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EVALUATION OF WALKING SPACE BY ROUGH SET MODEL

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Abstract: Recently in Japan, walking space is asked for various functions. It is important to show factor, which affects preference of walking space, on evaluation of walking space. The factor which affects people's preference is considered combination about various elements, rather than only one element; however, research which paid its attention to this combination is seldom done. The aim of the paper is evaluation of walking space including influence of the combination. The paper evaluates walking space by using Rough Set Model. The result of the paper shows the overlooked element has possibility, which turns into an important factor by considering combination.

Key Words: Walking Space, Pedestrian, Rough Sets Model

1. INTRODUCTION

The function of walking space has been required not only safety, but also a place of communication and recreation. Recently in Japan, walking space is maintained positively to improve its environment; for example, removing level difference for handicapped people, increasing road side tree to create good atmosphere, and so on. However, the walking space which was improved is not always to be comfortable for a pedestrian. The paper focuses on elements of walking space, which affect pedestrian's comfortableness.

The factor which affects people's preference is considered combination of various elements, rather than only one element; for example, people prefer the walking space with roadside tree, but this space is not always preferred, if the width of the walking space is narrow, it may not be preferred. And, in case walking space without trees, if the width of the space is wide

enough, it may be preferred. Aim of the paper is to show the combination of elements, which affects preference of walking space. There are some models considering combination in the existing research, such as Genetic Algorithm (GA), Neural Networks (NN), and so on, however those models have some disadvantages; GA has shortcoming, which can calculate only a few optimum solution, and the result of NN does not have notion input data. The paper evaluated walking space using Rough Sets Model.

2. COMPOSITION OF THE PAPER

First, the paper investigates people's preference to walking space on questionnaire survey. Items of questionnaire are following attributes;

a) Sex; men and women
b) Age; twenties and thirties
c) Number of Questioners; 20

The method of questionnaire is; first, show 28 photographs, then ask preference about each photograph. Answer is selected from ‘pleasant’, ‘unpleasant’, or ‘N/A’.

Next, we defined attributes which compose walking space. Then, we identified the composing elements of each walking space.

Finally, we evaluated walking spaces, based on preference combinations, using Rough Sets Model.

3. OUTLINE OF ROUGH SETS MODEL

Rough Sets Model (RSM) was advocated by Z.Pawlak in 1982. The Model was applied to specify the causal relationship of illness and condition from medical data, which becomes a sick cause. And now, the model is applied to the field of industrial design. The feature of RSM is setting information of object roughly, not correctly, in order to specify a certain object. For example, in case man specifies a certain object, man gets information on specific characteristics of the object rather than on all elements of the object correctly.

4. EVALUATION OF WALKING SPACE BY ROUGH SETS MODEL

4.1 Defining Composition Element of Walking Space

Table 1 shows the list of defined attributes and type of element, Table 2 shows the composition element of walking space photograph, which used in survey, and Fig.1 and Fig.2

are samples of photographs.

Table 1 Defined Attributes and Type of Element

Attribute	Type	Sign
Pavement	Asphalt	a1
	Interlocking Block	a2
Road Side Tree	N/A	b1
	Tree Roadway Side	b2
	Hedge Roadway Side	b3
	Tree and Hedge Roadway Side	b4
	Sidewalk Side	b5
	Both Side or Random	b6
Mount Up	Mount up	c1
	N/A	c2
Guardrail	N/A	d1
	Guardrail	d2
	Bollard	d3
Pole	Exist	e1
	N/A	e2
Textured Paving Block	Yellow	f1
	Color of Similar Shade	f2
	N/A	f3
Width	under 2m	g1
	2m - 4m	g2
	over 4m	g3

