An Implementation of Halfedge Data Structure in Catmull-Clark Subdivision for 2-Manifold Single-sided Surface

Yu Wang

August 2015

1 Introduction

2 Halfedge Data Structure

An object in 3D Euclid space can be represented by a mesh of polygons. A mesh contains three types of geometry element: vertex, edge, and face. The adjacency structure stores the topological information (adjacency and connectivity) of the mesh. The author chose halfedge data structure as the adjacency structure in this project to realize Catmull-Clark subdivision.

2.1 Vertex, Halfedge, and Face

The definitions and assumptions of vertex, halfedge and face are shown in table 1. An example for a single face is shown in figure.

	Definition	Assumption
Vertex	A 3-dimensional point	There are no overlapping vertex in a mesh. But overlapping vertices can exist in other meshes.
Halfedge	An edge that starts from one vertex and end at another vertex	A halfedge connects exactly two non-overlapping vertices and it has a direction
Face	A polygon that contains a loop of vertices and halfedges	A face has at least three non-overlapping vertices so it makes a polygon

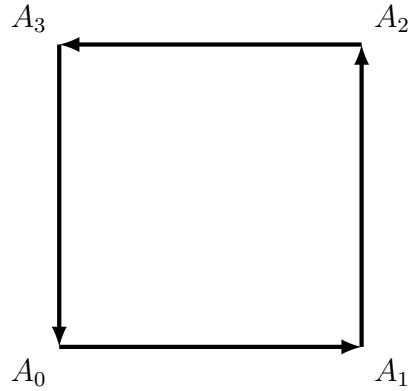Table 1: Definitions and assumptions of vertex, halfedge, and face

$$A_3 \qquad\qquad A_2$$

$$A_0 \qquad\qquad A_1$$

Figure 1: An example of single face made with four halfedges.

2.2 Face Connections

3 Catumll-Clark Subdivision

3.1 General Approach of Catmull-Clark Subdivision

3.1.1 Compute Vertex Positions of New Mesh

3.1.2 Make Connections of New Mesh

3.2 Sharp Crease and Boundary Feature

3.3 Mobius Connection

4 Offset Surface

4.1 Compute Vertex Normals

4.2 Positive and Negative Offsets

4.3 Mobius Connection Issue

5 Test Cases and Discussions

6 Contribution to Knowledge

7 Future Researches