Interactive City Generation

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Overview

We present a procedural city generation system to create large scale road networks and realistic building models suitable for real-time rendering. Our research aims to make the procedural generation of urban geometry an intuitive process.

- **Accessible** – Input data such as geographical maps or geo-statistical data should not be required to use the system.
- **Interactive** - Generation can be fully autonomous but by allowing the user to interact with the city it can be tailored to specific requirements.
- **Real-Time** - A city model is a large data set and algorithms must be carefully selected to enable real-time feedback.

The generation is integrated into a single interactive application that provides all parameters and controls within easy reach for an accessible city generation workspace.

Adaptive Roads

The primary road network is implemented as a connected graph with nodes that can be used as control points to interactively manipulate the road network. These manipulations take place in a graphical interface that provides a real-time display of the adaptive road network.

Constraints are employed to ensure the integrity of the road graph and a sampling strategy is used to adapt the roads to the terrain. To edit the road network the user simply positions the control nodes and the system plots the path in real-time providing immediate feedback. By fitting the road to the environment a sense of cohesiveness is achieved in the resulting road network along with increased realism and character.

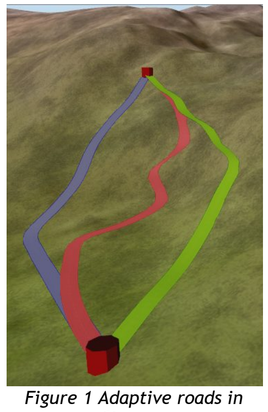

Figure 1 Adaptive roads in Citygen.
Blue - Minimum Elevation
Red - Least Elevation Diff
Green - Even Elevation Diff

