Research on the Characteristics and Evaluation of Nightscape along LRT wayside-In the Case of Toyama City

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ABSTRACT : *The measured parameters are available on-line over the Internet to any user.With people's increasing demand of nightlife activities, the nightscape has become more important than ever to enhance the image of city. In this study, we tried to analyze the effects and influence of the landscape lighting that produces the nightscape and pointed out that the optimal nightscapes along the LRT (Light Rail Transit) route. We selected Japanese first formal introduction of LRT urban landscapes as the research object, used the SD (Semantic Differential) technique to compare the difference between the daytime and the nighttime landscapes from vision engineering and measurement psychology. As a result, it became clear as follows; 1) The image evaluation of the nightscapes got higher estimation than that of daytime landscapes. The importance of the nightscape has been recognized once again. 2) The landscape lighting played the important role in the charming nightscape. 3) The optimal nightscapes along the LRT routes could be chosen with the result of factor analysis.*

KEYWORDS: *Light rail transit, Nightscape, Landscape lighting, Image evaluation, Factor analysis.*

I. INTRODUCTION

In recent years, people's lifestyles have been changing as they spend more time at night. Therefore, the importance of creating a beautiful nighttime landscape is high, and the construction of a beautiful nighttime landscape is becoming an indispensable and important element when considering landscape formation. As a result, it can be one of the important elements to improve the urban environment for citizens to live comfortably. As a result, citizens will become attached to their cities, and tourists and other visitors will be motivated to visit again[1].

Toyama City, which aims for "compact city development," is using the introduction of the LRT as an opportunity to create new symbols and tourist resources, in addition to promoting landscape improvement and redevelopment projects along the LRT line (Fig. 1). Furthermore, in anticipation of the opening of the Hokuriku Shinkansen in the spring of 2015, a lighting-up project utilizing existing buildings along the LRT line is underway.

The "TRAM de MUSEUM" project is being implemented. This project aims to integrate the LRT with the nighttime urban landscape, creating a new nighttime sightseeing experience unique to Toyama, where visitors can enjoy a fantastic lighting performance from the large windows of the LRT.

In order to attract more domestic and foreign tourists, it will become more and more important to create beautiful nighttime scenery.

Nakamura et al.[2], Okutani et al. [3], and Nagayama et al. [4] have conducted research on nighttime scenery. For example, Nakamura compared daytime and nighttime views, clarified impressions of illumination and their relationship to luminance distribution, and analyzed the structure of impression evaluation. Okutani analyzed the fractal dimension of the impression of landscape lighting by computer image processing, and described the relationship between impression evaluation and fractal dimension. As described above, there are research cases that quantify and analyze the impression evaluation of landscape lighting in nighttime landscapes,

but there are still few research cases that describe the creation of town attractions based on the characteristics and evaluation of nighttime landscapes along LRT lines in cooperation with town development.

Therefore, this study takes Toyama City, the first local city to introduce LRT in Japan, and compares "daytime views" and "nighttime views" along LRT lines using visual engineering and psycho-electrometric methods. The purpose of this study is to provide basic data for constructing a "beautiful and attractive nighttime urban landscape" in the future[5][6].

II. EXPERIMENT

The survey was conducted along two lines: the "Toyama Port Line," Japan's first full-scale LRT line, and the "City Loop Line," a newly introduced line. Samples were selected from buildings, parks, and characteristic landscapes that are widely recognized by citizens as representative symbols of Toyama Prefecture. The buildings were categorized according to their use and status of use:

(1) cultural and exhibition-related facilities (representative example: "Takashinokuni Bunka Kaikan"),
(2) historical buildings (representative example: "Toyama Castle"),
(3) administrative and public facilities (representative example: "JR Toyama Station"),
(4) commercial and tourist facilities (representative example: "Toyama City Hall"),
(5) parks and green spaces (representative example: "Toyama Kansui Park"), etc. (Table 1).

Table 1. The number and name of each landscape.

