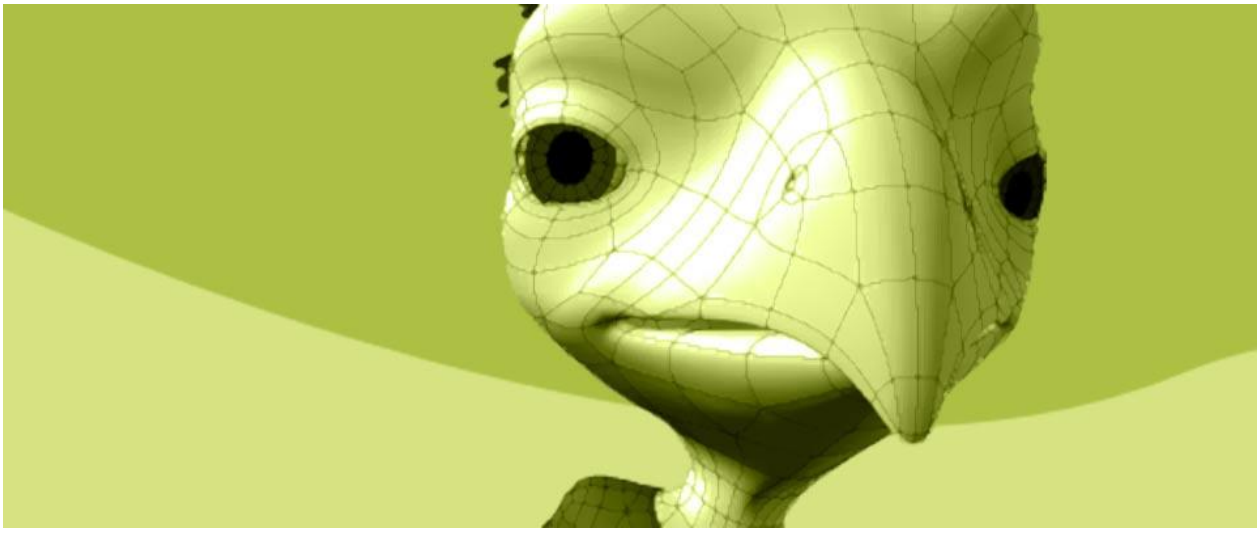
3D Model Surface flow – Why it matters

Why flow of polygons matters in 3D modeling: More definition with less polygons, correct deformations and better shading.

March 8, 2010



Often when someone new to 3D shows their first model online, the form lacks definition and the whole thing looks a bit play-doughy. And if they show the model wireframe, you can see the construction may have lots of polygons but the distribution is not even nor does it flow with the shape. It's often because they construct the model without changing surface flow.

Surface flow is directed with either the edges between the polygons or by polygons themselves – the same thing really. It is usually called edgeflow.

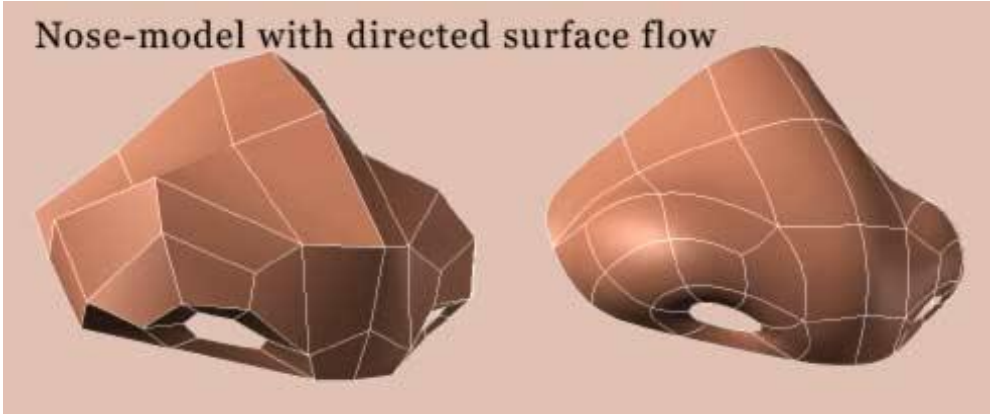
Benefits of good edgeflow

more definition with less polygons, an optimized mesh

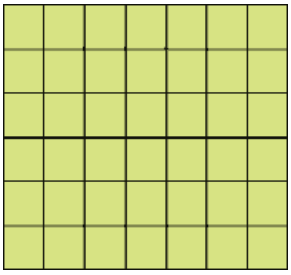
better deformation in animation (if built with anatomy in mind)

