Irosashi: Visualization of the Colors of a Building Which Leave an Impression to Identify Characteristics of an Urban Environment

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Abstract: The purpose of this research is to propose a GUI for visualizing data showing the characteristics of the city and evaluate its effect. The author was interested in visual impressions of the urban environment and wanted to share these impressions with others. First, I made a prototype of "Irosashi Treemap", which plots all colors used for buildings in the western part of Hakodate city. However, the colors displayed by the Irosashi Treemap differed from the impressions of the subjects who knew the western area due to the many achromatic colors. Therefore, I collected color from the triangular roof and walls on the first floor of the building I felt frequent. In addition, it was suggested that the "Irosashi Treemap" plotted all colors, making it difficult to understand the characteristics of the colors. Therefore, a prototype of "Irosashi Impression", which plots representative colors, was produced. In evaluation experiment, three subjects answered that the impression of the city was close to the impression of the color taken from the triangular roof and walls. In the future, we will ask many people to collect impressive colors of the city. And evaluate the effect of "Irosashi Impression".

1 INTRODUCTION

This is a study on GUI (Graphical User Interface) for Data Visualization that displays the color characteristics of urban environment. In order to show the characteristics of the city, the author collected data on the colors of buildings which left an impression (on the viewer) and used the data to represent the characteristics of the urban environment. Next, Data Visualization, which can interactively identify the characteristics of an urban environment by mapping the color of the building by a computer was proposed, and its effects were evaluated.

This study was carried out because the author was interested in the difference in the visual impressions of urban environments and wanted to share these impressions with others. The author hoped to share with his family and friends the differences in the impression between his hometown and his current residence in the city. However, reasons for the difference in impressions were not clear, and as a result, expressing those impressions in words was difficult. Using the city photos, I was able to share the whole picture of the city with others. However, the impression I wanted to convey was not the whole picture of the city, but the representative part of the city. Therefore, I wanted to consider a method for communicating the impression that we felt as a representative part of the city to others.

First, how people form an impression of a city was considered. According to Miura et al. impressions are unconsciously formed. Miura et al. defined *kansei* (feeling) as a function that intuitively processes vague information (Miura, 2000). The terms “vague” and “intuition” mean that people unconsciously extract and integrate information from the environment to form an impression (Miura, 2003). Miura et al. further stated that impressions were difficult to put into words and exceeded logic, and are related to knowledge (Miura, 2003). If this is applied to a city, it can be said that a person unconsciously integrates the objects and knowledge that comprise the city in order to form an impression (of the city).

Next, regarding factors which influence people in the formation of an impression of the city. Kawabata et al. stated that the color of an object affects visual perception. In addition, the city consists of many buildings. Inoue et al. considered that the color of building is important in understanding a city (Inoue, 2014). Similarly, it can be said that the color of the building represents the impression of a city.

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Therefore, a collection method of the colors of buildings that can accurately represent the impression of the city was considered.

It is difficult to convey the impression of a color in words to others. Therefore, symbols in a diagram which can convey the impression of a color to others were considered. The diagram shows vague information and can be shared with others. A map shows the characteristics of the world and is a representative example of how a diagram shares information with others. Nakamura considered that a map is based on the world structure in a person's mind (Nakamura, 1993). A world view can be interpreted by a map and shared with others. From this, it was considered possible to interpret the vague impression of the city by mapping the color of an urban building, and could be shared with others.

Data Visualization was considered as a method to represent the colors of a building as diagrams. Data Visualization is a method that allows users to interactively understand the meaning of data using a computer GUI (Graphical User Interface). In addition, by representing the color of a building with a computer, the user can compare the colors of different cities and understand the characteristics of each one.

In some cases, GUI for visualizing color features use color variables (RGB, CMYK, HSV, etc.) to plot all colors. However, I thought it was difficult to understand the features from the large number of displayed colors. Therefore, in order to convey color characteristics in an easy-to-understand manner, we proposed a GUI that plots representative colors.

The purpose of this study is to propose Data Visualization which can show the characteristics of a city and evaluate their effects. In order to show the characteristics of the city, the colors of buildings which left an impression were collected. Next, Data Visualization, which can show the characteristics of an urban environment interactively by mapping the colors of the buildings with a computer, was proposed and their effect was evaluated.