No	Landscape name	No	Landscape name
①	Koshinokuni Museum of Literature	⑨	CIC Building
②	Toyama Shimin Plaza	⑩	Toyama Ring Water Park
③	Toyama Castle	⑪	Toyama Daiwa Department Store
④	Toyama Electrical Building	⑫	Marier Toyama
⑤	Toyama City Hall	⑬	IkedayaYasubei Store
⑥	Toyama International Conference Center	⑭	Northern Japan Newspaper office
⑦	Urban Place	⑮	Hokuriku Electric Company
⑧	ANA Crowne Plaza Toyama	⑯	JR Toyama Station

For the landscape samples, we selected observation points where we could grasp the overall view and characteristics of the landscape, and photographed "day views" and "night views" from the same angles using a digital camera. Photography conditions were as follows:

(1) a digital camera (Canon EOS Kiss X5) with a focal length equivalent to 28 mm on a 35 mm film camera and a dedicated tripod;

(2) the day and time were chosen to be in good weather, 11:00 to 15:00 during the day (for daytime views) and 19:00 to 21:00 after sunset (for nighttime views), and in the case of daytime views, consideration should be given to daylight and backlight.

(3) The camera was positioned near the center line of the road along the LRT, and the height from the ground to the center of the camera lens was 1.5 m.

(4) The image quality was maintained at high resolution (approximately 17.9 megapixels). We also considered our field of view and viewing angle, and tried to make the landscape samples as natural as possible [7].

We took photographs for the sample according to the above-mentioned criteria. All the photographs were loaded into a personal computer and used to create a total of 32 landscape samples for experimental observation: 16 "day view" and 16 "night view" samples. An example of the "night view" sample actually used is shown in Fig. 1.

All the experiments were conducted in a dark room. A screen (W2.4m x H1.8m) was placed 4 meters in front of the subject, and one slide of the experimental landscape sample was randomly displayed on the entire surface of the screen using a projector. Fig. 2 shows how the subjects observe and evaluate their impressions of the landscape samples.
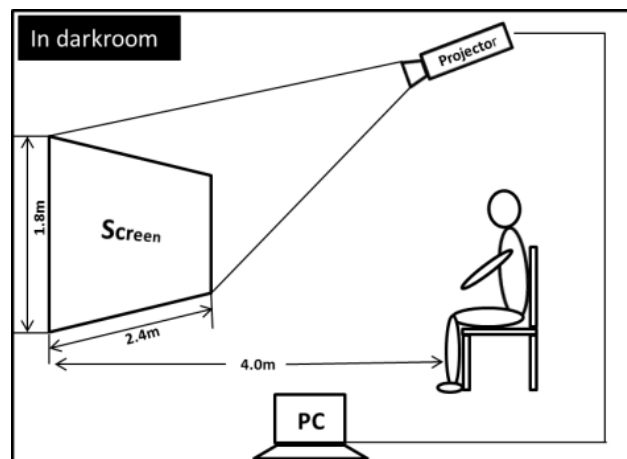
Fig. 1.   Sample photos of nightscape.

Fig. 2.   Experimental image.

The subjects consisted of 25 engineering students (18 males and 7 females) with an average age of 23.8 years, all of whom were familiar with the SD method. In addition, taking into consideration the psychological state of the subjects, i.e., their mood and physical condition, we conducted the experiment while taking breaks at regular intervals in order to reduce the error margin as much as possible[8][9].

In this experiment, we used the SD method (Semantic Differential technique) developed by C.E. Osgood, which is a typical method for landscape image evaluation experiments. [10][11]The SD method is an evaluation method in which the subject selects a numerical value for the degree to which he or she perceives a given impression word pair on a scale. Since this method can quantify the evaluation value for each evaluation item, it enables comparative analysis among multiple subjects. In selecting impression words, we referred to studies using the SD method[12]-[18]and selected 20 appropriate impression words (adjectives) for this experiment based on the following criteria (1) to (6). Based on the following criteria (1) to (6), we selected 20 appropriate impression words (adjectives) for this experiment. The evaluation scale is based on a 7-point scale[19], with "neutral" (0) as the center, and "little" (1 or -1), "quite" (2 or -2), "very" (3 or -3)(Fig. 3).