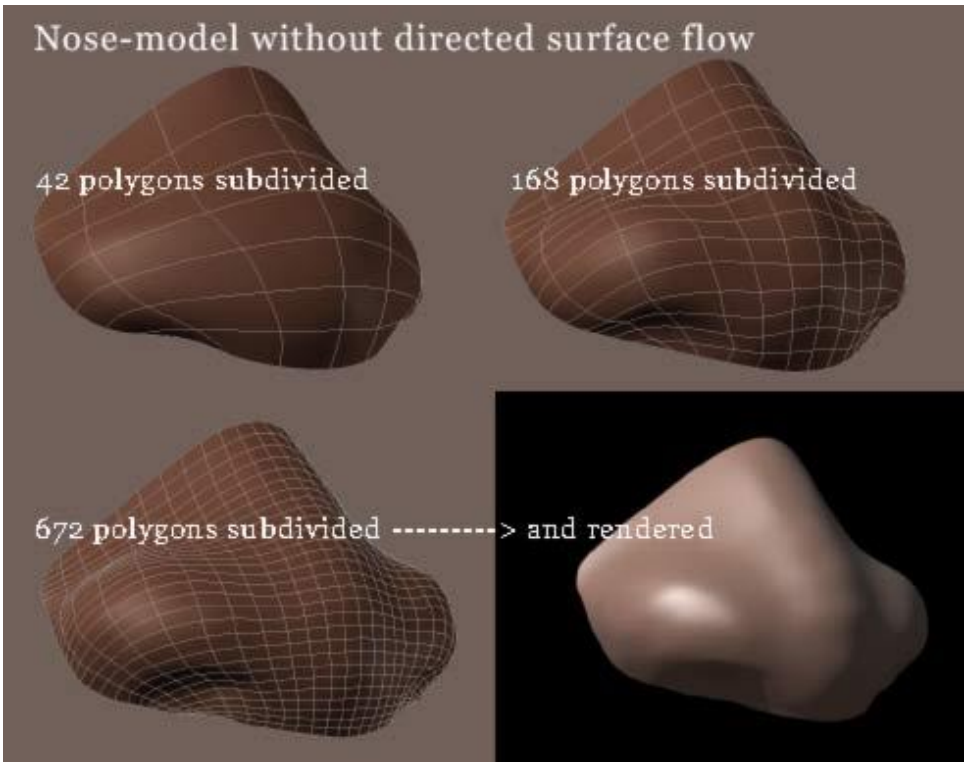
better shading

I'm illustrating the idea with examples of an organic shape – a cute nose.



Here it is done with good polygon/edgeflow, as a basemesh and as a subdivided mesh(control cage showing). The nose has 42 polygons. See the picture of a grid to see how many 42 really is.

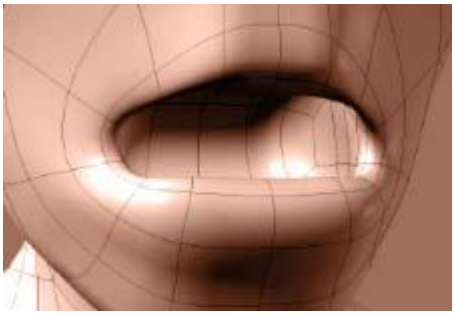




Now let's try achieve same shape and definition without any surface flow direction – starting with 42 polys.

As you can see, results don't get much better with more polygons, somewhat worse in fact. The model becomes difficult to work with. And I'd still have to increase polycount (=number of polygos) to achieve the same definition we get with less polygons, when using directed surface flow.

You CAN get good results this way in a sculpting program, working with thousands or millions polygons, but to get anything out that you can use in any other program, in games for example, or animate for that matter, you have to reconstruct the model surface flow.

