

# **BUILDING FACADE DESCRIPTION SYSTEM AND HISTORICAL FEATURE ANALYSIS METHOD BY ROUGH SET THEORY AND ALGORITHMIC LANGUAGE: A CASE STUDY ON THE TRADITIONAL ARCHITECTURE AND SETTLEMENTS IN GUNANJIE STREET, YIXING, CHINA**

WANG Xiao<sup>1</sup>, TANG Peng<sup>1</sup>, SHI Xing<sup>1</sup>

<sup>1</sup> *Southeast University, China*

*Member of Key Laboratory of Urban and Architectural Heritage Conservation, Ministry of Education, China*

**Keywords:** traditional architecture and settlements, conservation, building facade, historical feature, digital generation, Rough Set Theory, Processing

## **Introduction**

Considering the existing problem in the implementation of the conservation planning of traditional architecture and settlements' features in China, significant practicability and operability are still expected. As same as other historic districts with pressing demands for renovation, Gunanjie Street, in Yixing, China, is also facing a huge gap between general design and detailed implementation of the conservation planning.

This study focused on the approach to format a reasonable guideline in an objective perspective. In research, a new building facade description and evaluation system has been developed by using the intelligent information data technology to code and describe the morphological features of historical characteristic as the database and using the data mining to extract rules of traditional facade elements and their combination modes. Accordingly, the referable facades were generated by program. Meanwhile, the total cost of renovation could be calculated automatically based on morphological features with corresponding constructions, materials and labor charges, contributing to establish the acceptance evaluation and compensation decision [1].

The current researches of heritage conservation have applied Rough Set Theory and programming to morphological analysis and design as tools [2], [3], [4]. Especially in building surface and performance, programmable tools were used more frequently. The innovation of this study is combining knowledge discovery with generative design by a digital link to explore the solution for the problems mentioned above.

## **Main Methods and Tools**

1. Questionnaire survey was used to attain the judgement of buildings. The data collected was analyzed as the basis of sensibility evaluation.
2. Rough Set Theory is one of powerful tools to deal with fuzzy uncertainty applied to various fields, especially in data mining and machine learning [5]. It was employed to discovery knowledge and extract characteristics and rules of traditional facade and historical feature in this study.

3. Processing is an open-source programming language widely used for digital art and visual design [4]. Considering its superiority of graphic processing, the generation program in this study was written in Processing.

## Research Process

### 1. Present Status surveying and mapping

Each house on the street was photographed and the whole street facade images were built by splicing the photographs through surveying and mapping (Fig. 1).



Fig. 1: A part of mosaic street facade

### 2. Sensibility evaluation employing Rough Set Theory [2], [3]

48 samples were selected to represent all buildings, presented in the questionnaire for traditionality assessment investigation to respondents with and without an architectural background (Fig. 2). At the meantime, the facade was decomposed in to variety of elements and combination modes [6], [7], [8], coding for an evaluation form with survey result (Fig. 3). In other word, the facade was described by coding matrix, which can be learned by computer (Table 1). Then, the coding matrix would be calculated to induce decision of problem by knowledge reduction and rule mining based on Rough Set Theory, which can extract rules of traditional facade elements and their combination modes (Fig. 4) [5].



Fig. 2: Questionnaire



Fig. 3: Facade elements



Fig. 4: Rough set calculation software interface

Table 1: Evaluation result of facade traditionality

编号 (No.)	条件属性 (Conditional Attributes)														整体结构 (Monolithic Structure)	决策属性 (Decision Attributes)		
	屋顶 (Roof)		一层 (1st Floor)				二层 (2nd Floor)			其他要素 (Other Elements)								
	屋顶形式 (Roof Material)	屋顶材料 (Roof Style)	墙基材料 (Wall Base Material)	墙身材料 (Wall Material)	墙面开洞 (Window/Door Holes)	门 (Door)	窗 (Window)	墙身材料 (Wall Material)	墙面开洞 (Window/Door Holes)	窗 (Window)	阳台 (Balcony)	栏杆 (Handrail)	女儿墙 (Parapet)	批檐 (Eave)	雨棚 (Canopy)			
1	r1	t1	j2	m1	x1	d5	w2										z1	0
2	r1	t1	j2	m1	x1	d1	w3										z1	1
3	r1	t1	j2	m1	x1	d1	w6										z1	1
4	r2	t1	j2	m1	x1	d7	w12						k1				z1	0
5	r1	t1		m1	x1	d2	w9								c1		z1	1
...																		...
44	r1	t1	j1	m2	x1	d3	w7	n2	y16	w1							z4	0
45	r1	t1		m1	x11	d3	w1	n2	y16	w10				p1			z4	0
46	r1	t1		m2	x12	d4	w11	n2	y5	w10							z6	0
47	r1	t1		m1	x13	d1	w2	n5	y15	w9							z5	1
48	r1	t1		m1	x14		w5	n8	y15	w1					c1		z4	1