(1) Avoid ambiguous adjectives.

(2) Avoid adjectives that immediately infer the purpose of the survey.

(3) Avoid adjectives used by experts for special meanings or adjectives whose meanings change according to the subject's knowledge.

(4) Use adjectives that are gentle, sensual, and intuitive.

(5) Be varied so as not to concentrate on similar adjectives.

(6) To make use of adjectives used in previous studies[13][14].

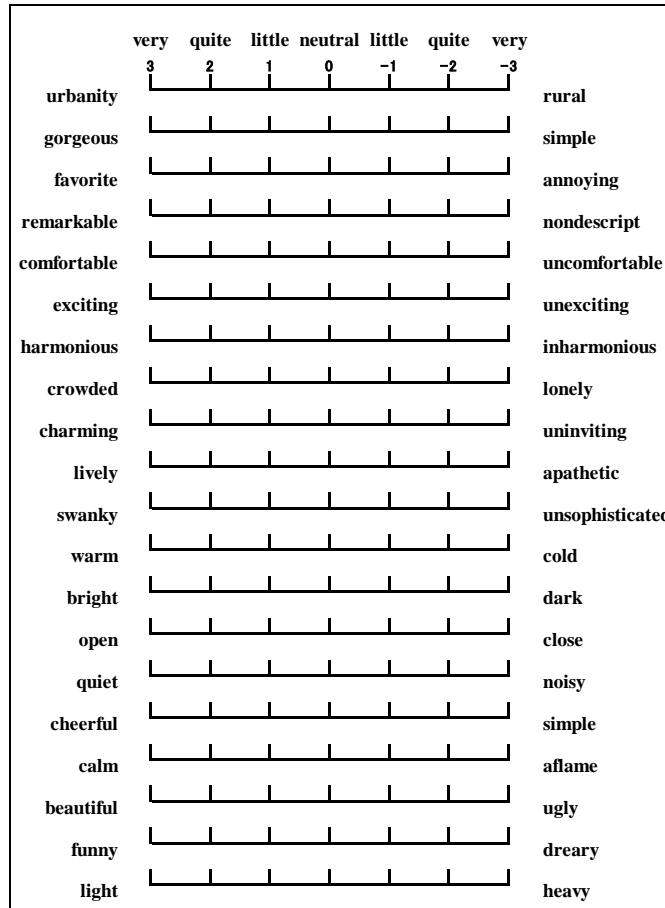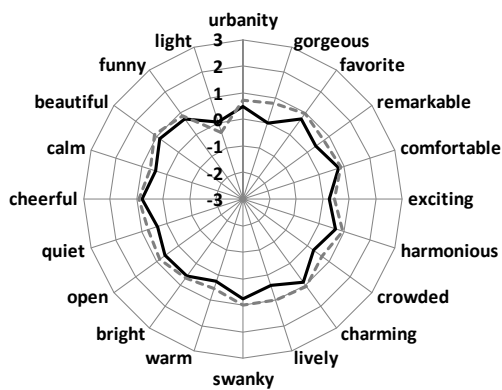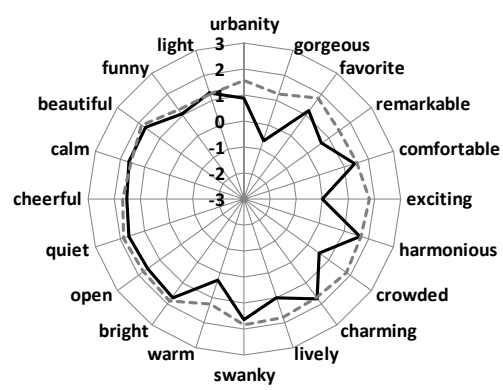|	very	quite	little	neutral	little	quite	very	
	3	2	1	0	−1	−2	−3	
urbanity								rural
gorgeous								simple
favorite								annoying
remarkable								nondescript
comfortable								uncomfortable
exciting								unexciting
harmonious								inharmonious
crowded								lonely
charming								uninviting
lively								apathetic
swanky								unsophisticated
warm								cold
bright								dark
open								close
quiet								noisy
cheerful								simple
calm								aflame
beautiful								ugly
funny								dreary
light								heavy

Fig. 3. Bipolar scales defined with adjectives on each end.

