

CREATIVE DESIGN OF COLOR PALETTES FOR PRODUCT PACKAGING

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ABSTRACT

This paper describes our latest work on assisting CPG (Consumer Packaged Goods) companies with their product packaging designs by providing color palettes that are visually appealing, novel and consistent with desired marketing messages for a particular brand and product. Specifically, we start by mining a large collections of images of different products and brands to learn about all the colors and color combinations that frequently appear among them. Meanwhile, a color-message graph is constructed to represent messages conveyed by different colors as well as to capture the interrelationship among them. Knowledge from both color psychology and information sources like Thesaurus are extensively exploited in this case. Now, given a particular product and brand to be designed for its packaging, along with the company's desired marketing message, we apply a computational method to generate quintillions of novel color palettes that can be used for the design. This process will leverage existing palettes used by same products of different brands or different products of the same brand, take in optional color preferences from users, identify then utilize the right colors to convey the desired marketing message. Finally, we rank the palettes based on assessment of their visual aesthetics, novelty and the way that different messages of the same palette interact with each other, so as to guide human designers to choose the right ones. Our initial demonstrations of this work to colleagues of subject matter have received very positive feedback. We are now exploring opportunities to collaborate with them to validate this technology in a controlled experimental setting.

Index Terms— Product packaging design, color psychology, color science, color palette, visual appeal, color composition, color message

1. INTRODUCTION

Everything around us conveys a message, no matter it is a company logo, a product package, or the clothes that we wear. This is universally true across different domains. Currently, such designs are mainly driven by the intuition and experiences of human designers. For instance, the red color is not to be worn by doctors or nurses, yet it is a good color for athletic uniforms as it conveys power and strength. One interesting question we could ask here is, can we have the computers

to do the design which conveys the right or desired messages? This leads to the goal of this work, *i.e.*, to foster a creative design by generating novel color palettes that convey the desired messages.

Specifically, our work focuses on the color design of product packages for CPG (Consumer Packaged Goods) companies. Packaging colors are one of the key elements that will set a company's business apart from others. According to a study conducted in [1], people make up their minds within 90 seconds of their initial interactions with products, and about 62–90% of such assessment is based on colors alone. Therefore, prudent use of colors can not only differentiate products from competitors, but also influence customers' moods and feelings, and consequently, steer their attitudes towards certain products.

Moreover, color also serves the best way to reflect and enhance a unified image and branding of a company's products. For instance, a company who wants to send message of *professional* and *serious* to consumers, will likely use very different packaging colors for its products than those used by companies whose products are more about *health* and *well-being*. In fact, this has been proven by [2] that packaging colors are *the* effective means of attracting attention, creating aesthetic experiences and delivering communication of quality and brand identity. There have been many other studies and researches along this line. For instance, Stoll *et al.* concluded that consumers' responses to product appearance are converted to brand preference, and the packaging attractiveness may in fact maintain attention, which enables information processing [3]. Underwood, Gordon, Garber, *et al.* have also shown that colors can be used to create brand identity [4], evaluate brands [5] and create brand meanings [6].

Leveraging the studies of these prior research, this work proposes a data driven approach to generate color palettes to assist product packaging designs that are not only visually appealing, novel, but also consistent with the brand messages that companies sends to target markets to attract buyers. Our framework is built upon work in the area of color science, color psychology and statistics. Fig. 1 shows the overall architecture. Specifically, the system takes a set of images of different brands and products as input, which will be used as our inspirations to creatively generate new color palettes. It then extracts color composition information from each image, resulting in a list of distinct colors along with

their proportions. Next, given a targeted product to be designed, along with its brand and desired brand messages, the system launches a computational method to generate quintillions of color palettes that meet specific criteria. To assist this creative process, a color-message graph is constructed based upon prior research on colors and their psychological efforts, as well as the mined interrelationships among messages. Finally, a small set of promising palettes are selected based on assessment of their visual aesthetics, surprise or novelty as compared to palettes in the repository, as well as how all messages, as conveyed by the same palette, interact or comply with each other. Finally, the human designers could choose the right palettes and apply them for designing the product packages.

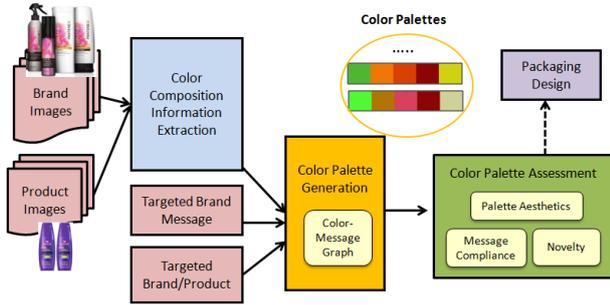


Fig. 1. Overall architecture of the proposed system.

