

## **A COLOUR COMBINATION KNOWLEDGE-BASED SYSTEM FOR DESIGNERS**

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**Abstract.** The purpose of this paper is to investigate colour combination tools of visual communication designers' need. Participants were twenty-three students of Visual Communication Design Graduate School to follow the questionnaire survey and seven students of Design Doctoral Program Graduate School to follow the interview survey. The findings display that visual communication designers seldom use web-based colour combination systems. Based on the findings, we developed a colour combination support system: the adobe illustrator plug-in to proof this hypothesis. The databases of the tool use the book of "colour combination charts", and the tool of this paper provides a personal database.

**Keywords.** Colour; colour image; colour set; colour combination.

### **1. Introduction**

The result of the graduated student surveys in 95 years from Ministry of Education of Taiwan indicates that 52% of total design departments is visual communication design departments, and vision plays an important role in visual communication design. In recent years, there are many colour studies or colour systems related colour combination, but can those support designers?

Attempts to collect colour combinations using questionnaire and statistical method have failed. Tsai and Chou (2007) offered a sounder theoretical basis for analyzing two evaluation methods. The study develops an automatic design support system to search for the near-optimal two colours set, and combines a gray theory-based colour-association evaluation method and a colour harmony-based aesthetic evaluation method. However, the result of colour combination may not satisfy designers' needs (Tsai and Chou, 2007).

The paper reports on five-year study (2004-2008) of a colour combination support system. The study explored two principal design problems:

1. There are many books of colour combination in current bookstores. Those books can provide suggestions of colour combination to visual communication designers to design. But colour sets are often too many for designers to remember.
2. Most design projects must complete in a short time. Designers often spend too much time to search the colour combination of colour image. And designers might not know most people believe what colour combinations is the colour image.

The purpose of this paper is twofold. First, we investigate colour combination systems of visual communication designers' needs. Second, we plan to build rule-based inference method, including the main colour definition, the colour manner definition.

Colour image is the common language of visual communication designers for colours. In this study, we hope to uses objective colour image in the colour books to build the colour combination support system. And we hope to examine to what degree can this system satisfy the needs of designers with five-year design experiences. Finally, we want to evaluate the reliability of the result through in-depth interviews.

## 2. Literature Reviews

Kao (2004) conducted a study regarding the effect of colour cognition and colour combination on changing the area and shape for Taiwan people. This study has two parts: the first part used 25 colour images to combine three colours and seven colours. They found that the method of "Select Sort" to select the fittest colour sample of colour image, and to analyze the colour combination principle. The second part selected each of three colours colour image to stand for the colour combinations, then to carry out the experiment of changing the area proportion and colour shape (Kao, 2004).

Chien (2005) used CIE uniform colour space and area colour harmony theory to produce harmony colour sets, and it can apply in other design fields. Designers can open the LOGO graphic, and press the interface button to analyze the colour image of this graphic. To use the colour difference formula to get the colour image of the smallest colour difference and to provide other colour combination suggestions (Chien, 2005).

Ou and Luo (2006) point out that only finite colour combinations are used because it is difficult to match more than two colours, and define what colour harmony is. They separated CIELAB value to 54 colour samples systematically,

including 5 no chromatic colour and 49 chromatic colour. They selected 17 Chinese students of Derby College in England that own ability of distinguish colours. The subjects including 11 males and 6 females sat in front of the CRT instrument to precede colour combination experiment. They examine the old colour harmony theorem, including the same hue principle, high lightness principle, and moderation lightness difference principle (Ou and Luo, 2006).

Tsai (2002) uses online questionnaire manner on phone product colour combinations to improve convenience. They use the Back-Propagation Networks of Neural Network algorithm to train colour image colour combination data, and to use genetic algorithm to get the optimum colour combination. But Tsai (2002) pointed genetic algorithm does not support designers to select the satisfying colour sets in this study.

Yang's (2007) study of using case-base inference and statistic questionnaire manner, CIEDE2000 colour difference formula and LCH colour space, to build Taiwan colour image colour combination database. Yang discovered the method of Group Nearest Neighbour to find the closely similarity colour image. The system simplifies complicated search process, and achieves the goal supporting designers. Yang suggested that "to add the system function: Define colour image colour combination by user themselves."

### **3. Methodology and Implementation**

The goal of this study is research how to support the visual communication designers. We want to build a system to evaluate whether the requirement functions can solve the study design problems or not. Participants were twenty-three students of Visual Communication Design Graduate School to follow the questionnaire survey, as well as five visual communication designers with more than five years of design experiences to follow the semi-structural interviews method. We discovered the rule-based method includes main colour, colour combination manner, and colour image words. To build the colour combination tool, Adobe Illustrator plug-in is used. This study separates rule-based method in two parts: the main colour (Figure 1), and colour combination manner (Figure 2).