Table 2 Composition Element of Walking Space Photograph

	Attribute	Pavement		Road Side Tree						Mount Up		Guardrail			Pole		Textured Paving Block			Width		
	Type	Asphalt	Interlocking Block	N/A	Tree Roadway Side	Hedge Roadway Side	Tree and Hedge Roadway Side	Sidewalk Side	Both Side or Random	Exist	N/A	N/A	Guardrail	Bollard	Exist	N/A	Yellow	Color of Similar Shade	N/A	under 2m	2m - 4m	over 4m
sample number	1	1						1		1				1	1				1		1	
	2	1					1				1			1		1			1		1	
	3	1		1						1				1		1			1	1		
	4		1						1		1			1		1			1			1
	5	1					1			1				1	1				1		1	
	6	1			1					1		1			1				1			1
	7	1		1						1				1	1				1	1		
	8	1				1				1				1	1		1				1	
	9	1			1					1				1	1				1		1	
	10	1							1	1				1	1				1		1	
	11	1							1	1				1		1			1		1	
	12		1						1	1				1		1	1				1	
	13		1						1	1				1		1	1				1	
	14		1						1	1				1		1		1			1	
	15		1				1			1				1		1	1				1	
	16		1						1	1				1		1	1					1
	17		1	1							1		1			1		1			1	
	18		1				1				1		1			1		1		1		
	19		1		1					1			1			1		1				1
	20		1						1	1				1		1	1				1	
	21	1			1					1		1			1				1			1
	22	1		1						1				1	1				1	1		
	23	1		1							1	1			1				1		1	
	24	1		1						1		1			1				1	1		
	25	1		1							1	1			1				1	1		
	26		1				1			1		1				1			1		1	
	27		1		1					1		1			1		1				1	
	28	1			1					1		1			1				1	1		

Fig.1 Sample NO.18

Fig.2 Sample NO.24

4.2 ANALYSIS OF COMBINATIONS OF ATTRIBUTES

First, we analyzed combinations of attributes which affect preference of sample from the result of questionnaire survey. In order to analyze combination, the method which called 'Reduct' on RSM. Aim of 'Reduct' is to reduce attributes which do not affect preference. Table.3 shows the result of 'Reduct' about three sample objects.

Table 3 Combinations of Attributes which Affect Preference

A	B	C
abdeg	befg	abcdeg
abefg		bcdefg
bdefg		
bcefg		

a:Pavement b:Road Side Tree c:Mount Up
d:Guardrail e:Pole f:Textured Paving Block g:Width

In case of sample A, the sample decides preference by following four combines;

a) 'Pavement', 'Road Side Tree', 'Guardrail', 'Pole', 'Width'
b) 'Pavement', 'Road Side Tree', 'Pole', 'Textured Paving Block', 'Width'
c) 'Road Side Tree', 'Guardrail', 'Pole', 'Textured Paving Block', 'Width'
d) 'Road Side Tree', 'Mount Up', 'Pole', 'Textured Paving Block', 'Width'

From the result, 'Road Side Tree', 'Pole', and 'Width' are contained in all combination; therefore those attributes are essential factors on the sample.

In case of sample C, differences between his combinations are 'Pavement' and 'Textured Paving Block'; therefore, when the sample pays attention 'Pavement', 'Textured Paving Block' is not to be factor of preference.

4.3 Analysis of Composing Element of Walking Space

Composition elements of walking space are focused, in order to analyze factors in detail. The paper calculates ‘Decision Rule’ by using RSM. ‘Decision Rule’ shows combinations of composition elements, which affect preference. Table 4 shows ‘Decision Rule’, which is evaluated ‘Pleasant’ by one sample.

