

A STUDY OF THE CHARACTERISTICS OF TRADITIONAL ROW HOUSES' FACADE IN THE ALLEY IN KARAHORI, OSAKA, JAPAN APPLYING INDUCTIVE LOGIC PROGRAMMING

Yuna Tanaka¹, Shigeyuki Okazaki¹, Noritoshi Sugiura¹

¹ Mukogawa Women's University, Japan

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Introduction

In this study, the characteristics of row house facades in the alley in Karahori, Osaka, Japan are analyzed using Inductive Logic Programming (ILP) [1], machine learning system that executes inductive reasoning. Traditional row houses, built during the Taisho period (1912 - 1926), populate this area (Fig. 1). The area is notable for its individual townscape of various "expression objects," such as plantings and furniture that are placed along the alleys and used in the everyday lives of the inhabitants. It has been reported that the 2-D configuration rules of the elements in the traditional building facades were described [2], but very few attempts have been made at finding rules of 3-D composition of them. In this study, we define the facade as a 3-D model to include the concept of depth and extract the 3-D composition rules of facade.

Methods



Fig. 1: View from the point of V

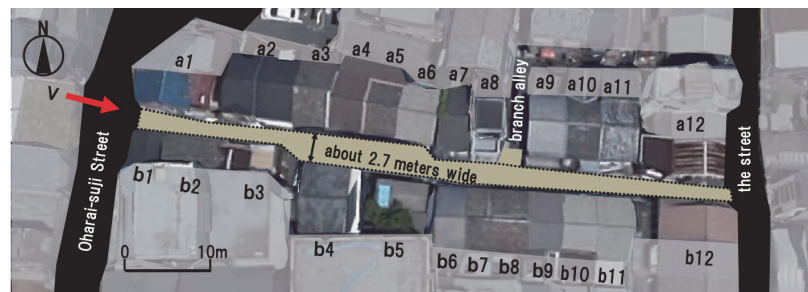


Fig. 2: Satellite image of the site in analysis Satellite image [3]

We focused on the alley that had the greatest number of expression objects, as determined during a field survey. This alley is connected to Oharai-suji Street, which contains many traditional row houses. We analyzed 24 of the houses facing this alley (Fig. 2) and the breakdown of 24 houses is as follows: 3 detached houses (a8, b4, and b5), one middle class apartment (b3), and 20 traditional row houses (a1 - a7, a9 - a12, b1, b2, and b6 - b12).

Our analysis consisted of the following steps: [STEP1] We created elevations of the houses and extracted the building and expression elements that constitute their facades (Fig. 3). We further defined two types of relations: relations on the vertical plane and relations in the depth direction (Fig. 4). [STEP2] Using this data, we assembled 3-D models with computer-aided design (CAD) (Vectorworks 2010). [STEP3] The 3-D models' data were converted into Prolog descriptions (Figs. 5 and 6) by an extension program for Vectorworks that we designed to recognize the relations between elements. [STEP4] These descriptions were input to Progol (ALEPH ver.5) [4], an ILP system, to induct the rules that express

peculiar characteristics of the facade. Input data to Progol consists of positive examples, negative examples, and background knowledge. Each element is regarded as an example to be used for inductive reasoning. Each element type and relation between elements is inputted as background knowledge, constituting an “is-a hierarchy” based on the inclusion relation (Figs. 3 - 6). The elements of one side of two adjacent houses were set as positive examples and the elements of the other house were set as negative examples. Progol constructed the rules that are true on the positive examples and false on the negative examples from these data. [STEP5] The rules were inducted by converting the positive and negative examples (Fig. 7). [STEP6] The above steps (STEP1 - 5) were applied to each house. We call the rules found by comparing to an adjacent house “primary rules.”

