Development of Color (Light) System Using the Theory of Mathematics and Logics from the Book of Changes

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Abstract: This research is to develop practical color systems using the theory of the Book of Changes. From the preceded research the method for extracting colors while extracting numbers for a hexagram value from the Book of Changes and corresponding to RGB value was developed, but as it created a number of different possible numbers due to various variables and hypothesis, this research is to extract the accurate color system among those possible numbers. From the total 3,000 possible numbers, while excluding general principles of the Book of Changes, generation of similar patterns, and illogical possible numbers, the total of 6 possible numbers is generated. However, it wasn't able to extract one final color system. But it still had an opportunity to study unique properties of color systems using the Book of Changes. The reason why it didn't extract one final case was that it wasn't able to fully understand the Book of Changes, and it will need more research to extract one case out of the 6 cases created through this system.

Key words: the Book of Changes, the Theory of Mathematics, Color System, Color Solid

1. Introduction

1.1 Background

Design is the concept and the system which started in the age of imperialism and Industrial revolution in Europe, and it was transferred to America while based on the West where it was combined with commercialism. It can not be regarded as appropriate only because it is originated from the Western, but, while interpreting design from the philosophy and thoughts from the East, we need to develop it into the system for Asia. This will eventually expand design in easy and essential ways. Therefore, this research is to develop a color system using the theory of the Book of Changes which largely influenced the culture of the East, and to investigate the possibility to integrate concrete and practical Eastern cultures to modern design rather than to approach it with abstract and conceptual ways.

1.2 Preceded research

The start of this research is originated from the research on the colors from five different directions in 2003.

"Study on possibility in interpreting the color system from the viewpoint of Orientalism [1]" which was orally presented in 2003 Korean Society of Design and Science had the original system for this research. While dealing with numeric values to the hexagram from the Book of Changes, and by responding to red, green, blue (primary colors of color tones) and red (magenta), blue (Cyan), yellow (primary colors of light tones), colors have been extracted for this research. Based on this research Mi-Rang Yang wrote the thesis on "Study on possibility in creating the color system from the viewpoint of Orientalism" in 2004 for MFA thesis. However, preceded research wasn't able to develop all the cases containing hypothesis, possible numbers, and verification process on the hypothesis. Therefore, the basic system for this research is to succeed the frame of preceded researches, and to find the one which mostly reflects the property of the Book of Changes amongst color systems originating into three thousands different cases.

1.3 Purpose of the research

By the meaning and the boundary of the research, this has the purposes as following.

- Application to modern times which is practical and applicable from the tradition: It is to search for design principles or methods and elements which can be applied or utilized to modern times from the culture and tradition of the East.

- Development of color systems which can be used today with the Theory of Mathematics and Logics from the Book of Changes: it is to verify preceded researches using the Theory of Mathematics from the Book of Changes, and to develop stable color systems with the overall verification on different cases.

1.4 Boundary of the research

- Development of color (light) systems limited to 64 colors centering on 64 hexagrams from the Book of Changes

: As the research is performed while focusing on 64 hexagrams from the Book of Changes, extracted colors also are limited to 64 colors, and it partly used the principle of Theory of Mathematics from the Book of Changes (circulation, comparison, similarity, and significance)

: This research is not an approach toward "Eui-Ri-Hak (義理學: Science on will and reason)" focusing on interpretation from the approaching viewpoint of the Book of Changes, but it is the research with the viewpoint from the Theory of Mathematics emphasizing images and numbers.

- Research on the colors of light tones

: It is the research for color systems, but the research is limited to light. In other words, it is the research about the colors of light tones. It is because 3 primary colors of light tones are considered to be more stable than the 3 primary colors of color tones, and as it is the research based on the composition of colors on a computer, it is more appropriate to realize colors of light tones than color tones itself.

1.5 Principles and properties of the Book of Changes in the way of Theory of Mathematics

The Book of Changes is described as "Yeok(易, as Korean)", and is called as "Yeok-Gyeong (易經, as Korean)".

