Maps of 3D Environments

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Problem and Motivation

Automatically-generated 2D maps are now commonly used. The problem of automatically generating maps displaying paths between two locations easily extends to 3D environments. Such maps may be useful for way-finding in complex architectural environments, such as the mock example from Tufte, below, of a map from a museum kiosk. A tool for generating maps of 3D environments would also be useful for other visualization tasks involving paths in 3D.

Developing a mostly-automated system for generating such maps with little user input and scarce semantic information beyond the raw geometry presents several interesting challenges: segmentation and analysis of the input, selection of a clear set of lines indicating the desired shortest path, selection and adjustment of the proper visualization parameters to produce a final static image.

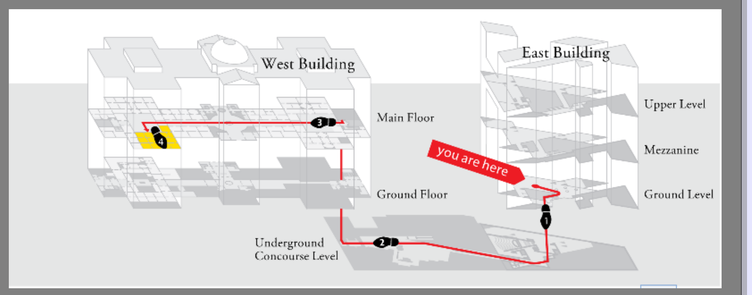


Image from E. Tufte, "Visual Explanations"

Future Work

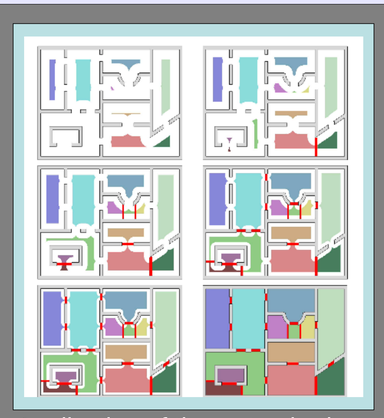
- Given the breadth of the system, there is much room for enhancement.
- Of high importance is further improvement of the generated roadmaps, which have no guaranteed quality. While the currently produced graph accurately represents room connectivity, its edges do not clearly express navigational cues. A force-directed approach might be applied to create the paths between nodes in the shortest path.
- Investigation into rendering styles that better depict the internal structure of buildings in the exploded views.
- Additional view parameters might be exposed to the optimization scheme and the energy function refined.

Approach

Room Segmentation

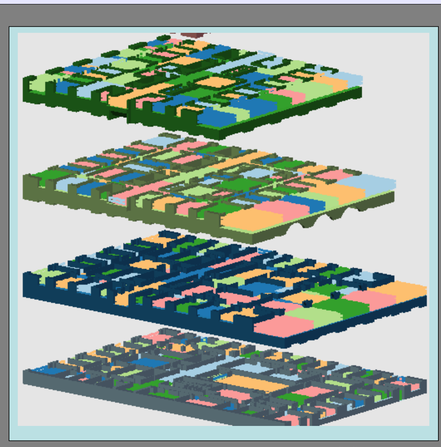
Given the environment geometry and the height of a navigating entity, the system begins by finding all potential rooms. A voxel representation is produced and a layer of 'walkable' voxels a certain distance above solid voxels are operated upon.

The watershed transform, the classical image segmentation algorithm, is performed on a distance map of these voxels, partitioning space and geometry roughly into rooms.

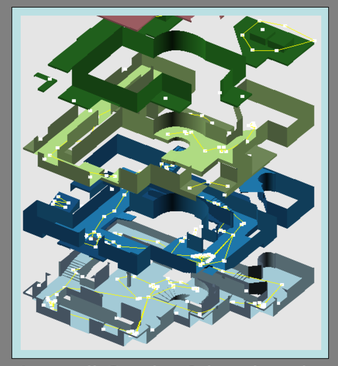


Application of the watershed transform in 2D.

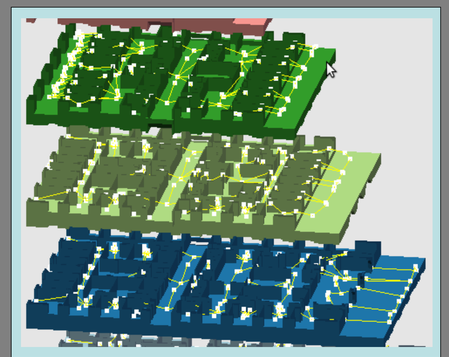
From Haumont et al., "Volumetric Cell-and-Portal Generation"



The resulting segmentation of four floors of Soda Hall



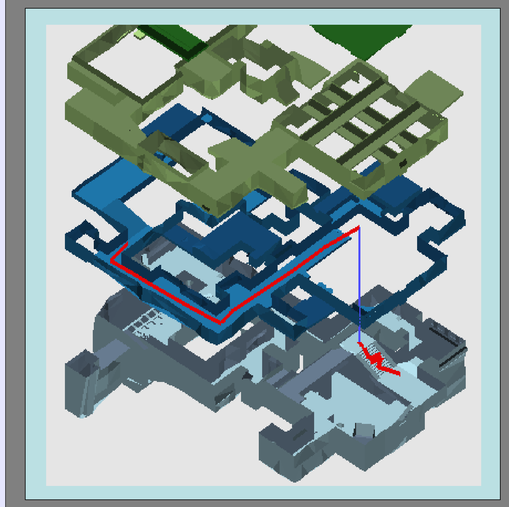
A small Quake 3 level and its roadmap

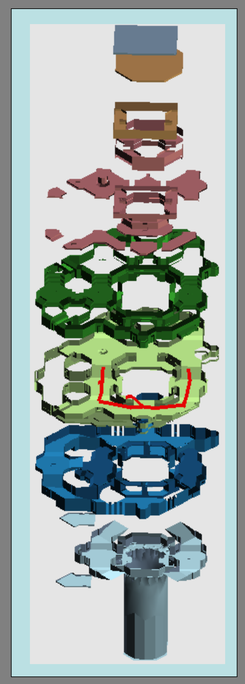


The Soda Hall model and its roadmap.

Roadmap Extraction

The distance map and the output of the watershed transform are used to create a graph of rooms and their interconnections. A node is placed at each regional maxima of the distance map. Nodes are then placed at the 'dams' of the watershed algorithm, connected to the node representing the room on each side.





Floor Segmentation

Niederauer et al.'s method of splitting architectural environments is used to select heights at which to split the structure to produce the final exploded view.

View Optimization

The final image is an exploded view of the structure from an axonometric view. Wherever the path is occluded by scene geometry, it is rendered with a dotted line style, and a thinner line connects the path between exploded floors.

The view direction and split distance are set by the application of a simulated annealing optimization algorithm. The energy function exacts a cost for occluded path pixels, deviation from the path corner angles from 3D to 2D, path self-intersections, and the area of the visualization.