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The Analysis of the Characteristic of Composition Elements for the Traditional Townscape by Inductive Logic Programming: Focusing on Bamboo Blinds in the Gionshinbashi District

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Abstract: The purpose of this study is to analyze the characteristics of each facade of all buildings on both sides considering having bamboo blinds or not along the Shinbashi-dori Street in the Gionshinbashi district. Composition elements are described in 4 attributes; types, position on the facade, color, and form, which is expressed in first order logic. The rules of the elements were extracted in whole facade on each side by ILP. Followings findings has been made about the characteristics of the rules on both sides: [1] the facade on the north side are composed with various types of composition elements, in contrast to it, the facade on the south side are composed with architectural composition elements having the horizontal regularity of the size for the entire frontages of buildings with their uniform color with bamboo blinds, and [2] on the north side with their characteristic variety of form, in contrast to it, on the south side with their uniform color without bamboo blinds.

1. Introduction

The Gionshinbashi district represents a historically valuable townscape and has long been designated a traditional architecture preservation district (Figure 1). There are many traditional tea houses built from the late Edo period to the early Meiji era frequently, the townscape of Gionshinbashi district were highly refined in terms of architectural design. For the preservation and revitalization of the traditional townscape, we need to grasp how the characteristics of the townscape is formed by architectural composition elements such as roofs and windows, and arrangements such as bamboo blinds comparing to other districts or in the same district. Furthermore, to grasp the characteristic of the building original appearance which took off a bamboo blind as well as such a facade of the bamboo blind is considered to connected for the acquisition of the knowledge about the preservation of the building in Gionshinbashi district. Therefore, the purpose of this study is to analyze the characteristics of facades of buildings to clarify the differences between the both of characteristics on both sides of Shinbashi-dori Street in Gionshinbashi district considering having bamboo blinds or not.

Figure 1. View of the Shinbashi-dori Street

In this study, we use Inductive Logic Programming[1] (ILP) for analysis. ILP is machine learning system based on expressive first-order logic that executes inductive reasoning and generalizes of results from a large quantity of examples with various and complicated attribute information to generate new concepts comparing the two groups of examples. We regarded characteristics of the townscape are ascertained referring to roofs, openings, and all other architectural composition elements making up existing townscape, as well as arrangements of plants and decorations, as individual "composition elements," and deconstructed buildings into basic units of these elements.

Many past studies have dealt with the townscape of Kyoto, including the Gionshinbashi district. In a study by Monnai, symbols marking the townscapes were systematized from elevations of the traditional townscape of Kyoto, and then a database was built describing how they were related. Furthermore, this database was used to quantitatively analyze similarity and diversity in the distribution of symbols in the townscape. In addition, in a study by Saito, ILP was used in a similar to this study to establish the method for deriving the configuration rules of form elements in traditional facades after landscaping, in the Sanneizaka district to compare elevations of facades before and after landscaping was analyzed. These studies attempted to ascertain the characteristics of elements in elevations, and the premise that the townscapes were ones in which bamboo blinds had been hung. Consequently, the elements of facades in the overall facade did not include a concept of depth.

However, actual townscapes are formed in three dimensions by such as the overhanging of eaves and lattice windows on the street side. Thus, to ascertain the characteristics of townscapes spatially is important, accounting for the actual appearance of buildings hidden behind bamboo blinds. Based on the previous studies, the distinctive feature of this study is approaching all

"composition elements" incorporated into townscapes on both sides of Shinbashi-dori Street, with a focus on whether or not there are bamboo blinds. Attribute information including depth, is described based upon first order logic. Furthermore, the descriptions are analyzed using ILP in order to grasp the characteristics of traditional townscapes using extracted rules.

2. Methods

2.1. ON FIELD SURVEY AND DRAFTING OF ELEVATIONS

The subject of this study is the 32 buildings (north side: 16 buildings, south side: 16 buildings) on Shinbashi−dori Street (Figure 2). The facades of all buildings on both sides were photographed and a measurement survey conducted on field survey. Furthermore, these photographs were composed of elevation images with some photos (Figure 3). The buildings in Gionshinbashi district represent a mixture of various building styles with different frontage sizes between the different buildings. Based upon the on field survey, the basic townhouse eave frontage size was approximately 3.3 m, and building numbers were assigned to each analyzed building based on these sizes. However, more than one building number was assigned to buildings with frontage of 3.3 m or greater using 3.3 m as a basis (building numbers on north side: g1 to g20, building numbers on south side: o1 to o19).

Figure 2. Satellite image of Gionshinbashi district
Google Earth (2017) ©2017 Google, Building image ©2008 ZENRIN, Image land set Data SIO, NOAA, U.S. Navy, NGA GEBCO

2.2. DEFINITIONS OF ATTRIBUTES

Four attributes are defined for "composition elements": types (57 types), position on the facade (number of levels: 4 types, horizontal arrangements: 3 types), color (28 types), form (shape: 49 types, material: 21 types, height: 3 types).

[Type] All visible composition elements on building walls of architectural composition elements such as roofs and openings, plants and furniture were defined as composition elements. These elements peculiar to the Gionshinbashi district are named referencing district preservation plans by the Kyoto City Government Urban Planning Bureau[2] (Figure 4).

[Position on the facade] Types of position on the facade are established as follows on elevation for each building: Vertical arrangements consist of 4 types for number of levels 1 to 4; horizontal arrangements consist of 3 types divided into left side, middle, and right side (Figure 5).

[Color] The Photoshop color sampling tool is used to retrieve the color of each element in building photographs in RGB values, which are then converted to the Munsell color system to define colors. Colorless transparencies among them indicate glass. In addition, different types of combinations of multiple colors are also defined, such as when a post passes through color backing a wall, a wall with exposed timbers, for example (Figure 6).

