Constructing Geometric Regularity underlying Building Facades
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Geometric Regularity

Geometric regularity constitutes a basis for designers to initiate the formulation of building shapes and urban forms. For example, Le Corbusier considers the regulating line “an inevitable element of architecture” and uses it as a “means” for understanding and creating good designs. Thomas Beeby argues that the acquisition of knowledge on geometric construction plays a crucial role in the education of architecture design. This paper illustrates a computational approach to constructing the regularity of architectural geometry. The formal structure underlying a single façade and continuous facades are examined (Figure 1).

Façade Composition

The composition of façade has, for a long time, been an important subject of study in architecture. Nevertheless, most of the current studies related to this subject focus on the problem of a single building or style. To make a greater contribution to the design of architectural façade within an urban context, it is insufficient to take into account only the compositional properties of an individual façade or façade style. Rather, the significance of the relations between facades ought to be recognized. Moreover, due to the advance of computers and mathematics, it is possible to employ new techniques to investigate the geometric problem of façade composition in greater detail.

Framework of Analysis

This study proposes a concept of global context to explore the composition of a set of continuous facades. The term global refers to the overall structure of the continuous facades, and local context is used to denote the partial composition of the structure. A set of continuous facades is acquired through the linear arrangement of a number of single facades. Thus, the framework of analysis can be described as three levels of composition: (1) global context; (2) local context; (3) single facade. The morphological information regarding global and local contexts is derived through the computation of the basic elements of the single facades. The elements can be classified into two types: Frame and Infills. The frame is defined by an overall shape and vertical/horizontal dividing lines which represent columns/beams. Infills are openings (windows,
doors), balconies, and roofs. Corresponding to these elements, four shape grammars are established to describe the composition of a facade systematically.

**Automatic Clustering**

Based on the aforementioned framework, a computer program named FADS (Facade Analysis and Derivation System) is developed. FADS is written in AutoLisp under the environment of AutoCAD. Seven agglomerative hierarchical methods of cluster analysis are implemented in the program. They are Single-Link, Complete-Link, UPGMA, WPGMA, UPGMC, WPGMC, and Ward’s Method. To test the performance of FADS, two types of street facades of Taiwan are employed as case studies. They stand for formally **homogeneous** and **heterogeneous** urban contexts, respectively. The first type, selected from LuKang city, consists of 14 facades with similar style. As shown in Figures 2, the analytic result is made up of 3 drawings which depict the **rhythms** underlying the layers of frame, opening and balcony. In comparison, the homogeneous structure exhibits much more regular rhythms than the heterogeneous does.

**Symmetry and Regulating Lines**

In addition to the agglomerative hierarchical methods, FADS also incorporates algorithms which are developed for computation of symmetry and search for regulating lines. As shown on the left-hand side of Figure 3, the axes of symmetry at various levels of depths can be uncovered through the application of the algorithm of symmetry. The result of the application of FADS to the computation of symmetry and the search for the regulating lines underlying the street facades of LuKang is shown on the right-hand side of Figure 3.

**Extensible Constructing**

It is observed that many implicit geometric properties of façade composition can be uncovered computationally. Morphological attributes such as **axiality, symmetry, proportion** (shown as regulating lines), **rhythm, ratios of solid and void** can be represented graphically. The analytic drawing which consists of various layers of drawings can appear as a whole in terms of global context. In contrast, each analytic drawing corresponding to a local context (e.g. rhythm of openings) can also appear as an isolated layer. Moreover, the final geometric guidelines is a suggestion of FADS for the design of a new facade. These analytic results may constitute a useful visual structure for designers to understand the existing urban formal context and, based on the structure, to create new building forms.
Last but not least, FADS is designed as a flexible system which allows further addition and/or deletion of subsystems. For example, a roof grammar may be defined and added to the current system to increase the capability of FADS in dealing with the problem of urban skyline. It is also clear that the same techniques and algorithms can be applied to the study of plan composition. Note that the geometric analysis can be tedious and error-prone if done by hand. It is thus suggested that FADS be further developed toward a comprehensive, computational tool for constructing the regularity of architectural geometry.

References


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