Evaluation Method of Urban Landscape with Expert System

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***Abstract*— This study applied expert system for urban landscape evaluation in order to lead urban landscape of local cities to moderate level. This system is considering characteristics of the objective city. First, we examined present administration of urban landscape. Through analyzing the constitutions of urban landscape, three frames: "Main Structure", "Surroundings" and "Cultural Climate" were set. The results described three aspects: "Structure design", "Visual harmony" and "Environmental compatibility", for the evaluation of urban landscape. Moreover, we can investigate sources of the results and consider improvement with this system. Therefore, it is concluding that this system can output evaluation score and can provide concrete advices for urban landscape. On the other hand, this study could present vision of urban landscape of local cities.**

***Keywords*— Evaluation Method, Urban Landscape, Expert System**

I. INTRODUCTION

In this research, we aim to establish the evaluation method of urban landscape. So, it is important to classify and sort the evaluation knowledge which the specialist only has, and to make easily using data base. This evaluation method will be practical for improvement of urban landscape in local cities. Generally, it is useful for improvement of urban landscape to ask advices of specialist, or opinions of residents. Sometimes person who work on these projects must go and look up the situation and surroundings. We can know the urban landscape generally "good" through the advice of a specialist especially. However, an advice cannot be asked to a specialist always anywhere.

In this research, we try to apply the Expert System which is one of the artificial-intelligence techniques for the evaluation method. As a case study, the urban landscape in Ogaki City which is a typical local city in Gifu prefecture is evaluated. One of the reasons why urban landscape in a local city should be investigated is caused by urban sprawl. Although there is a time enough to plan the philosophy and regulation in city planning, there is a worm-eaten spot construction act as if neglecting the land use and circumference environment.

II. STRUCTURE AND ADVANTAGE

A. Structure of Expert System

Expert System has several good points. We adopted Expert System for the way to use the evaluation knowledge which only experts have. The way used at Expert System frequently is inference based on the knowledge. In this research, Production System is adopted for the inference. Knowledge is expressed next pattern at the System: "IF… (Conditional sentences) THEN…(Conclusion sentences)". Expert System is consisted from three parts (Figure.1).

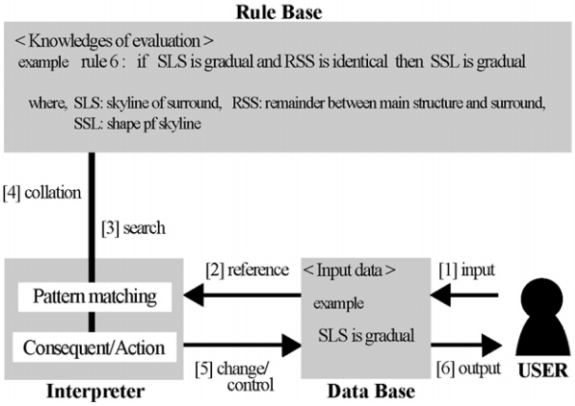


Figure.1 Structure of Expert System

"Rule Base" is an aggregate of evaluation knowledge. "Data Base" is the part which keeps data of interpretation, consequences and intermediate data. "Interpreter" is the part for promoting inference. That is to say, this part carries out selecting rules, applying rules and making the end. This system is carried out in numerical order, [1] to [6], showed by Figure.1. "Interpreter" searches rules whose Conditional sentences fit data held into "Data Base".

B. Advantages of Using Expert System

In this research, advantages of Using Expert System are described. One of the advantages, in the Expert System, that rule's pattern is easy and its meaning is clear. Thus, it can be clear to understand the conditions and criterions of good urban landscape. Another advantage is the point that it is easy to add and revise rules. The reason why this point is effective is that we need to add or revise knowledge with the various occasions of urban landscape evaluation. Added to these, Expert System is easy to trace origins of consequence by its clear inference process. It is easy the logic to be used in another occasion, because the point we have to watch is clear.

III. APPLICATION OF EVALUATION SYSTEM

A. Philosophy of evaluation

The structure of an image must be analyzed before setting the evaluation logic. Then, three frames which constitute an urban landscape are described. An urban landscape consists of scenery components, such as height of a building, and a color etc. An image of urban landscape component determines goodness of urban landscape.

Then, the scenery component was classified into the following three frames. a) "Main structure": the elements about the structure leading role of the area. b) "Surroundings": the elements about visible circumference of main structure. c) "Cultural climate": the elements about invisible circumference of main structure.