[Form] Types of form are defined by three attributes: shape, material, and height. Types of shape are defined as two-dimensional basic figures and three-dimensional solid graphic

Figure 3. Elevation of the both sides of facade of Gionshinbashi district
(a) elevations with bamboo blinds (north side: hg1 to hg20, south side: ho1 to ho19), (b) elevations without bamboo blinds (north side: ng1 to ng20, south side: no1 to no19)

including whether has lattices, patterns or not. Three-dimensional type defines a type based upon numerical values obtained from measurement surveys of height, width, and depth. In addition, composition elements that are very small in size and forms that are difficult to ascertain are defined as aggregates of multiple composition elements. In addition, materials are defined referencing district preservation plans by the Kyoto City Government[3]. Three types of height are used, broadly dividing height into 450 mm or less, 450 mm to 900 mm, and 900 mm or more based on actual measurements (Figure 7).

Figure 4. Types of composition elements of facade (57 types)

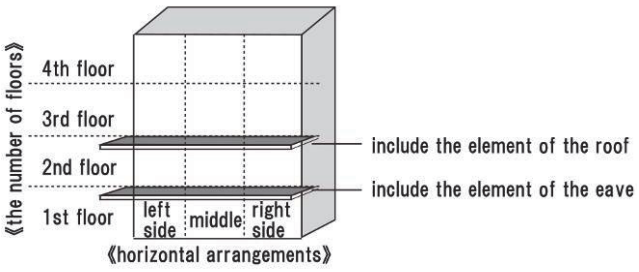


Figure 5. Types of position on the facade
(Number of levels: 4 types, Horizontal arrangements: 3 types)

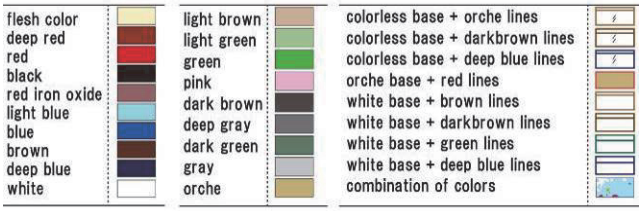


Figure 6. Types of colors of composition elements (28 types)

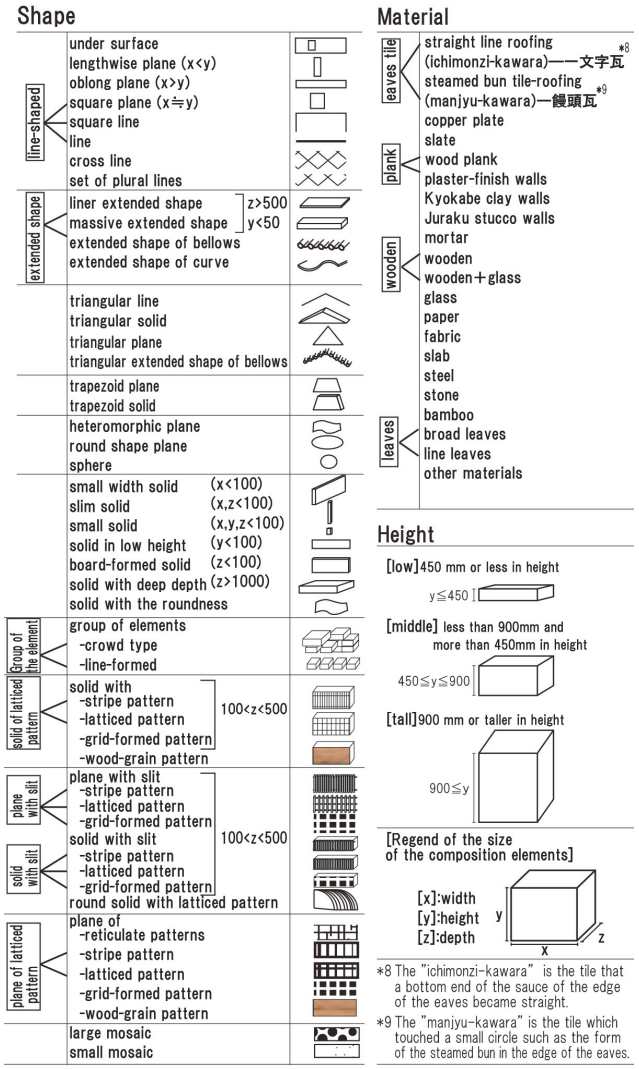


Figure 7. Types of form of composition elements
(Shape: 49 types, Material: 21 types, Height: 3 types)

2.3. INPUT DATA TO PROGOL

Progol, which is one ILP system created by Muggleton (1995), allows arbitrary Prolog Programs as background knowledge and arbitrary definite clauses as examples. Input data to Progol consists of a set of positive examples, a set of negative examples and background knowledge. In this study, each composition element is regarded as an example. However, large roofs and walls extending across entire frontages, as well as very small exterior elements such as plants, represent large differences in surface area on elevations. Hence, buildings are divided into different levels vertically and are divided horizontally into three sections: a left side, middle, and a right side. Thus a composition element represents one example belonging to one of these sections. Each four attributes (type, position on the facade, color, and form) described as background knowledge. In addition, "is-a hierarchies" were defined. The hierarchies of the attributes based on inclusion relation are known in advance. In order for the examples and background knowledge to be inputted into Progol, they are described in Prolog description based on first order logic. The description for examples and background knowledge are as follows: Descriptions of examples are made using the predicate "townscape." The IDs of composition elements are substituted into examples. The attributes of the four composition elements are described using the respective predicates of "type",

"position", "color", and "form". In addition, the "is-a hierarchies[4]" are described as a Horn clause with an implication symbol ": -[5]" attached. The formats for these descriptions for examples and background knowledge are shown in Figure 8. Descriptions of the attributes for the four composition elements above are inputted into Progol (ALEPH ver. 5[6]), which is one ILP system, and then rules for composition elements are extracted for the overall of facade.

