Estimation of impression of store interior design based on color features extracted using object segmentation

Naoki TAKAHASHI *, Takashi SAKAMOTO **, Hiroko SHOJI * and Toshikazu KATO *

* Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan
naoki@kc.chuo-u.ac.jp
hiroko@kc.chuo-u.ac.jp
1-kato@kc.chuo-u.ac.jp

** National Institute of Advanced Industrial Science and Technology, AIST Kashiwa, Kashiwa II Campus, University of Tokyo,
6-2-3 Kashiwanoha, Kashiwa, Chiba 277-8608 Japan
takashi-sakamoto@aist.go.jp

Abstract: The aim of this study is to analyze the impression provided by a color image and the color information contained in the image. To process a large number of color images, we used a method of extracting representative colors from an image based on pixel information. In this study, we developed a method to combine image recognition technology using deep learning with representative color extraction technology, and analyzed the impression and color characteristics of design for store interior images. We collected color images of store interiors along with their tagged keywords from the web. Representative colors were extracted via a method using region division by deep learning. Furthermore, we analyzed the characteristics of the representative colors included in the corresponding images for the keywords "natural," "modern," and "cute," which were frequently used in the collected data to express the impression of the store design. The tendency of color features was analyzed for each image. For example, in "natural" designs, there were many colors close to yellowish green, which were associated with objects such as "plant" and "tree". Such knowledge is important for design support, that is, knowledge of the color to be incorporated into the design, as well as of methods to incorporate that color.

Keywords: Image processing, Representative color, Kansei, Visual impression

1. INTRODUCTION

Recently, in the marketing field, not only the functional value of a product but also the emotional value has come to be emphasized. In other words, it is important for consumers to have a favorable experience through consumption behavior. Understanding what consumers feel and imagine regarding a product is an important marketing concern.

When people acquire information about products, one of the important sources is image data, such as photographs. Currently, a large amount of image data exists on the Internet, and emotional information is associated with image data on social media, review sites, data sharing sites, etc. Image data are considered to have potentially more sensibility information than text data, and it is of great significance to study methods for estimating impressions and sentiments from pictures.

The impression that a person receives from an image depends on various factors. Although the significant factors differ depending on the field of the target product, color information is important and easy-to-analyze for any type of image [1]. However, different target fields have different meanings and impressions of colors; thus, to be applicable to a wide range of fields, the analysis must consider not only pixel information but also the connection between the semantic information of images and color information. Therefore, it is necessary to establish a suitable analysis method.

The aim of this study is to analyze the relationship between the impression that a color image gives to a person and the color and semantic information contained in the image. We analyzed the store design of restaurants. This is because we have previously studied interior color design, and the means for analyzing the semantic information in interior images [2]. The reason is that it was easy to collect images of the store, and various psychological effects of the color design of the restaurant on consumers have been reported [3]. We believe that the results of this study can be used to support the creation of desirable impressions of designs.
2. RELATED WORK

Takahashi et al. proposed color features to compare and categorize brand images from interior brand photographs and conducted a quantitative analysis of the brand image in the feature space [4]. As a result, in the target interior brands, the characteristics of each brand could be represented by the neutral colors of red, orange, cyan, and blue. We also analyzed the relationship between the representative colors of restaurant homepage images and the price range [5]. We demonstrated that there was a negative correlation between the saturation of the representative colors of the homepage image and the average budget [5]. In these studies, the extracted representative colors were not associated with the semantic information of the objects in the image.

Kaneko et al. proposed a method for realizing a color coordination system, which extracts a color scheme that matches the impression in the target space [6]. However, in this method, only the target space prepared by the system can be used. Moreover, when dealing with the relationship between the color scheme and the image in the target space, the influence of the objects in the space was not considered.

3. METHODS

3.1 Data acquisition

Store design images were collected from Store Design.COM [7] using web scraping. On this website, multiple photographs and keywords that express the characteristics of the design are associated with each store. In this study, keyword information was acquired along with images. The colors used in the interior of restaurants are known to have the effect of stimulating and relaxing appetite, and it is highly useful to investigate the relationship between design and psychological effects and emotional values. Therefore, in this study, we focused on images of restaurants. In addition, among the collected keywords, the ones that expressed the impression of the store design and were frequently used on the website, that is, "natural" (ナチュラル), "modern" (モダン), and "cute" (かわいい), were targeted for the analysis. "Cute" in kanji notation (可愛) and in hiragana notation (かわいい) were equally considered.

3.2 Feature extraction

For the collected images, the area division method proposed by Zhou et al. [2] was incorporated into the corresponding part of the representative color extraction method of Takahashi et al. [4,5], and each image was divided into areas and the representative colors of each area were extracted. The procedure for extracting representative colors is as follows.

Figure 2 depicts the process of extracting representative colors. The image on the upper left of Figure 2 is the original image, and the image on the upper right is the area divided by the method of Zhou et al. The pixels of each area are replaced by the average of the pixel values contained in the area. The method proposed by Zhou et al. realizes semantic segmentation by using a neural network that learns object information in an image, unlike classical segmentation that uses only the brightness gradient. Each area obtained is given a label (e.g., “floor,” “wall,”

![Figure 1. Examples of images used for the experiment: natural (left), modern (center), and kawaii (right)](image-url)
“table”) indicating the type of object. Because there are similar colors among the average colors of each area (e.g., the same wooden furniture), the colors of the areas are clustered into a smaller number of colors. The lower part of Figure 2 shows the average colors of the six clusters, and each cluster is associated with the object information corresponding to that area. This made it possible to understand the correspondence between the types of objects in the image and the extracted representative colors. Herein, the L * a * b * color system was used as the color information to be extracted.

