Use of Splines in Creating Flexible Virtual Environments

Achal Oza and Ronald R. Mourant
Virtual Environments Laboratory, MIE Department
Northeastern University
mourant@coe.neu.edu

1 Introduction

Three-dimensional virtual environments can be tedious to create and change. Road networks and their associated terrain can be particularly difficult to model and modify because they are often defined using static elements which must be changed manually. We have implemented a roadway/terrain system based on 3-D splines. The splines can be turned into ribbons that represent roadways [Willesmsen, 2000]. These ribbons can be annotated with lane markings and roadway signs. The terrain can be decorated with vegetation. Changing the positions of spline control points changes the entire environment. Ribbons are associated with the terrain by using a height map as described below.

2 Creating Ribbons And Networks

A multi-lane highway can be generated based on a set of control points. First, a Catmull-Rom spline is fitted along them. Next, we find a parallel spline that is located some *r* distance away. These two curves are rendered as a triangular strip, as shown in Figure 1, and are textured accordingly, creating a road. A network is formed when various paths make reference to the same control points, as shown in Figure 4. Proper road geometry is generated when two paths connect to create a junction.

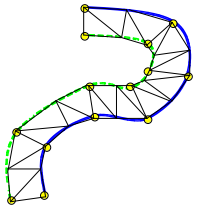

Figure 1: Converting a spline into a ribbon.

3 Modeling Associated Terrain

We create the terrain height map in two phases. First, we define height values for any cell that contains a road segment. This height is found by interpolating along the splines defining the road network. The remaining areas of the height map for the virtual environment are populated with a grayscale bitmapped image of a rendered cloud. A smoothing filter can be applied to prevent sharp transitions in terrain.

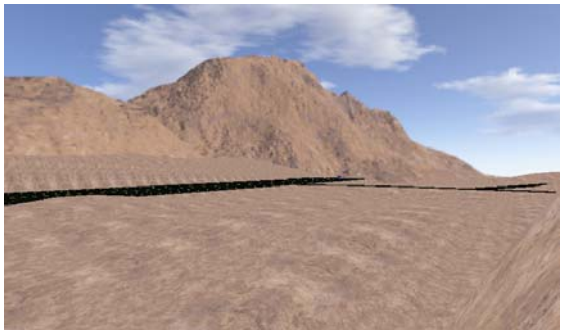

Figure 2: Terrain with heights from roads and the grayscale height map image.

4 Associating Vegetation With Terrain

Vegetation is placed using a curvilinear coordinate system that is based on the splines [Willemsen, et al. 2003]. Thus, the trees, plants, etc. are all positioned in relation to the nodes that make up the road networks. For a given node, we specify the type and density of the vegetation, and the perpendicular range to the road over which the vegetation will be staggered. This creates a more natural appearance.

Figure 3: Examples of ambient vegetation.

5 Autonomous Traffic

We propose autonomous vehicles that are event driven and contain three event related objects: the current event, the next event, and a queue of remaining events. An event may be of a variety of types: a start-path event, an end-path event, a rest period, a lane change, etc. Each contains a location and other pertinent information (the locations are described in curvilinear coordinates). A rest period event, for example, takes places at a specified *t* offset from a given node and will cause the vehicle to stop for a given duration. The vehicle forms a node traversal list containing the route the vehicle must travel along in order to visit each location in the event list, as shown in Figure 4 [Wang, et al. 2005]. The nodes for this list come from the various paths of the road network. One restriction on such a system is that given multiple paths between two locations, the shortest path will always be chosen.

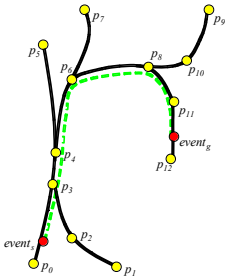

Figure 4: Road network with an autonomous traffic path.

6 References

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Willemsen, P., Kearney J., and Wang H. 2003. Ribbon Networks for Modeling Navigable Paths of Autonomous Agents in Virtual Urban Environments. In *IEEE Virtual Reality Conference*. 79-86.