While there have been many research efforts on studying the impact of colors on product packaging designs as referenced above, most of them are qualitative studies. One work from Deng *et al.* conducted user studies to examine aesthetic color combinations in a product self-design task using the NIKEiD online configurator [7]. Specifically, it developed a similarity-based model of color relationships which models the choice likelihoods of color pairs as a function of the distances between colors in the CIELAB color space. Interesting findings such as people de-emphasize lightness and focus more on hue and saturation, as well as people like to combine similar colors for the shoes, were identified. Nevertheless, [7] does not offer any prescriptive solutions for shoe designs.

Some other work in this area focuses more on the holistic package designs. For instance, Orth and Malkewitz conducted a consumer survey and concluded with general guidelines on how to select the right type of packaging design to achieve the desired consumer brand impression [8]. Specifically, they categorized all packaging designs into five holistic types: massive, contrasting, natural, delicate and nondescript designs, and suggested that sincere brands should have natural package designs, exciting brands should have contrasting designs, and sophisticated brands should have natural or delicate designs. Nevertheless, how to design a package falling into one of these five types is out of its scope.

To our best knowledge, our work is among the first to develop and apply computational methods to creatively generate

color palettes that can be readily used for product packaging designs. These palettes would not only be visually appealing, but convey the targeted brand messages as well.

For the rest of paper, we briefly describe the color composition information extractor in Section 2, then we detail the construction of a color-message graph in Section 3. The creative color palette generation process is elaborated in Section 4, followed by the palette assessment in Section 5. Finally, we report the current status of this work and discuss the ongoing work in Section 6.

2. COLOR COMPOSITION INFORMATION EXTRACTION

This module forms the building block of the entire system, which extracts color-related information from an input image. Specifically, it consists of the following two steps: 1) extract distinct colors, along with their proportions, from the image by applying a multi-resolution color quantization and indexing mechanism; and 2) name each color based on a mapping table of color values (in RGB format) and color names, which is pre-constructed based on some web sources [9].

In particular, we have applied an octree structure-based color quantization approach to cluster and identify distinct colors, which has been approved to be very efficient and effective in the context of image indexing and retrieval [10]. Since these colors are represented by RGB values, we then name them with specific color names. This is achieved by finding the closest color in the mapping table based on Euclidean distance in LUV color space. Fig. 2 illustrates this process where output of the given image is shown on the right. Proportions of extracted colors are represented by the stacked vertical bar alongside. As we expected, the top four colors of this particular image are identified to be linen white, brown, black and dark-golden-rod.

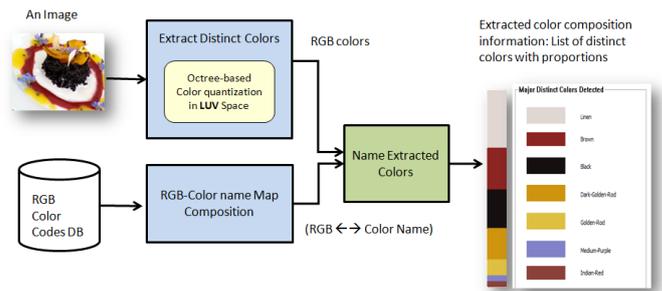


Fig. 2. Process of color composition information extraction.

3. COLOR-MESSAGE GRAPH CONSTRUCTION

Color psychology is the study of color as a determinant of human behavior. A general model of color psychology relies

on basic principles such as “color can carry specific meaning, which is either based on learned meaning or biologically innate meaning” and “the perception of a color causes automatic evaluation by the person perceiving, which forces color-motivated behavior” [11].

Very rich literatures can be found on studying colors and their psychological effects for a broad range of areas. Examples include marketing [1], academic and sports performance [12, 13], store designs [14], *etc.* While it is true that color meanings are subjective and vary with people, there are indeed broader messaging patterns to be found in color perceptions. Researches have also shown that there is a real connection between the use of colors and customers’ perceptions of a brand’s personality [15]. For instance, Apple uses white color to show its love of clean and simple design, while black is the color of power, authority and control. Black makes products appear heavier and more expensive and transmits a higher perceived value [16]. On the other hand, as red conveys energy, passion and strength, using red for packaging can stimulate senses and excites potential purchasers.

Based on the aforementioned prior academic research as well as the domain expertise in this area [16], we have thus compiled a comprehensive table which maps a message to color(s) that convey corresponding psychological meanings. One portion of such table is shown in Table 1, where we see that one message can be represented by multiple colors, and one color can have multiple meanings. Note that culture and context would be two dynamic factors in interpreting color messages, so theoretically, we could compile multiple tables *w.r.t.* these two parameters. Nevertheless, we use one table to ease the illustration of the approach here.