3. Analysis

Examples of descriptions for composition elements inputted into Progol are shown in Figure 8 based upon the formats for descriptions defined in the preceding section. Each set of composition elements for the facade on each side of at constitute one group. By considering one set of composition elements as positive example and another set of composition elements as negative example, classification rules are extracted applying to the positive example. Based on the above, two analyses are performed, "Case-A" of comparing facades on both sides with bamboo blinds and "Case-B" of comparing facades on both sides without bamboo blinds. The characteristics of the respective facade are discussed according to the extracted rules for the composition elements of the overall of facade on both sides.

In Case-A, 105 rules for composition elements are extracted from the groups of north side, and 92 rules are extracted from the groups of south side. In analysis Case-B, 104 rules are extracted from the groups of north side, and 81 rules are extracted the groups of south side. In this study, "coverage" is used as the main evaluation criteria for rules executed from both sides of facade in two cases if analysis using ILP. Coverage is the total number of positive examples explained by rules for the total number of positive examples and is regarded as a significant rule as long as the coverage value is large[7]. In this study, rules marked the coverage more than 1.15% are considered representative rules often appearing in both analyses, and are subject to discussion. The rules extracted from analyses of Case-A and Case-B are categorized into the following three patterns:

[Result-1] Same descriptions of rules extracted from Case-A and B, and also with the same coverage marked (Figure 9)

[Result-2] Same descriptions of rules extracted from Case-A and B, but with higher coverage marked in Case-B (Figure 9)

[Result-3] Rules each extracted from Case-A or B with no commonalities (Figure 10)

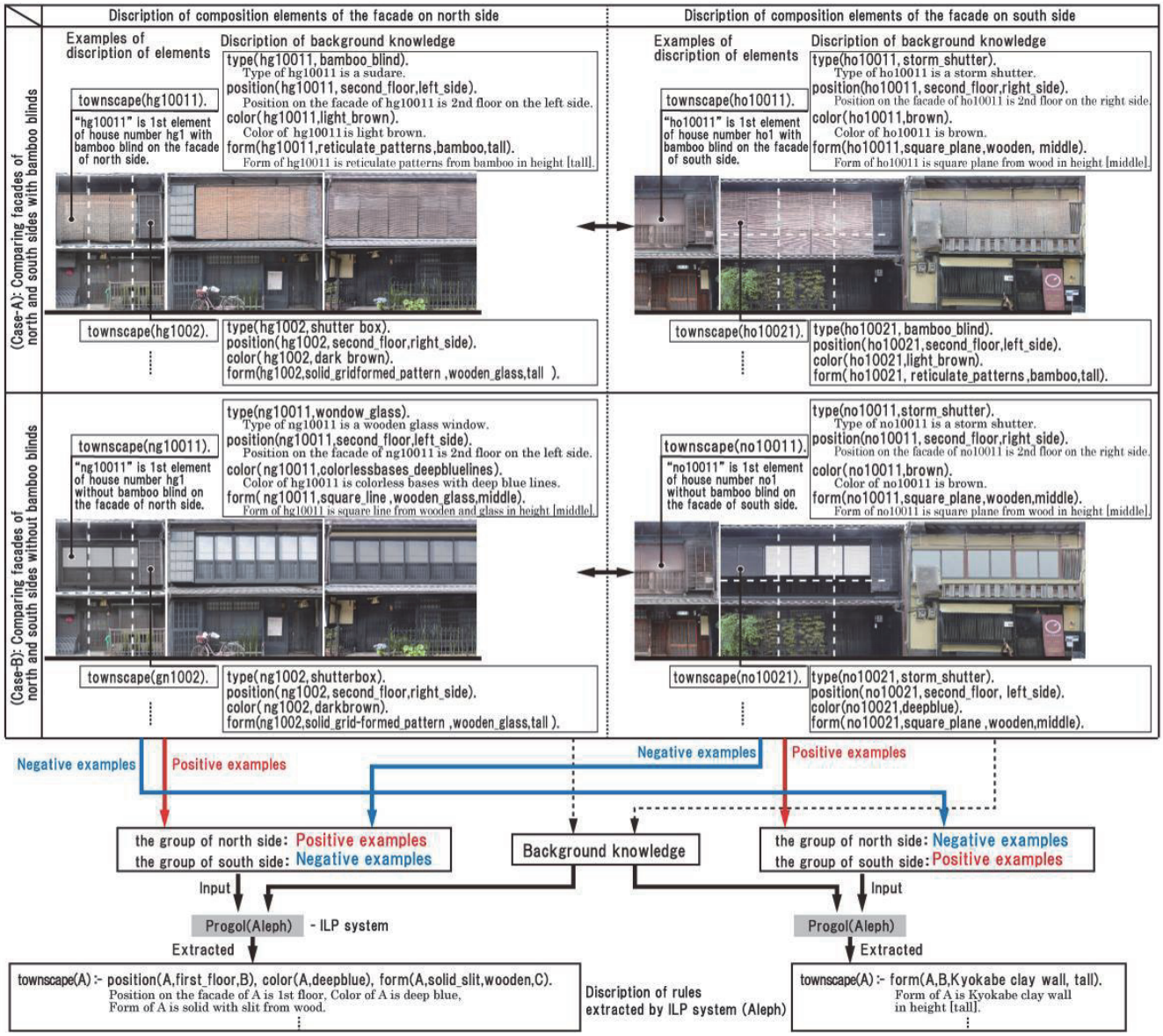


Figure 8. Description of examples, background knowledge, and rules extracted by comparing both sides of facades in Case-A and B

Figure 9. The result of the rules extracted from Case-A and B, and also with the same coverage [Result-1(rule number on north side: Rg1-/ on south side: Ro1-)], and rules derived from Case-A and B, but with high coverage for Case- B [Result-2 (rule number on north side: r-ng1-/ on south side: r-no1-)]