The factor analysis method was used to analyze the evaluation data of the SD method. This analysis makes it possible to ascertain the overall impression of the subject from similar impression words [20].

III. EXPERIMENTAL RESULTS

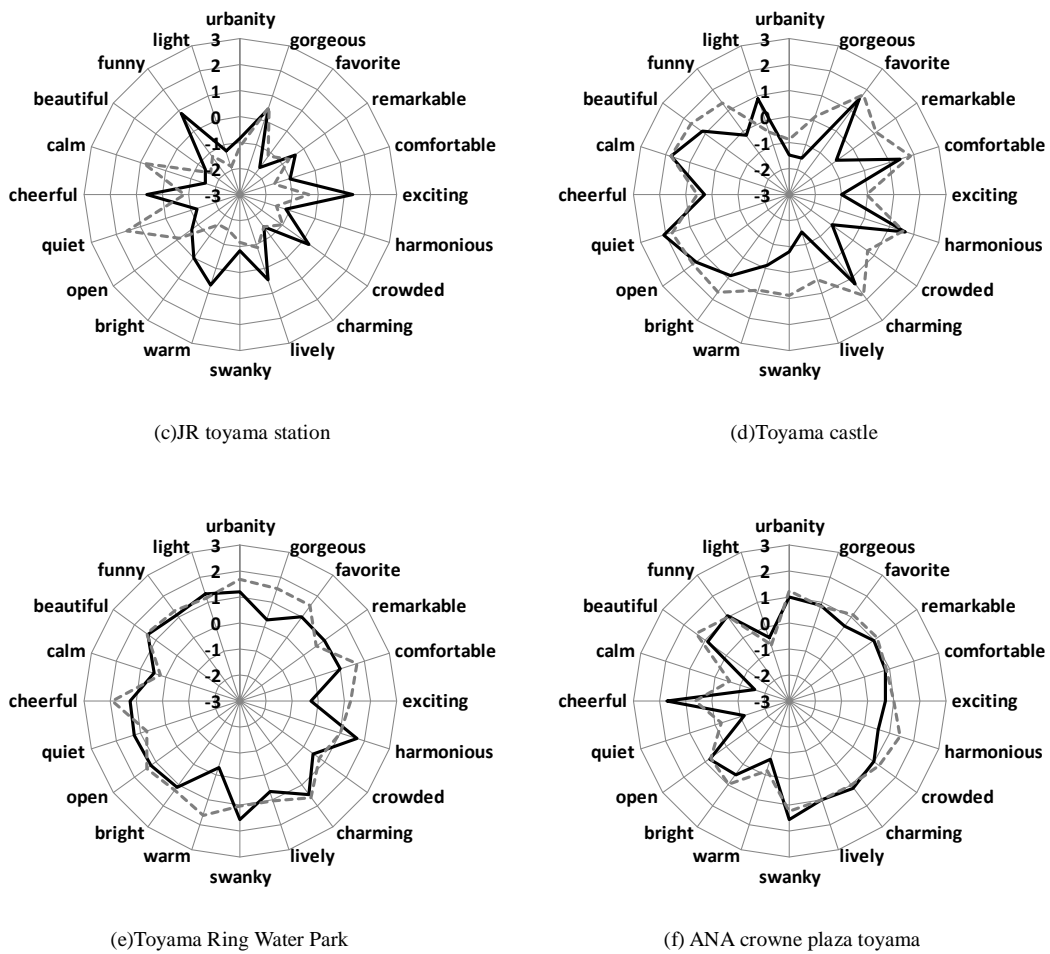(a)Overall mean   (b)Koshinokuni museum of literature

(c)JR toyama station

(d)Toyama castle

(e)Toyama Ring Water Park

(f) ANA crowne plaza toyama

Fig. 4.   Image Evaluation Results.