The apartment should be evaluated, because the number of them has been very large in local city like Ogaki-shi. So they have big influence on an image by their existences [2]. Then, the apartment was set as the "Main structure". Moreover, a "Cultural climate" frame does not appear on an image. For example, the atmosphere of the area, or area using, etc. is classified into a "Cultural climate" frame.

B. Set up of the last evaluation criteria

Next, it is necessary to set up the last evaluation criteria. Here, the three last items were drawn from the evaluation logic, and these are described as below. The following things were considered as evaluation logic in a local city. 1) If the harmony is an only criterion of urban landscape evaluation, it becomes a uniform scene anywhere and the identical landscape will be lost. 2) Since the environment of the suburban area in local cities will change rapidly, it is important to keep the visible harmony as every place need. 3) In order to make the individuality of area, the harmony with cultural climate should be considered. The last evaluation criteria were set up based on this logic. A) "Structure design": What evaluates good of the design of the main structure, B) "Visual harmony": the thing which evaluates harmony of the main structure with the surrounding environment at the point of visible harmony, C) "Environmental compatibility": the thing which evaluates harmony of the main structure with the cultural climate at the point of invisible harmony. It corresponds with three frames, respectively.

The zoning map (Figure.2, refer to [3]) which expresses the outline (Table.1 refer to [4]) and a "master plan of landscape" of Ogaki City here was shown. Such as "water-front" is seen in zones, Ogaki City is called "Suito (means water-front city)" because of its rich water-front space. Through examination of the master plan of this city, it is developed that individuality and

harmony suit to the place has been important and will be more serious in Ogaki City. This point is decided as "Environmental compatibility".

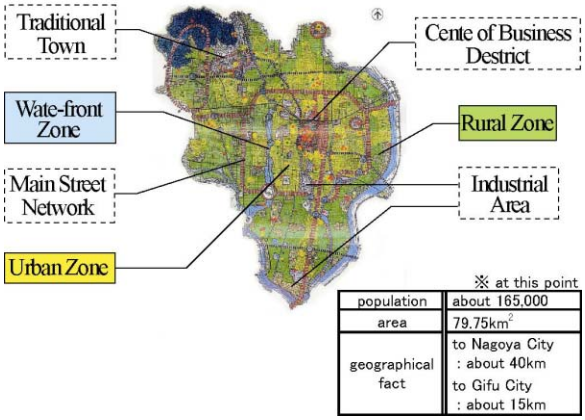


Figure.2 Zoning Map of Ogaki City

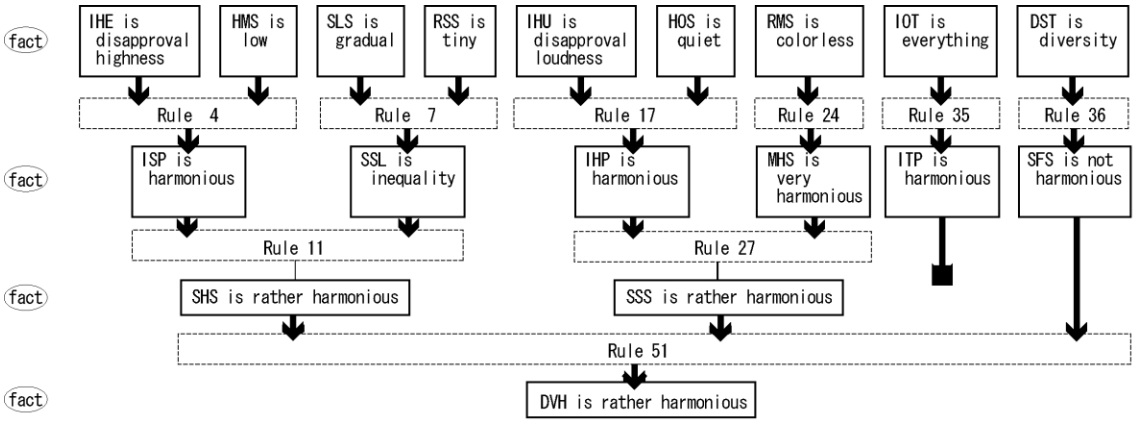
C. *How to arrange evaluation knowledge*

According to the philosophy of urban landscape evaluation, evaluation knowledge is arranged through setting up variables and rules in the system.

