Advanced Computer Graphics presentation summary

Marc Babtist & Sebastian Wehkamp
s2446472 & s2589907

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1 Introduction

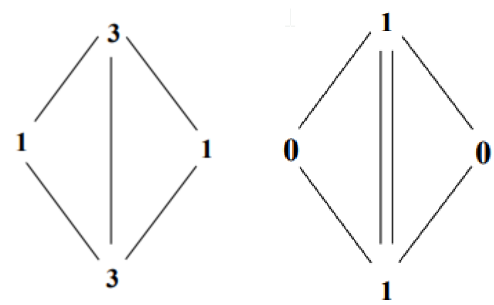
One of the most common ways to model complex smooth surfaces is by using a framework of Non-Uniform Rational Basis Splines (NURBS). These are mainly used because they already exist in popular commercial systems. However trimming these surfaces is prone to numerical error and it is difficult to maintain smoothness at the seams when the model is animated. This imposes some topological restrictions on NURBS models.

To overcome these problems subdivision surfaces can be used. These surfaces do not require any trimming and their smoothness is guaranteed. Although these surfaces had been used before this paper[1], the usage was not yet widespread. This is mostly because systems have been developed to add features to NURBS models which do not work by default on subdivision models. An example of such a feature is variable radius fillets: corners with a variable sharpness. To implement this the main idea is to generalise infinitely sharp creases in order to obtain creases whose sharpness can vary from zero (smooth) to infinite.

Infinitely sharp creases are convenient for representing piecewise-smooth surfaces. However in the real world surfaces are not infinitely sharp but are always smooth when viewed sufficiently close. For animation we would like to capture these tightly curved shapes.

2 Method

The method described in the paper is based on Catmull-Clark subdivision. The authors of the paper have added a single parameter to the representation: the sharpness. Besides this, they use *hybrid subdivision*. The general idea is to use two sets of rules: one set for a finite, arbitrary amount of subdivision steps, followed by a set that use the subdivision limit. This allows the smoothness to only depend on the second set of rules. The rules for smooth and crease edges are shown in Figure 1a and Figure 1b respectively. By using infinitely sharp



(a) Smooth edge (b) Regular crease edge

Figure 1: Edge subdivision masks. Double lines denote sharp edges [2].

rules during the first few steps, followed by smooth rules for the ones after, we can obtain surfaces that are sharp at coarse scales (from afar) but smooth at finer scales (up close).

There are two main cases to consider.

Case 1 concerns a constant integer sharpness s crease. We use the infinitely sharp rules s times, then switch to the smooth rules. This means that every edge with $s > 0$ is subdivided using the sharp rules; the two subedges that result from this have a sharpness $s - 1$. When an edge has $s = 0$, we consider it smooth. In the case that $s \to \infty$, we use the sharp rules for all steps.

Case 2 covers constant, non-integer sharpnesses s. To solve this, we simply use case 1 on the floor and ceiling of s. Then, taking the ceiling as our starting point, we interpolate the positions. Taking $s \uparrow$ and $s \downarrow$ as the ceiling and floor respectively, and v_i as a vertex position:

$$v_i = (1 - \sigma)v \downarrow_i + \sigma v \uparrow_i$$

where $\sigma = (s - s \downarrow)/(s \uparrow - s \downarrow)$.

The case where the sharpness is not constant but varies along an edge is also covered, but outside the scope of this presentation. Refer to Appendix B in the paper[1] if you are curious!

References

[1] Tony Derose, Michael Kass, and Tien Truong. Subdivision surfaces in character animation. *Proceedings of the 25th annual conference on Computer graphics and interactive techniques - SIGGRAPH 98*, 1998.

[2] Hugues Hoppe, Tony Derose, Tom Duchamp, Mark Halstead, Hubert Jin, John Mcdonald, Jean Schweitzer, and Werner Stuetzle. Piecewise smooth surface reconstruction. *Proceedings of the 21st annual conference on Computer graphics and interactive techniques - SIGGRAPH 94*, 1994.