## 3.1. DEFINE THE MAIN COLOUR

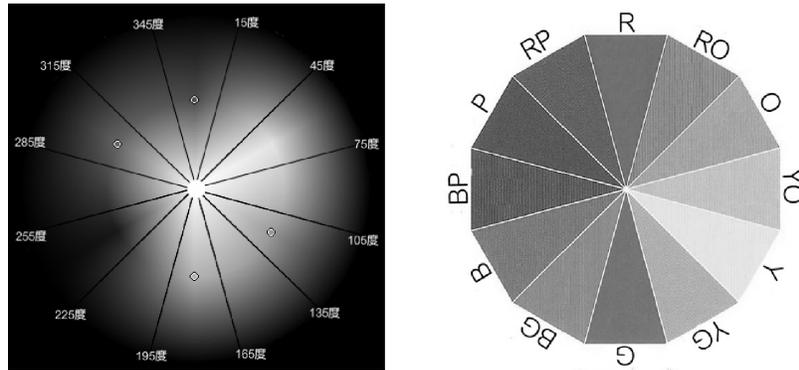


Figure 1. The left figure shows the system defines the main colour range, and the right figure shows the Colour Index colour books defines the main colour range

TABLE 1. 12 main colour names of colour books and the matching H range

Red	$H \in (-15^\circ, 15^\circ]$	Green	$H \in (165^\circ, 195^\circ]$
Red & orange	$H \in (15^\circ, 45^\circ]$	Blue & green	$H \in (195^\circ, 225^\circ]$
Orange	$H \in (45^\circ, 75^\circ]$	Blue	$H \in (225^\circ, 255^\circ]$
Yellow & orange	$H \in (75^\circ, 105^\circ]$	Blue & purple	$H \in (255^\circ, 285^\circ]$
Yellow	$H \in (105^\circ, 135^\circ]$	Purple	$H \in (285^\circ, 315^\circ]$
Yellow & green	$H \in (135^\circ, 165^\circ]$	Red & Purple	$H \in (315^\circ, 345^\circ]$

- Rule 1 IF R THEN ( -15 angle < Hue <= 15 angle )  
 Rule 2 IF RO THEN ( 15 angle < Hue <= 45 angle )  
 Rule 3 IF O THEN ( 45 angle < Hue <= 75 angle )  
 Rule 4 IF YO THEN ( 75 angle < Hue <= 105 angle )  
 Rule 5 IF Y THEN ( 105 angle < Hue <= 135 angle )  
 Rule 6 IF YG THEN ( 135 angle < Hue <= 165 angle )  
 Rule 7 IF G THEN ( 165 angle < Hue <= 195 angle )  
 Rule 8 IF BG THEN ( 195 angle < Hue <= 225 angle )  
 Rule 9 IF B THEN ( 225 angle < Hue <= 255 angle )  
 Rule 10 IF BP THEN ( 255 angle < Hue <= 285 angle )  
 Rule 11 IF P THEN ( 285 angle < Hue <= 315 angle )  
 Rule 12 IF RP THEN ( 315 angle < Hue <= 345 angle )

3.2. DEFINE THE COLOUR COMBINATION MANNER

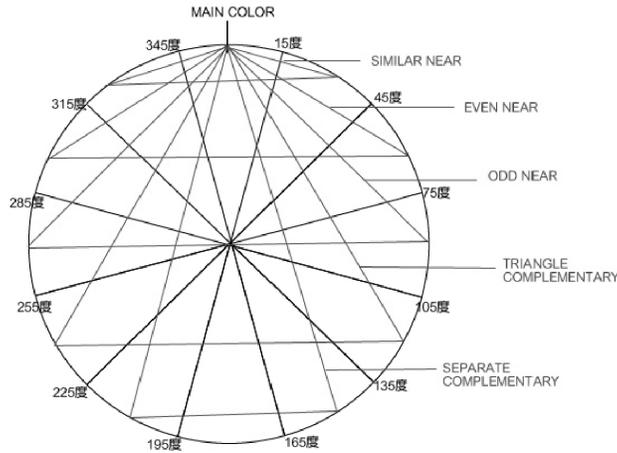


Figure 2. Three colours of colour combination manner, including Similar near, Even near, Odd near, Triangle complementary, Separate complementary

TABLE 2.4 system define three colours of colour combination H range

Colour combination manner	Main colour $H_1$ and colour $H_2, H_3$
Similar Near	$H_1 \in (-15^\circ, 15^\circ] \cap H_2 \in (15^\circ, 45^\circ] \cap H_3 \in (315^\circ, 345^\circ]$
Even Near	$H_1 \in (-15^\circ, 15^\circ] \cap H_2 \in (45^\circ, 75^\circ] \cap H_3 \in (285^\circ, 315^\circ]$
Odd Near	$H_1 \in (-15^\circ, 15^\circ] \cap H_2 \in (75^\circ, 105^\circ] \cap H_3 \in (255^\circ, 285^\circ]$
Triangle Complementary	$H_1 \in (-15^\circ, 15^\circ] \cap H_2 \in (105^\circ, 135^\circ] \cap H_3 \in (225^\circ, 255^\circ]$
Separate Complementary	$H_1 \in (-15^\circ, 15^\circ] \cap H_2 \in (135^\circ, 165^\circ] \cap H_3 \in (195^\circ, 225^\circ]$