2 RELATED WORKS

2.1 Color Characteristics Analysis in an Urban Environment

The Seibu Area in Hakodate City, Japan, is lined with building painted various colors. Morishita et al. collected previous paint colors by shaving the paint off a building and displayed the color characteristics in a table (Morishita, 2004). The colors of a building are classified into 13 main colors, and a table summarizes the number of appearances of each color. In the table, colors characteristics are supplemented with text. Conte et al. analyzed the color of buildings focusing on light, time, vegetation and nature The color characteristics of the Italian city of Matera are shown (Conte, 2018). Conte et al. filmed the city of Matera from 15 directions and compared the color characteristics of each direction. The studies by Morishita et al. and Conte et al. are interesting in that the colors of buildings were collected in order to show the characteristics of the city.

2.2 Color Characteristics Analysis in Image Engineering

Muroya et al. analyzed the change in color in the vertical and horizontal directions of a painting and showed the characteristics of the painting (Muroya, 2017). Muroya et al. divided the painting into equal sections and analyzed the colors. Also, Takahashi et al. considered a method to extract representative colors from images composed of complex colors in reference to human visual perception (Takahashi, 2016). Takahashi et al. collected colors from all the objects in the image, and then colors which persons felt were the same were grouped together.

2.3 Data Visualization Representing the Visual Characteristics of Urban

Dudek et al. proposed Data Visualization that combined ratiograms and diachrograms in order to represent historical change of a city (Dudek, 2010). A ratiogram represents the form, structure, and function of building, while a diachrogram represents its life cycle such as building construction and repair. Dudek et al. showed the characteristics of a city by focusing on the structure and history of a building.

2.4 Data Visualization Representing Color Characteristics

PixelChart is Data Visualization that analyzes the colors in images uploaded by users and distributes the colors to CMYK values (Andrei, 2018). In addition, PHOTOTRAILS analyzes the colors of photos uploaded to SNS by city. This Data Visualization divides photos into hue values (Nadav, 2013). PixelChart and PHOTOTRAILS show all collected colors using color variables such as hue and CMYK. PixelChart and PHOTOTRAILS are diagrams that target and represent a single image.

2.5 Research Concept

In this study, how to collect the colors of a building that give an impression and use of a diagram to easily convey the characteristics of colors are evaluated. Consequently, how to collect the colors of a building in a way that accurately shows the impression of the city was considered. In addition, colors that leave an impression, rather than all the colors painted on the building, were collected.

In order to easily convey color characteristics, representative colors were plotted. In this way, it was hypothesized that users could easily understand the characteristics of the city. In addition, an interactive diagram (color representation) to compare colors was also prepared. By comparing different cities interactively, it was assumed that users could understand the characteristics of a city well.

3 RESEARCH PROCESS

The author prototyped a GUI prototype that plots the colors of the building. And I cognitively analyzed the effect of the GUI. In addition, we considered the results of analyzing the prototype and prototyped a new prototype.

First, an "Irosashi Treemap" that collects and plots all the colors used in the building was created. From the results of the evaluation experiment, collecting colors that could express the impressions of the viewer were thought to be needed in order to demonstrate the characteristics of the city. Therefore, colors from buildings that left an impression were collected and "Irosashi Impression" was created.

4 PROTOTYPE1: Irosashi Treemap

The prototype, "Irosashi Treemap" (Figure 1) shows the characteristics of the city by plotting all the colors used in a building using the Treemap method (Johnson, 1991). Users can freely generate diagrams by selecting specific items (Area, Building Type, Building Part).

4.1 Irosashi Treemap Structure

"Irosashi Treemap" plots colors within a certain range using the Treemap method. Consequently, even if the number of displayed colors changes depending on the item selected by the user (Area, Building Type, Building Part), the diagram is always the same size, allowing users to compare different cities. Colors are classified into 14 hues. Each hue, the parent data, is displayed in descending order of frequency ratio for all colors starting from the top left of the screen. Colors that are child data are displayed in order of brightness from the upper left. The size of each node increases according to the number of collected colors.

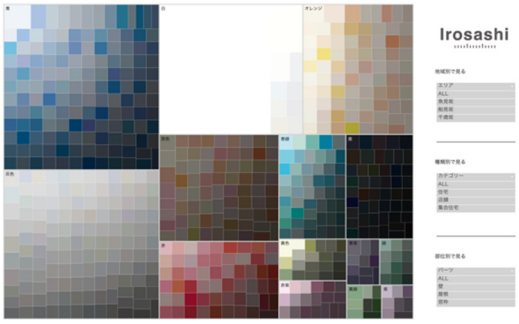

Figure 1: Irosashi Treemap Basic Screen.