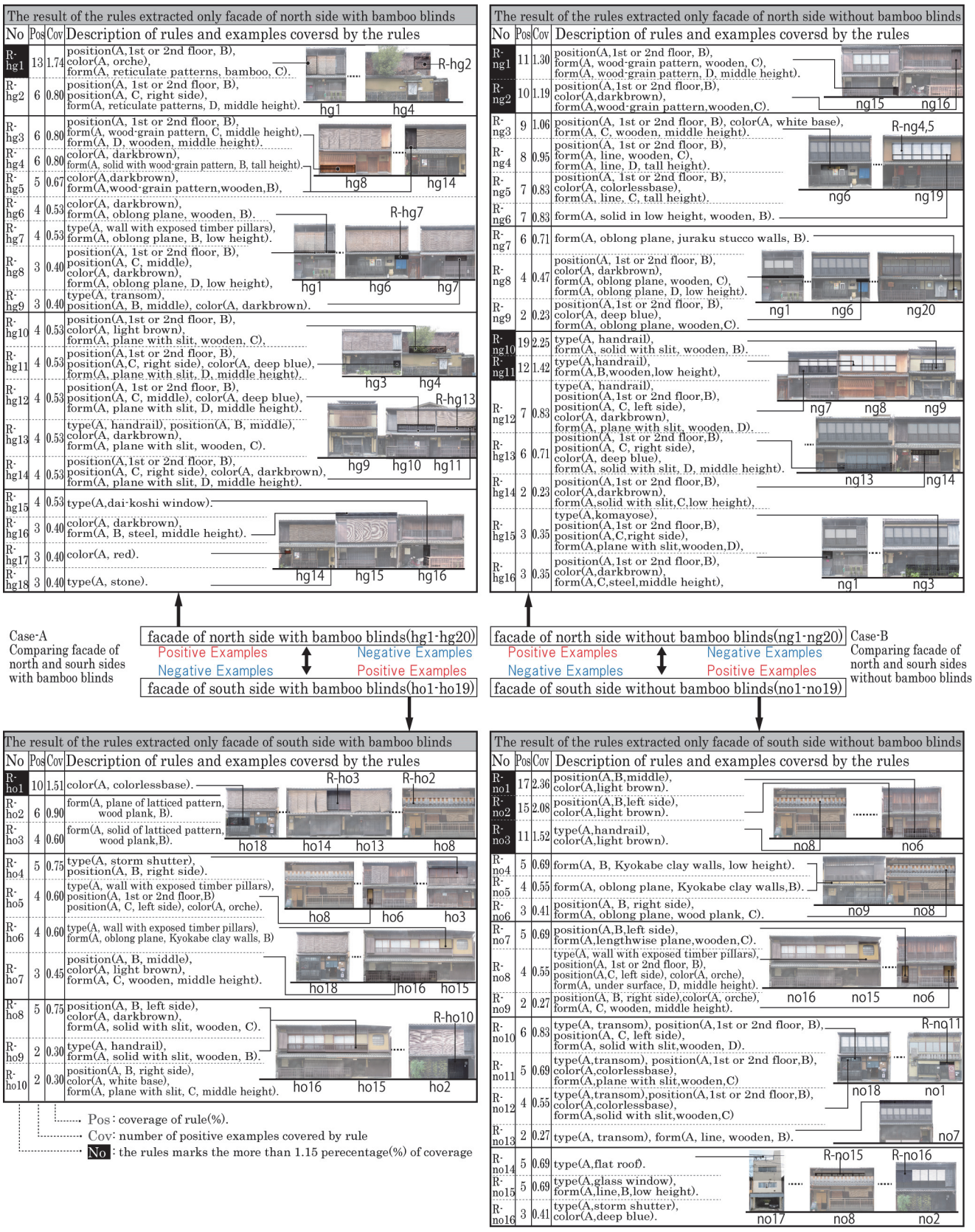


Figure 10. Rules each extracted from Case-A or B with no same descriptions of rules between two analyses [Result-3]
rule number on north side in Case-A: R-hg1-/ Rule number on south side in Case-A: R-ho1-
rule number on north side in Case-B: R-ng1-/ Rule number on south side in Case-B: R-no1-

4. Discussion

4-1. CHARACTERISTICS OF COMPOSITION ELEMENTS EXCLUDED BAMBOO BLINDS

Rules for both sides with and without bamboo blinds extracted from analyses Case-A and B with exactly the same descriptions in category of pattern [Result-1], may be said to indicate characteristics of composition elements in the facade on both sides where sections with bamboo blinds have been excluded. These rules yield the following as the main differences between composition elements on the two sides. First, in terms of form, is (1) under surface, followed by six in terms of type: (2) spandrel wall, (3) wall, (4) shutter box, (5) projecting lattice window, (6) signboard, and (7) eave for type (Figure 11).

(1)Under surface: Many walls on the north side have a plaster finish, many recently rebuilt building walls on the south side are characterized as composed of materials such as Kyokabe clay walls, steel, or mortar.

(2) Spandrel wall: Major differences in material are seen on the both sides, but spandrel walls on the north side are often found to be on the left side on the facade and colored dark brown or brown, while spandrel walls on the south side are seen with different characteristics in the middle and are dark brown or deep blue in color.

(3) Wall: Regarding differences between walls with exposed timber pillars on either side, planking with a wood-grain pattern is used on the north side, while Kyokabe clay walls with no patterns are used on the south side.

(4) Shutter box: On the north side, shutter box are often placed on the right side on the facade, on the other hand, on the south side they are placed on the left side on the facade.

(5) Projecting lattice window: Projecting lattice windows in the facades on the north side include both Oyako-lattices and Shimotaya-lattices and have deep blue and dark brown color. On the other hand, the projecting lattice windows on the south side have only Shimotaya-lattices, and a frequent rule is that they have a deep blue color.