Fig.4(a)~(f) shows an example of the results of impression evaluation. For each landscape sample, the average of the image evaluation results for all subjects is shown in polar coordinates.

In each figure, positive impression adjectives are placed in the circumferential direction. In the radial direction, evaluation values are taken, with the outer position of the circle indicating a higher evaluation value for each adjective. The parameters are "daytime" and "nighttime.

First, Fig. 4(a) shows the average value, which can be said to indicate the tendency of landscape evaluation for "day view" and "night view," respectively. Overall, the image evaluation of the "daytime view" and the illuminated "nighttime view" showed that the area enclosed by the closed curve was larger in the order of "daytime view" and "nighttime view". In other words, the image evaluation of the "night view" was generally higher than that of the "day view" in the evaluation of each landscape sample. The samples that were particularly characteristic were (b)~(f) "urbanity," "gorgeous," "remarkable," "open," "crowded For adjectives such as "urbanity," "luxurious," "warm," "open," and "quiet," there was a large difference in the evaluation results between "daytime view" and "nighttime view.

Next, the characteristic individual landscapes are shown below.In the Koshinokuni Bunka Kaikan, Fig. 4(b), the image evaluation of the "night view" was generally higher than that of the "day view. Among them, "urbanity," "gorgeous," "remarkable," "exciting," "crowded The difference was particularly pronounced for adjectives such as "urbanity," "gorgeous," "remarkable," "exciting," "crowded," "lively," and "warm.

On the other hand, at JR Toyama Station, Fig.4(c), unlike the previous results, there was a large variation in the evaluation values, and the evaluations of "day view" and "night view" were reversed. In particular, "urbanity," "comfortable," "harmonic," "beautiful," "funny," "light The evaluation values of adjectives such as "urbanity," "comfortable," "harmonious," "beautiful," "funny," and "light" were very low.

The "night view" adjectives were highly evaluated except for "light" and "quiet" in Fig.4(d), which were highly evaluated in Toyama Castle. Specificall︎Night ﹏orite," "remarkable," "comfortable," "harmonious,"

"charming," "bright," "quiet," "quiet," and "comfortable" were the most highly rated. The adjectives "quiet," "calm," "beautiful," and "funny" tended to be highly evaluated.

In Toyama Kansui Park, the evaluation values were high for both "daytime" and "nighttime" adjectives, and all adjectives showed positive values, although there was some overall variation in the results shown in Fig. 4(e). Among the adjectives, "gorgeous," "comfortable," "exciting," "warm," and "wonderful" had particularly high evaluation values for "night view.

In the ANA Crowne Plaza Hotel, the left side of the circle is different from the right side of the circle, and the left side of the circle has a lower evaluation value and a larger variability. In particular, the evaluation values of "day view" and "night view," such as "light" and "cheerful," were inverted. Also in "night view," adjectives such as "harmonious," "beautiful," and "bright" tended to have high evaluation values.

In order to better interpret the results of each landscape sample, a factor analysis was conducted on the mean data of the image evaluation of each adjective pair in each landscape sample, based on the results obtained from the subjects.

