Interactive Procedural Street Modeling

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1 Introduction

This sketch presents a solution to efficiently model the street networks of large urban areas. Parish and Müller [2001] were the first to note that the street network is the key to create a large urban model. While this algorithm created a high quality solution, the method does not allow to incorporate user-control. To address this limitation we provide a rather different alternative to street modeling that allows to integrate a wide variety of user input. The key idea is to use tensor fields to guide the generation of street graphs. A user can interactively edit a street graph by either modifying the underlying tensor field or by changing the graph directly. This allows for efficient modeling, because we can combine high-level and low-level modeling operations, constraints, and procedural methods. The major contributions are as follows: (1) We are the first to introduce a procedural approach to model urban street networks that combines interactive user-guided editing operations and procedural methods. (2) We are introducing a new methodology to graph modeling in general. The idea of tensor-guided graph modeling together with the tight integration of interactive editing and procedural modeling has not been explored previously in related modeling problems, such as modeling of bark, cracks, fracture, or trees.

2 Methodology

Street Networks: We model a hierarchy of streets: *major roads* and *minor roads*. Major roads are typically major business roads and local highways, and minor roads are usually residential and back roads . We store a street network as a graph $G = (V, E)$ where V are a set of nodes and E are a set of edges. Nodes with three or more incident edges are *crossings*. We store attributes with nodes and edges, such as road width, road type, pavement markings, and the type of lanes. One of the most fascinating aspects about street graphs is the wide variety of different patterns. Our modeling methodology can handle several patterns, such as radial patterns, grid patterns, and crack like patterns, all with a wide range of regularity.

Street Networks as Streamlines of Tensor Fields: A dominant aspect of street patterns is the existence of two dominant directions. This observation inspired us to use tensor fields to guide the street placement. Tensor fields give rise to two sets of tensor lines: One follows the major eigenvector field, and the other the minor eigenvector field. Our solution to street modeling is to interactively create a tensor field that guides the road network generation. The user interface allows to place regular and singular elements in the tensor field, smooth tensor field transitions, paint directions with a brush like interface, and place discontinuities.

Work Flow: Our system employs a three-stage pipeline. First, terrain and population density maps are either procedurally generated, painted, or extracted from real data sets. Next, the user creates a tensor field on the the terrain using the editing tools provided by our system. At the end of this step, nicely-spaced major and minor tensor lines are generated according to the tensor field. These lines form a graph. Finally, the user can modify the graph. This graph can then be used as input to a procedural modeling tool to create three-dimensional geometry for roads, buildings, and vegetation.

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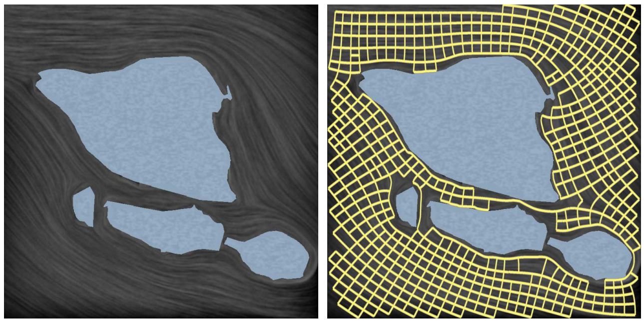

Figure 1: A user-designed tensor field (left) guides the generation of a street graph (right).

Results: Using a land / water map from a bay in San Diego we created a scene shown in figure 2.

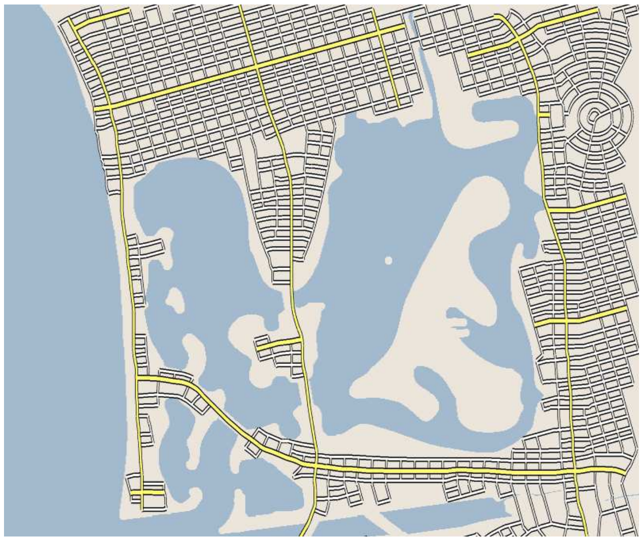

Figure 2: A street graph designed with our system. The street network includes a radial pattern, several regular pattern, noise, interaction with water and the coastline, and a two level street hierarchy.

References

PARISH, Y. I. H., AND MÜLLER, P. 2001. Procedural modeling of cities. In *Proceedings of ACM SIGGRAPH 2001*, ACM Press, E. Fiume, Ed., 301–308.