Rapid 3D Building Modeling by Sketching

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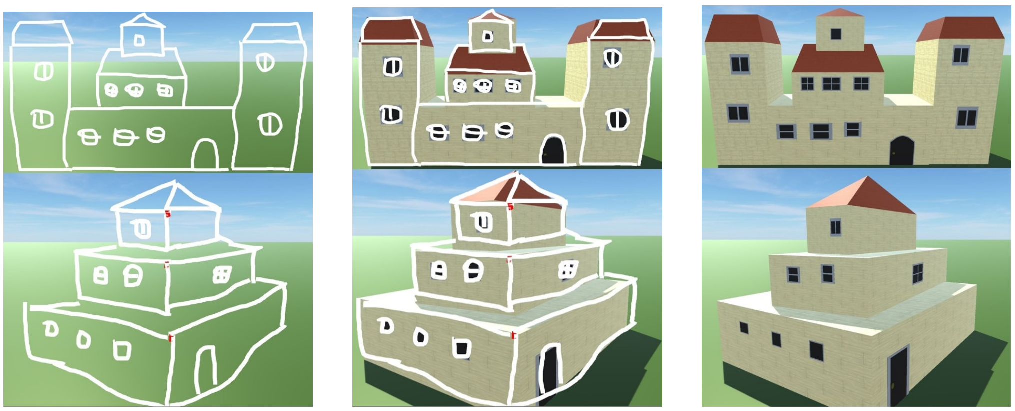

(a) Input sketches (b) Overlap (c) 3D models

Figure 1: Modeling 3D buildings from 2D sketch input.

ABSTRACT

This paper proposes an intuitive tool for users to create 3D architectural models through 2D sketch input. A user only needs to draw the outline of a frontal or oblique view of a building. Our system recognizes the parts drawn in a sketch and estimates their types. The estimated information is then used to compose the corresponding 3D model. Besides, our system provides additional assistant tools for rapid editing. The modeling process can be iterative and incremental. To accomplish a building complex, a user can gradually create their models from one view to another. Our experiment shows that the proposed interface with sketch analysis tools eases the process of 3D building modeling.

CCS CONCEPTS

• **Human-centered computing** → **Graphical user interfaces**; • **Computing methodologies** → **Shape inference**; **Shape modeling**.

KEYWORDS

sketch-based interface, sketch analysis, 3D architectural modeling, rapid prototyping

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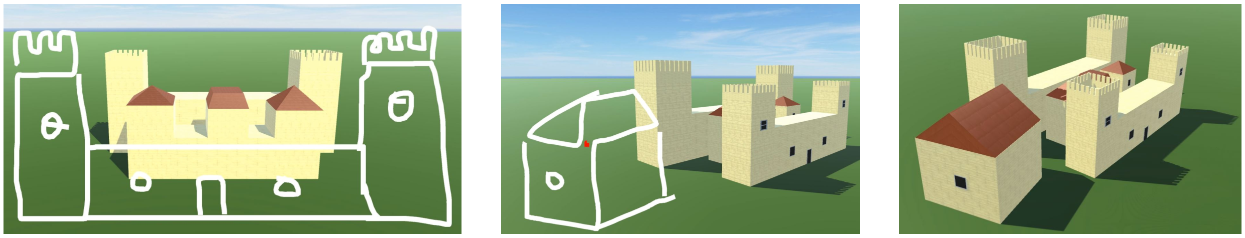
1 INTRODUCTION

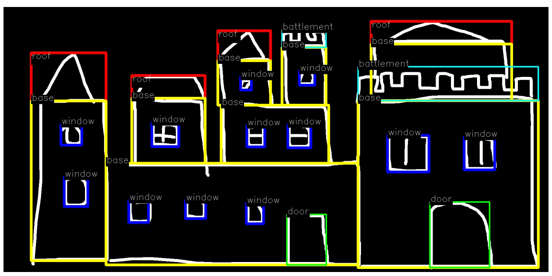
For a novice or amateur user, sketching is one of the most intuitive way to convey a 3D scene that she(or he) images. However, finding the association of a 2D sketch in 3D space is difficult due to its ill-posed and distorted lines. Igarashi and Hughes [2001] proposed inferring possible operations of users and demonstrated the results as small thumbnails for selection. Zheng et al. [2016] interpreted a sketch of a man-made scene as a labeling problem based on candidate planes annotated by users in the beginning. Nishida et al. [2016] used a convolutional neural network (CNN)-based approach and procedural models to interpret the user sketch. They decomposed the modeling process into multiple stages and users sketched building parts in certain order.

In this paper, we propose an interface with the help of recognition techniques as well. Instead of drawing parts step by step, a user using our system can outline a whole frontal or oblique view of a building with a touch screen, stylus or mouse. The proposed system then detects and decomposes the 2D line sketch into semantic parts, and uses a procedure-modeling method to compose a 3D building according to the estimated types and parameters of semantic parts. Figure 1 shows three examples of directly 3D modeling from sketch input.



(a) (b) (c)

Figure 2: The incremental design process of a building complex.



(a) Labeled part regions

Figure 3: The labeled parts and regions of an input sketch.

2 OUR APPROACH

There are three major stages for the proposed system to construct a 3D building model. Given a sketch of an entire view of a building, the first stage, part detector, identifies the categories and regions of parts within the sketch. The regions of these parts can overlap each other, and the strokes and structures drawn by a common user are usually distorted. To tackle these difficulties, we adapted the faster R-CNN [Ren et al. 2015] due to its efficiency and tolerance to distortion. After examining the positional properties of parts relative to the nearest base and parsing a structure grammar, we can obtain the hierarchical architecture of the building. The orientations of parts can be estimated through homography. An example of part region estimation is shown in Figure 3.

An essential issue of training is collection of an appropriate dataset. Since it is labor-intensive for users to draw various kinds of building sketches, we therefore enriched the dataset by both acquiring real sketches and generating synthetic training data. We collected 3D building models from online model depositories and rendered these models from different viewpoints. The Canny edge detector was used to extract edges from images as replacement for strokes drawn by users. To increase the diversity of the dataset and mimic user sketches, we further distorted the projected lines in images, irregularly scaled lines and regions in images, and added dot noise around the lines.

To have varied appearances, we define multiple appearance types for each category. The second stage is to classify the types of cropped regions from the first stage. Given the bounding box of a target part, we evaluate the intensity distribution along the vertical and horizontal directions, and use a decision tree classifier to distinguish the types. In the third stage, our procedure-based 3D modeler composes the 3D model according to these estimated metadata.

A friendly interface with tools, including alignment and repetition, is provided for model editing. Users can decorate their buildings by directly sketching on the generated 3D models, e.g. adding a window, balcony, etc. Our system also supports modeling in multiple steps. To design a building complex, users can first sketch one side of the building and gradually extend the model from different views. An example about incremental design process is shown in Figure 2.

Our experiments illustrate that the proposed sketch interface is easy to learn and can reduce the input overhead for users. We think the proposed system can be a complement to existing modeling tools. For instance, users rapidly generate prototypes with our sketch interface, and then they can carefully refine the details with other tools. In our future work, we consider incorporating patch composing techniques [Lee et al. 2018] to enhance the model details.

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