Color Your Feeling

*Design Support System for Color Coordination*

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**Abstract:** Color selection plays a vitally important role in creating impressions of individuals or companies because colors have sensibility aspects and relate to some images or associations. Based on both the theory of color harmony and the sensibility ergonomics, some quantitative and systematic researches on the color image have been developed. In this paper, we suggest a color coordinate system that supports the color analysis and the color harmony functions using color images, which can be captured by corresponding adjective words. We focus on a system prototype for interior design domain to exemplify our concepts in this paper, even though this system can be applied for all design domains.

1. **INTRODUCTION**

Much of our perception of physical world includes our identifying objects by vision, and colors are typically essential to our vision. Because colors have perceivver-dependent properties, it seems to be considered as subjectivism. However, the concept of color harmony has to be removed from the realm of subjective attitude into that of objective principle (Itten, 1970). For example, most people will think red color represents hot feeling and blue color represents cold feeling. This fact reveals that most people have common sense for color, and colors also have objective essences. Moreover, based on both the theory of color harmony evolved from the nineteenth century and the sensibility ergonomics, some quantitative and
systematic researches on the color image have been developed in many objective ways.

From 1990s the rapid spread of color monitor as an output device and advancement of digital technology allow designers to move paper-based traditional research to computer-aided design (CAD) area. Current software related to color provides color palette function to select desired colors easily. Some of the simple color picker software are built into the operation systems. Sometimes software provides different color palette system such as RGB, HSB, CMYK, etc. However, the major issue in handling color is the huge amount of data, as there might be more than ten million kinds of colors. When designers want to coordinate some colors with one or another color, they should deal with delicate variations in a lot of data so that the reasons often cause that the result of color coordination depends on designers’ training and ability or push designers for referring and comparing with hundreds of colors and spending a lot of time. Therefore, just providing traditional color picker is not intelligent enough to provide designers with faster or more efficient color coordination.

This paper proposes a color coordination system that supports designers by matching their sensibilities with a group of colors in the color coordinating process. The system integrates color analysis sub system with color harmony sub system to select the type of color harmony or inspect exhaustive alternatives to find out the best match with the designers’ intention.

This paper has the following tasks to satisfy these objectives:

1. Get a color image of a given picture from the color analysis knowledge base and the color image database.
2. Generate a set of colors matched with the color image.
3. Select a color from the set of colors and a type of color harmony.
4. Generate harmonious colors from the color harmony knowledge base.
5. Display the color coordination to check if the result is satisfied or not.

In this paper, we focus on an interior design system prototype to exemplify our concepts in this paper, albeit this system can be applied for all kinds of design products.
2. HUMAN-COMPUTER SYSTEMS DESIGN USING COGNITIVE MODEL

Among the phases of information presented from computer to users, the phase related to color or shape is users’ cognitive perception (Ito and Nakakoji, 1996). Cognitive models are those models which represent the human being’s sensory and cerebral processing system, his characteristics and limitations related to the elements of that system, and the outcome of such processes (Hasdogan, 1996). Cognitive models in HCI point of view is task-based models because these models were developed based on the emphasis on people interacting with computers and the dominant information processing paradigm of cognitive psychology (Benyon, 2004).

To develop effective human-computer systems, there are several levels of abstractions at which we want to describe the system in HCI point of view; the organizational level, the workplace level and the operational level (Benyon and Imaz, 1999):

- **Organizational level**: to consider the design of working practices and the impact of new technologies on organizations
- **Workplace level**: to design for the activities which users will undertake, at the structures and artifacts which enable people to pursue the goal
- **Operational level**: to look at how knowledge is constructed, represented or how it is distributed through the system, or consider the usability of system and the cognitive and emotional demands that systems make on people

We describe below each level of cognitive models in greater detail.

3. ORGANIZATIONAL LEVEL

As mentioned in Chapter 2, cognitive models represent the human being’s sensory. The designer’s sensibilities are represented using color images, which can be captured by corresponding adjective words.

3.1 Sensibility Ergonomics

Sensibility ergonomics can be defined as follows; it is a kind of engineering integrated emotional agreement into the human-computer interface (HCI) design. In the United States, the term human factors engineering is often used, while the term Kansei engineering is used in Japan. The technology of sensibility ergonomics can be used to understand
the relationship between the factors of designers’ feeling and the design elements. Because of the fuzzy characteristic of an image, using color language is the most convenient method to select the color, which can be agreed by most of people (Nagumo, 2000). As mentioned in the previous section, most people have a common image for a group of colors, therefore, we use color images to represent the colors.