Table 4 ‘Decision rule’ of Pleasant by One Sample

Decision Rule	Photograph Number											
	2	4	12	13	14	15	16	17	18	19	20	C.I.
a2d3		○	○	○	○	○	○				○	0.583
a2b6		○	○	○	○		○				○	0.500
e2f1			○	○		○	○				○	0.417
f2					○			○	○	○		0.333
b6f1			○	○			○				○	0.333
c2e2	○	○						○	○			0.333
d2								○	○	○		0.250
a2c2		○						○	○			0.250
e2g3		○					○			○		0.250
a2g3		○					○			○		0.250
b6g3		○					○					0.167
d3g3		○					○					0.167
c2d3	○	○										0.167
b4c2	○								○			0.167
b4d3e2	○					○						0.167
b6c2		○										0.083
c2g3		○										0.083
b4f1						○						0.083
f1g3							○					0.083
a2b1								○				0.083
b6e1												0.083
a2g1									○			0.083
b4g1									○			0.083
b2e2										○		0.083
a1b4e2	○											0.083
b1e2g2								○				0.083

Table 4 shows that the sample evaluates following walking spaces as ‘Pleasant’;
Photograph Number; 2, 4, 12, 13, 15, 16, 17, 18, 19, 20

‘Decision Rule’ shows combinations of composition elements, which are included in walking space evaluated 'Pleasant'. And, ‘○’ shows that the ‘Decision Rule’ is included in each photograph. ‘C.I.’ is called ‘Covering Index’ on RSM that shows the ratio, which includes ‘Decision Rule’ with walking spaces evaluated 'Pleasant'.

From the result, ‘Decision Rule' which show high value are as follow;

a) [a2d3]; ‘Pavement type is Interlocking’, ‘Guardrail type is Bollard’
b) [a2b6]; ‘Pavement type is Interlocking’, ‘Road side tree is set up both side or randomly’
c) [e2f1]; ‘No Pole’, ‘Textured paving block color is yellow’
d) [f2]; ‘Textured paving block color is similar shade’

Table.5 shows ‘Decision Rule’, which is evaluated ‘Unpleasant’ by one sample.

Table 5 ‘Decision rule’ of Unpleasant by One Sample

		Photograph Number								
		7	9	11	22	23	24	25	28	C.I.
Decision Rule	b1e1	○			○	○	○	○		0.625
	e1g1	○			○		○	○	○	0.625
	b1d1					○	○	○		0.375
	d1g1						○	○	○	0.375
	c2d1					○		○		0.25
	c2e1					○		○		0.25
	a1b1c2					○		○		0.25
	b1c2f3					○		○		0.25
	b2d3		○							0.125
	b2g1								○	0.125
	b2f3g2		○							0.125
	a1b1g2					○				0.125
	a1b6e2			○						0.125
	b1f3g2					○				0.125
	a1d1g2					○				0.125
	a1b2g2		○							0.125
	b1c2g1							○		0.125
	a1c2g1							○		0.125
	c2f3g1							○		0.125
	b6e2f3g2			○						0.125
	b6c1e2f3			○						0.125
	d1e1f3g2					○				0.125
	a1c1e2g2			○						0.125
	c1d3e2f3g2			○						0.125

Table 5 shows that the sample evaluates following walking spaces as ‘Unpleasant’;
Photograph Number; 7, 9, 11, 22, 23, 24, 25, 28

From the result, ‘Decision Rule’ influence to preference ‘Unpleasant’, are as follow;

a) [b1e1]; ‘No road side tree’, ‘Exist Pole’
b) [e1g1]; ‘Exist Pole’, ‘Width is under 2m’
c) [b1d1]; ‘No road side tree’, ‘No Guardrail’
d) [d1g1]; ‘No Guardrail’, ‘Width is under 2m’
e) [c2d1]; ‘Mount Up’, ’No Guardrail’
f) [c2e1]; ‘Mount Up’, ’Exist Pole’

Comparing the two ‘Decision Rule’ shows, ‘c2, e2’ is in pleasant rule, but ‘c2, e1’ is in unpleasant rule; therefore preference will change by combination of ‘Mount up’ and ‘Pole’. Thus, we can show that combination of element may affect preference by using RSM.

4.4 Comparison to Quantification Method II

The paper compares RSM and Quantification Method II, in order to show characteristic of RSM in detail. The paper analyzes factors, which affect pedestrian's comfortableness by using quantification model II. Table.6 is the result of quantification model II, and Fig.3 is category score graph.