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[1] Young-Mok Park, Mi-Rang Yang

There are a number of different stories on the origin of the Book of Changes, but Bok-Hee (伏羲, as Korean)'s written theory is general[2]. And "Sip-Ik (十翼, as Korean)" which explains a hexagram and "Hyo(爻, as Korean)" from the Book of Changes which can be seen today is delivered as Confucius' creation. It also has deep relationship to Taoism and Buddhism, and created large portion on the philosophical background of Eastern Asia. The Book of Changes is the system of 64 hexagrams in which a symbol of yin and yang ("Hyo") is reiterated into six divisions. "Eui-Ri-Hak (義理學: Science on will and reason)" is to study and translate focusing on the meaning of the Book of Changes, and Theory of Mathematics is a study of symbol systems. Theory of Mathematics was developed by necromancers in "Han(漢) dynasty" after "Qin(秦) dynasty", but with its collapse there are few traces on researches[3]. Data related to Theory of Mathematics from the Book of Changes are not enough, and its contents are not simple as well. Eventually it wasn't able to reach the deep principle of Theory of Mathematics. Therefore, this research will apply simple principles of the Book of Changes such as differentiation into 64 hexagrams from the Book of Changes, circulation of 64 hexagrams, "Dong-Hyo"(動爻 or 變爻, as Korean), and circulation of 12 hexagram groups from "Tae-Geuk (the source of the dual principle of yin and yang)".

2. Development of color systems by the principle of Theory of Mathematics from the Book of Changes

2.1 Color system development process

The process is simply composed of five steps and these steps can be found from <Table 1>.

1st step: setting up corresponded number values of hexagrams from the Book of Changes

It is the step for extracting numbers corresponded on "Hyo (爻, as Korean)" for transforming "Hyo" into number values for the first time, and it creates the value of "+," and "-" by numbers and yin and yang. This research is to correspond with 1, 0 and 1(meaning of being or not being)/ 3, 2(numbers of yin and yang from the Book of Changes)/ 6, 9(numbers of yin and yang from the Book of Changes), and to substitute with total number of 22 cases while applying "+" and "–" to each number and the sequence of numbers (3 and 2 or 2 and 3).

2nd step: Setting up substitution methods of number values of hexagrams from the Book of Changes

It is the step to define number values by the different location of "Hyo," hypothesized numbers, and the value of yin and yang. As it is seen from <Table 1>, even same hexagrams create different unique values of a hexagram from the Book of Changes by substituting numbers from the top or from the bottom. This research acquired two different possible numbers, and was preceded as following.

3rd step: Corresponding numeric value of hexagrams from the Book of Changes to the value of color

It is the step to correspond to a group of "1st Hyo" and "2nd Hyo", a group of "3rd Hyo" and "4th Hyo", and a group of "5th Hyo" and 6th Hyo" to RGB. It is the step of verifying which group of red, green, and blue (primary color of light) is included in red, green, and blue. Even after transforming into number values while grouping hexagrams from the Book of Changes into each 2 "Hyo," it still creates the problem to correspond to values from each group of top, middle, and bottom to certain RGB values. Since it was not easy to judge, all 6 cases of RGB,