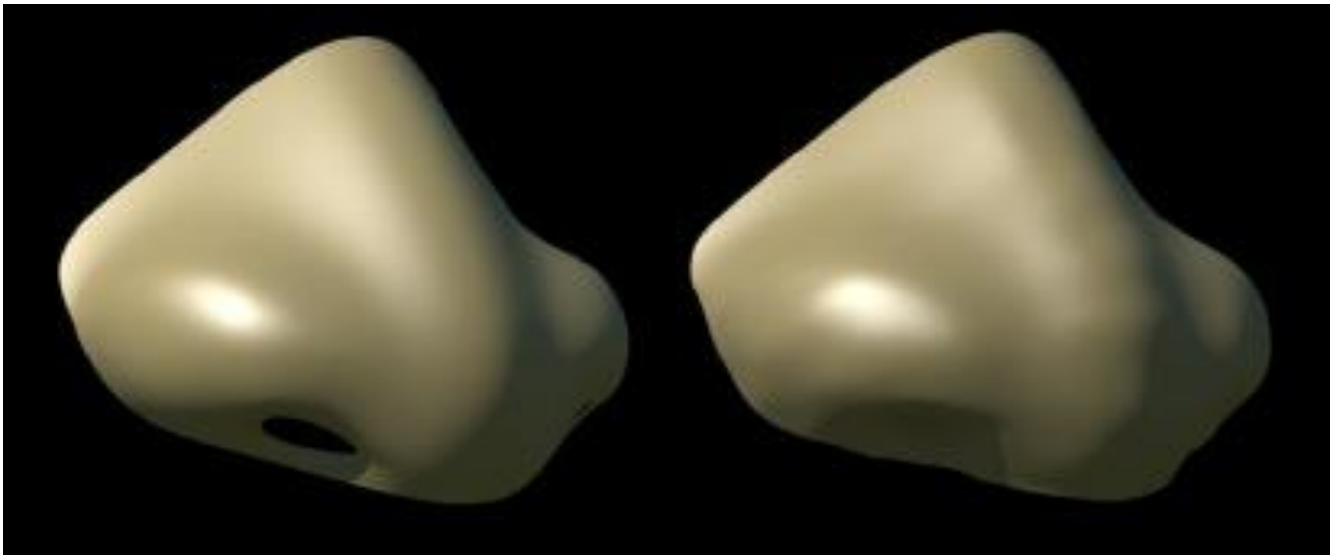


Animated models benefit from good surface flow when flow is correct in places where the deformation happens, like around the mouth. See the pic. And sorry but I shan't torture myself by building a poor mesh for comparison. Just imagine a rough head shaped tube here with a polygon or few pulled in for the mouth. If you think that's bad, imagine what happens when it is animated.

Good surface flow also improves shading simply because having a flow that defines the shape nicely from the ground up, you have every big and small part of said mesh aligned along the shape and not against it. Also with good flow you do not have mesh issues (poles, etc.). When virtual light rays hit those parts, they reflect and refract as they should. Shading, that is highlights and shadows and all, looks like it should. I have no irrefutable proof on this, but can say from experience that models with good edgeflow render better.

To conclude building without edgeflow is harder, needs more polygons and renders worse. Our nose is not the best example, but the difference should be apparent in the render below.

Left nose is with good edgeflow, right is without.



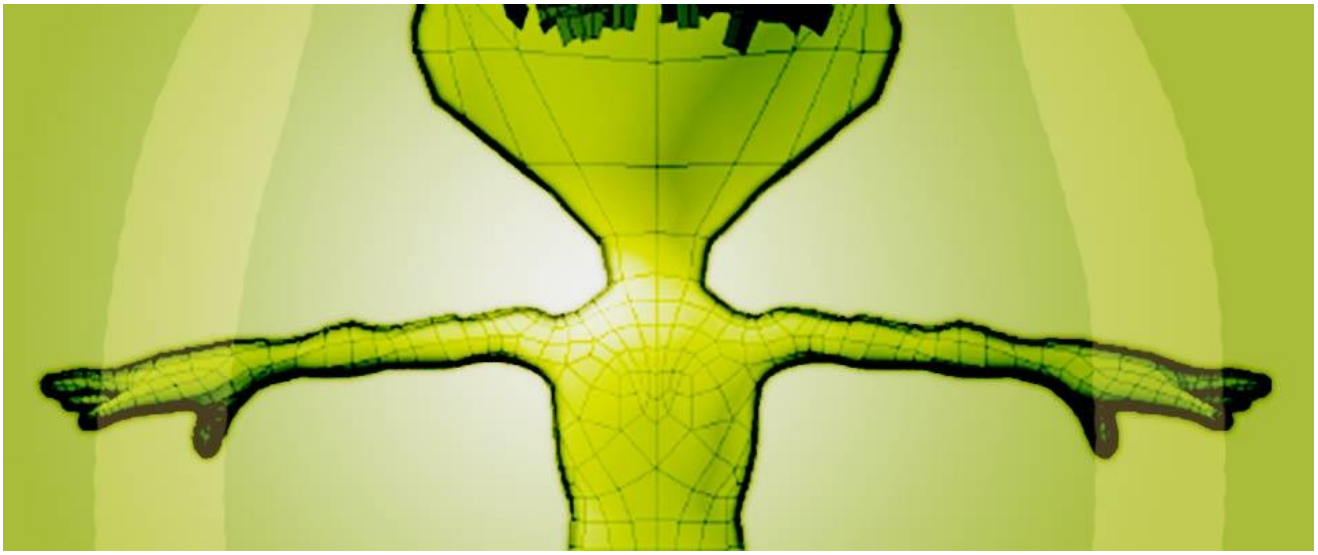
Besides the bit about animation, all of the above also applies to hard surfaces models, not just character models. So model with directed flows, model well. We'll go into edgeloops and modeling for animation later.

This whole article, the concept, is one of those things I wish somebody had explained to me a long long time ago. So here it is, in my words. I hope somebody out there benefits from it. If you found the article useful, or if you think it's all nonsense, please comment – let me know.

