FEATURE-BASED PREDICTION OF THE INTERIOR LAYOUT OF BUILDINGS

KUI YUE AND RAMESH KRISHNAMURTI
School of Architecture, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA
kyue@andrew.cmu.edu, ramesh@cmu.edu

Abstract. A system using exterior observable features to predict the interior layout of those buildings, whose space and topology can be described by shape grammars.

1. Problem

It is not generally difficult for a human to roughly predict the layout of the interior of a building from observations of external or surrounding features such as entrances, windows, ornaments, decorations, etc, and more so, for familiar buildings. On the other hand, this is an extremely hard task for a machine to accomplish given present day technology.

The exact mechanism of human recognition remains unclear; yet, we may safely conclude that such ability has to rely on reasoning based on accumulated knowledge of the past. In the absence of such knowledge, for example, for an individual in an unfamiliar, say different cultural or vernacular, setting, it might still be difficult to guess the interior layout of the buildings or even the type of building. This is typical of the kind of problems encountered in building restoration and preservation activities.

As an illustration, when noticing a small window on the second floor of a house, we may guess that the interior room is a bathroom. An acceptable form of reasoning can be: Usually rooms on the second floor are bedrooms and bathrooms. Bedrooms typically have the larger windows. As the window in the example is small and it is on the second floor, we may guess that it belongs to a bathroom. This leads us to conjecture that if there are ways to provide a machine with necessary knowledge, together with algorithms to reason against feature inputs, the machine might be capable of prediction.

2. Research question

The proposed problem is extremely difficult in general, although it may be tractable for buildings that can be described by shape grammars (Stiny, 2006). A shape grammar is developed from a methodological examination of corpora of designs specified by a set of building characteristics. A general paradigm for shape grammar development is documented in the published literature — notable examples include Duarte (2005), Downing and

Flemming (1981), Flemming (1987), and Koning and Eizenberg (1981). These illustrate the capacity of a shape grammar to capture spatial and topological information in buildings. A shape grammar can be viewed as a form of computational representation of building knowledge. The research question then becomes, in particular, on which building features are needed, how to obtain and represent such features, how to modify existing shape grammars into a form that is appropriate for reasoning, and then to design an algorithm which can be applied to reason with such knowledge.

3. Approach

We adopt a 3-step approach with certain tasks handled in parallel. First, we assume availability of building features and develop the methodology and prototype on a control environment using a known grammar for buildings with known layouts. The focus here is to create appropriate data structures and algorithm to represent and reason with building patterns. Next, we aim to rid the assumption of a known grammar by designing a semi-automatic mechanism to generate building patterns from features, making it possible to dynamically create the desired patterns. This step will push the research a step closer toward practical use. Third, we target feature extraction based on prior knowledge in the form of building patterns. The input will be photo images with building patterns, with output, a set of building features.

4. Current status

We are working on manual derivation, preparatory to the computational algorithm. The test case is the Queen Anne House. We are exploring possible representations for features and estimated rooms to ensure that incompleteness is handled correctly. Roughly, the procedure is to first distinguish front and back, then determine the hallway, and lastly estimate the other rooms such as parlor, dinning room, kitchen, etc, that usually surround the hallway. Common building knowledge have proved helpful, e.g., typical ratio of a room, common thicknesses of walls, and possible axes of symmetry associated with features such as doors, windows, chimney, etc.

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