- Rule13 IF TSC THEN Similar Near
- Rule14 IF TSC THEN Even Near
- Rule15 IF TSC THEN Odd Near
- Rule16 IF TCC THEN Triangle Complementary
- Rule17 IF TAC THEN Separate Complementary
- Rule18 IF Similar Near THEN ( -15 angle < Main <= 15 angle )  
AND ( 15 angle < Hue <= 45 angle )  
AND ( 315 angle < Hue <= 345 angle )
- Rule19 IF Even Near THEN ( -15 angle < Main <= 15 angle )  
AND ( 45 angle < Hue <= 75 angle )  
AND ( 285 angle < Hue <= 315 angle )
- Rule20 IF Odd Near THEN ( -15 angle < Main <= 15 angle )  
AND ( 75 angle < Hue <= 105 angle )  
AND ( 255 angle < Hue <= 285 angle )

- Rule21 IF Triangle Complementary THEN ( -15 angle < Main <= 15 angle )  
 AND ( 105 angle < Hue <= 135 angle )  
 AND ( 225 angle < Hue <= 255 angle )
- Rule22 IF Separate Complementary THEN ( -15 angle < Main <= 15 angle )  
 AND ( 135 angle < Hue <= 165 angle )  
 AND ( 195 angle < Hue <= 225 angle )

We called the tool colour combination plug-in tool. The tool is developed using Adobe ExtendScript Toolkit 2. The plug-in is based on Adobe Illustrator CS3. WampServer2.0 is used to build the database. The tool contains a personal database, a colour book of Colour Index database, and a rule-based inference database. When users using the tool interface to communicate with the system, the operating data is saved into the rule-based inference database.

The interface (Figure 3) of the tool contains the buttons of “Open”, “Save”, “Similar Near Colour Combination”, “Even Near Colour Combination”, “Triangle Complementary Colour Combination”, ”Search”, and the text field of “Main Colour”, “Colour Image Words”.

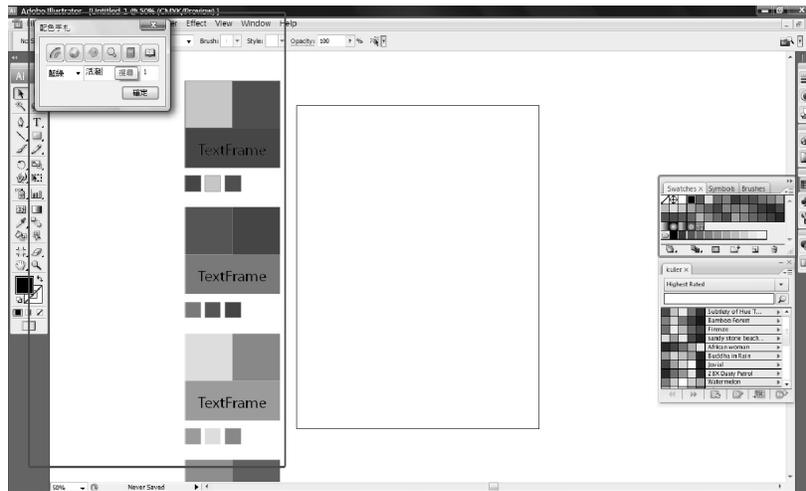


Figure 3. The colour combination plug-in tool

The tool functions contains of the three part: (1) the tool allows users to type in the Chinese colour image words to search the colour combination (2) the tool can save colour area proportion (3) The tool can select the main colour and the colour combination manner to provide the colour combination suggestions. The colour combination manner includes “Similar Near Colour Combination”, “Even Near Colour Combination”, etc. (Figure 4)