Modeling for animation – Body

Describing the benefits of edgeflow and edgeloops in 3D modeling and the general ways to use them on a human/humanoid torso and limbs.

March 15, 2010



Character modeled for animation is modeled to deform well in animation

To begin check out my article on surface flow, if you already haven't. And then, to go further we need to understand edgeloops. Quoting guru Bay Raitt:

"An Edge Loop is an interlocking series of continuous mesh edges used to accurately control the smoothed form of an animated subdivision surface."

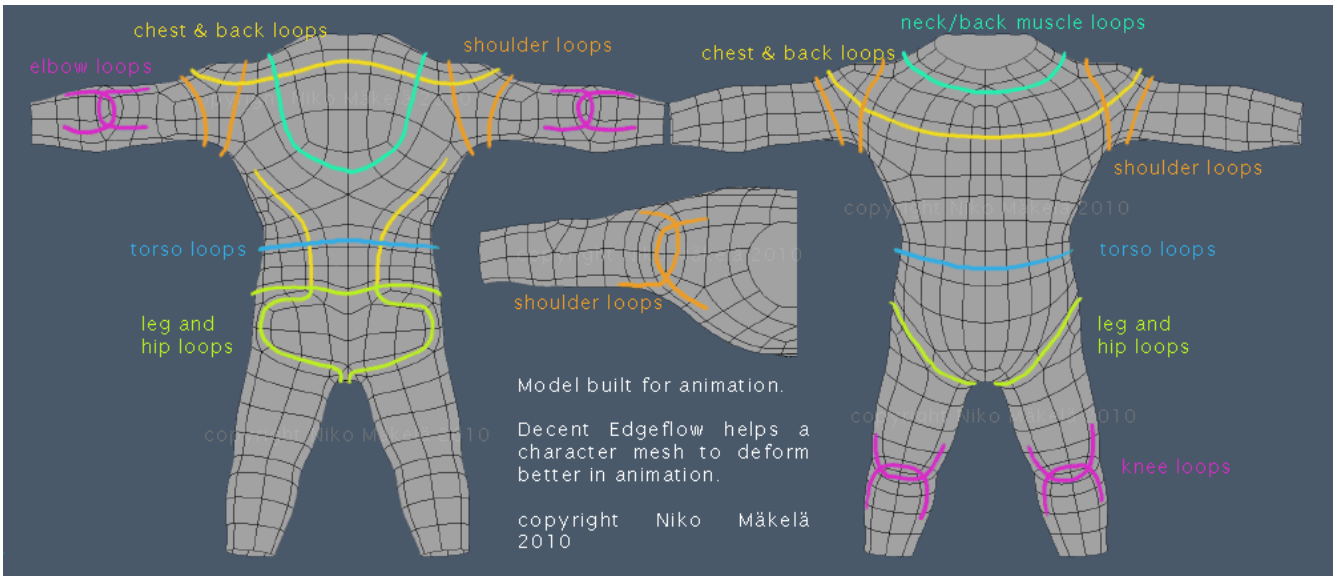
Edgeflow and Edgeloop are essentially the same thing. **Flow as a loop separates areas, defines shapes and directs edgeflow. You use loops in places where major deformation happens in animation.**

Overall edgeflow within each looped area matters, too. **Idea of a good flow, as I see it, is that when stretching or compression happens the polygons are already aligned towards the change.** Then the deformation is usually problem free.

The general advice is to model the flows following the main muscles under the skin. It can get needlessly complex considering how many muscles move a human body. Some people have been obsessing over edgeloops for years. Luckily you only need loops for main muscle groups or body masses. Think what main masses/muscles move in a character and how. Direct the surface to flow along them and form loops around them. The loops may be interlocking and that's all good. Then they mix and crease together better.

What if you want superb muscle definition? Much of the missing detail can be added with displacement maps (from Zbrush, Mudbox and the like), and when the base moves correctly the displaced 'muscles' on it move mostly alright, too. Though if you want realistic flexing muscles, you need a heavier setup, like morphs to drive the fine sculpted-detail changes to fit specific poses – but this gives a good base to start from.

What are the Main Masses moving in a human/humanoid?



Back of a character bends below the chest. You need loops going around the torso. Chest bends too, even the rib cage below deforms, however the musle masses on chest and shoulder & back-area have more effect on the shape change, shoulder having clearest effect. You should have flow from chest directed to flow over the shoulder and to the back. Please note my optimization here has lead to a pole, a 6 edges intersection, in the middle of the back. It is not troubling me, but if you build similiar mesh you may want to add few polygons in that region to get rid of the pole.

The arm-mass connects to the shoulder and the problem area is over the arm-socket.

Head and neck moving about affects the area around the neck and some ways to the back.