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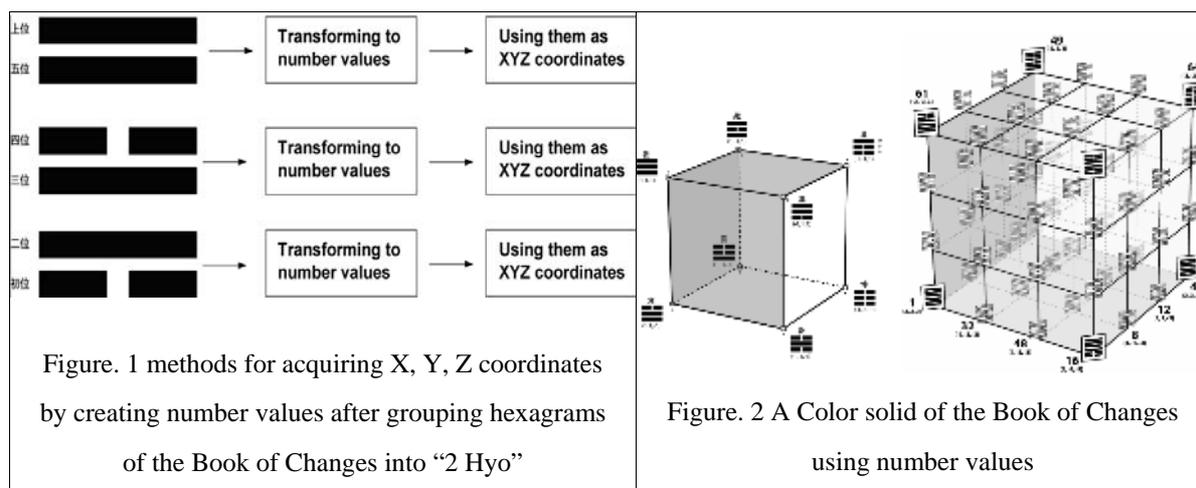[2] Poong-Woo-Ran, History of Chinese Philosophy, p599
[3] History of Chinese Philosophy, p77, P106

RBG, GRB, GBR, BRG, and BGR has been created and preceded into the next step.

4th step: Creating color systems by substituting "Bok-Hee-Seon-Cheon-64-Gwae-Bang-Won-Do (伏羲先天64卦方原圖, as Korean)"

As it is seen from 1st to 4th step, with the reason of the repetition on similar hexagrams or values of hexagrams, groups created by similar compositions, and similarities on RGB correspondent values, it eventually extracted 4 patterns and 24 cases. For these 4 cases, and for 24 patterns substituted with 6 different RGB combinations, I created color systems which are proportionate to the Book of Changes. The composition of color systems used widely known structure of "Bok-Hee-Seon-Cheon-64-Gwae-Bang-Won-Do."

5th step: the case for corresponding 1, 2, and 3 group to the value of XYZ axis when composing the color solid. It is the step to grasp whether color solid is naturally forming while transforming color system into a color solid. As "Bok-Hee-Seon-Cheon-64-Gwae-Bang-Won-Do" describes at the beginning of research, by grouping hexagrams from the Book of Changes into 2 "Hyo" (Figure 1), transforming it into number values, and using it as XYZ values, it creates solids of 64 hexagrams from the Book of Changes (Figure 1).

| Figure. 1 methods for acquiring X, Y, Z coordinates by creating number values after grouping hexagrams of the Book of Changes into "2 Hyo" | Figure. 2 A Color solid of the Book of Changes using number values |