Total of 296 images used to set up variables and rules. These 296 images are composed of 8 actual landscape images and 288 virtual landscape images. We prepared these 288 virtual landscape images in following combination of various factors: 3 kinds of height, 4 kinds of colors, 4 kinds of surroundings, 3 kinds of environmental compatibility and 2 kinds of width. In order to examine whether another effective knowledge exists except for actual landscape, we used virtual landscapes.

Tabel.1 Rule of Evaluation Logic

number of total rules	evaluation criteria	number of rules	group name	number of rules	example
126	**A)** Structure design	21	rules for determination of the intimacy of structure	8	ruleA)-5 **if** SMS is small **then** MSD is very intimate
			rules for detarmination of the individuality of	6	ruleA)-14 **if** RSO is roundish **then** MSD is very individuality
			rules for lead to rank of A)	7	ruleA)-21 **if** MSD is not intimate **then** DSD is not good (rank E)
	B) Visual harmony	66	rules for determination of the harmony of size	13	ruleB)-1 **if** IHE is disapproval lowness and HMS is high **then** ISP is harmonious
			rules for determination of the harmony of color	17	ruleB)-22 **if** DSH is rather simple and RMS is identical **then** MHS is rather harmonious
			rules for determination of the harmony of figure	15	ruleB)-38 **if** DST is simple and RST is artifical and EOH is inhabit **then** STS is rather harmonious
			rules for lead to rank of B)	21	ruleB)-63 **if** SHS is not harmonious and SSS is rather harmonious **then** DUH is less good (rank D)
	C) Environmental compatibility	39	rules for detarmination of the harmony of mood	34	ruleC)-21 **if** NAC is activity and ASS is calm **then** ECC is not provided
			rules for lead to rank of C)	5	ruleC)-35 **if** ECC is very provided **then** DCL is very good (rank



where, IHE: ideal of height, HMS: height of main structure, ISP: harmony of ideal and proper size, SLS: skyline of surround, RSS: remainder between main structure and surround, SSL: shape of skyline, IHU: ideal of hue, HOS: hue of main structure, IHP: harmony of ideal and proper hue, RMS: relation between main structure's hue and surround's, MHS: harmony of main structure's hue and surround's, IOT: ideal of texture, ITP: texture of main structure, DST: diversity of surround's texture, SFS: harmony of main structure's form and surround's, SSS: harmony of main structure's size and surround's, SHS: harmony of main structure's hue and surround's, DVH: degree of Visual Harmony

Figure.3 Process of Evaluation for Visual harmony

Each image set up and took in the following conditions: Basic pictures were taken keeping the distance 50m and the angle of 45 degrees from the main structure, regarding to the same condition. So, the evaluation might not be affected with images.

The evaluation knowledge were derived from examination of the ranking which the professionals evaluate samples and arrangement of existent knowledge, advises and so on. [5] Considering the connection between urban landscape and the last criteria, several medium factors were defined, and finally 126 rules (showed in Table.1) were derived.

D. Arrangement of evaluation knowledge

Evaluation knowledge is arranged through the process above. The following example is the process of evaluation for "harmony between the hue of main structure and that of surroundings" in "Visual harmony" (Figure.3).

If the heights of the structure are similar, the skyline of that landscape will be like to a straight line. It can be said that the structures are uniform in the size and that image harmonizes. This is "shape of skyline" and there are two passage of "gradual" and "inequality" in this category. In order to determine this category, we have only to know how the shape of skyline is and the gap of height between main structure and others.

The using of building on the place is also related to urban landscape evaluation. For example, a tall apartment is not proper on the neighborhood of low residences. This category has two passage, "harmonious" or "not harmonious", decision of this is made by "the ideal of the height" determined with a neighboring thing and the using and height of main structure. The relation of both of factors estimates "harmony between the size of main structure and that of surrounding".

Evaluation is advanced as mentioned above.

Like "IF ISP (harmony of ideal and proper size) is harmonious AND SSL (shape of skyline) is gradual THEN SSS (harmony between the size of main structure and that of surroundings) is very harmonious", sentences which express the relation: "factor" = "category", are held in condition parts and conclusion parts of the rules in the system. 126 rules for urban landscape evaluation are into the constructed system.

In this evaluation system, it is need to input 16 landscape components in all as input data. These data are inputted into the input screen of Figure.4. And evaluation of each evaluation criteria is outputted as five steps of ranks of A-E. The final output is an evaluation score and outputs the totaling point of three evaluation criteria as 15-point full marks (Figure.5).