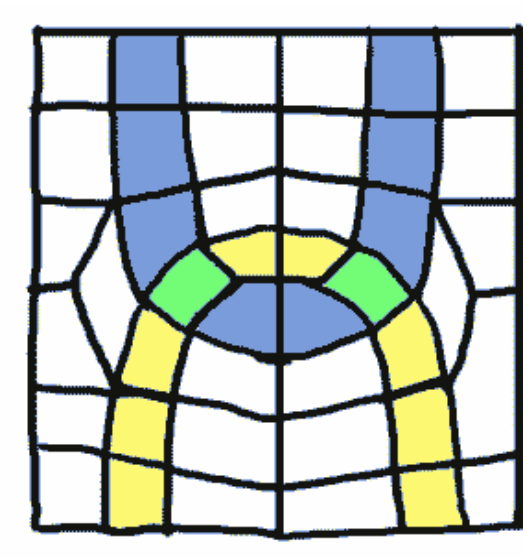
Legs move the buttocks as well. The mass movement limits to top of the hip bone, pretty much.

With arms and legs the problematic bits are knee and elbow both. Masses of back- and forelimb come together and separate there. The loops help to give more mass on the outside part of the bending limb, giving material for both parts that bend away and a centerline that stays more or less in place. You may get by with a tube-like structure here for cartoon-characters where things aren't that exact OR by having many loops that you carefully weight to bones to deform just right.

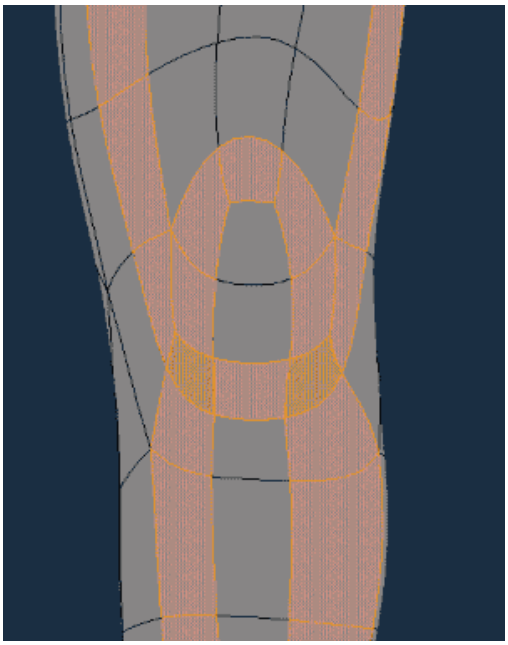
Highlights and edges show the flows I like to use for this model.

Disclaimer: Please note this is definitely not the only way to do this, just A way. You can get by with less loops, more loops or with different loops. Whatever works, works – I find these work for me.

The loops shown, in limbs and at the top of the shoulder, are variations of a very useful x-loop. See the diagram of a more complete version of it.



Also here is another version, a knee with more 'mass' left in. You can do varied X-loops.



Read more about edgeloops here http://web.archive.org/web/20120422232142/http://www.3darts.com.br/tutoriais/edge_loop.php. Original article has expired but can still be found in Google archive (Thanks Terry). It is in Portuguese. Here is a translation to English.

Modeling for animation – Testing to find proof

Let's test an edgelooped character mesh, one of the things I preach for, against a 'normal' mesh. Is it better for animation?