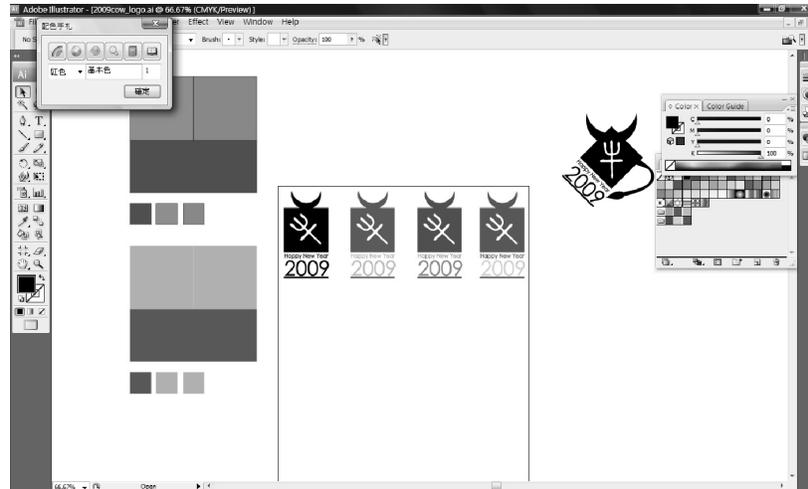


Figure 4. The colour combination plug-in tool

#### 4. Result and Discussion

The findings of questionnaire show 2D graphic designers often use the Adobe Illustrator, that means is 2.74 (the highest score is 3, the lowest score is 0) and seldom use web-based colour combination systems. Based on the findings, we developed a colour combination support system: the Adobe Illustrator plug-in. The system's databases use the book of "colour index" and the system provides three functions: one is to build the personal database and colour image database, another is to update the colour image database, and the other is to save different colour combination of displaying colour area proportion.

We made the hypothesis that it is better to use the rule-based method found colour combination include the colour book colour combination. If colour set numbers is higher than 50% of the colour book, we accept the hypothesis. To use rule-based method to find the colour combination of the Colour book: Colour Index, and to combine colour theory. The results include 60.53% of the basics colour image colour combinations. We can add colour combinations of other colour books or colour combination web database, to increase the intersection of the rule-based method and the colour combinations of colour book "Colour Combination Charts". We can see in Figure 5.

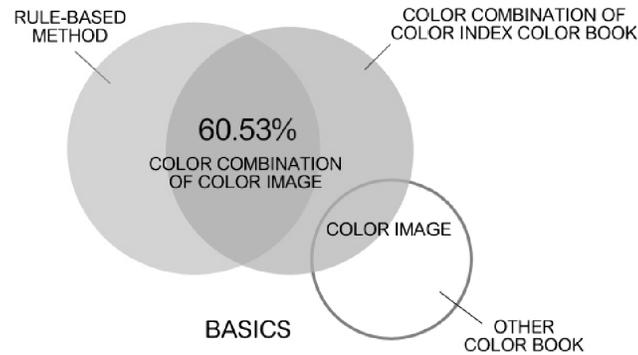


Figure 5. Colour image colour combinations

## 5. Conclusion and Further Work

For example, a study is to train the questionnaire data (Tsai, 2002). A paper of “A Study on Application of the Spatial Colour Image to Design” use fuzzy theory to run the emotion image database (Ou, 2000). Those let us think: can Artificial Intelligence algorithms support designers design?

We can use knowledge rule-based method data to analyze the attribute of personal database, colour combinations and colour combinations of colour books, to product new colour image colour combinations and to provide designers other colour combination suggestions. We also can use artificial neural network algorithms to train colour combinations data of colour image, to product designer’s habitual colour combinations and to improve designers’ activities efficiency. We envision such system in Figure 6.

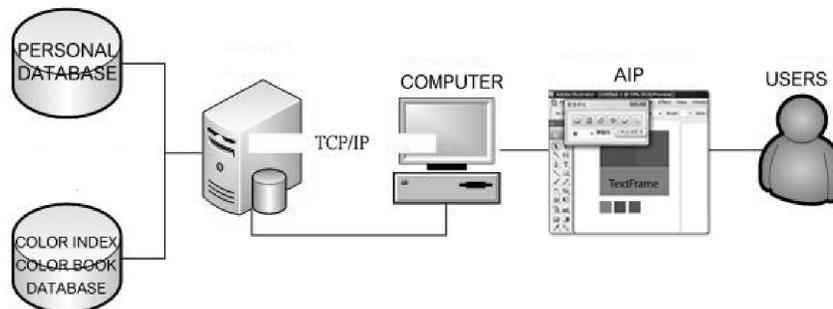


Figure 6. Use Artificial Intelligence algorithms to support designers design

In addition, we consider whether designers need support function for automatic colour harmony? We read the paper of Colour Harmonization to realize the mathematic models of colour harmony, the models factor include form, scale and colour space to describe colour harmony relationship (Matsuda 1995; Tokumaru et al. 2002). Therefore we can use Munsell's (1969) area colour harmony formula and Matsuda's (1995) colour harmony mathematic model to change the colour proportion and the figure harmonize immediately. (Cohen-Or et al., 2006)

In the further work, we plan to provide additive mixture and subtractive mixture, and colour combination algorithm to show colour mixture's colour which is produced by various colours. And, we plan to continuously develop on various emotions using colour theories to let users select colours, and to provide the function of different product colour combination suggestions.

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