

Automatic Generation System of Product Package Designs Based on Review Information

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Abstract. Product package design is an essential means of advertising the product to consumers. When creating them, it is crucial to consider the impression consumers have of the design. However, there is a problem that it is difficult to create a design that appropriately reflects the impression information, which is large-scale and complex. To solve this problem, two novel systems are proposed in this paper. The first one is a review analysis system, which inputs reviews of arbitrary products as text information and shows what kind of impression of the product consumers have. The second one is an automatic generation system of product package designs. It is a system that outputs a product package design that appropriately reflects the impression word extracted from the concept of the product. The results of the evaluation experiment clarified the effectiveness of the proposed systems in terms of the ability to convey the concept of product to generated product packages.

Keywords: Package design, Impression, Automatic design generation, Color

1. Introduction

There are various methods to appeal to consumers with a company's products, including advertisements on television, in newspapers, and on the Internet. Among these methods, the in-store environment, where consumers can physically interact with products, is believed to have a direct impact on their purchasing behavior. Consequently, advertising strategies within this environment are deemed very important. Effective product package design plays a critical role in accurately conveying the product's image and concept to consumers, positively influencing their desire to purchase. Therefore, it is crucial that the product package design appropriately reflects 'impression information,' which pertains to the kind of impression people will have, during its creation [1-3].

In this context, numerous studies have explored how different design elements of product packages, such as background colors and logos, influence consumer impressions. These studies include investigations of the relation between the flavors of potato chip products and the colors used in their packages [4], the impact of simplicity in package design on brand perception [5], the effects of logo placements on consumer impressions [6], and the influence of colors on brand image [7].

These studies show that modifying design elements can alter the impression information conveyed to consumers. Moreover, consumer impressions are likely to differ, indicating that impression information is both extensive and complex. Thus, accurately reflecting impression information in product package design presents a significant challenge.

This study aims to elucidate the relation between different elements of product package design and the impressions they elicit in consumers. Furthermore, by systematizing this impression information, the study endeavors to automate product package design creation, leveraging product review data and concepts. In particular, this study clarifies the relation between impression words and the colors used in packaging and confirms the effectiveness of the proposed method in conveying impressions through the selected colors.

2. Related Work

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Numerous studies have focused on evaluating the impressions of product package designs. For instance, Nadeesha et al. explored the relation between sensory preferences and purchasing intentions for chocolate packages, using descriptors like 'healthy' and 'luxurious' to assess sensory preferences [8]. Such descriptors are widely employed to articulate design impressions and sensory preferences. Given their use in the design process, this research categorized these descriptors as 'impression words,' and utilized them to represent impression information.

Research on the automatic generation of graphic designs also exists. Shunan et al. introduced a system capable of automatically generating advertising posters by using deep learning [9]. This system produced advertising posters automatically based on product images and texts provided by users. Its configuration was informed by interviews with designers, incorporating detailed design elements like backgrounds and product images to facilitate an automated generation process that mirrors designers' workflows. Nonetheless, the system encountered challenges in incorporating impression information into the generated designs, failing to capture a critical aspect of graphic design: the emotional response of consumers to the designs. Therefore, it is necessary to consider the impressions elicited by each design element, such as background color and font, to create an automated generation system.

3. Proposed Systems

To address the issue stated in the previous section, this study proposes two systems. The first one is a review analysis system that visualizes impression information about a product by extracting 'impression words' from its reviews, as illustrated in Fig. 1(a). The second one is an automatic generation system of product package designs using impression words derived from the product concept to create package designs, as shown in Fig. 1(b). The review analysis system highlights the prevailing impressions associated with specific products or categories. The automatic generation system of product package designs is developed with these results, enabling the creation of product packages based on impression information, which is critical to product creation. Figure 1 provides a detailed illustration of each system.

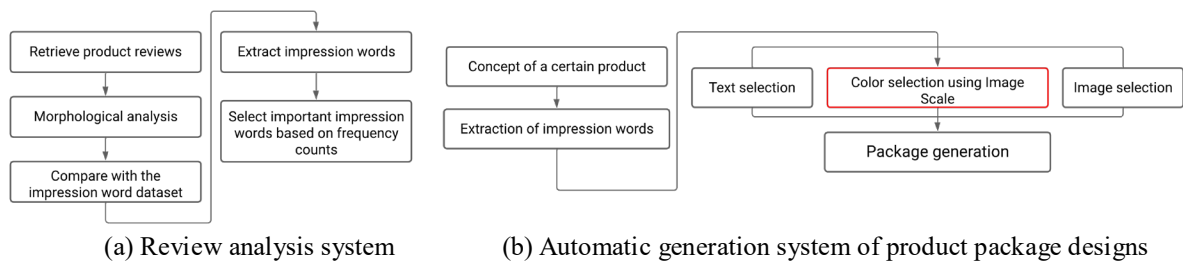


Fig. 1: Flowcharts of the two proposed systems

Firstly, in the review analysis system, product reviews are collected from product review sites as text data. These reviews are then subjected to a morphological analysis, breaking down the text into individual parts of speech. This analysis enables comparison with a predefined dataset of impression words, which comprises the 180 impression words identified from the Image Scale [10] described later and their synonyms. Through this comparison, impression words relevant to products are extracted from the review texts. Subsequently, these impression words are quantified for each product. This quantification enables the visualization of impression information for each product, represented through the frequency and variety of extracted impression words.