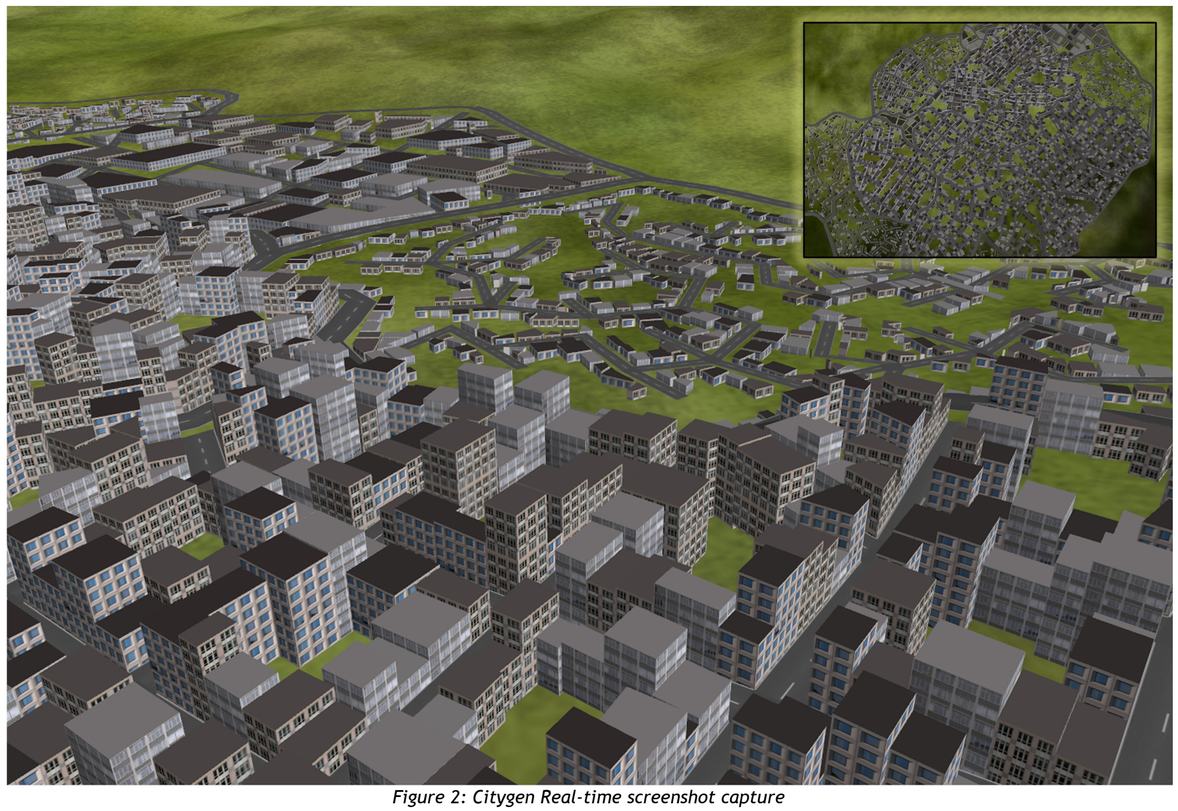

Figure 2: Citygen Real-time screenshot capture

Cell Extraction

City cells or neighbourhoods are formed from the closed loops of the primary road graph. To obtain the cells boundaries we extract the minimum cycle basis. The algorithm takes the position of nodes into account processing them by their xpos and finds the MCB using clockwise ordering.

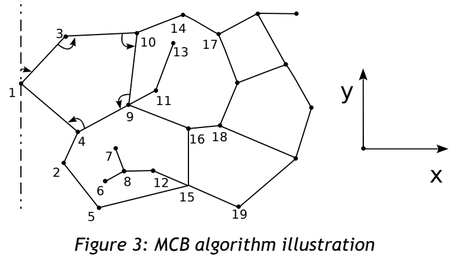

Figure 3: MCB algorithm illustration

Each cell is self-contained and requires only the boundary road and a small set of parameters to execute road generation.

Road Generation

Roads are generated using a growth based algorithm that constructs road networks with the aim of servicing land area. Road construction begins from the bordering primary boundary roads and terminates when no further beneficial roads can be added. Proposed road segments are refined using a smart snapping algorithm. If a segment intersects or is within a defined snap distance of a neighbouring segment it connects to that segment using an existing node if possible.

Parameters used to control road generation include:-

Segment Size, *Degree*, *Snap Size* and *Connectivity*.

Snap size alters the efficiency of the road network and the connectivity parameter controls the road network flow. A random seed is used and parameter deviances introduce relevant noise to the generation. The parameters are easily accessible and their effect can be viewed in real-time.

Lot Division

Enclosed regions of the primary and secondary road network are subject to a lot division process that extracts valid boundaries useful for building construction. The lot division algorithm operates on both convex and concave shaped lots and also supports the presence of filament roads. The algorithm works by subdividing each region into two or more lots and operates recursively until a target lot size is reached. Any lots that do not have road access are excluded.

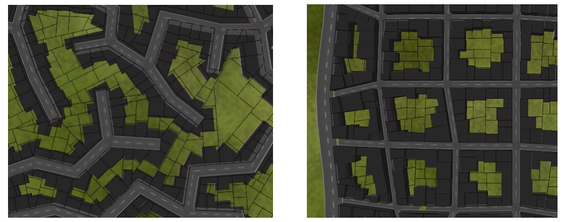

Figure 4: Lot Division on suburbia and down-town.

To increase the number of lots that are positioned perpendicular to their access road subdivision is prioritised along sides with road access.

Building Construction

Buildings can be placed on the identified lots created from the road generation. Hints are attached to each neighbourhood to indicate what class of building should be generated and how it is positioned on the lot. Down-town building make full use of lot space while suburban buildings retreat in from their road access side and also from each other.

An early prototype is under development to construct buildings with complex geometry. A parametrized shape grammar is used to construct ordered rule sets which perform recursive functions splitting high level building elements into low level elements. A building shell is generated by vertically extruding the lot polygon. Rules are applied in order to recursively generate the lower-level elements.

Figure 5: SG prototype

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