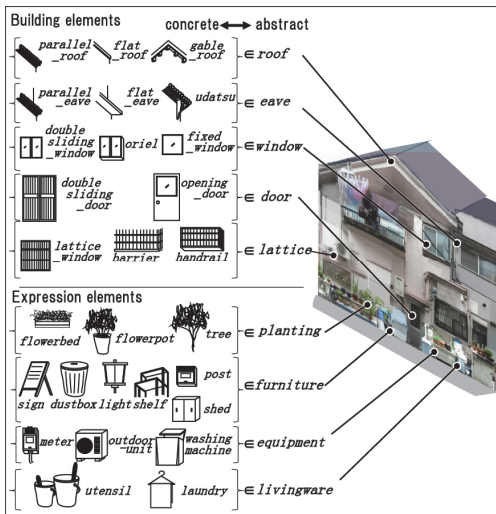


Fig. 3: Types of elements of facade

		Relation between elements on the vertical plane															
		adj_h				adj_v				detached_h				detached_v			
Description		_ub	_u/b	_m	_s	_lr	_l/r	_m	_s	_ub	_u/b	_m	_s	_lr	_l/r	_m	_s
Relation in the depth direction	same plane																
	cover																
Relation between elements in the depth direction	touched																
	close plane																
		extension_h				extension_v				corner				overlap			
Legend		-v : vertically -h : horizontally -ub : top and bottom alignment -u/b : top or bottom alignment -lr : right and left side alignment -l/r : right or left side alignment -m : out of alignment -s : out of alignment -bs : back face and foreground face alignment -os : back face or foreground face alignment															

Fig. 4: Types of relations between elements

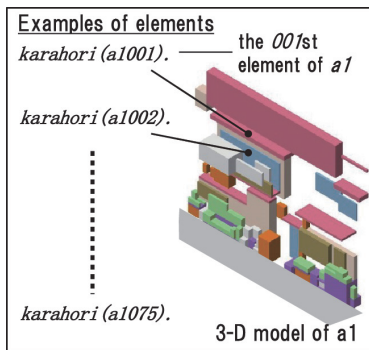


Fig. 5: Descriptions of examples

Types of elements type(a1001, flat_eave). type(a1002, doublesliding_window).	— Type of a1001 is a flat_eave. — Type of a1002 is a double sliding_window.
Types of relations relation (a1001, detached_v_m, cover, a1002).	— Relation between a1001 and a1002 is detached_v_m (on the vertical plane), and cover (in the depth direction).
Is-a hierarchy of elements type(X, doublesliding_window):- type(X, window).	— a double sliding_window is a window.
Is-a hierarchy of relations relation(X, detached_v, A, Y):- relation(X, detached_v_m, A, Y).	— detached_v_m in relation between X and Y is detached_v (on the vertical plane).

Fig. 6: Descriptions of background knowledge

	Description of primary rules	Meaning the rule	Examples covered by the rule
a1 Positive examples a2 Negative examples input to Progol	Rules of a1 karahori(A):- relation(A, detached_v, close_plane, B), relation(B, detached_v, touched, C), type(C, utensil). ⋮	Relation between A and B is detached_v (on vertical plane), close_plane (in depth direction), Relation between B and C is detached_v (on vertical plane), touched (in depth direction), Type of C is a utensil.	
Negative examples Positive examples	Rules of a2 karahori(A):- relation(A, detached_v, cover, B), type(B, roof_hirairi). ⋮	Relation between A and B is detached_v (on vertical plane), cover (in depth direction), Type of B is a hirairi_roof.	

Fig. 7: The primary rules by comparing a1 with a2

Results and Discussion

The results of our analyses are shown in Fig. 8. The primary rules extracted from each house were arranged in order of high coverage. Coverage is defined as the ratio of positive examples covered by the rules to the total number of positive examples [1]. In comparison with the left side and comparison with the right side, we found some of the exact same rules. We call these “individual rules” that strongly express the individuality of the house.