4.2 Collecting Colors Represented by Irosashi Treemap

Colors of the buildings in the Seibu Area of Hakodate City were collected. Buildings in the Seibu Area have characteristic colors for the roof and walls. Furthermore, window frames also feature distinctive colors. The colors of the buildings in the district are mainly divided into three parts: roof, wall, and window frame. Therefore, colors were collected from these parts. Seibu is a hilly area, so colors were collected by individual slope.

Colors were collected from eight slopes in the Seibu Area (Nizyukken Slope, Daisan Slope, Hachiman Slope, Motoi Slope, Saiwai Slope, Chitose Slope, Funami Slope, Uomi Slope). Colors were then extracted from a photograph of the building using the eyedropper function of "Adobe Illustrator" (Figure 2).

Figure 2: Colors Collected from Pixels on Roofs, Walls, and Window Frames in Building Photos.

A csv file with four elements: "Building Type", "Building Part", "Color Code (Hexadecimal)", and "Collected Slope" was created. Users can freely

generate diagrams by selecting 8 slopes, 23 types of buildings (Houses, Stores, etc.) and 3 building parts (Roof, Wall, or Window Frame) (Figure 3).

Figure 3: The Colors of the Buildings at Hachiman Slope (Left) and Funami Slope (Right).

4.3 Irosashi Treemap Evaluation Experiment

Purpose. The purpose of this experiment was to evaluate whether "Irosashi Treemap" could represent the color characteristics of the city.
Subjects. 5 university students, 9 non-students.
Procedure. Subjects answered a questionnaire describing the color characteristics of buildings in the Seibu Area and were instructed on the use of the "Irosashi Treemap". There was no time limit and the subject could work at his own pace. When the subject was finished, a questionnaire on understanding the color characteristics of the buildings in the Seibu Area and an interview on the use of "Irosashi Treemap" were carried out.

4.4 Experimental Results and Discussion

In this section, collection method of building colors and easy-to-understand color diagrams based on the experimental results are considered.

4.4.1 Color Characteristics Differ According to the Subject's Impression

Each subject had visited the Seibu Area before and had an impression of the colors of the buildings. Nine of the 14 subjects described a large number of achromatic colors as colors different from characteristic colors which left an impression. Three subjects answered that the colors of different slopes looked the same. From the above results, due so many achromatic colors, the colors of "Irosashi Treemap" were considered to differ depending on the impression by the subject. One reason for the collection of so many achromatic colors is that all the colors which do not leave a strong impression and are overlooked by people were collected. Hence, consideration of a collection method that can collect colors which leave an impression is needed.

4.4.2 Examination of Easy-to-Understand Colors

In order to represent the color characteristics of the city, it is necessary to express the characteristic colors of a building in an easy-to-understand manner. However, average score to the question "Could you understand the characteristic colors?" (answered after the subject used "Irosashi Treemap") was 3.78 on a scale of 1-5. Consequently using a diagram to express the colors in an easy-to-understand manner is considered needed.

4.4.3 Compare Colors of Different City

Four subjects answered that the color characteristics were difficult to understand. Subjects answered that the color characteristics were difficult to understand because the colors could not be compared for individual slopes. In addition, three examinees answered that the number of displayed colors differed by slope. The number of colors displayed on "Irosashi Treemap" varied depending on the number of buildings adjacent to the slope (Figure 4). Therefore, comparing colors is considered difficult.

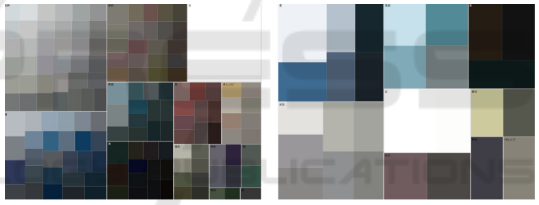

Figure 4: The Number of Different Building Colors Displayed for Each Slope.

One subject answered that the position where the colors were displayed differed for each slope (Figure 5). It was difficult to keep track of the color he wanted to compare each time he selected a slope and generated a diagram. In response to the above, the reason why color characteristics cannot be displayed is that the number of display colors and the display position differ by slope.