The process of the automatic generation system of product package designs is initiated by inputting the product concept as text data. From this input, the system identifies the most significant impression word through quantification. This word then serves as a crucial input for a suite of element selection algorithms, including the 'color selection algorithm,' 'product image selection algorithm,' and 'text selection algorithm.' By feeding the impression word into these algorithms, design elements that align with that product concept are selected. The selected design elements are combined to generate the product package design. This research focuses on the color selection algorithm, highlighted in red in Fig. 1(b) and further elaborated in Fig. 2. According to Fig. 2, the impression word derived from the product concept serves as the input for selecting a color that aligns with the images the word evokes, by utilizing the Image Scale. The Image Scale

[10] clarifies the association between colors and word images via factor analysis, displaying this relation on a unified coordinate plane. This facilitates the selection of a color that closely matches the images of the impression word. Based on the input of the impression word, two colors are chosen for each input: a 'selected color' for the background and its 'complementary color' for a design element, specifically where the product name is displayed. This selection leverages the color scheme technique, using the complementary color to highlight the section with the product name against the background. Hence, this color selection algorithm effectively determines two colors for the package design—one for the background and another for the product name, ensuring the colors reflect the intended impressions.

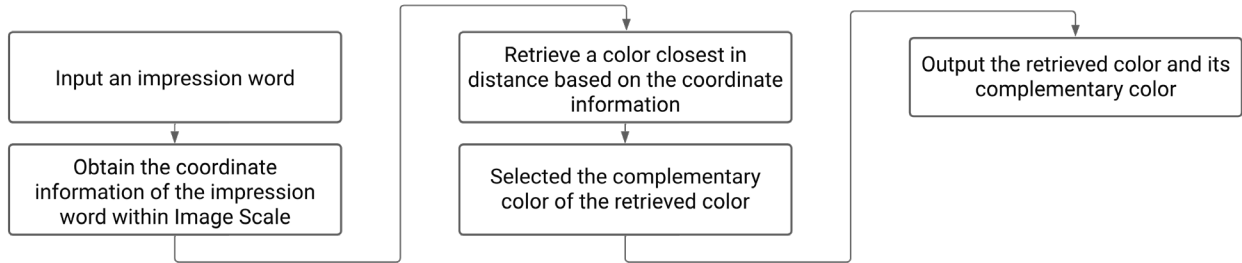


Fig. 2: Color selection algorithm

4. Evaluation Experiment

The objective of this research is to automate the creation of product package designs that accurately reflect impression information. To evaluate the proposal, an experiment was conducted with product package designs generated using the color selection algorithm described previously. The experiment aims to assess two key aspects: the 'validity' of the package designs—ensuring they are appropriate for their intended product package purposes—and the 'impression conveyance ability,' which evaluates how effectively the designs convey the intended impressions to people who look at the package.

4.1. Experimental Method

First, three types of existing products (snacks) in rectangular packages were selected for the experiment. These products' concepts were obtained from the companies' websites in the form of descriptions and catchphrases as text data. The most significant impression word for each product was identified from the product concept as stated in the previous section. Table 1 shows the products' names and the corresponding impression words. Each impression word was then used as the input for the color selection algorithm to determine appropriate colors, which are the retrieved color and its complementary color stated in Fig. 2, for the package design.

Table 1: Existing products and their impression words used in the experiment

	Product 1	Product 2	Product 3
Product's name	Langue de Chat	Picola Strawberry	Rasucere
Impression words	Pale	Cute	Gentle

Based on the selected existing products and their impression words, product package designs were generated using the proposed system. Since this experiment focuses on evaluating the color selection algorithm in the proposed system, only the background color of the package and the color of the area where the product name is written were changed from the original product package design, keeping other design elements constant. As an example (not a real one), Figure 3(a), (b), (c), and (d) show a set of generated packages for an existing product: the original package, a package with only the color of the product name area (text area) changed, a proposed package, and a dummy package, respectively. The text data of "2Packs" in the original package, which is not related to this evaluation, was removed.