(6) Signboard: On the north side signboards are dark brown in color and are often placed on the left side. On the other hand, on the south side, signboards are often white and placed on the right side.

(7) Eaves: A characteristic of both sides is dark green eaves. Those on the north side utilize extended shape of bellows and roof tiles, while those on the south side use massive extended shape and copper plate.

Peculiar characteristics with no differences other than those above on the north side are wing walls, plantings, cascade glazing, enclosures, posts, advertisements, and nameplates. These installations are not essential constituents of buildings. On the other hand, on the south side there are composition elements that are colorless and equipment; in other words, glass and composition elements using modern materials such as those found in steel facilities and equipment.

4-2. CHARACTERISTICS OF RULES WITH HIGHER COVERAGE WITHOUT BAMBOO BLINDS

As for rules with higher coverage in the whole facade without bamboo blinds in category of pattern [Result-2], the rules for the facades on the north side have characteristics of wooden composition elements with cross lines, composition elements that are dark brown in color and have a wood-grain pattern placed on the right side, flesh-colored composition elements placed on either the left or right (Figure 12). Composition elements with cross lines is thought to be seen in cascade glazing in building g5 (Figure 13). Wood-grain pattern with dark brown in color is thought to be a mainly seen in second-floor storm shutters, and flesh-colored composition elements is thought to be the characteristic of plaster-finish walls.

The facade on the south side, the characteristic is storm shutters, plane with slit in brown color, oblong plane with middle height. The facade on the south side are said to frequently have these composition elements installed on the inside with bamboo blinds.

4-3. DIFFERENCES IN RULES APPLYING ONLY TO THE FACADE WITHOUT BAMBOO BLINDS

There are four differences in the characteristics of rules in category of pattern [Result-3], corresponding only to facades on both sides without bamboo blinds: (1) handrails, (2) oblong plane and (3) linear shapes in terms of form, and (4) colorless bases in terms of color (Figure 14). Discussion of differences in these rules is as follows:

(1) Handrails: The facade without bamboo blinds on the north side is often dark brown in color. In contrast, on the south side, there are only ones that are light brown in color, although they are not characterized by a focus on handrail form. The handrail in building ho8 is an example (Figure 15).

(2) Oblong plane: The facade without bamboo blinds on the north side, Juraku stucco walls are often seen, while on the south side, Kyokabe clay walls are common, so there is a clear difference in wall material.

(3) Linear shapes, (4) Colorless base: The facade without bamboo blinds on the north side characterized linear composition elements tall in height, and have flat slits and three-dimensional slits, with various depths for slit-shaped composition elements. In contrast, the facade without bamboo blinds on the south side, composition elements that are low in height, such as wooden transoms and glass windows 450 mm or shorter in height, often have linear shapes or colorless bases.

4-4. DIFFERENCES IN RULES APPLYING ONLY TO THE FACADE WITH BAMBOO BLINDS

As for differences in rules in category of pattern [Result-1, 3] applying only to the facade with bamboo blinds as follows (Figure 16):

(1) Handrails: Handrails in the facade on the north side are seen to characteristic of a flat with slit form, while handrails on the south side are seen to be different with a three-dimensional slit. Bamboo blinds on the north side are on the same plane as buildings, while on the south side, either there are bamboo blinds on the second floor, and handrails are seen to be extending out from the outer walls of buildings in building o8 (Figure 15).

(2) Patterns: A wood-grain pattern is frequently seen on the north side, while a lattice pattern is frequently seen on the south side. If there are also not bamboo blinds, the differences are arised in the patterns of composition elements, such as shutter boxes.

(3) Transoms are characterized by being dark brown and arranged in the middle of facade with bamboo blinds. In contrast, on the south side, regardless of whether or not there are bamboo blinds, if transoms have a white background (that is, if glass is not used), then the characteristics is found on the left side.

(4) Plane with slit are often placed in the right side on either facades of the north and south sides. Furthermore, they are seen on the north side on composition elements of various colors, including light brown, deep blue, and brown, and are 450 mm or taller in height. In contrast, on the south side, the characteristic of composition elements is 450 mm or less in height, when they are colored deep blue or brown.