Table 6 The Result of Quantification Method II

categoty	range		partial correltion coefficirnt	
Pavement	1.2485	2	0.5792	2
Road side tree	1.5360	1	0.6581	1
Mount up	0.0714	7	0.0685	7
Guardrail	0.5410	6	0.4390	4
Pole	0.5848	5	0.3909	5
Textured Paving Block	0.6378	4	0.3741	6
Width	0.6754	3	0.5266	3

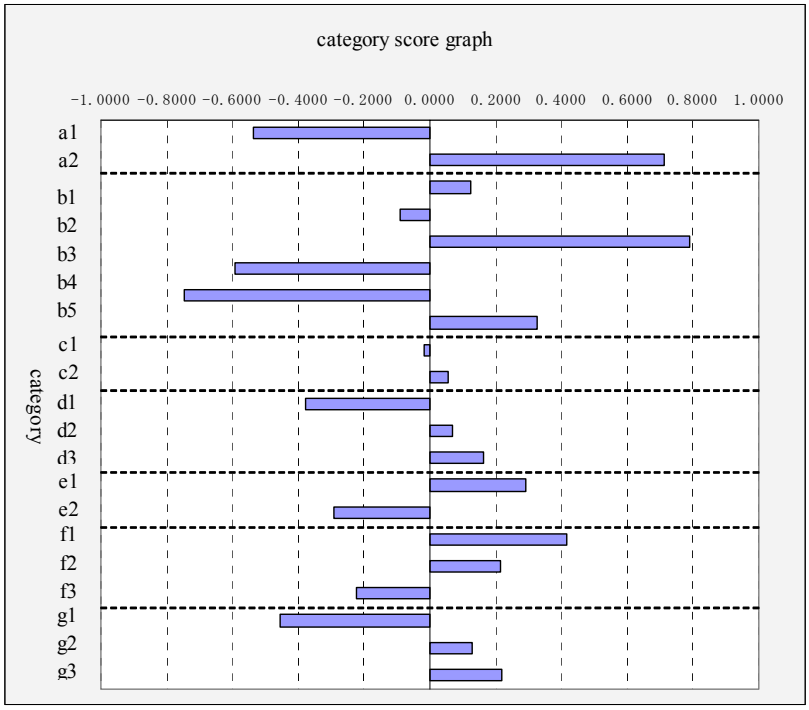

Fig.3 Category Score Graph of Quantification Method II

The result of Quantification Method II is as follow;

a) Attributes which affect preference to ‘Pleasant’ are ‘Pavement’, ‘Road Side Tree’, ‘Guardrail’, and ‘Width’.

b) Composition elements affect preference to ‘Pleasant’ are ‘Interlocking Block Pavement’, ‘Road Side Tree is set up Random’, ‘Guardrail type is Bollard’, and ‘Width is over 4m’.

The results of comparison are as follow;

a) Result of RSM shows the all attributes, which analyzed on quantification method II.

b) RSM can show overlooked attributes by considering combination, such as 'Pole', 'Mount up', and 'Textured Paving Block'.

c) RSM can cover almost all composition elements, which analyzed in quantification method II.

d) RSM be able to show overlooked composition elements.

4.5 Annexed Decision Rule on Many Samples

The paper showed 'Decision Rule' on each sample. This paragraph annexes each 'Decision Rule' as 'Decision Rule on Many People'. Fig.4 shows annexation flow of each 'Decision Rule'.

