KNOWLEDGE REPRESENTATION AND REASONING FOR AIR-NAILER COLOR CONFIGURATION BASED ON HSV SPACE

Fan Jing, Shen Ying and Wang Zhihao

Software College, Zhejiang University of Technology, Hangzhou, P. R. China

Keywords: Color Configuration, Color Representation, Color Reasoning, CAD.

Abstract: Computer aided color design is one of the hotspots in industrial design area. Based on current color configuration research, this paper focuses on knowledge representation and reasoning of color design for air-nailer color configuration system. Firstly, color representation including color type and color value is discussed. Secondly, color reasoning based on HSV space among main color, first assistant color and second assistant color is investigated. At last, the application is represented, which has been tested efficiency and accurate in air-nailer color design.

1 INTRODUCTION

Computer aided color design (CACD) is a kind of computer aided technology. As we all know, a product with better color configuration will win at similar performance and price. Computer aided color configuration system comes to help people doing better job. Commonly, the color design software has powerful functions of color presentation such as quick painting, color mixing and digital specification of color. Theories of color configuration provide guide to the implementation of color configuration application systems (Faber, 2006). Since the feeling of color, evaluation of color assortment, and the color schemes are complex tasks related to many fields, there are still some unsolved problems in existed systems, such as how to supply multiple choices for color assortment; how to apply domain knowledge in specific color design; and how to evaluate color design under individual preference difference.

Besides its key position in design process, color design has its own art characteristics such as uncertainty and divergence (Xiangyang, 2004). It is hard for designer to fit all constraints. The research of knowledge representation and reasoning of color configuration focuses on providing methods to solve the problems.

In this paper, we introduce the knowledge representation and reasoning of color configuration used in a computer aided air-nailer color configuration system. Color representation for specific air-nailer product is the first thing to deal with. Then we define three types of color area in air-nailer appearance: main color area, first assistant color area and second assistant color area. By investigating their relationship, we set up reasoning strategy (Yunhe, Shouqian and Enwei, 1999). At last, we explain our cases briefly and present the interface of the system.

2 COLOR REPRESENTATION

2.1 Color Type Representation

Color type can be denoted as a quadruple called ColorType. ColorType =(PA, SA, MT, CC). Here PA is private attribute, SA is shared attribute, MT is a set of method and CC is collision condition.

PA = (HArea, SArea, VArea) (1)

SA= (CType, Cdescription, Csysmbol, Cusage, Charmony) (2)

MT=(HSVtoRGB (), RGBtoHSV ()) (3)

CC=(CCType, CHSVArea, CCReason) (4)

CHSVArea = (CHArea, CSArea, CVArea) (5)

HArea, SArea, VArea correspond to H, S, V fields for color type in HSV space, where H means Hue, S means Saturation and V means Value. Each pair of HArea fields is supposed not to be intersected.

Jing F., Ying S. and Zhihao W. (2009).
KNOWLEDGE REPRESENTATION AND REASONING FOR AIR-NAILER COLOR CONFIGURATION BASED ON HSV SPACE.
In *Proceedings of the 11th International Conference on Enterprise Information Systems - Artificial Intelligence and Decision Support Systems*, pages 356-359
DOI: 10.5220/0002001403560359

CType is the name of color tone. Cdescription, Csysmbol, Cusage and Charmony denote respectively the description, symbolic meaning, applicable situation and matching degree.

Two kinds of algorithms are listed in MT. They supply the conversion between HSV space and RGB space of color (Berlin and Kay, 1969).

CCType is the name of color tone which conflicts with current color. CHSVArea = (CHArea, CSArea, CVArea) is the conflicted color area. CHArea, CSArea, CVArea correspond to H, S, V fields in CHSVArea. CCReason is the reason of confliction. A color type may have multiple conflicted types.

2.2 Color Value Representation

Color value in each region of different configurations belongs to a color type. In our scheme, class ColorDetail inherits all non-private attributes from ColorType. Here ColorDetail is denoted as a five-tuple with Identifier ID and listed in (6), while Identifier ID is listed in (7). Although same color value can be used in whole design process repeatedly, the function and usage method of the color usually are different in the different stage, and ID is necessary to distinguish the different use. ID is only a part of ColorDetail and not of ColorType. And Pid means configuration procedure of that the color is used, Lid denotes region the color is in.

$$\text{ColorDetail}=(\text{ID}, \text{PA}, \text{SA}, \text{MT}, \text{CC}) \tag{6}$$

$$\text{ID} = (\text{Pid}, \text{Lid}) \tag{7}$$

$$\text{PA}=(\text{HValue}, \text{SValue}, \text{VValue}, \text{RValue}, \text{GValue}, \text{BValue}, \text{RGBValue}, \text{CName}) \tag{8}$$

PA is a private attribute. HValue, SValue and VValue are the values of H, S, and V fields in the HSV color space. Method HSVToRGB () in MT can translate HSV space into RGB space and return RValue, GValue and BValue. RBGValue can be gotten by other relative method. CName is the name of typical colors. It can be NULL.