Next, the kernel density was estimated for the color information extracted from the image, and the attribution probabilities of each color for the three impression keywords were obtained. Among these, those with an attribution probability of 0.8 or more were designated as colors representing the characteristics of the impression. A scatter plot was created with the a * value of the color on the horizontal axis and the b * value on the vertical axis. Based on the scatter plot, clustering was performed using the k-means method.

4. RESULTS

The collected data can be summarized as follows:

"natural": 7618 images collected from 1191 stores;
"modern": 4907 images collected from 789 stores; and
"cute": 1500 images collected from 425 stores.

From Figure 3, in cluster 2 of "natural," the value of a * was distributed in the range of approximately -10 to -50, and the value of b * was distributed in the range of approximately 50 to 70. The object names of the areas from which these colors were extracted were "plant" and "tree." In cluster 2, the value of a * was distributed in the range of approximately 10 to 50, and the value of b * was distributed in the range of approximately -50 to -70. The object name of the area from which these colors were extracted was "sky." The image from which "sky" was extracted was not the design of the interior of the store, but the image of the exterior. Furthermore, in "wall" and "floor," which are the object names often detected in "natural," no color belonging to the cluster was found.

Next, in "modern," in cluster 1, the value of a * was distributed in the range of approximately -30 to -50, and the value of b * was distributed in the range of approximately -40 to -70. The object names of the areas where these colors were extracted were "wall," "ceiling," "floor," etc.

Finally, in "cute," the value of a * was distributed in the range of approximately 30 to 50 and the value of b * was distributed in the range of approximately -20 to -10 in cluster 2. The object names of the areas where these colors were extracted were "wall," "counter," "sofa," etc.

5. DISCUSSION

From the results, it was found that many colors close to yellowish green tend to be used in "natural" designs. Many of the colors were extracted from plant-related objects such as "plant" and "tree." In addition, many of the extracted "wall," "floor," and "ceiling" objects had colors
close to white. From these observations, it can be said that the "natural" design can be expressed by arranging plants with a color close to yellow-green in the store and using a color close to white for the walls, floor, and ceiling. In addition, in the "natural" image group, many images used wood, such as tables and chairs with visible grain. In the method proposed in this study, the material of the object is not known. However, if the material of the object can be taken into consideration, it may be possible to form a more accurate image model. The left column of Figure 1 is an example of an image where a representative color having a high attribution probability to "natural" is extracted.

It was found that dark blue and purple tend to be used more often in "modern" designs. The color was extracted from "wall," "ceiling," etc. From the image, it can be seen that the wall itself may appear dark blue or purple, but it is actually a different color, and dark blue or purple may be extracted under the influence of lighting. There were many such objects. In this study, many of the walls, ceilings, and interiors affected by the lighting actually seemed to have a white color. This is believed to serve the purpose of spreading the impression of the color of the illuminating light throughout the store by taking advantage of the property that white colors easily reflect light. From these observations, it can be said that in the case of a "modern" design, a "modern" impression can be formed by using these colors for lighting, etc., instead of placing actual objects with dark blue or purple colors. Thus, white objects that easily reflect light are considered to be effective. The center of Figure 1 is an example of an image where a representative color having a high attribution probability to "modern" is extracted.

Lastly, "cute" designs tended to use pink and light purple. There were many objects such as "wall" that occupied a relatively large area in the store. From these observations, it can be said that, to make a "cute" design, a "cute" impression can be formed by arranging pink or light purple on a wall or other objects that have a large area. The right column of Figure 1 is an example of an image where representative colors having a high attribution probability to "cute" are extracted.

6. CONCLUSION

In this study, we expressed the characteristics of the three impressions of "natural," "modern," and "cute" by associating the representative colors of the store design images of restaurants with objects. As a future study, it is first necessary to apply the proposed method to impression words other than the three used in this study. In addition, based on the results obtained herein, it is necessary to evaluate whether people are actually impressed as imagined. This is planned to be studied in the future. In this study, we focused on the representative colors and object names of images. However, if the material of the object can be taken into consideration, it may be possible to clarify the characteristics of the image in further detail.

ACKNOWLEDGMENTS

We would like to thank Mr. Yusuke Iwai, who was our initial research member until he graduated from Chuo University, for the data acquisition and summarizing experimental data. This work was partially supported by Collaboration Research Fund, Institute of Science & Engineering, Chuo University.

REFERENCES

[1] Haruo Hibino: Design and Psychology on Color: Introduction to Design Psych. Journal of the Color Science Association of Japan, Vol. 29, pp. 148-149, 2005.
[2] Bolei Zhou, Hang Zhao, Xavier Puig, Tete. Xiao, Sanja Fidler, Adela Barriuso, Antonio Torralba: Semantic Understanding of Scenes through the ADE20K Dataset, International Journal of Computer Vision, Vol. 127, pp. 302-321, 2019.
[3] Satyendra Singh: Impact of Color on Marketing, Management Decision, Vol. 44, 783-789, 2006.
[4] Naoki Takahashi, Takashi Sakamoto, Toshikazu Kato: Color-analysis of Image Photography of Interior Brand based on Extraction of Representative Colors and Clustered Color-features, Transaction of Japan Society of Kansei Engineering, 15, pp. 203-212, 2016.
[5] Naoki Takahashi, Hiroko Shoji, Takashi Sakamoto, Toshikazu Kato: Effects of Price Range on Color Features of Website Images of Restaurants, Journal of the Color Science Association of Japan, Vol. 42, pp. 27-30, 2018.
[6] Tamao Kaneko, Yasushi Shimizu: Color coordination system that search and learn color theme matching specified impression [translated from Japanese], Data Engineering Workshop, B4-2, 2002.
[7] Store Design.COM [translated from Japanese]. https://www.tenpodesign.com/ (2021/1/15 Accessed)