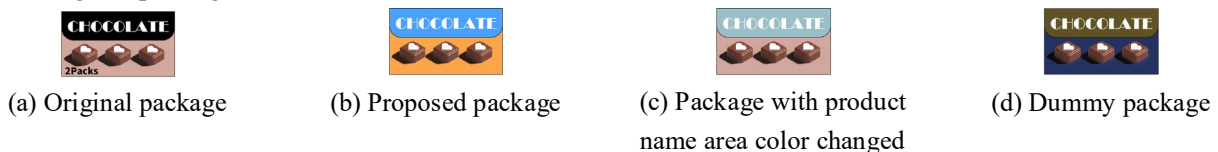


Fig. 3: A set of generated packages

In this evaluation experiment, when matching a color to an impression word on the Image Scale, it was difficult to select only one color that was closest to the plane coordinates of the impression word. Therefore, the two of the closest colors to the coordinates were selected. Hence, two packages for one existing product were generated, accordingly. It means that four packages, in total, for each existing product were compared and evaluated: a package with product name area color changed, two proposed packages, and a dummy package. Four packages labeled A through D for three existing products shown in Table 1 were created as shown in Table 2. In the experiment, each product was presented to the examinees in order from A to D for evaluation. The order of the packages presented for each product was changed.

Table 2: Packages used in the experiment

	A	B	C	D
Product 1	Proposed package 1	Proposed package 2	Dummy package	Package with product name area color changed
Product 2	Dummy package	Proposed package 1	Proposed package 2	Package with product name area color changed
Product 3	Package with product name area color changed	Dummy package	Proposed package 1	Proposed package 2

A subjective evaluation experiment was conducted with 32 participants, encompassing both genders, aged between 20 and 24 years old. Participants were shown Packages from A to D one by one and were asked to rank them from 1st to 4th place based on both their 'interest' level and 'desire to purchase' level for each product. Additionally, participants were asked to assess the suitability between the package design and its corresponding impression word for each package, using a four-point scale: "suitable", "somewhat suitable", "not very suitable", and "not suitable".

4.2. Experimental Results

Tables 3 and 4 show the results of the subjective evaluation of 'interest' level and 'desire to purchase' level in each existing product, respectively. The numbers in the tables represent the median of each rank, with the first through fourth rankings replaced by a number from 4 to 1. Thus, a higher number indicates a more positive response. Texts in red and in blue correspond to proposed packages and packages with only the product name area color changed, respectively. Therefore, texts in black means dummy packages.

Table 3: Median of 'interest' level

	A	B	C	D
Product 1	2.5	2	3	3
Product 2	1	3.5	2	3
Product 3	3	3	2	2

Table 4: Median of 'desire to purchase' level

	A	B	C	D
Product 1	3	2	2	3
Product 2	1	4	2	3
Product 3	3	3	2	2

These results indicate that 'interest' level and 'desire to purchase' level were relatively correlated. Packages created based on impression words tended to be rated relatively well. Although the package designs based on the proposed system did not yield relatively low results, they were not always the best in all cases. This was probably because the product package designs generated by the proposed method used only the "colors" selected by the color selection algorithm and, hence, did not meet all the criteria for generating effective product packages. To enhance the efficacy of product package designs, incorporating additional design elements, such as font types, might yield more favorable results.

Figure 4 shows the evaluation results of the ability to convey impressions. In this figure, "suitable" to "not suitable" is replaced by a number 4 to 1, and the distribution is visualized as a box-and-whisker diagram.

