Automatic generation of 3-d building models from multiple bounded polygons

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Based on building polygons or building footprints on digital maps shown in Figure 1, we propose a GIS and CG integrated system that automatically generates 3-D building models. A 3-D urban model as shown in Figure 2 is an important information infrastructure that can be utilized in several fields, such as, landscape evaluation and urban planning, and many other business practices. However, enormous time and labour has to be consumed to create these 3-D models, using 3D modelling software such as 3ds Max or SketchUp. In order to automate the laborious steps, we proposed the GIS and CG integrated system that automatically generates 3-D building models from building polygons on a digital map. As shown in Figure 1, most building polygons’ edges meet at right angles (orthogonal polygon). A complicated orthogonal polygon can be partitioned into a set of rectangles. The integrated system partitions orthogonal building polygons into a set of rectangles and places rectangular roofs and box-shaped building bodies on these rectangles. In order to partition an orthogonal polygon, we proposed a useful polygon expression (RL expression) and a partitioning scheme that is used in deciding from which vertex a dividing line (DL) is drawn. In this paper, we propose a new scheme for partitioning building polygons and for creating a complicated shape of building models based on orthogonal multiple bounded polygons.

Procedural modelling is an effective technique to create 3-D models from sets of rules such as L-systems, fractals, and generative modelling language. Müller et al.(2006) have created an archaeological site of Pompeii and a suburbia model of Beverly Hills by using a shape grammar with production rules. They import data from a GIS database and try to classify imported mass models as basic shapes in their shape vocabulary. If this is not possible, they use a general extruded footprint together with a general roof obtained by a straight skeleton computation (Aichholzer et al.,1995). The straight skeleton can be used as the set of ridge lines of a building roof, based on walls in the form of the initial polygon (Aichholzer et al.,1996).

Figure 1, Building polygons on a digital map
Figure 2, An automatically generated 3-D urban model
The roofs created by the straight skeleton are limited to hipped roofs or gable roofs with their ridges parallel to long edges of the rectangle into which a building polygon is partitioned. However, there are many roofs whose ridges are vertical to a long edge of the rectangle and these roofs cannot be created by the straight skeleton since the straight skeleton treats a building polygon as a whole and forms a seamless roof so that it cannot place individual roof independently on partitioned polygons. To create a various shape of 3-D roofs, building polygons are to be partitioned into sets of individual rectangles. The automatic generation system consists of GIS application (ArcGIS, ESRI Inc.), GIS module and CG module as shown in Figure 3. The source of a 3-D urban model is a digital residential map that contains building polygons linked with attributes data such as the number of stories and the type of roof (gable roof, hipped roof, gambrel roof, etc.). The GIS module pre-processes building polygons on the digital map. Pre-process includes partitioning orthogonal building polygons into sets of rectangles, generating inside contours for positioning walls and windows of a building. The CG module receives the pre-processed data that the GIS module exports, generating 3-D building models.

In case of modelling a building with roofs, the CG module follows these steps: (1) generation of primitives of appropriate size, such as boxes, prisms or polyhedra that will form the various parts of the house (2) Boolean operation on these primitives to form the shapes of parts of the house, for examples, making holes in a building body for doors and windows (3) rotation of parts of the house (4) positioning of parts of the house (5) texture mapping onto these parts according to the attribute received (6) copying the 2nd floor to form the 3rd floor or more in case of building higher than 3 stories.

In this paper, we propose a scheme of prioritizing the DL that cuts off a branch roof, based on the length of the DL. Since each roof has the same gradient in most multiple-roofed buildings, a roof of longer width is higher than a roof of shorter width and ‘probable multiple-roofed buildings’ take the form of narrower branch roofs diverging from a wider and higher main roof. By applying polygon partitioning algorithm, the system divides polygons along the thin parts of its branches. After being partitioned into a set of rectangles, the system places 3-D building models on these rectangles.

![Digital map](image)

**Figure 3. Flow of Automatic Generation for 3D Building Models**

**References**