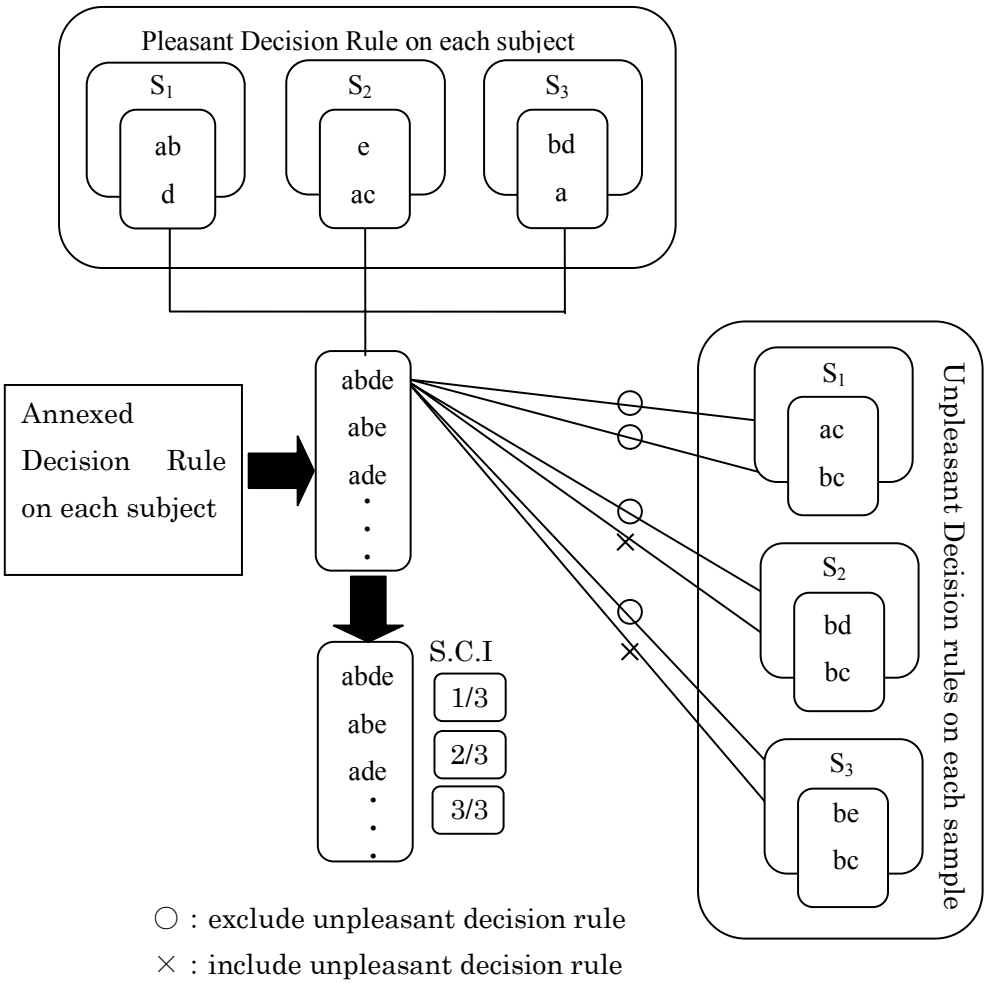

Fig.4 Annexation Flow of Each 'Decision Rule'

First step of annexation flow is to annex each pleasant rule; then, rejecting annexed rules that are contained in unpleasant rule.

Table.6 shows that annexed pleasant decision rules on many people.

Table 6 Annexed Pleasant Decision Rules

		S.C.I.
annexed pleasant decision rule	b5	1.00
	b3	1.00
	b6g6	1.00
	d3g3	1.00
	e2g3	1.00
	b6c2	1.00
	c2g3	1.00
	a1f1	1.00
	b6e1	1.00

S.C.I. in the table is 'Sample Covering Index'. S.C.I. is the ratio of sample, who has the annexed pleasant decision rule, and number of all sample. The result shows that S.C.I. of all annexed pleasant decision rules is 1.00; therefore, the walking space, which contains those rules, is pleasant walking space.

5. CONCLUSION

The paper shows the factor, which affects people's preference by considering combination of various elements by using RSM. And, the factor, which is not important element on existing method, will be important factor by consider combination.

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