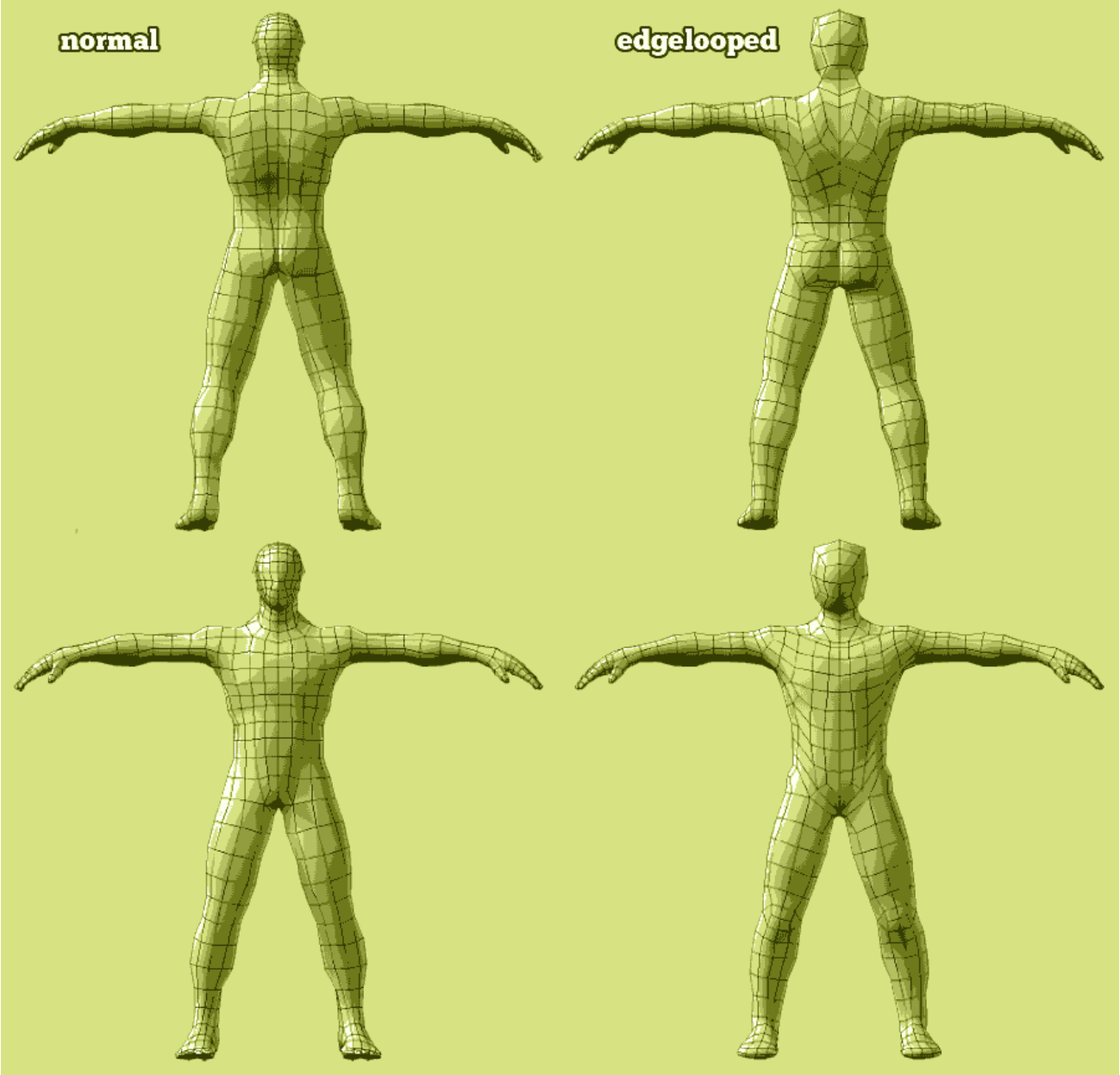
March 31, 2010

Earlier I wrote Why Surface Flow Matters and a bit about Modeling For Animation. Here I wish to show the benefits with visual examples.

I will compare how two character meshes deform in animation. To make this comparison mean something, I have selected one of the best base meshes I could online find without a directed edgeflow.

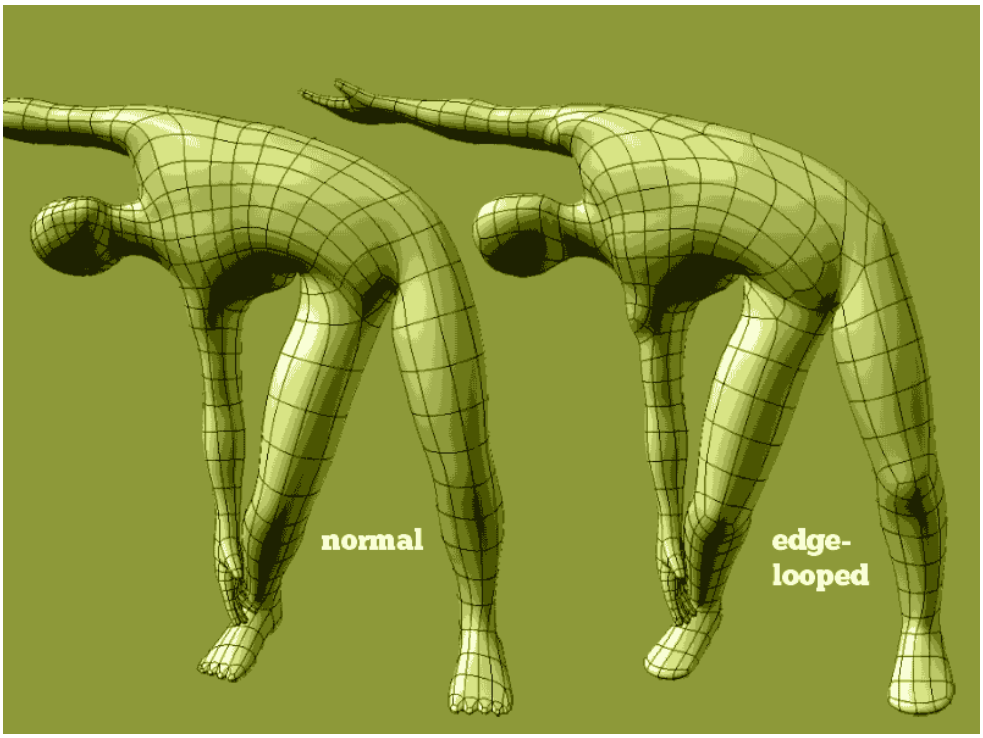
Mesh on left is made by unknown person. It has nice even division of polygons – good for sculpting.

