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博士の専攻分野の名称	博士（学術）
学位記号番号	博理工甲第 995 号
学位授与年月日	平成 27 年 9 月 18 日
学位授与の条件	学位規則第 4 条第 1 項該当
学位論文題目	Methodological Study on Structured Landscape Assessment for Landscape Planning Based on Visual Components （視覚的構成要素に基づく景観計画のための構造化された景観評価手法に関する方法論的研究）
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論文の内容の要旨

This study was conducted with the objective of finding out the perceivable effect of figures and backgrounds of the residential streetscapes, and their connections on visual complexity. The visual complexity depends on the amount of information a viewer can observe from visible area. The information includes a number of visual elements along the streetscapes, and their diversity and interconnections. Complexity can be broadly classified into, structural complexity, functional complexity, structural hierarchical complexity and functional hierarchical complexity. The objective of the research is to develop a method to analyze the structural hierarchical visual complexity in residential streetscapes, which was not addressed in the past and which is very important in setting landscape regulations, than just the general visual complexity. The hypothesis applied for this research is that, when the spatial arrangement and the spatial connections of the figures and backgrounds along the streetscape become complex, the structural hierarchical visual complexity becomes high; therefore, the structural hierarchical visual complexity can be measured by analyzing the taxonomic diagrams of figures and backgrounds. The visual elements of 70 residential streetscapes from urbanization controlled, medium urbanized and highly urbanized areas at the vicinity of Saitama University, Japan, were classified into figures and backgrounds using human perception of 20 subjects. The identified figures and backgrounds were arranged in a taxonomic diagram representing their connections. Figure 01 displays one of such taxonomic diagrams.

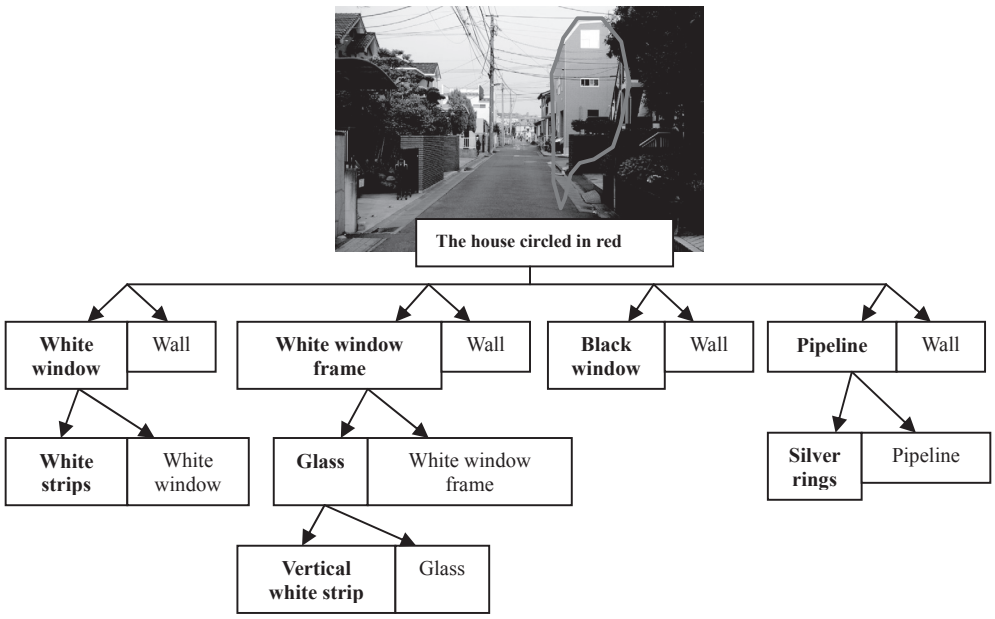

Figure 01: Taxonomic Diagram drawn to a Major Visual Element

Figure and background classification technique was applied to find out the distinction and the connections among the visual elements of the streetscapes. The structural hierarchical visual complexity increases when the variety (distinction) and the dependency (connections) increase. Drawing taxonomic diagrams, to depict the identified distinctions and connections between the figures and backgrounds is another novel approach applied for this research. As the variety and the connections between the visual elements in the streetscape increase, accordingly, by looking at the taxonomic diagrams of the streetscape elements, it was clear to get an idea about the streetscape structural hierarchical visual complexity. To prove the structural hierarchical visual complexity reflected by the variations in the size of the taxonomic diagram, the taxonomic entropy was utilized. Taxonomic entropy gives a numerical value reflecting the variety and the connections between the elements in the taxonomic diagram.