SA includes shared attributes of ColorType. If a color has special attributes, SA of sub class ColorDetail will cover SA from super class ColorType. MT here is similar in ColorType, but MT of ColorDetail can't cover the MT of super class.

Collision condition CC inherits from ColorType.

3 REASONING PROCESS IN COLOR CONFIGURATION

In our air-nailer samples, there are 2% monochrome, 45% dual-color and 53% triple-color. Obviously, simple style is very popular in air-nailer color design. Accordingly, decision of main color, first assistant color and second assistant color are the three stages in our configuration process.

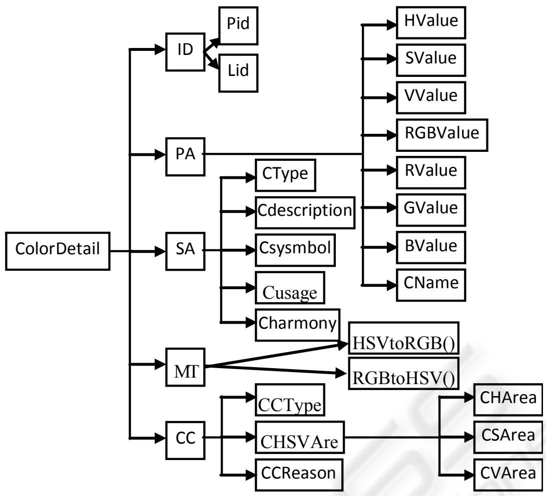

Figure 1: Tree structure of ColorDetail.

3.1 Main Color Decision

The process of air-nailer main color decision is presented in Figure 2.

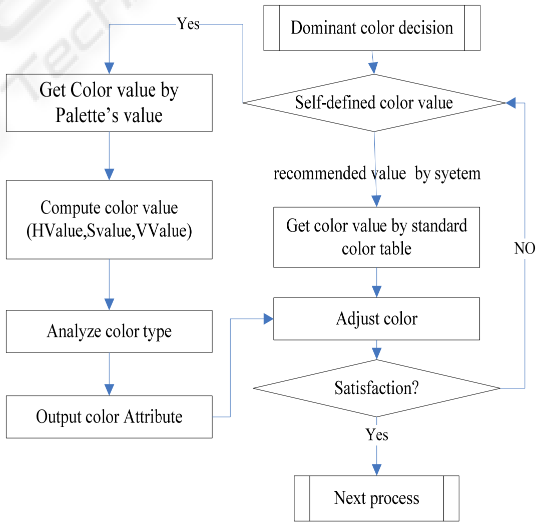

Figure 2: Main color decision process

There may be two different cases as follows:

1. User chooses color value, system will reason and analyze whether the color value is suitable. It can be seen as reasoning from color value to color attribute. For example, if user offers a red color with the RGB value 0x80000h, our air-nailer color design

system is expected to deduce its implicit information such as applicable situation, meaning and color type.

2. User knows color attribute and applicable situation, while system recommends suitable color. It can be regarded as reasoning from color attribute to value.

3.1.1 Reasoning from Value to Attribute

During main color decision procedure, if user chooses the color Main_part_color in RGB form with color palette, as Main_part_color belongs to class ColorDetail, it can turn to $HValue_1$, $SValue_1$, $VValue_1$, $RValue_1$, $GValue_1$, $BValue_1$, and $RGBValue_1$ in PA using method HSVToRGB () in ColorDetail. Pid_1, Lid_1 in ID can also be computed during color configuration when $Pid_1=1$ denotes main color, and Lid_1 means the id of area to be determined.

Once we set main color, some analysis has to be done. From $HValue_1$, $SValue_1$, $VValue_1$ in Main_part_color, $ColorType_1$ can be deduced to get responding $Cdescription_1$, $Csymbol_1$, $Cusage_1$ and $Charmony_1$. All four attributes make references for designers.

3.1.2 Reasoning from Attribute to Value

In this reasoning, user determines the condition set R according to needs of color description, symbolic meaning, applicable situation and matching degree. The condition set R includes condition identifier set RequestId and condition information set UserRequest. We named color type set as ct_l, color value set as cd_l. ColorType(x) denotes that x is color type, Include(A, b) denotes that b belongs set A , Have(a, b)denotes that a has attribute b.

The reasoning rule is as follows:

$$\exists x\ (\ ColorType(x) \vee Have\ (x, R)\ ) \rightarrow \forall y(\ Include(x, y) \vee\ Have(x, R)\ ) \quad (9)$$

If one kind of color has specific attribute, then all the color value belong to this kind should have this attribute.

Then we can deduce color value from its attribute as follows.

System will try to match table ct_1 in air-nailer color configuration standard database with user requirement R. Then the matched set of color type is called CType.

Based on CType, system will search color table cd_1. Since color value CD inherits shared attribute SA in color type, then we can get expected result as set P.

3.2 First Assistant Color Configuration

First assistant color can be deduced just like main color. According color harmony theory, we set color configuration rule to deduce which color is suitable as assistant color. We need to decide hue, lightness, purity for the assistant one.