3.2 Color Image

Nagumo (2000) classifies 160 color images captured by adjective words, each of which has 9 to 24 colors. He uses x-y coordinate system to categorize thousands of colors using adjectives. The vertical axis represents time and the horizontal axis represents energy. Figure 1 illustrates the image scale for color.

![Figure 1. The image scale for color (redrawn from Nagumo (2000))](image)

Using color image to coordinate color, designers can get the result more precisely and quickly. However, there are several drawbacks when we use the paper-based data form, even though we are able to use a specific color
image with corresponding colors. The major problem with this is that the data is arranged sequentially.

A second drawback of using books is their static nature. Once they are printed, data cannot be inserted or updated. It is also impossible to combine or merge data from heterogeneous sources. Finally, because CMYK for printing and RGB for monitor take two different color spaces, the colors not in the intersection area cannot be convertible so that the designers may not able to get the same color to the monitor what they see from the book. For these reasons, developing a digital color image system offers a promising application for the design domain because it can overcome some limitations of traditional methods of information storage and exchange in the design industry.

Although it is possible that one viewer’s perception of color may be different from another’s, experimental evidence suggests that the relationships between colors are, in many respects, universal, and thus relatively free from individual and cultural influences (Jacobson and Bender, 1996). This fact can be utilized to build a general architecture for adding guidance to interactive systems.

3.3 Color Harmony

Color is not beautiful or ugly when it is stand-alone. It starts to be meaningful only if color is placed next to each other. Most of the theory of color harmony is based on color wheel. According to Itten (1970), we organize 11 types of color harmony, which are listed in Figure 2.

Color harmony is influenced by adjacent background. Because of the interaction among foreground and background colors, each color looks different. Therefore, color harmony system should consider the visual context. For example, the system can keep visual identity by unified background. However, if the foreground color is very close to the background color, the unified background can be changed to the appropriated one.

4. WORKPLACE LEVEL

This level deals with two issues; design for the activities which users will address and construct the structures and artifacts which enable people to pursue the goal. From those points of view, we try to understand the general activities of color coordination probed by previous works and point out advantages and drawbacks in those works to develop our innovative solution. The outline of the proposed system is shown in the next step.
4.1 Related Researches and Software

Several researches or Commercial-Off-The-Shelf (COTS) software are in the past 5 years.

Hsiao (2000) applies digital information to computer aided design to execute consultative glossaries from consumers’ perceptual demands in color planning. The objectives are to make designers and consumers closer and to achieve color aided marketing. The result of consultative system is a color set according to measures of fuzziness under different consultative condition. However, the system is lacking of color harmony function so that users are hard to make color harmony among a set of suggested colors corresponding a color image.

Tokumaru et al. (2002) propose a system that automatically composes color schemes, which are in harmony with a color inputted in the system and correspondent to user’s image. They make fuzzy rules to evaluate harmony
of color scheme. In the proposed system, effective judgments of color harmony and color image are executed and suitable color schemes can be acquired by the system. However, the color schemes lack of considering the size, because specific color in different area has different color effect. Moreover, the system does not apply the color scheme to the target objects directly so that the designer still has to do several trial-and-errors to apply and compare each color combination.

Ueki and Azuma (2003) develop methods and system that support a Web page designer to decide appropriate color combination for a specified image. After that, they apply their system to support background color coordination for Web page by the use of the analysis. If a designer uses this system, the designer can know the combination of colors by the intended Web page impression. The designer does not need to have sensibility or knowledge for colors. However, the system can only deal with background of a simple type of web page layout so that it is still not enough to handle realistic web page color coordination. In addition, the system also lacks of color harmony functions.

Through Internet we gathered several color harmony applications like Color Wheel Expert, ColorImpact, Color Wheel Pro, etc. to compare their advantages and disadvantages. Some basic color harmony types based on the color harmony theory are given, but all software provides the function of user defined color harmony to make their system flexible and extensible. Most of the software use the default templates to apply their color harmony types, because it is relatively easy to make the harmonious system fit to the chosen shape, size, and colors. However, using fixed templates makes their systems quite limited. If a designer has totally different kinds of design from any of the default templates –unfortunately, those situations happen very often–, those systems will not be much helpful.

Based on the related researches and software described above, a beneficial and enhanced system is conceived. First, analyzing color information is needed to acquire designer’s concept beforehand. Second, providing color harmony function is useful to make color coordination. Finally, if the system can provide a function to get pictures from outside, it will be more flexible; only dealing with fixed templates or just support recommends colors are not satisfied.