$$H = -\sum p_i \log_2 k_i$$

Where, H is taxonomic entropy, p_i the probability of i^{th} species and k_i the taxonomic distinctness of i^{th} species.

In consequence, when the taxonomic diagram is vertically and horizontally lengthy, the taxonomic entropy increases. When the taxonomic diagram is small in both directions, the taxonomic entropy becomes small. Therefore taxonomic entropy calculation is a prolific effort to display the structural hierarchical visual complexity numerically. According to the calculations, 70 residential streetscapes located in the Saitama city, Japan, displayed taxonomic entropy in between 2.3 and 3.0. These 70 residential streetscapes grouped into 20 streetscapes in highly urbanized areas, 30 streetscapes in medium urbanized areas and 20 streetscapes in urbanization controlled areas based on the building density. Based on the urbanization level the taxonomic entropy differed. Consequently, the highly urbanized streetscapes obtained values in between 2.8 to 3.0, medium urbanized streetscapes obtained 2.6 to 2.8 taxonomic entropy values and the urbanization controlled residential streetscapes obtained values in between 2.3 to 2.6. When the taxonomic diagram is vertically and horizontally lengthy and the arrangement of the elements of taxonomic diagram is irregular, the complexity becomes high depicting a large number of figures whose spatial connections impart high visual complexity to the streetscapes.

The results obtained through taxonomic entropy were statistically tested using two factor factorial ANOVA test. ANOVA test proves that there is no significant variation in the structural hierarchical visual complexity in the forward

and backward directions of the tested streetscapes (p value > 0.05). However, based on the availability of the streetscape features, the structural hierarchical visual complexity showed a significant variation (p value < 0.05).

Taxonomic entropy represents the visual complexity level of streetscapes. It depends on the perceivable figures and backgrounds. Hence this value is very useful for urban planners and architectural planners in designing streetscapes and building facades. Furthermore, this research method is useful in setting up landscape regulations. Once the taxonomic entropy values for best landscape types of different landscapes are identified, those values can be applied to evaluate the landscape complexity of existing landscapes as well as to build the new landscapes to match with the human perception. Taxonomic entropy calculation primarily based on the subjective analysis of figures and backgrounds. Therefore the value may change based on the variation in human perception and based on the counting method of figures and backgrounds.

論文の審査結果の要旨

Streets are important elements of a city, and, especially, residential streetscapes are important places to perceive and appreciate the quality of life of the residents. The street, frontage of residential buildings along the street, commercial sign boards, skyline, street pavement, lighting, vegetation and elsemore are all important parts of street's visual elements. These visual elements are cumulatively responsible for the visual complexity of the streetscape. Visual complexity is an important phenomenon in landscape planning to create a pleasant environment to the people live in the place and for the visitors.

Visual complexity can be measured in two; structural visual complexity and structural hierarchical visual complexity. The complexity caused by the visual structures such as number of elements, shapes of elements, color of elements, and elsemore is called structural complexity (considering the variety of aspect), while visual complexity caused by the visual structures and their invisible connections is called structural hierarchical visual complexity (with variety and connections).

The main objective of the study is to develop a method to analyze the structural hierarchical visual complexity in residential streetscapes, which was not addressed in the past and now is very important in setting landscape regulations. Furthermore the research has two specific objectives; to assess the differences in structural hierarchical visual complexity in forward and backward directions of the same streetscape and to assess the applicability of new methods in streetscape planning and designs. The hypothesis applied for this research is that, when the spatial arrangement (variety) and the invisible connections (dependency) of the figures and backgrounds along streetscape become complex, the perceivable visual amount becomes high increasing the structural hierarchical visual complexity. Therefore, structural hierarchical visual complexity can be measured by analyzing the taxonomic diagrams which represent the variety and dependency of perceivable visual elements along streetscapes.