Harmony parameter set including six conditions is named as HSpace. Similarly, there are ten conditions are chosen for purity and lightness called SSpace and VSpace separately.

$$HSpace=\{\alpha_1, \dots, \alpha_6\}(\alpha<=180) \quad (10)$$

$$SSpace = \{\beta_1, \dots, \beta_{10}\}\ (\beta<=\max\ (SValue_1, 100\text{-}SValue_1) \quad (11)$$

$$VSpace=\{\delta_1, \dots, \delta_{10}\}\ (\delta<= \max\ (VValue_1, 100\text{-}VValue_1) \quad (12)$$

Assistant color value can be reasoned if user set condition α_i, β_m, and δ_n ($i\in[1,6]$, $m\in[1,10]$, $n\in[1,10]$, i, m, $n\in N$). The equation is listed as follows:

$$HValue_2=\{HValue_1+\alpha_i\ , HValue_1-\alpha_i\} \quad (13)$$

$$SValue_2=\{SValue_1+\beta_m, SValue_1-\beta_m\} \quad (14)$$

$$VValue_2=\{\ VValue_1+\delta_n\ , VValue_1-\delta_n\} \quad (15)$$

Sometimes, the value of $Hvalue_2$ will beyond range of [0,360]. If it is greater than 360, it can be revised as $\theta=\theta-360$. Otherwise, if it is less than 0, it can be revised as $\theta=\theta+360$. If the value of $SValue_2$ or $VValue_2$ is not valid ([0,100]), then set flag as “1” to denote that it is invalid. Since $HValue_2$ must have two items, $SValue_2$ and $VValue_2$ may have one or two items, Cartesian product of all three sets of hue, purity and lightness ($HValue_2$* $SValue_2$*$VValue_2$) can get 2 to 8 items. Thus we get set First_assist_color_Union by method HSVToRGB () in method set MT of ColorDetail.

$$First\_assist\_color\_Union = \{S\_Color_1, \dots, S\_Color_i\}\quad 2<= i <=8,\ i \in n \quad (16)$$

The last step for assistant color configuration is conflict detection. Since main color type called $ColorType_1$ has been defined at previous stage, so as conflict condition CC inherits from $ColorType_1$. Each item called S_Color_i in Fisrt_assist_color set can be converted from RGB space to HSV space at first. Next, if parameter hue Hue_i, purity $Saturation_i$ and lightness $Value_i$ in S_Color_i locate in CC’s CHSVArea and $Hue_i\in CHArea$, $Saturation_i \in CSArea$, $Value_i \in CVArea$, then we conclude that S_Color_i conflicts with Main_part_color. The color value will be marked at this point to warn the user.

3.3 Second Assistant Color Configuration

Second assistant color can be deduced after main and first assistant color being set. It means that input Main_part_color, First_assist_color and conditions, and then output Second_assist_color. It is similar to first assistant color configuration, but in detail the settings of hue, purity and lightness are different.

4 APPLICATION

We complete a system with intelligent reasoning and multivariate comprehensive evaluation for air-nailer color configuration. Main functions of the system are listed. Figure 3 shows typical modules (in Chinese).

Figure 3: Main color configuration and Preview.

1. Color Configuration. It provides some assistant design information during color configuration, mainly including: color analysis, condition color configuration, conflict detection, etc.
2. Color Configuration modification. It provides parameters to adjust color configuration.
3. Color Evaluation. It evaluates the practical appraisal on a completed color configuration, and gets a comprehensive evaluation about the current scheme.
4. Color Configuration Preview. It applies the completed color configuration to air-nailer pictures, and gives the preview.
5. Color Scheme Saving. It collects and saves these successful color configuration schemes.
6. Information Management. It provides the functions of input, update and deletes color knowledge, configuration rules, configuration instances, etc.

5 CONCLUSIONS

Color basic theory and color harmony theory are combined well using in the method of knowledge representation for air-nailer color configuration. In this paper, we describe a color knowledge model briefly, it can be applied in the field of air-nailer color design, and it also implements bidirectional reasoning between color value and color attribute. This model partially solves the problem about reasoning difficulty caused by color diversity. In this model both precise-matching and fuzzy-matching have come true, and good analysis results can be gotten when system judges color collision.

From the research, it can be seen that color knowledge model will provide an effective assistant to the designer, and improve efficiency and quality of a design scheme.

ACKNOWLEDGEMENTS

This paper is supported by the project of Science and Technology Planning of Zhejiang Province (No. 2005C11038, 2007C21011), and of Department of Education of Zhejiang Province (No. 20070273).

REFERENCES

Berlin, B., Kay, P., 1969. *Basic Color Terms: Their Universality and Evolution*. University of California Press, Berkeley.

Burchett, K., 2002. Color harmony. In *Color Research and Application*.

Faber B., 2006. *Color Psychology and Color Therapy: A Factual Study of the Influence of Color on Human Life*. Kessinger Publishing.

Munsellm, A., 1969. *A Grammar of Color*. New York Press.

Xiangyang, Z., 2004. Research of Color Design Method in Information Device Modular Customization. Southwest University of Technology. (in Chinese)

Yunhe, P., Shouqian, S., Enwei, B., 1999. Development and trend in computer aided industry design. In *Computer Aided Design and Graph Journal*. CADG Press. (in Chinese)