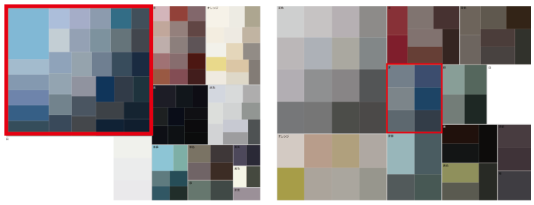

Figure 5: The Hue is Displayed at a Different Position for Each Slope.

4.4.4 Problems of Irosashi Treemap

According to the results of the evaluation experiment, the following four issues were observed for “Irosashi Treemap”.

・ Collection method of building colors which can leave an impression with the viewer.

・Creation of diagrams that can display colors in an easy-to-understand manner.

・ Creation of diagrams that have the same number of displayed colors and which can compare the colors from different cities.

・ Creation of diagrams that can display colors in a predetermined position and compare the colors from different cities.

Based on these issues, a preliminary survey and prototype production were conducted to reexamine the color collection method.

5 PROTOTYPE2: Irosashi Impression

“Irosashi Impression” shows representative colors collected from buildings that leave an impression. The user can select the city and the number of displayed colors (1 to 10 colors) and freely generate diagram. The user can switch between “Color View Mode” (Figure 6) and “Box Plot Mode” (Figure 7) that distributes colors according to hue values. The colors are displayed in a uniform size depending on the number of colors selected by the user.

“Irosashi Impression” displays a certain number of representative colors at predetermined positions according to the hue value. This diagram allows users to compare the colors of different cities and understand the color characteristics of each city.

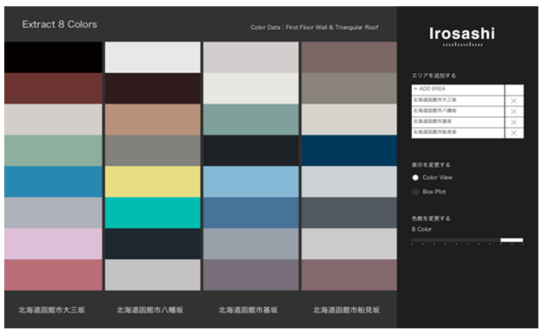

Figure 6: Color View Mode of Irosashi Impression.

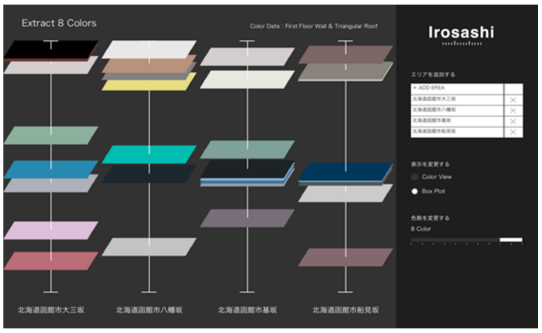

Figure 7: Box Plot Mode of Irosashi Impression.

5.1 Irosashi Impression Structure

“Irosashi Impression” plots representative colors using the kmeans ++ method (Arthur, 2007). A representative color is the average value of each cluster and the Euclidean distance closest to each other(Lab color space). The kmeans ++ method was used instead of the kmeans method (Macqueen, 1967) in order to prevent the representative color from changing every time the user selects the number of displayed colors.

5.2 Collecting Colors That Represent an Impression

A method to collect colors that leave an impression with the viewer was considered by sketching common color points in buildings that left an impression with the viewer as he walked through the slopes in the Seibu Area. As a result of the examination, colors were collected from the triangular roof and walls on the first floor of the buildings which left an impression with the viewer (Figure 8). The triangular roof and walls of the building were frequently seen in walking. Colors were extracted from four slopes in the Seibu Area, Hakodate City (Daisan Slope, Hachiman Slope, Motoi Slope, Funami Slope).

Figure 8: Colors Collected from Pixels on Triangular Roof and Wall of the First Floor in Building Photos.

5.3 Irosashi Impression Evaluation Experiment

The Purpose. The purpose of using Irosashi Impression was to evaluate whether the colors collected from the triangular roof and walls on the first floor of the building closely matched the impression of the viewer.

Subjects. 3 university students and 7 graduate students.

