Interactive City Generation Methods (sap_0172)

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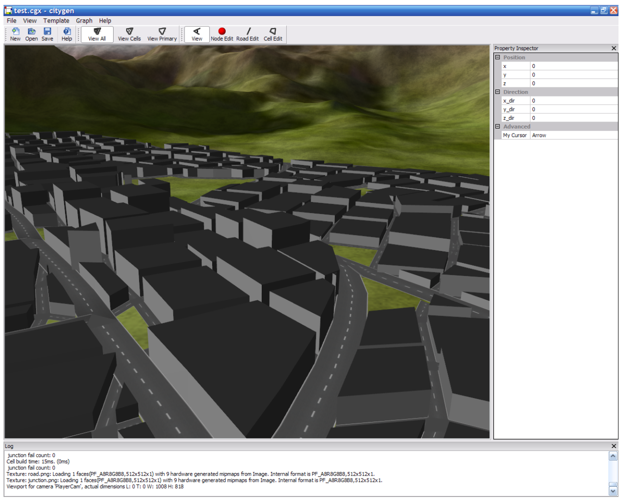


In this sketch we present an interactive real-time city generation system. The aim of such a system is to apply procedural techniques to rapidly generate detailed city models suitable for use in graphics applications. Most commonly, the underlying road network for the city is generated first and is used as a basis for positioning buildings and other features. Existing work includes CityEngine [Parish and Müller 2001] which uses geo-statistical image maps and L-systems to generate road networks. Other researchers have employed agent-based simulation of land use [Lechner et al. 2004], or templates encapsulating common road patterns [Sun et al. 2002].

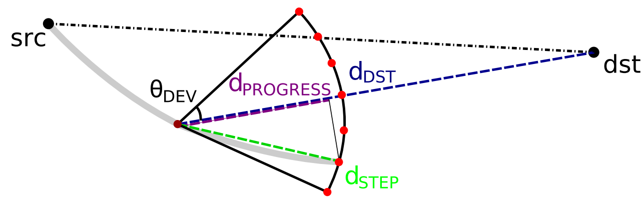
These techniques can produce good results but they rely on the existence of data sets which have to be imported and employ generation algorithms that are inefficient or difficult to control. Our approach is distinct in that we aim to provide accessible and intuitive controls to allow the user to guide the road network generation process in real-time. Another novel aspect is the use of an algorithm to generate adaptive roads that follow the topology of an underlying terrain model.

The primary road network is represented in the form of a graph that is mapped to the surface of the terrain model and whose nodes can be interactively manipulated by the user. These nodes represent intersections and the edges represent primary roads. Manipulations include dragging and dropping nodes, adding or removing edges, and loading new graphs. These manipulations take place within the context of a graphical interface which provides a real-time display of the terrain mapped road network.

A key feature is that all the edges in the graph are used to generate adaptive roads. This means that constraints are employed in order to force the road to follow the terrain on which is it situated. The user positions the nodes and the system plots roads between these nodes and does so in real-time providing immediate feedback. By fitting the road to the environment its validity is ensured along with realism, character and a sense of cohesiveness in the resulting network.

Roads are calculated by starting from a source point and sampling a set of control points at regular intervals to define the path to the destination. Each control point proposed travels a distance d_{STEP} and deviates from the direction of the destination point less than an angle θ_{DEV}. A set of possible control points is obtained from a fan of n evenly spaced samples which are distributed over an arc of degree $2\theta_{DEV}$

The ideal sample is one which has the closest ratio between distance covered and elevation as the total road ratio:



$$elevation_{STEP} \, / \, d_{PROGRESS} \;==\; elevation_{DEST} \, / \, d_{DST}$$

Successful road termination occurs when a sample is within d_{SNAP} of the destination point, this is guaranteed by ensuring $\theta_{DEV} < 45^{o}$ and $d_{SNAP} > d_{STEP} * \cos(\theta_{DEV})$. The resulting roads meander when necessary but not aimlessly and weave through hilly terrain finding even paths to ascend large elevations.

Primary roads generated in this manner form the boundaries of neighbourhoods or cells within the city. Accurate cell boundaries are extracted from the graph using a Minimum Cycle Basis (MCB) algorithm. The resulting data structures provide a cell adjacency graph suitable for use as a paging mechanism to facilitate real time rendering.

Secondary roads service the local area within cells by providing access to and from the primary road network. The construction of these roads is achieved using a growth algorithm similar to the L-systems found in the CityEngine [2001]. Generation is very efficient and takes place in real-time using a flexible algorithm that spreads over the cell surface in a parallel fashion similar to organic growth. Road construction is sensitive to existing infrastructure and new segments prefer to connect and extend existing roads. Each neighbourhood has a parameter set whose values are fed into the growth algorithm to control the generation process. This allows the user to create a range of road network patterns on a cell by cell basis and view the results in real time. Our algorithm can generate a range of different road patterns from the tightly controlled raster patterns typical of city centres to the loose meandering patterns of suburban development.

References

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