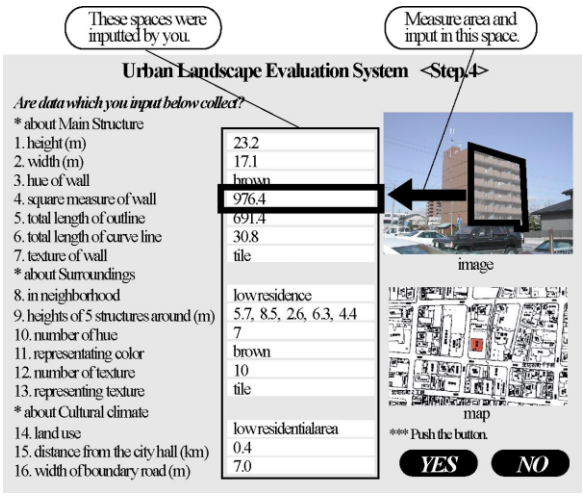


Figure.4 Sample of Input Data

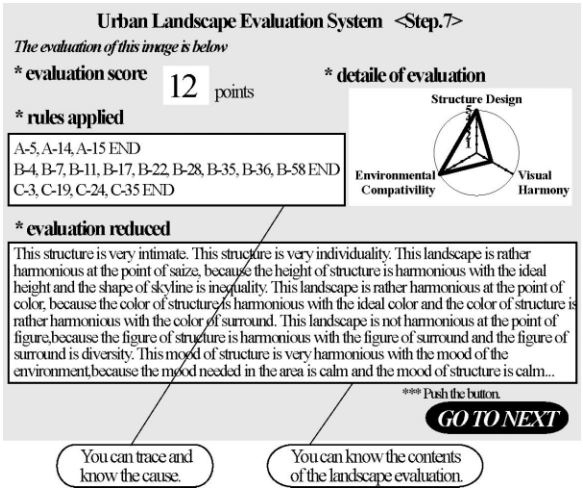


Figure.5 Sample of Output Data

E. Application of evaluation system

It is necessary to confirm the system's action for application of system. There are 296 images which wre used for making philosophy and rules of evaluation. These 296 images are evaluated actually, and the consequences are analyzed below. Figure.6 shows the distribution of evaluation scores.

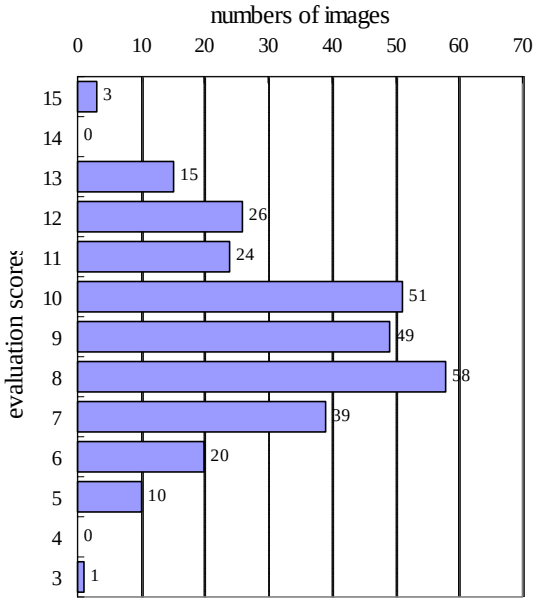


Figure.6 Distribution of evaluation scores

From Figure.6, it can be read the concentration of scores around 9 points. The landscape which have 7 points to 10 points are said to consist the middle class in evaluation. Therefore, it might be said that if the score of image is under the 6 points, that landscape is not good. On the other hand, if the score of image is over the 11 points, that landscape is good. Table.2 shows the consequence of evaluation, including highest and the lowest sample. And Figure.7 is their images.

It can be said that the upper image, the highest landscape, is good urban landscape. Because there is a small and quiet main structure in low residential area considered the calm mood defined by this place's environment. On the other hand, the lower image, the lowest landscape, is not good urban landscape, because there is a very big and loud main structure having coercive mood in low residential area. We could confirm the system's action based on the evaluation knowledge which we had established.

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F. questionnaire survey

The process of application of evaluation system needs verification. In this section, consequence of questionnaire survey for the system's generality. We had a questionnaire survey of 25 students of Gifu University.