To conduct the factor analysis, a principal component analysis was first conducted to determine the number of factors. The eigenvalues of the factors for the correlation matrix between each adjective pair are shown in Fig.5. Since two factors with eigenvalues of 1.0 or more were extracted and the cumulative contribution ratio was 80.06% (Table 2), a factor analysis was conducted with the number of factors set to "2" in consideration of the possibility of semantic interpretation.
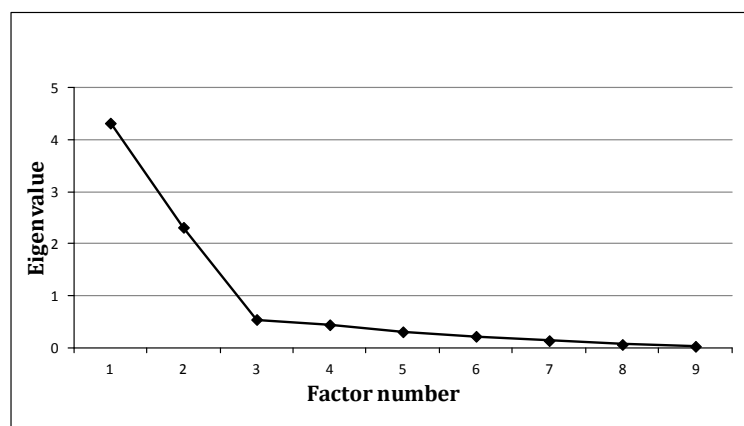

Fig. 5.   The intrinsic value of factor.

The resulting factor loadings for each adjective pair and the contribution of the factor after varimax rotation up to the second factor are shown in Table 2. The factor loadings indicate the influence of the factor on each endorsement item, and the factors were interpreted in terms of their factor loadings. The first factor had a contribution of 48.53% and included adjectives such as "comfortable," "harmonious," "beautiful," "charming," and "favorite. The second factor was interpreted as the "evaluation factor" because it included adjectives such as "beautiful," "charming," "favorite," and so on.

The second factor, with a contribution rate of 31.53%, was interpreted as the "activity factor" because of the high factor loadings of adjectives such as "lively," "crowded," "exciting," and "gorgeous"[21][22].

Based on the results of the factor analysis, a plot of the factor scores for each landscape sample is shown in Fig.6. The horizontal axis represents the first factor, "Evaluation," and the vertical axis represents the second factor, "Activity. The first factor, "Evaluation," indicates that the positive side is more favorable and the negative side is less favorable, while the second factor, "Activity," indicates that the positive side is "lively" or "bustling," and the negative side is "calm" or "quiet. The parameters are two levels: "night view" for the points indicated by triangles, and "day view" for the points indicated by diamonds.

Fig.6 shows that, as a general trend, "activity" and "evaluativeness" of "night view" exceeded those of "day view. In particular, the factor score of "night view" tended to increase significantly in "activity" on the vertical axis. This difference is thought to be mainly due to the appropriate landscape lighting effects at night, which gave the impression of more liveliness and vitality compared to the "daytime" view. Specifically, the landscape samples with particularly high scores for "activity" on the vertical axis were Aubade Hall, ANA Hotel, and Marie Toyama. The landscapes that stood out in the negative direction were Ikedaya,Toyama Castle, and JR Toyama Station, which were found to have very low factor scores. The main reason for the negative evaluation is thought to be the "liveliness and bustle" of commercial and tourist facilities, while historical landscapes such as Ikedaya and Toyama Castle tend to give the impression of being "calm and quiet. On the other hand, the station square and sidewalks of JR Toyama Station are very narrow, and adjectives such as

"light" and "open" related to the sense of openness were rated low, and the station is illuminated at night only in a part of the station building, which is thought to be mainly due to the overall lack of light. The main reason for this may be that the nighttime lighting is only implemented in a part of the station building, and the overall light is low.

As for "evaluability" on the horizontal axis, the landscapes that score high in the positive direction are Toyama Kansui Park, Takashinokuni Bunka Kaikan, andToyama Castle. On the other hand, the landscapes that stood out in the negative direction were JR Toyama Station and CIC Building. In the highly evaluated landscapes, unique landscapes such asToyama Kansui Park, which has a lot of greenery and is well lit, and Toyama Castle, which is beautifully illuminated with LED lights, tended to stand out. On the other hand, the landscapes with low evaluation include commercial landscapes, station buildings, and other landscapes in the city that give a conventional impression. Furthermore, the main reason for the negative evaluation of the CIC building is the use of fluorescent mercury lamps for lighting. Although fluorescent mercury lamps provide sufficient illumination, their color rendering is low, resulting in a gray, flat appearance. In addition, the electric poles in front of the station building and the electric cables in the sky above the JR Toyama Station are considered to be obstructing the "evaluativeness" of the landscape.