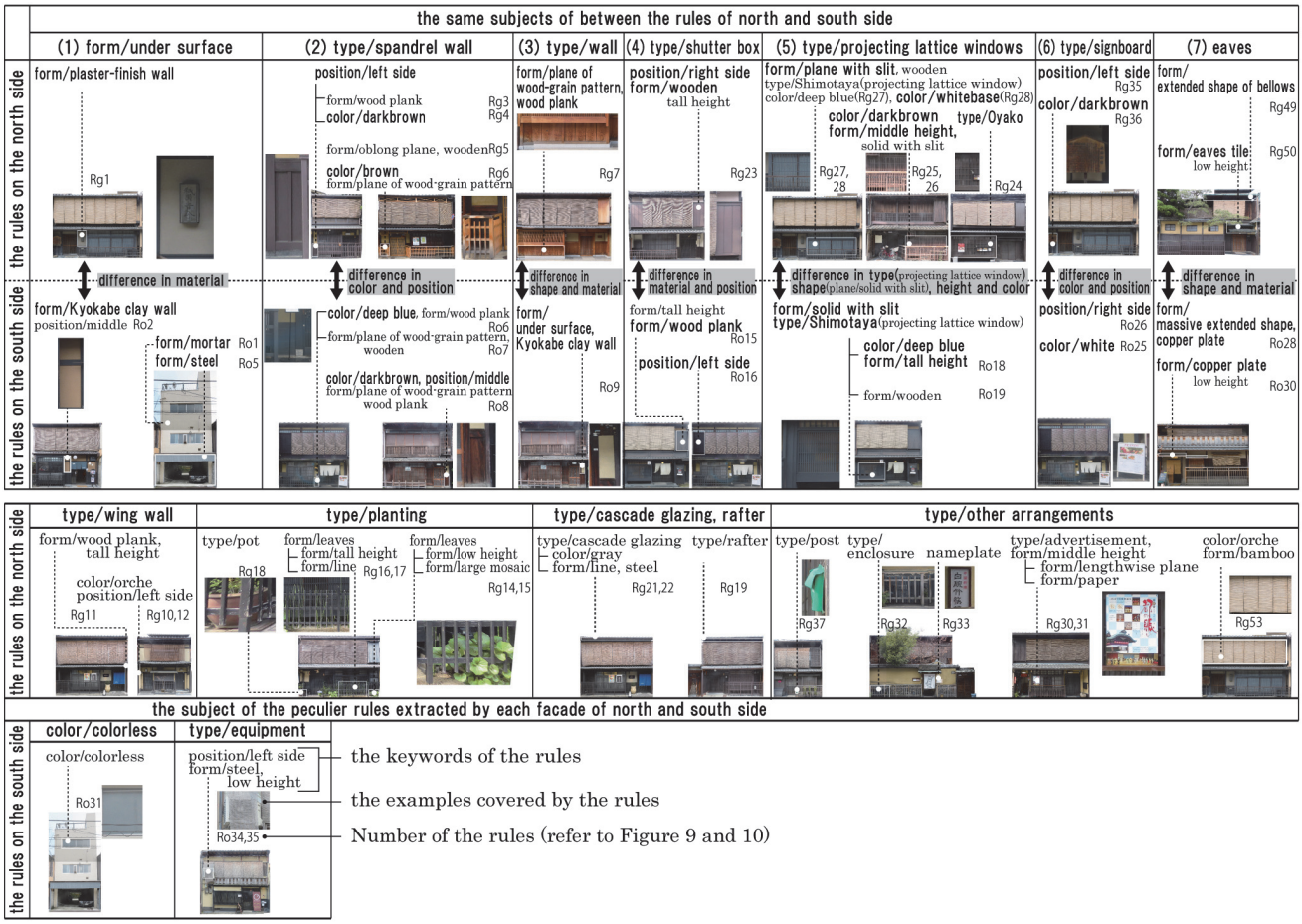


Figure 11. The characteristics of rules extracted from analyses Case-A (with bamboo blinds) and Case-B (with bamboo blinds), and also with the same coverage (Higher level: rules extracted with differences between both sides, Lower level: peculiar rules extracted from each sides of facade)

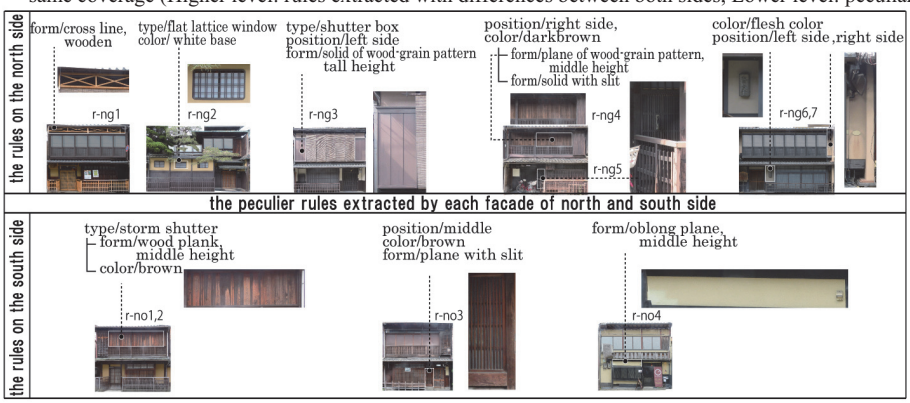


Figure 12. The characteristics of rules with higher coverage without bamboo blinds