The way of questioner survey is explained below. There are eight images of urban landscape in Ogaki City which were chosen from our earlier 296 images as typical type of landscape. The examinee should make a ranking of these eight images according to their opinion for good urban landscape.

Table.3 shows the details of eight samples in questionnaire survey. And this shows "observation ranking" which as the marks put by the examinees and "estimation ranking" which was derived from using the evaluation system, too.

Table.2 Consequence of the highest and the lowest landscape

No.	Structure Design	Visual Harmony	Environmental Compativility	total score	ranking
232	rank A	rank A	rank A	15	1
234	rank A	rank A	rank A	15	1
236	rank A	rank A	rank A	15	1
...	...	...	...	...	...
2	rank D	rank D	rank E	5	286
8	rank C	rank E	rank E	5	286
21	rank D	rank D	rank E	5	286
22	rank D	rank D	rank E	5	286
23	rank D	rank D	rank E	5	286
25	rank D	rank D	rank E	5	286
45	rank C	rank E	rank E	5	286
46	rank C	rank E	rank E	5	286
47	rank C	rank E	rank E	5	286
49	rank C	rank E	rank E	5	286
7	rank E	rank E	rank E	3	296

Sample No.232

Sample No.7

Figure.7 Images of sample

Table.3 Result of Questionnaire Survey

sample	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
No.(/296)	110	134	31	234	69	141	162	199
height of main structure	middle	middle	large	small	large	middle	middle	middle
color of main structure	brown	dark gray	brown	dark gray	white	dark gray	white	green
land use	low residential area	low residential area	commercial area	low residential area	commercial area	commercial area	low residential area	commercial area
distance from the city center	surrounding	surrounding	surrounding	urban area	center area	center area	urban area	surrounding
width of bounrdary road	narrow	narrow	wide	narrow	wide	wide	narrow	wide
average score (8 to 1 point as ranking)	5.8	5.2	4.4	4.1	3.3	2.8	1.6	0.9
observation ranking by questionnaire survey	1	2	3	4	5	6	7	8
estimation ranking by evaluation system	2	3	7	1	8	5	4	6

In bottom of Table.3, two lines shows ranking of landscape. Such as the ranking of landscape (c) and that of landscape (d) are different between observation ranking and estimation ranking. The number of correlation coefficient of raking is 0.47. It is not explain good performance. But, this situation shows that only the philosophy of this evaluation system is different from opinions which examinees had. One of the reasons of these differences, there is a tendency that people regard several colors as harmonious landscape. Because in this system, the colors of surroundings counted by number, so this human's sense of color can not be explained.

Constructed system could output similar ranking without upper situation according to the philosophy. The evaluation systems should not always express the people's opinion to the landscape. However, it is one of the most important points of evaluation systems to explain people's sense of urban landscape. It needs to improve in this point.

IV. CONCLUDING REMARKS

The expert system is applied to evaluation method of urban landscape in this study. The findings for this research are summarized as follows: 1) the data base was constructed by arranging logics of urban landscape evaluation in local cities. 2) The evaluation system of urban landscape could be applied using Expert System. This system enables to use expert's evaluation knowledge only picking input data. And, we can use this system in the occasions making good urban landscapes. Added to these, 3) it was enable o trace origins of consequence. 4) And also it could be added and revised easily. And, 5) several problems of constructed system were clear.

The future direction of this research will be the growth as evaluation system. So, we will do the following approaches. We will revise the problems concerned with "Structure design" and "Visual harmony". These problems were cleared in this research. And we will add new evaluation knowledge.

REFERENCE

[1] Hiroki ITO: Application of Artificial Intelligence to Image Evaluation of Electric Steel Tower, Japanese Society of Civil Engineering, 2000. (In Japanese)

[2] Hiroko KOJIMA, Naoto TANAKA, Masashi OKUSHIMA, Takamasa AKIYAMA: Study on Evaluation of suburban landscape, Proceedings of the Infrastructure Planning, 2004. (In Japanese)

[3] Dept. of City Planning in Ogaki City: The Master Plan of Urban Landscape in Ogaki City, 1997. (In Japanese)

[4] Ogaki City: The Basic Survey of Urban Landscape in Ogaki City, 1994. (In Japanese)

[5] Osamu SHINOHARA edited: Design and Planning of landscape in civil engineering, new compendium series of civil engineering No.59, Giho-do publishers, 1987. (In Japanese)