Mesh on the right, is mine and built for both sculpting and animation. It is almost exactly the same size and shape as the first. I have rigged both meshes in Messiah with one rig – they both do exactly same motions. I haven't done any weighting of bones to the mesh – Messiah bones have a good effect on the mesh by default. **Point is that with this setup the only difference you can see comes from the meshes**.

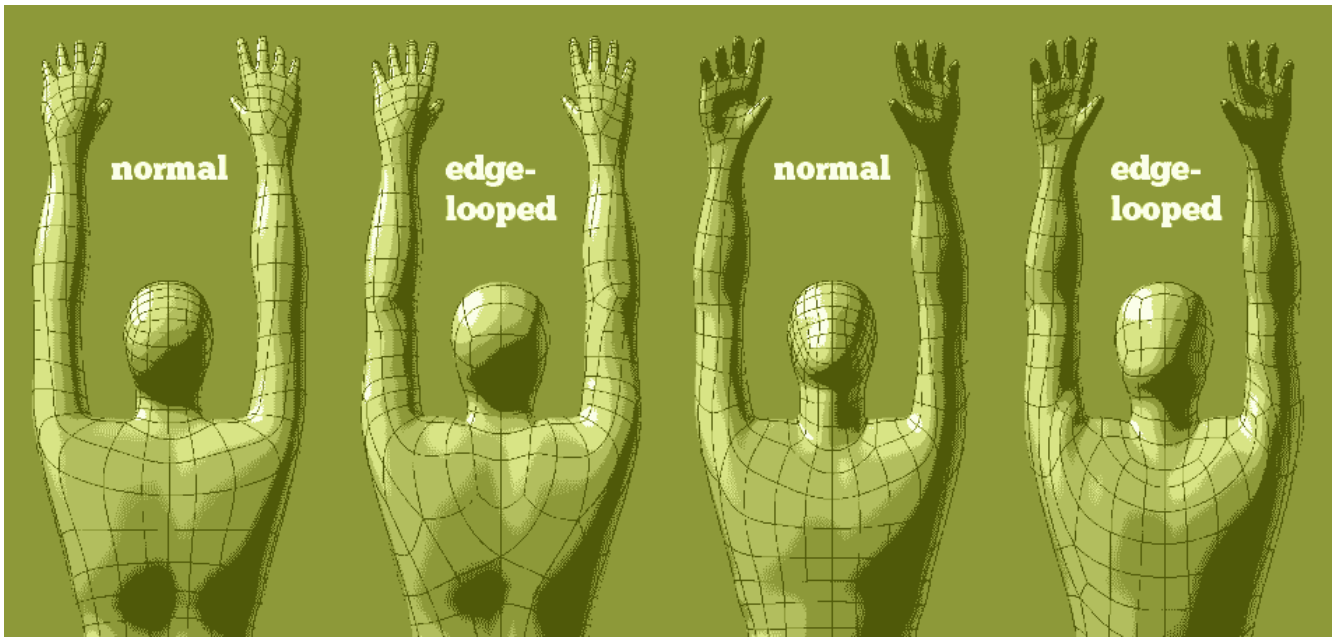


My Edgelooped-mesh has different head and no toes as I was lazy and many characters will be wearing shoes anyway. **The edgelooped mesh has about the same number of polygons <u>in the body</u> as the 'normal' mesh, but more definition because the flows define shape. The flow also helps maintain shape in extreme motions, like seen in the stretching example**.

Observe the general form, especially upper shoulder and chest area and the hip. See how the edgeflow helps to keep the shape and how it deforms it a bit better? Difference is not notable everywhere, but it is there and it is important.