### 3. Digital generation by programming based on Processing [4]

Through programming in Processing development environment, present facade status drawn in 3dm format could be read by layer to further processing (Fig. 5). Redundancy elements could be eliminated and expected traditional elements could match in appropriate locations according to rules at present. The generation result after optimization could be used as referable facades in the guideline (Fig. 6).



Fig. 5: Processing software interface with generative facade



Fig. 6: A part of referable facade

### 4. Repair cost automatic calculation according to construction and details

Because each facade element corresponds to a construction technology and cost accordingly, total cost could be calculated automatically during the generation process, which helps to acceptance evaluation and compensation decision.

### 5. Guideline compilation [9], [10]

## Discussion

It should be noted that this study is still primary, some deliberations still needed. Firstly, for example, more samples are needed. Secondly, elements classification must be objective and recognized according to local tradition and features. In addition, more functions and code optimization of generation program are expected. What's more, some other effective algorithms also could be used in the future. And the relationship between guideline and policy in social perspective is also a possible direction of further research.

## Conclusion

This study aims to establish a building facade description system and historical feature analysis method by using Rough Set Theory and Processing. The procedure and result can be used as a relative universal tool in guideline compilation, acceptance evaluation and compensation decision, expected to improve the serious situation of historical districts conservation in China.

## References

- [1] TANG Peng, LI Xinjian, KYOTO'S POLICY ON PRESERVATION DISTRICTS FOR GROUPS OF HISTORIC BUILDINGS, *Architecture & Culture*, No.125, pp.170-175, 2014. (In Chinese)
- [2] Saito, A., Minamoto, J., & Matsushita, D. Study on Description Methods for Concept of Traditional Facade by Employing Ontology : A case of Sanneizaka preservation district for groups of historic buildings(New Frontiers of Architecture and Urbanism in Information Driven Society)[J]. *総合論文誌 [Comprehensive Dissertation]*, No.4, pp.101-105, 2006. (In Japanese)
- [3] Saito, A., Munemoto, J., & Matsushita, D. Study on Inference of Combination Rules of Form Elements by Sensibility Evaluation Employing Rough Set Theory: A case of Sanneizaka preservation district for groups of historic buildings. *J. Archit. Plann.*, AIJ, No.594, pp.85-91, 2005. (In Japanese)
- [4] LI Biao, *Architectural Generative Design: Searching for CAS-Based of Generative Art in Architectural Design*, Southeast University Press, Nanjing, 2012. (In Chinese)
- [5] PANG Jifang, Research on Method of Knowledge Acquisition Based on Rough Set Theory. Master thesis: Hefei University of Technology, 2013. (In Chinese)
- [6] CHENG Haoran, the Inheritance and Protection of the Construction Process of the Traditional Settlements: Case Study of Ancient South Street, Yi Xing, Jiang Su Province. Master thesis: Shanxi University, 2006. (In Chinese)
- [7] QIAN Cen, Research of the Construction Technology of Traditional Architecture in Southern Jiangsu Taking Ancient Villages in Suzhou Dongting Dongshan and Xishan as an Example. Master thesis: Jiangnan University, 2014. (In Chinese)
- [8] YAO Chengzu, ZHANG Zhigang. *Construction Method*. China Building Industry Press, Beijing, 2009. (In Chinese)
- [9] *PRACTICAL CONSERVATION GUIDELINES FOR TRADITIONAL COURTYARD HOUSES AND ENVIRONMENT IN THE ANCIENT CITY OF PINGYAO*, United Nations Educational Scientific and Cultural Organization (UNESCO), Paris, 2015. (In Chinese)
- [10] *CONSERVATION MANAGEMENT GUIDELINES FOR TRADITIONAL COURTYARD HOUSES AND ENVIRONMENT IN THE ANCIENT CITY OF PINGYAO*, United Nations Educational Scientific and Cultural Organization (UNESCO), Paris, 2015. (In Chinese)