Table 1. A map from messages to packaging colors.

Message	Packaging Color
Adventure	Orange
Affordability	Orange
Authority	Black
Calmness	Blue
Cheerful	Yellow, Orange
Cleanliness	Blue, Turquoise, White
Creativity	Black & Magenta, Light Blue, Yellow
Innovation	Yellow, Purple, Magenta
Health	Green, Brown
Passion	Red
Security	Blue, Brown, Green
Wholesome	Dark Green, Brown

From the table, we also see that there are certain interrelationship among the messages. For instance, *creativity* and *innovation* are synonyms, while *adventure* and *security* are likely antonyms. We have thus built a message ontology by exploring the relationships among messages according to cer-

tain knowledge sources such as Thesaurus. Fig. 3 shows one portion of such ontology graph, where each node indicates one message and is filled with a representative color. A solid link between two nodes indicates a synonymic relationship while a dashed line indicates an antonymic relationship. Note that for illustration purpose, when a message is conveyed by multiple colors, we only use one of its colors in the graph.

4. COLOR PALETTE GENERATION

We are now ready to generate color palettes to assist product packaging design. This process consists of both divergence and convergence (or pruning) steps. Fig. 4 shows the overall processing flow. Specifically, it takes three inputs from users including the targeted product, brand, and messages. An example of such design task could be “Design a *Cereal* product package for *Quaker* which conveys *fun* and *nutritiousness* messages to the market”. Other parameters such as the targeted customer segments or countries can also be taken as inputs, but for now, we omit them here.

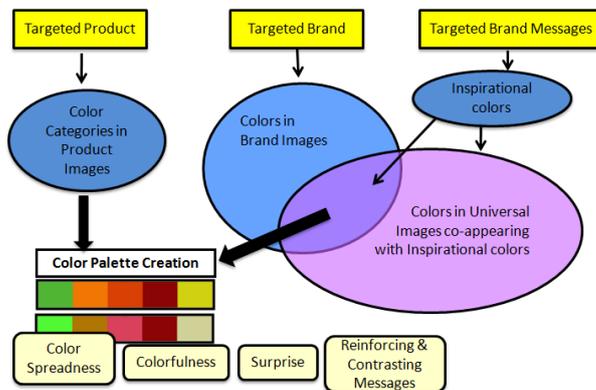


Fig. 4. Process flow of color palette generation.

4.1. Color Statistics Analysis

As a preparation, we first conduct some statistical analysis of colors from various image sets, as illustrated below.

Step 1: Given the targeted product (say, “cereal”), we first identify color categories that exist in all cereal product images in our repository, based on the pre-extracted color composition information (as shown in Fig. 4). By color category, we mean the type or name of a color such as Red or Black. A category of Red in this case, can consist of a whole range of red colors of different shades and tints. Next, we rank all color categories based on their occurrence frequency. We denote the set of color categories by CC .

Step 2: Given the targeted brand (say, “Quaker”), we identify colors that exist in all repository images of Quaker products and denote them as BC . We represent each color by its RGB values and associate it with its occurrence frequency.

tions generated from each successive combination. Random sampling is applied in this case to identify the top colors of each category among those whose weights are above a certain threshold. It is worth pointing out that by applying random sampling instead of selecting the top colors strictly based on weights would bring in color diversity and introduce nice unpredictability into the generated palettes.

Step 4: Output the final set of color combination as the generated color palettes. Fig. 5 shows a screen shot of an output where the targeted brand and product are *Quaker* and *Cereal*. The targeted message is *uplifting*. The total number of possible combinations without any pruning is shown to be $1.044E+043$. The final output is presented in form of a table, with its header naming the color categories of each palette. Each row indicates one generated palette and its actual color for each category is expressed in RGB. For instance, with the highlighted palette, its first color is *cyan* (15, 83, 75), second color is *deep-sky-blue* (23, 87, 147), etc. The selected palette is visually shown on the right.