Procedure. The subjects walked through two slopes (Daisan Slope, Hachiman Slope) in the Seibu Area, and the impression left by the colors of the building was written on the questionnaire. After walking through each slope, the subjects were shown with a screen of 5 representative colors of roof, wall, and window frame (Pattern 1) and a screen of 5 representative colors of triangular roof and wall color on the first floor (Pattern 2) (Figures 9 and 10), and the impression of the color was written in the questionnaire. Next, the subjects were asked how the impression of the color of the building when walking through the slope matched the impression of the colors in Pattern 1 and Pattern 2, respectively, on a scale of 1-5.

Figure 9: All the Building Colors (Pattern 1) and the Triangular Roof and Wall Colors of the Building (Pattern 2) Collected on the Daisan Slope Displayed Using Irosashi Impression.

Figure 10: All the Building Colors (Pattern 1) and the Triangular Roof and Wall Colors of the Building (Pattern 2) Collected on the Hachiman Slope Displayed Using Irosashi Impression.

5.4 Evaluation Experiment Results and Discussion

In this section, we show the experimental results of evaluating the color impression displayed by "Irosashi Impression". In addition, we describe how to collect the colors of the building that left an impression from the experimental results, and how to create a diagram showing the color characteristics.

5.4.1 Collecting Colors of a Building That Leave an Impression

Figure 11 shows the average value of how well the impression formed from the colors of the building on a slope matched the impression from the color of “Irosashi Impression”. For Daisan Slope, the average value for Pattern 2 was high. For Hachiman Slope, there was no difference between the average values of Pattern 1 and Pattern 2. In addition, normality could not be confirmed in the evaluation of Pattern 2 of Daisan Slope and Hachiman Slope. Wilcoxon's rank sum test was used to determine significant difference in the evaluation of Patterns 1 and 2 for Daisan Slope and Hachiman Slope. However, no significant difference between Daisan Slope ($p = 0.37 > 0.05$) and Hachiman Slope ($p = 0.85 > 0.05$) was observed. From these results, further room for consideration in the collection method of colors that leave an impression is suggested. Although, three subjects replied that the color of Daisan Slope Pattern 2 was close to the color impression they felt when going down the slope. Although there was no significant difference, Daisan Slope may have been more effective in color correction method for expressing people's impressions. In the future, we will reexamine the method of collecting colors so that multiple people can collect impressive colors and share urban impressions.

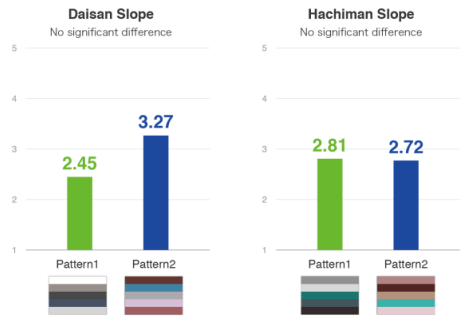

Figure 11: Degree the Impression from the Color of the Building on the Slope matched the Colors of Pattern 1 and Pattern 2.

5.4.2 Diagram Representation of Color Characteristics

In this experiment, five colors were plotted from the colors collected using “Irosashi Impression”. However, impressions may change depending on the number of displayed colors. In the future, allowing the subject to freely select the number of colors to be displayed and then evaluating the impression of the colors is planned. Furthermore, in this experiment, the color size was displayed evenly. However, the impression may change depending on the size of the color display. In the future, we will consider a method of displaying colors in a size corresponding to the area of the sampling part.

6 FUTURE WORK

The color correction method proposed to express people's impressions proposed in this study focused on external factors such as building parts. However, the impression of the viewer may also be influenced by internal factors such as interest. Therefore, it is possible that not only buildings but all objects affect people's impressions. In the future, analysis of the factors that affect the viewer’s impression will be carried out by having multiple subjects collect the colors which left an impression with them, and then reexamine the color collection method. The collected colors will then be plotted using “Irosashi Impression”, and whether the characteristics of the city could be shown in the results will be evaluated.

7 CONCLUSIONS

The purpose of this study is to propose data visualization that can show the characteristics of a city and evaluate its effect. In order to show the characteristics of the city, the colors of buildings that left an impression with the viewer were collected. In addition, the color of the building was visualized with a computer, a Data Visualization that interactively displayed the characteristics of the city was proposed and its effect evaluated. From the experimental results of “Irosashi Impression”, the impression viewers formed of a city was influenced not only by external factors such as building parts, but also by internal factors such as interest. In the future, a method to collect the colors of a building that can show the impression of a city will be reconsidered, and the effect of “Irosashi Impression” will be reevaluated.

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