Table 2.   Factor loading to adjectives.

| Variable Name	No.1(Evaluation)	No.2(Activity)
Comfortable	0.969047172	0.04943547
Harmonious	0.934657141	-0.025114283
Beautiful	0.921890238	0.115394226
Charming	0.902306398	0.138171099
Favorite	0.894991338	0.046307605
Calm	0.883632875	-0.177324858
Cheerful	0.800734429	0.557142167
Swanky	0.780504913	0.674065295
Funny	-0.718055535	0.586844132
Lively	0.199353347	0.950263054
Crowded	0.243656404	0.945828803
Exciting	-0.058079067	0.907254039
Remarkable	0.366687188	0.885814567
Gorgeous	-0.305178155	0.844292318
Bright	0.340734429	0.808441318
Warm	0.454123061	0.79036606
Open	0.179133633	0.750652953
Light	0.520504913	0.71660601
Urbanity	0.343843896	0.366060098
Quiet	0.18654283	-0.27535434
Contribution Rate	48.53%	31.53%
Cumulative Contribution Rate	48.53%	80.06%
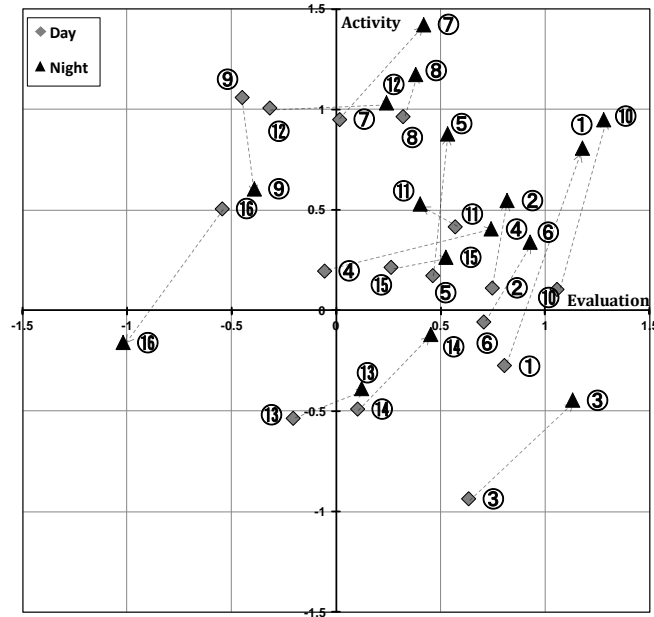
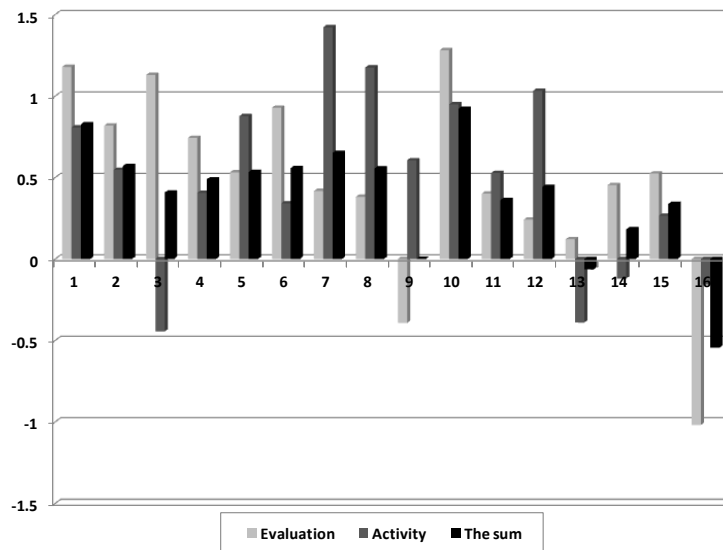**Fig. 6.   The rendering effect in each landscape.(Evaluation× Activity)**

Fig. 7.   Factor value of landscapes.(Evaluation, Activity and The sum of two factors)

Table 3.   Night view points along the LRT routes.

