaded view.

The main difficulty with Softimage weighting, as suggested previously, is not in any lack of ability to add to the influence of joints, but in limiting or removing that influence. You can take away the influence of a joint from vertices, but not while still maintaining the weighting otherwise. For instance, if some under-arm vertices are mistakenly assigned a mere 8% to the lower arm you could change its weighting easily with Reassign Manually. But let's say the vertices are already smoothly weighted to two different spine joints and a shoulder joint. Changing the vertex weighting to 100% to any joint will ruin the weighting to the other joints. Unfortunately, Modify Weights doesn't help because you can't remove weighting from vertices and still retain a total of 100% weighting to other vertices. Softimage's weighting tools, advanced as they are, focus on adding weights and increasing influence, but the reverse, which is just as critical to control, remains under represented.

Meet the Challenge In any but the simplest or most cartoony of character models, envelope weighting can be a daunting task. It's easy to become disillusioned when your 3D model doesn't deform quite right even after days of careful attention. In 3D software, joint and skin properties are certainly oversimplifications of what is actually occurring in nature. As our muscles move our bones, for instance, fleshy skin slides over muscles showing the masses and form. The subtle changes that occur on the surface of our skin as we move are numerous and difficult to simulate; tendons pull and tense, muscles glide beneath skin, skin whitens in tensed areas, and skin folds in numerous tiny creases. Each of these can be addressed in the software to one degree or another, but taking on all of them as a whole is an enormous task. It's these same difficulties that make character setup such a fascinating challenge. ●

David Gallagher runs Utah-based Cineframe Animation, a studio specializing in 3D characters. He's the author of the Softimage Character Kit training video series and designed the Softimage QuickBlend and YouMap plug-ins. Find out more at: www.cineframe.com.