Figure 13. The facade of g5 having cascade glazing with cross lines

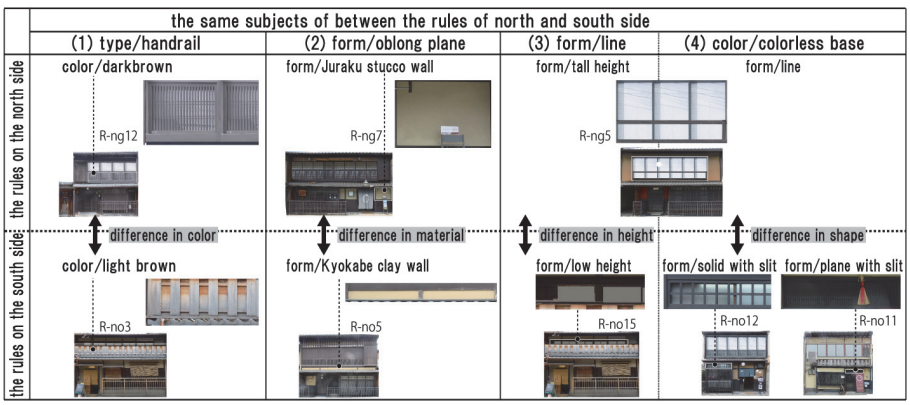


Figure 14. Differences in the characteristics of rules without bamboo blinds

Figure 15. The facade of ho8 having a handrail colored in light brown

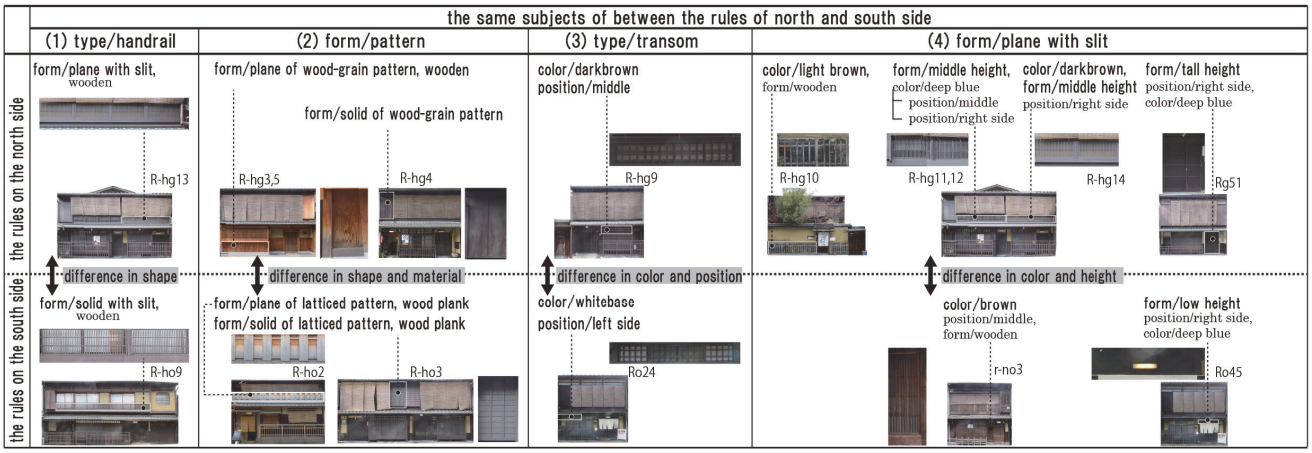
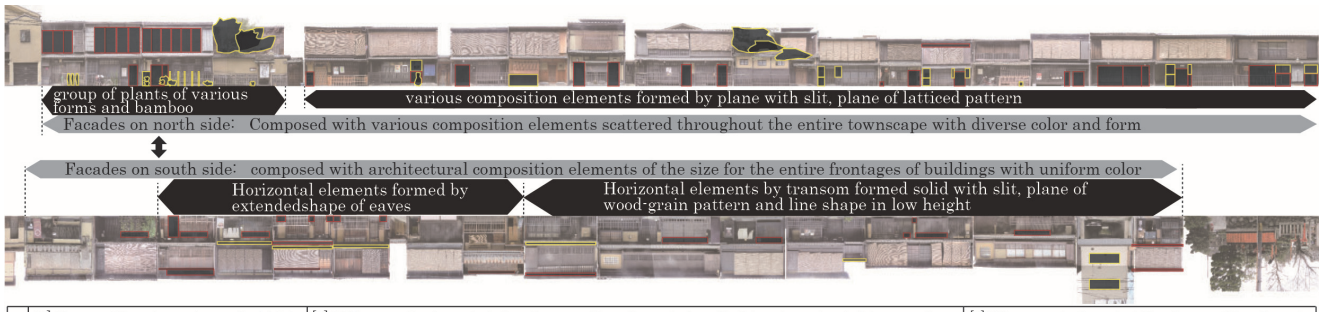


Figure 16. Results for rules seen only in facades on both sides with bamboo blinds
(Four differences in facade composition elements shown on both sides)

4-5. CHARACTERISTICS OF COMPOSITION ELEMENTS WITH HIGH COVERAGE

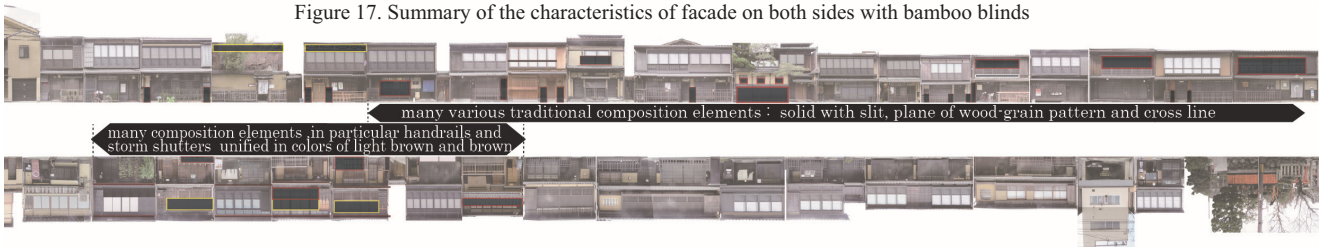
Rules extracted from the facades on both sides by analyses Case-A and B that are high in coverage may be said to be peculiar rules frequently included in all facades. Here, rules with coverage of more than 1.15% are subject to discussion (rule numbers with black background color in Figure 9, 10). Examples of composition elements corresponding to these rules are indicated in each sides of north and south of the whole facade, follows is a discussion of the characteristics of overall facade. What is a discussion of the characteristics of overall facade with bamboo blinds (Figure 17).

Composition elements with high coverage in north side are characterized by composition elements greatly varying in type, color, and form. The characteristics of types are plaster walls, plant arrangements, and plank spandrel walls on the left side of the facade. And there are many composition elements colored in deep blue and formed by plane with slit, and formed latticed pattern. In addition, many of these composition elements show characteristics of those making up part of all buildings, as well as being found in installations. On the other hand, on the south side include composition elements belonging to architectural composition elements such as transoms colored in white base



	[1] Composition elements marked high coverage with bamboo blinds			[2] Differences in characteristics of composition elements described in rules extracted from analyses (A) and (B) as same coverage, rules in black background marked high coverage (Figure12)									[3]Differences in characteristics of composition elements between both sides with bamboo blinds (Figure 14)			
north side	deep blue plane with slit tall height	bamboo	plane of latticed pattern middle height	plaster-finish walls	left side	grain pattern wood plank	right side wooden	Oyako・Shimotaya deep blue plane (slit) darkbrown solid (slit) middle height	left side darkbrown	bellows tiles	planting wing wall arrangements cascade glazing	plane with slit	plane of wood-grain pattern	middle darkbrown	middle/ tall height middle darkbrown deep blue light brown
	material			position	shape material	position material	type(lattice window) color, shape, height	position color	shape material	equipment	shape	shape	position color	height,color
south side	transom whitebase solid with slit wooden	brown line low height	plane of wood-grain pattern low height	Kyokabe clay wall mortar steel	middle	under surface Kyokabe clay wall	left side wood plank	Shimotaya deep blue solid (slit), tall height	right side white	line copper plate	colorless	solid with slit	plane of latticed pattern	left side whitebase	middle right side brown deep blue
*The rules of coverage is over 1.15% refer to Figure 9 and 10 excluding the table [2].				under surface	spandrel wall	wall	shutter box	projecting lattice window	signboard	extended shape of eaves	peculier characteristics of composition elements	handrail	pattern	transom	plane with slit

