A Tile/Scenario Algorithm for Real-Time 3D Environments

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1 Introduction

A basic technique used for viewing models of urban environments is tiling [Steed and Frecon 1999]. A large urban model can be partitioned into square tiles. Only an appropriate subset of tiles (based on where the viewer is looking) is loaded at a time. Large virtual driving environments have also employed tiles. The National Advanced Driving Simulator [Papelis et al. 2003] has a library of tiles than can be combined to form a drivable environment. Their tiles may consist of a city block, highway sections, etc. Our extension is to embed driving scenarios into tiles and to permit the generation of a random sequence of drivable tiles. A scenario is a situation designed to invoke a response by the driver of a user-controlled vehicle [Wu et al. 2005].

2 Embedding Scenarios in Tiles

Our tiles may contain roads, signs, trees, buildings, and autonomous objects (AOs) such as vehicles, pedestrians, and traffic control devices (traffic signals). A tile can also have triggers which are used to activate AOs. A trigger is represented by a circle whose circumference contains the activation point and the center of the AO being activated. If the user-controlled vehicle enters the circle, the AO is activated. Each AO has it own set of programmable behaviors. A lead vehicle is a special AO that the user is instructed to follow through the road network. The beginning and ending road segments of each tile is a standard two lane road designed to facilitate tile connections. Each title is enclosed by a circle in order to detect when the user-driven vehicle enters the tile.

3 Building the Database

An experimenter can enter a random sequence of tiles in a configuration file. The number of tiles depends on the complexity of the tiles and available RAM. Each tile has two properties: 1) offsets in X and Z from the tile's entry point to the tile's exit point, and 2) the angle between its entry point and exit point. We call this angle the tile's exit angle (EA). At load time, using properties 1 and 2, transformations are executed to create a drivable road network based on the sequence of tiles entered in the configuration file. In the virtual environment, the first tile in the sequence is placed at X = 0, Z = 0 with zero rotation, since the entry road of all tiles was designed to point down the negative z axis. The beginning location of the second tile is set to the first tile's offsets in X and Z. The second tile is rotated the number of degrees of the EA of the first tile. In general, for $i \neq 1$, the ith tile is placed at the cumulative offset of the previous tiles, and is rotated the number of degrees of the cumulative EAs of the previous tiles.

4 Detecting Tile Entry

The transformed values of the center point of a tile are used to detect if the user-controlled vehicle has entered a tile. If the location of the user-controlled vehicle is inside the tile's enclosing circle, the vehicle has entered the tile. At this time, we set the vehicle's position to X = 0, Z = 0 to avoid transforming trigger locations and positions of A0s.

5 Run-Time Tile Control

A maximum of three tiles are rendered at any given time. When tile i >= 3 in a sequence of tiles is entered by the user-controlled vehicle, tile i-2 is no longer considered, and tile i+1 is added. Note that all tiles are loaded at load time. The switching of what tiles to render is thus easily done in the main rendering loop. Figure 1 is a screen capture of the crosswalk scenario.

Figure 1: Is someone in the crosswalk?

6 Future Directions

One extension is to enable the vehicle to traverse the constructed drivable route in the reverse direction. This would entail additions to the database at load time, and defining triggers when traveling in the reverse direction. A second extension is to enable connections between tiles where the roads have elevation.

7 References

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