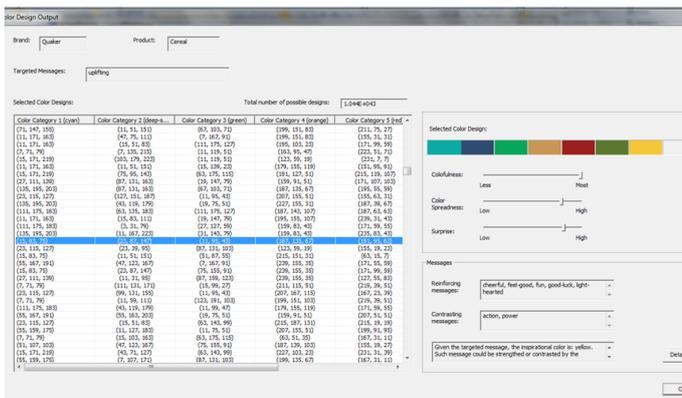


Fig. 5. A screen shot of the system output.

5. COLOR PALETTE ASSESSMENT

Once the color palettes are generated, we further provide a set of metrics to assist users to choose their desired ones (see Fig. 4). These metrics assess the aesthetics and novelty of each palette, as well as exploring how different messages conveyed by the same palette interact with each other.

5.1. Aesthetics Assessment

We propose to assess the aesthetics or visual appeal of a palette by measuring its *colorfulness* and *color spreadness*. These two color metrics have been popularly applied to measure the aesthetics and quality of images and videos as studied in [17, 18], we have thus employed them here for our task. Specifically, colorfulness measures the perceived intensity of a specific color to human eyes. The higher the color intensity, the more the colorfulness of a palette. On the other hand,

color spreadness measures how widely colors are spread across a color wheel. A large spreadness score for a given palette would indicate that it has a good variety of colors. Our assumption here is, the larger these two scores, the more appealing the palette is. These two measures are shown for the selected palette in Fig. 5.

Note that the interpretation of these two measures is very specific to product and market. For instance, if the product is targeted for children, then using a palette with high scores of colorfulness and spreadness may be a good idea as that will make the product look fun and cheerful. Nevertheless, if the targeted customer segment is professionals, then a product with a fewer neutral colors such as black, gray and silver, may be more appropriate.

5.2. Novelty Assessment

An artifact that is novel should be unusual, surprising, has a wow factor and changes the observer’s world view. Novelty can be quantified by considering a prior probability distribution of existing artifacts and the change in that probability distribution after the new artifact is observed, *i.e.* the posterior probability distribution. Recently, such a quantization has been given the name *Bayesian surprise* and has been shown empirically to capture human notions of novelty and saliency across different modalities and levels of abstraction [19]. Mathematically, this cognitively-inspired Bayesian surprise can be defined as a Kullback-Leibler divergence as follows:

$$\begin{aligned} \text{Bayesian surprise} &= D(p(M | A) \parallel p(M)) \\ &= \int_{M_0} p(M | A) \log \frac{p(M|A)}{p(M)} dM, \end{aligned} \quad (1)$$

where M indicates a set of artifacts known to the observer, with each artifact in this repository being $M \in M_0$. Also, a new artifact that is observed is denoted by A . $p(M)$ indicates the probability of an existing artifact, and $p(A | M)$ is the conditional probability of the new artifact given the existing artifacts. Via Bayes’ theorem the conditional probability of the existing artifacts given the new artifact is $p(M | A)$.

We have thus applied this measurement to assess how novel a palette P is, where the new artifact A in Equation 1 refer to the colors in P , and M indicates all colors that have been previously used by images of the targeted product in our repository.

5.3. Message Compliance Analysis

Since a palette likely consists of multiple colors and thereby conveying multiple messages, it would be interesting to see how these messages interact with each other and especially how they comply with the targeted brand messages. We conduct such message compliance analysis by checking all relationships between messages represented by the colors in a palette according to the color-message graph. In the end, we

shall identify two sets of messages where the first one contains those that are synonymic to the brand messages, while the other one for antonymic messages.

For instance, given the targeted message being *uplifting* for the example in Fig. 5, we find that the selected palette has also conveyed messages such as cheerful, feel-good, fun, good-luck and light-hearted, which are consistent with uplifting. On the other hand, it also sends off some contrasting messages such as action and power. Note that whether it is a good or bad idea to have conflicting messages coming from the same palette is ultimately up to human designers' decisions, who will take other designing factors such as patterns, pictures and texts into account.

6. DISCUSSION AND FUTURE WORK

We demonstrated an implementation of the system to multiple subject matter experts (SMEs) colleagues and have received very encouraging feedback. We are now exploring opportunities to collaborate with some of them to validate this technology in a controlled experimental setting.

As for future work, there are a few directions that we can take to advance this work: 1) design more sophisticated pruning strategy for the divergent palette generation process; 2) create a richer framework to represent the relationship between colors and messages by accounting for culture and context of the message interpretation; 3) incorporate other design elements such as texture and pattern into the scope of this work; and 4) apply the underlying technology to other applications such as fashion advisory, interior design and advertisements creation.

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