Figure 17. Summary of the characteristics of facade on both sides with bamboo blinds



	[1] Composition elements marked high coverage without bamboo blinds		[2] Characteristics of composition elements without bamboo blinds which rules covered more positive examples than with bamboo blinds, rules in black background marked high coverage (Figure 12)					[3] Differences in characteristics of composition elements between both sides without bamboo blinds (Figure13)			
north side	plane of wood-grain pattern middle height darkbrown	handrail solid with slit wooden middle height	cross line wooden	flat lattice window white base	darkbrown, right side - plane of wood-grain pattern - solid with slit	shutter box, left side solid with wood-grain pattern tall height	flesh color - right side - left side	darkbrown	Juraku stucco wall	tall height	line
								color	material	height	shape
south side	light brown, handrail, middle or left side		storm shutter brown wood plank, middle height		brown middle plane with slit	oblong plane middle height		light brown	Kyokabe clay wall	low height	solid(slit) plane(slit)
	*The rules of coverage is over 1.15% refer to Figure 9 and 10 excluding the table [2].							handrail	oblong plane	line shape/ colorless base	

Figure 18. Summary of the characteristics of facade on both sides without bamboo blinds

and formed by solid with slit, line and plane of wood-grain pattern are present across entire frontages. In addition, colors are characterized by uniformity, whether light brown or colorless. From this, it was possible to show clear differences in facades on each side: diverse facades on the north side with a variety of composition elements scattered throughout the whole facade and uniform townscapes on the south side with architectural composition elements; horizontal elements formed by extended shape of eaves, having the horizontal regularity of the size for the entire frontages of buildings with their uniform color.

Next is a discussion on characteristics of the facade without bamboo blinds (Figure 18). On the north side, there are cross lines, flat lattice windows colored in white color based, plane of wood-grain patterns colored in dark brown, and handrails formed by solid with slit. In contrast, the south side is characterized by storm shutters with brown colors and light brown composition elements. Consequently, there are differences between the north side with their characteristic variety of form and south side with their uniform color.

The differences are found between north and south sides considering whether or not there were bamboo blinds. The facade of north side has a variety of types with bamboo blonds, in contrast, a variety of form without bamboo blonds. The facade of south side has with their uniformity and horizontal regularity, in contrast, with their uniform color without bamboo blinds.

Conclusion

In this study, we analyzed the characteristics of the facade on both sides, considering whether or not there were bamboo blinds in the Gionshinbashi district using ILP. We made the following findings: (1) the characteristics of the whole facade on both sides with bamboo blind sections excluded having individual differences among seven differences of composition elements: under surface, spandrel walls, walls with exposed timber pillars, shutter boxes, projecting lattice windows, signboards, and eaves; (2) the characteristics of rules with higher coverage without bamboo blinds are indicated the elements, such as storm shutter, installed on the inside with bamboo blinds, and no differences between both sides; (3) the characteristics of facade without bamboo blinds having differences between four composition elements: handrails, oblong plane, line shapes, and colorless bases; (4) the peculiar characteristics of facade with bamboo blinds having peculiar differences among four differences of composition elements: patterns and handrails, transoms and planes with slits.

Furthermore, based on rules with high coverage frequently appearing on the facades on both sides, it was possible to find the differences in whole facades on both sides, whether or not there were bamboo blinds: [1] the facade on the north side are composed with various types of composition elements, in contrast to it, the facade on the south side are composed with architectural composition elements having the horizontal regularity of the size for the entire frontages of buildings with their uniform color with bamboo blinds, and [2] on the north side with their characteristic variety of form, in contrast to it, on the south side with their uniform color without bamboo blinds.

Endnotes

1. ILP is a machine learning system based on first-order logic, which executes inductive reasoning.
2. Composition elements are extracted referencing “structure,” “roof and eaves,” “walls,” “materials,” and “color” per exterior style described in the “Kyoto Traditional Architecture Preservation Related Municipal Ordinance, Gionshinbashi Traditional Architecture Preservation District Preservation Plan” by the Landscape Policy Division of Kyoto City Government Urban Planning Bureau.
3. Reference was made to Table 2.1 “Standards for Building Exterior Style, Material and Color” on “Kyoto Traditional Architecture Preservation Related Municipal Ordinances, Gionshinbashi Traditional Architecture Preservation District Preservation Plan” by the Landscape Policy Division of Kyoto City Government Urban Planning Bureau.
4. An “is-a hierarchies” based on the generalized inclusion property of abstract representation is established as background knowledge beforehand.
5. In this study, an expression abstracting types of each attributes is provided to set an inclusion property for the “is-a hierarchies.” Their relationship is described using an implication symbol “:-.” Specific expression descriptors and values for composition elements in Figure 4 to 7 are substituted into the right side, and their abstract representations are substituted into the left side.
6. In this paper, one of the versions of Progol, ALEPH ver.5, was used. ALEPH was implemented by S.H. Muggleton and L. De Raedt in Prolog based on the Progol algorithm. Input data to Progol consist of a set of positive example, a set of negative example, a set of background knowledge, and mode declarations used by Progol to guide the prosess of constructing a generalization from its examples. From these data, hypothesis are constructed.
7. Coverage indicates what percentage of all examples is explained by a hypothesis extracted rule.

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