4.2 Framework for the Proposed System

The outline of the proposed system is shown in Figure 3. The system is composed of two sub-systems, “Color Analysis Sub System” and “Color Harmony Sub System”. Designers can run these two sub-systems independently or combine them together.
Color Image Database

The central piece of the system is a Color Image Database (CID), which is organized into appropriate adjective categories. Each category has 3 to 11 adjectives to describe typical feelings of a set of colors. From Nagumo (2000) we extract 160 color images grouped by 23 adjective categories and save them into the CID. On each color image 9 to 24 colors are allocated. This color image database can be customized to represent designers’ specific definitions to achieve an expandable feature.
4.2.2 Color Analysis Knowledge Base

The main function of Color Analysis Knowledge Base (CAKB) breaks down a full picture into pixels and calculates RGB color value for each pixel. Each color can be ranked and proportioned using percentages according to the number of pixels contained on the picture. Taken up to 70% of the total area (100%) colors from the top are compared with the data in CID. CAKB uses CIE 2000 color different formula to calculate the similarity between two colors and to match one color image to one or several others. The user can decide the tolerance threshold.

4.2.3 Color Harmony Knowledge Base

Eleven types of color harmonic methods are saved in the Color Harmony Knowledge Base (CHKB). Given a specific color, the designer can select a type of color harmony or exhaust all the 11 methods. The system then will find the best matches for the designer. CHKB provides color harmony functions, which not only outputs individual harmonious but also calculates and weighs their areas to get the better solutions. CHKB also has a color adaptation function to meet the designer’s specific favour. This function depends on the User Preference Database (UPD) which will be discussed in the next section.

4.2.4 User Preference Database

The capability to allow color preference makes the system more efficient. After a designer has decided a color combination and has applied to the picture, UPD records the personal color choice. When the designer uses the system next time, the system checks the record in UPD and calculates personal offset between CID and UPD. The UPD becomes more powerful over time as designers solve more problems and thus add more color solutions to the database to be re-used when needed.

5. OPERATIONAL LEVEL: IMPLEMENTATION

To understand the application at the operational level, we can consider the interface of system in cognitive artifacts. Among user interface styles “what you see is what you get” (WYSIWYG) technique can always tell what final result will be and be more intuitive, especially applying to the color coordination. The prototype has used an Object-Oriented Software Engineering (OOSE) methodology, which governs analysis, design,
implementation, and test phases. It also has been implemented by Java, an object-oriented language, to fully take advantage of accessibility through multiple platforms and capability to connect the system in any place.

Designers can start with a picture captured from any particular domain. In our example shown in Figure 4, we obtain a picture from interior design domain.

![Figure 4. Main screen of the proposed system](image)

### 5.1 Color Analysis Sub System

The acquired picture is dispatched to Color Analysis Knowledge Base (CAKB) to investigate colors in the picture. The CAKB analyzes colors according to the gross area (100%), calculates the percentages to be taken by each color and displays in the screen maintaining the ratios (Figure 5). The designers can create their own color image word to save it to Color Image Database (CID) or get the suggested color image word from the CID. If the designer wants to get the adjective from the system, he/she sends the colors analyzed in CAKB to CID to match with the specific color image for describing the group of colors. CID offers the best matching color image to the designer can decide whether to accept the result. If the designer accepts
the result, all colors related to the color image will be listed in the screen, and the designer would also be able to get the RGB value for each of the colors by clicking on it.

![Image of the system with color analysis wizard](image)

*Figure 5. The system with color analysis wizard*

## 5.2 Color Harmony Sub System

The designers can use this Color Harmony Sub System (CHSS) either continuing from the Color Analysis Sub System (CASS) or starting this system from first principles. In either case, a color image would be given into this sub system. Similar to CASS, the system extracts all the colors from CID that match to the color image and displays them on the screen. The designer selects a desired color from the color list to harmonize the initial image. The designer can choose to experiment with only one type of color harmony among the eleven classes or exhaust all the options provided by our system. The CHSS also provides another two advanced functions. One is that the system can make recommendation to the designer based on his/her past selections or preferences from User Preference Database (UPD). The other is that the system can suggest different set of harmonious colors areas, i.e., there are some commonly accepted rules, for example, some vivid colors cannot take up a large portion of an image, etc.
One example is shown in Figure 6 where the system suggested alternatives are displayed. The designer can select a desired alternative and apply the colors to the picture.

![Color Harmony Wizard](image)

*Figure 6. The system with color harmony wizard*

### 6. CONCLUSION

This paper proposed a color coordination system that supports the color analysis function and the color harmony function by using color images. We create a new system which is not only a “smart e-palette”, which is able to overcome traditional rough combinations of RGB values, but also “purpose-oriented”, in that it can be used with two knowledge bases and databases. Given this system, the designers are no longer required to possess expert level color knowledge to make ideal color. The system increases design efficiency and accuracy in expressing your *feelings*. 
REFERENCES