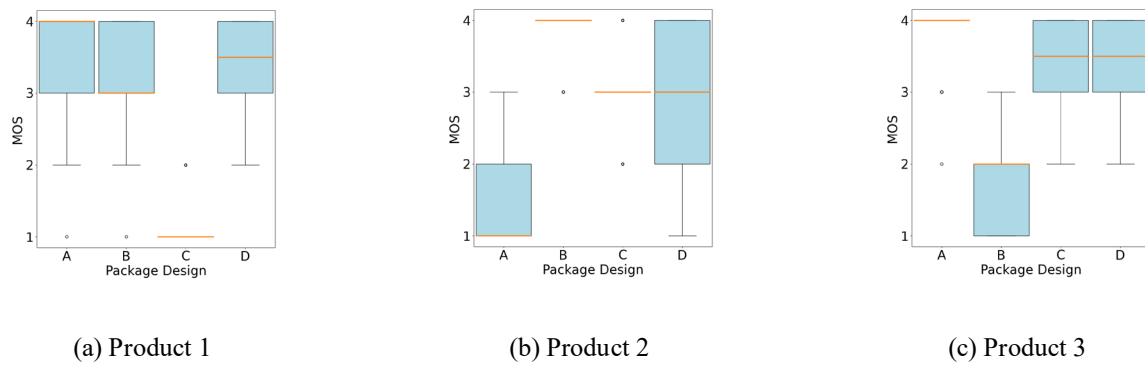


Fig. 4: Evaluation results of impression conveyance ability

Figure 4(a), which illustrates the image suitability for the impression 'pale' of Product 1, shows that packages A and B, informed by the impression word, achieved medians of 4 and 3, respectively. This indicates a successful conveyance of the intended impression. Similarly, for the impression 'cute' associated with Product 2, packages B and C recorded medians of 4 and 3, respectively in Fig. 4(b), affirming the accurate conveyance of the impression. Lastly, the evaluation for 'gentle' in Product 3 revealed that both packages C and D, based on the impression word, had medians of 3.5 in Fig. 4(c), further demonstrating the effective conveyance of the intended impression.

These results confirm a high level of impression conveyance ability for all the impression words evaluated in this experiment: 'pale,' 'cute,' and 'gentle.' Thus, it can be concluded that applying colors selected through the color selection algorithm to product package designs enables the accurate conveyance of the impressions associated with these evaluated impression words.

5. Conclusions

This study proposed two systems aiming at leveraging impression information for the automatic generation of product package designs, drawing on product review data and product concepts: a review analysis system and an automatic generation system of product package designs. Furthermore, this study evaluated the color selection algorithm's effectiveness within this system, focusing on its suitability for product package design and its capacity to accurately convey specific impressions. Although the evaluation indicated that the system's designs may not fully meet the criteria for effective product packages, it exhibited a high ability to convey the evaluated impression words, demonstrating the algorithm's potential effectiveness in this context.

For future tasks, it is necessary to broaden the range of impression words beyond those evaluated in this study. The three impression words assessed represent just a small fraction of the potential descriptors that could inform the design creation process. Hence, future research should extend the verification process to a wider array of impression words, further exploring the relation between colors and words. Moreover, there is a need to evaluate additional design element selection algorithms, including those for text and product image information. Such verification is essential for enabling a more nuanced generation of product packages based on the impressions consumers hold, ultimately fulfilling the research objectives more comprehensively. Additionally, it is necessary to compare other methods proposed for the automatic generation of product packaging and further confirm their effectiveness.

6. References

- [1] Sidrah Waheed, Marium Mateen Khan, Nawaz Ahmad, "Product Packaging and Consumer Purchase Intentions," *Market Forces*, Vol. 13, No. 2, 2018, pp. 97-114.
- [2] Rizwan Raheem Ahmed, Vishnu Parmar, Muhammad Ahmed Amin, "Impact of Product Packaging on Consumer's Buying Behavior," *European Journal of Scientific Research ISSN*, Vol. 122(2), 2014, pp 125-134.
- [3] Arun Kumar Agariya, Ankur Johari, Hitesh K Sharma, Udit N S Chandraul, Deepali Singh, "The Role of Packaging in Brand Communication," *International Journal of Scientific & Engineering Research*, Vol. 3, Issue 2, 2012.

- [4] Betina Piqueras-Fiszman, Charles Spence, "Crossmodal correspondences in product packaging. Assessing color-flavor correspondences for potato chips (crisps)," *Appetite*, Vol. 57, Issue 3, 2011, pp. 753-757.
- [5] Yan Wang, Jing Jiang, Xiushuang Gong, Jie Wang, "Simple = Authentic: The effect of visually simple package design on perceived brand authenticity and brand choice," *Journal of Business Research*, Vol. 166, 2023.
- [6] Rui Dong, Mark R. Gleim, "High or low: The impact of brand logo location on consumers product perceptions," *Food Quality and Preference*, Vol. 69, 2018, pp. 28-35.
- [7] Lauren I. Labrecque, George R. Milne, "Exciting red and competent blue: the importance of color in marketing," *Journal of the Academy of Marketing Science*, Vol. 40, 2012, pp. 711-727.
- [8] Nadeesha M. Gunaratne, Sigfredo Fuentes, Thejani M. Gunaratne, Damir Dennis Torrico, Caroline Francis, Hollis Ashman, Claudia Gonzalez Viejo, Frank R. Dunshea, "Effects of packaging design on sensory liking and willingness to purchase: A study using novel chocolate packaging," *Heliyon*, Vol. 5, Issue 6, 2019, e01696.
- [9] Shunan Guo, Zhuochen Jin, Fuling Sun, Jingwen Li, Zhaorui Li, Yang Shi, Nan Cao, "Vinci: An Intelligent Graphic Design System for Generating Advertising Posters," *CHI '21: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, No. 577, pp. 1-17.
- [10] Shigenobu Kobayashi, "Color Image Scale," Kodansha, 2001 (in Japanese).