Landscape type	The optimal nightscapes	
Park	⑩	Toyama ring water park
Culture	①	Koshinokuni museum of literature
	⑥	Toyama international conference
	②	Toyama shimin plaza
Business	⑦	Urban place
	⑧	ANA crowne plaza toyama
	⑫	Marier toyama
Public facility	⑤	Toyama city hall
History	③	Toyama castle
	④	Toyama electrical building

In addition, in order to select the optimal "nightscape" from a quantitative perspective, a vertical bar graph comparing the first factor score (evaluation), the second factor score (activity), and the sum of the two factor scores for each landscape sample is shown in Fig. 7. The following (a)~(c) were examined for the "optimal nighttime scenery" along the LRT line according to Fig. 7.

(a) The nighttime views with the highest scores for both "evaluativeness" and "activity" are (10), (2), (5), (6), (7), and (8), respectively.

(b) The nighttime landscapes with high 'evaluativeness' were found to be, in descending order, (10), (1), (3), (6), (2), (4). The landscapes that differed from 'a' were (3) Toyama Castle and (4) Toyama Electric Building, which are "historical landscapes.

(c) The nighttime landscape with high "activity" was (7) ,(8) ,(12) ,(10), (5) ,(1) in descending order. The nighttime landscapes that differ from 'a' are (8) ANA Crowne Plaza Hotel and (12) Marie Toyama, both of which are "commercial/business landscapes".

Based on the above, the "optimal nighttime viewpoints along the LRT line" are shown for each landscape type (Table 3). In selecting viewpoints, it is desirable to select landscapes that are high in both the first factor "evaluativeness" and the second factor "activity," but the required functions and roles differ depending on the type of landscape. For example, a "commercial/business landscape" such as a downtown area should be highly active because of its liveliness and vitality. On the other hand, a "historical landscape" such as Toyama Castle should be highly "evaluative" because of the importance of elements such as calmness and tranquility.

By the way, the impression of the townscape that visitors and business travelers get when they exit Toyama Station is directly related to their impression of Toyama and has a significant impact on their willingness to spend and expectations during their stay in Toyama, making it a particularly important scenic point. As shown in Fig. 8, the factor scores of JR Toyama Station are low for both "evaluativeness" and "activity." Therefore, it is necessary to remodel the surrounding area by undergrounding utility poles, lighting up the station, and improving the station building design to further enhance its image.

IV. CONCLUSION

This experiment showed that the image evaluation of the "nightscape" along the LRT tended to exceed that of the "dayscape," and the importance of the "nightscape" was recognized once again.

The first factor, "evaluativeness," is related to "amenity creation" and "image enhancement," and the second factor, "activity," is related to "creation of liveliness" in the cityscape. Furthermore, the results of the factor analysis suggest that in order to select more desirable nighttime landscapes, it is effective to focus on the factor scores of "evaluativeness" and "activeness," which have large factor loadings.

The role of "landscape lighting" is important to create a beautiful and attractive "nightscape," but it is necessary to understand the characteristics and purpose of the landscape rather than simply lighting it.

This experiment, entitled "A Study on the Characteristics and Evaluation of the Nighttime Landscape along the LRT Line," examined the "nighttime landscape" in the central area of Toyama City using visual engineering and quantitative psychology. We hope that the results obtained above will help us to reexamine and reaffirm the "nighttime landscape" and to consider the creation of a beautiful nighttime landscape and its attractiveness in the future.

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