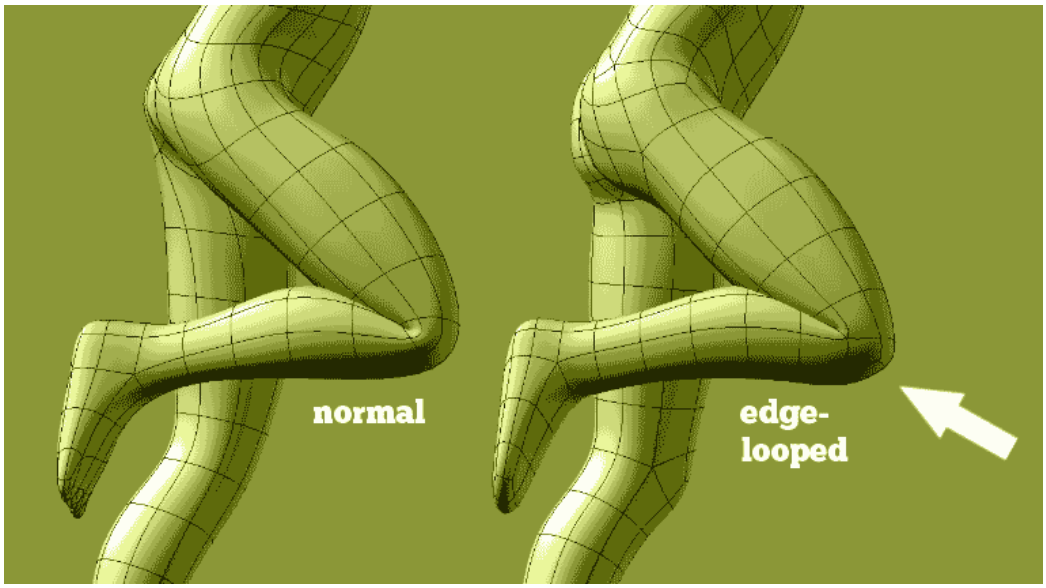


You may argue the first mesh would show the same definition if we just pushed points around and added a few polygons. But that's just it – unless you add those polygons as carefully placed loops, you will have to add a lot more than 'a few' to get the same definition edgelooped mesh has with less polygons.



Some might also say that the flows don't matter that much in animation production, because when final mesh is subdivided to gazillion polygons at render-time, there will be more than enough for joints and to keep the definition. I disagree. Base mesh is the one that gets animated, it sets base grid for the final – any problems in the base are still present in the final. And I dare say they become more visible in a highly detailed mesh.

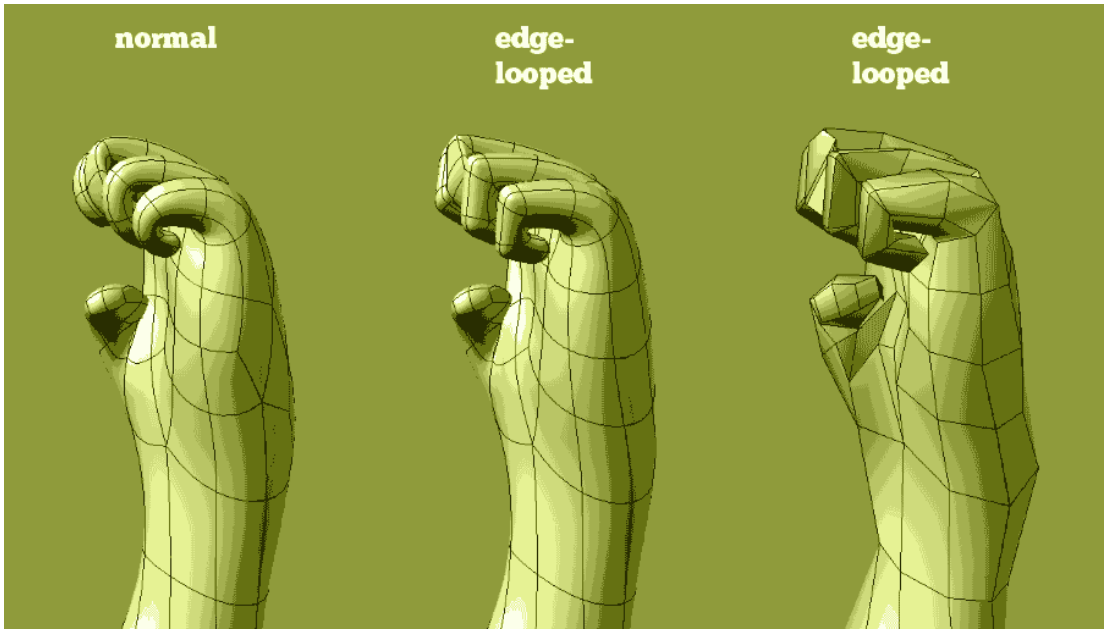
Last examples show how the edgeloops help in joint areas. With the knee I'm using the loop shown in Modeling For Animation-article (see image with lots of loops). Pleasee see benefit also at the hips and the buttocks.



Same works at elbow and at shoulder-top. The loop 'binds' the parts together and provides material for both sides of the outward bending limb – keeps the volume.

With fingers I'm using a simpler 'loop' to keep polycount low.

It adds one more edge on the out bending part and helps to keep the volume. It also introduces triangle-polys.



Conclusion

Mesh with evenly spaced polygons does well in animation and a mesh with planned edgeflow does even better. No surprise there, but I needed to test it anyway.