Structural hierarchical visual complexity measurement needs to satisfy at least two aspects of visual complexity; they are the differentiation and connections. To measure these two aspects, Gestalt's explanations on the figure and its background identification and the taxonomic entropy were selected. The process of increase of visual elements is called differentiation, which is similar to the increase of the number of figures and backgrounds consist in the root visual element when dividing it into children figures and backgrounds. The process of increase in the number or strength of connections is called integration, which is similar to the progressive division of root visual element into children figures and backgrounds.

The study has several unique features such as, this is the first study, which addressed the structural hierarchical visual complexity of landscape (invisible structure), this is the first attempt to apply figure and background concept to represent the order of the visual perception of landscapes, this is the first study to display the order of the visual perception associated with variety and dependency of the perceivable visual elements as a taxonomic diagram (invisible structure associated with visual perception) and the most important point is this study successfully applied taxonomic entropy which was first used in biology to measure structural hierarchical visual complexity in landscapes.

To achieve these objectives, the visual elements of 70 residential streetscapes from urbanization controlled, medium urbanized and highly urbanized areas in the vicinity of Saitama University, Japan, were classified into figures and backgrounds using human perception of 20 subjects. An intensive field work was done with each subject on each streetscape for forward and backward directions. While travelling with the subjects, the figures and background

identified by subjects were video and voice recorded.

After finalizing the identified figures and backgrounds by subjects were arranged in a taxonomic diagram representing the order of visual perception with their invisible connections to each other. Then, the taxonomic entropy was applied to statistically analyze the structural hierarchical visual complexity.

The taxonomic entropy is an indication of the structural hierarchical visual complexity of the streetscape. The calculated taxonomic entropy values for residential streetscapes ranged between 2.3 and 3.0. When the taxonomic diagram is vertically and horizontally lengthy and the arrangement of the elements of taxonomic diagram is irregular, the taxonomic entropy value becomes high depicting a large number of figures whose spatial connections impart high visual complexity to the streetscapes.

To statistically test the differences of taxonomic entropy values for forward and backward directions and the different urbanization levels in the streetscapes, an ANOVA test was undertaken. The results of the ANOVA test displayed that there is no significant difference (p value 0.62>0.05 and F value less than F critical) in the taxonomic entropy values for forward and backward directions of the streetscapes. The p value of urbanization level is less than 0.05 (0.000) and F value is greater than the F critical value; consequently, there is a significant difference of the taxonomic entropy based on the urbanization level of streetscapes. The interaction between two directions and the urbanization level did not show any significant difference.

Streetscape design changes caused to change the visual perception and the order of visual perception. It causes change of the shape of the taxonomic diagram. Accordingly, the taxonomic entropy value changes. Thus the taxonomic entropy is very important in landscape design and planning as well.

Taxonomic entropy best represents the structural hierarchical visual complexity. Taxonomic entropy gives values based on both variety and dependency. It depends on the taxonomic diagram. Taxonomic diagram represents the order of human visual perception of figures and backgrounds. Therefore, taxonomic diagram is sensitive to the visual perception changes. Taxonomic diagram changes when the amount of perceivable visual information changes. Perceivable visual information changes with the landscape design changes. Therefore Landscape changes cause to change the visual perception and it causes to change the taxonomic entropy.

As stated above, the authors approach combining Gestalt Theory and hierarchical Taxonomic Entropy theory to the analysis of streetscapes is not yet taken in the domain of urban landscape studies, as far as referable document survey, and it is quite unique and challenging to consider structural relations between visual landscape in front of the viewer and regional landscape as a total image of a region in a quantitative way, which deserves for degree on doctor level study at least as a one step for discussions regarding the methodology contributing structured landscape assessment.