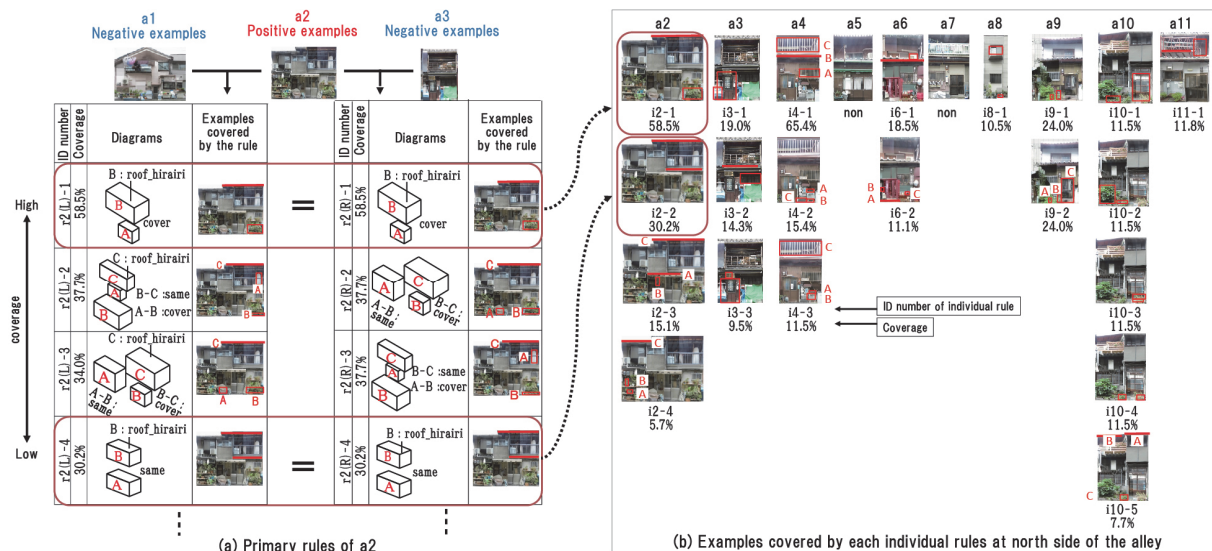


Fig. 8: Results of the analyses using Progol

The primary rules with the highest coverage in the houses that are on both ends of the alley are regarded as individual rules exceptionally. In this paper, we focus on the individual rules with the highest coverage and try to interpret them. Figure 9 shows our interpretation summary.

(1) Comparison of the total number of individual rules

The traditional row houses (a2 - a4, a9, b2, b7, b9, and b11) and the detached house (b4) have over three individual rules. The detached house (b4) has many individual rules because it has many expression elements. We can conclude, therefore, that most traditional row houses have many individual rules.

(2) Trend in relations in the depth direction between elements

Most of the houses (a8, a9, a11, a12, b1-b3, b7, b9, b11, and b12) refer to the relation in edge alignment between elements. In contrast, four traditional row houses (a1 - a4) located close to Oharai-suji Street have different types of relations that are out of alignment between elements. We therefore conclude that the rules of the traditional row houses refer to different types of relations in the depth direction between adjacent houses.

(3) Trend in relations on the vertical plane between elements

The rules of houses a1, a2, a4, a6, a8, b1, b2, b3, b4, and b7 refer to the relations in the vertical direction, such as “detached_v.” In contrast, the rules of houses a9 - a12, b9, b11, and b12 refer to relations in the horizontal direction, such as “detached_h.” Thus, conclude that the two groups divided by a branch alley have different types of regularity; that is, the west and east side groups have rules regarding the relations in the vertical and horizontal direction, respectively.

(4) Characteristic area of the alley

Four traditional row houses (a2 - a4 and b2) located near Oharai-suji Street have many individual rules. Furthermore, one of the individual rules marks the highest coverage in each case. This area is therefore the most characteristic part of this alley.

the total number of the individual rules		many individual rules (over 3 rules)				many individual rules (over 3 rules)								
		1	4	3	3	0	2	0	1	2	5	1	1	
Contents of individual rules	the highest coverage	45.3%	the highest of all primary rules				—	18.5%	—	10.5%	24.0%	11.5%	11.8%	28.6%
	relation between elements in the depth direction	different types of relation between adjacent houses				—	cover	—	same types of relation			same types of relation		
	relation between elements on the vertical plane	regularity of vertical direction				regularity of horizontal direction								
		close plane / touched	cover	touched	cover	—	cover	—	same plane	same plane	close plane	same plane	same plane	
		detached_v	detached_v	overlap	detached_v	—	adjacent_v	—	detached_v	detached_h	adjacent_h	detached_h	detached_h	
facade of north side														
alley														
facade of south side														
Contents of individual rules	relation between elements on the vertical plane	regularity of vertical direction				regularity of horizontal direction								
	relation between elements in the depth direction	same types of relation				same types of relation								
	the highest coverage	27.4%	the highest of all primary rules				—	—	23.1%	—	24.0%	—	12.5%	55.9%
the total number of the individual rules		1	5	1	3	0	0	3	0	5	0	3	1	

Fig. 9: The characteristics of the facade

Conclusion

In this study, we found the characteristics of peculiar rules of the building and expression elements of traditional row houses in the alley in Karahori, Osaka using ILP. We made the following findings: (1) most traditional row houses have many individual rules; (2) traditional row houses (a1 - a4) have rules that refer to 3-D composition in relation to the depth direction; (3) the two groups divided by a branch alley have different types of regularity in relation on the vertical plane; and (4) traditional row houses (a2-a4 and b2), which are located close to Oharai-suji Street, are the most characteristic of the alley.

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