As types completed in the prior step are not completely extracted, as it is seen from <Figure 2>, it created the color solid with the composition corresponding to the value of "upper Hyo/5th Hyo" to X coordinate, the value of "4th Hyo/3rd Hyo" to Y coordinate, and the value of "2nd Hyo/1st Hyo" to Z coordinate. From those 4 different patterns it created 6 color solids with the pattern including "1", "-1/T" (substituting numbers from the top) of 2nd pattern from 64 hexagram color patterns.
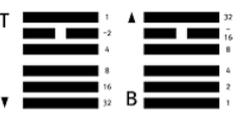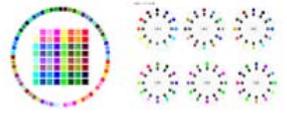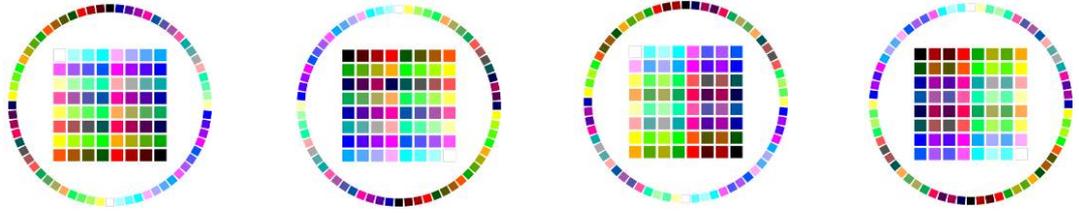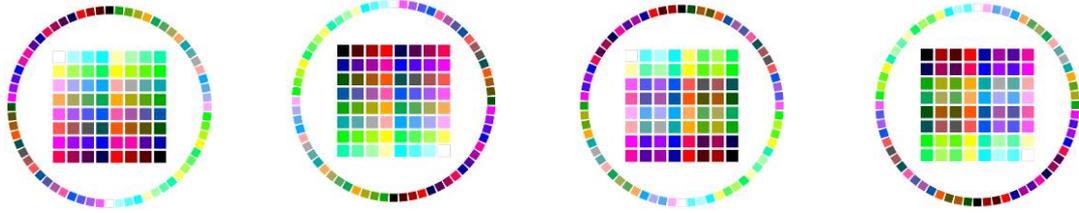
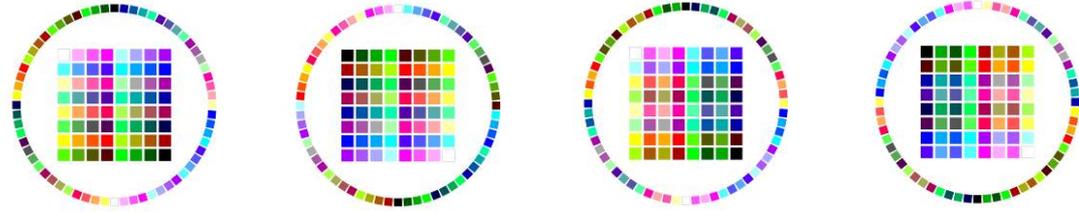| Main event	Event contents	Predicted Case	Actual Research
Extracting corresponding number values	1/0, 1/3, 2/6,9	Creating 22 different cases of possible numbers	Creating 22 different cases of possible numbers
Extracting "+" and "-" values by number values	+, -		
Reducing corresponding values and "+", and "-" values	Excluding composition of 2,3 and 6,9		22-8(composition of 2,3 and 6,9)=14 EX)1, -1, or 3, 2
Extracting orders for substituting number values with the location of hexagrams		Creating 2 different possible numbers (22*2=44)	14 (Substituting number values) * 2 (T or B)=28 EX) 1,-1/T or 1,/-1/B
Substituting number values and with the location of hexagrams by the different corresponded and +, - values			Excluding 3,2/9,6 after extracting repeated numbers (28-16=12)
Extracting substituting number values by the location of hexagrams while grouping them into 3 groups with "2 hyo"			
Corresponding maximum values and minimum values acquired from 3 groups into 0, 255.	Maximum value to 0, Minimum value to 255 Maximum value to 255, Minimum value to 0	Creating 2 different possible numbers (44*2+88)	12 cases*2 (3=255 or -3=255)= Creating 24 different cases EX) 1, -1/T/3, 255 or 1, -1/B/-3,255
Replacing number values from 3 groups to RGB values of 0, 85, 170, and 255.			4 different patents (24 cases)
Corresponding replaced values by 0,85,170, and 255 into RBG, GRB, GBR, BRG, and BGR.		Creating 6 different possible numbers (88*6=528)	4 different patents (24 cases) *6 (Possible numbers from RGB) = 24 cases(144 possible numbers)
Creating color systems based on Bok-Hee 64 Gwae-Bang-Wond-Do Creating color systems of 12 hexagrams * 6 groups			Creating 24 types of 24 different color system of the Book of Changes
Verification on color systems			Reduced to 6 different types (total 35 cases)
Developing color solids/ Corresponding substituted number values by the location of hexagrams while grouping them into "2 Hyo" with XYZ coordinates	XYZ, XZY YXZ, YZX ZXY, ZYX	Creating 6 different possible numbers. (528*6=3)	Creating only for XYZ Creating color solids of 6 different types (total 36 cases)

Table. 1 Research Process

Pattern1. RGB /1,-1/T/-3,255   Pattern2. RGB /1,-1/T/3,255   Pattern3. RGB /1,-1/B/-3,255   Pattern4. RGB /1,-1/B/3,255
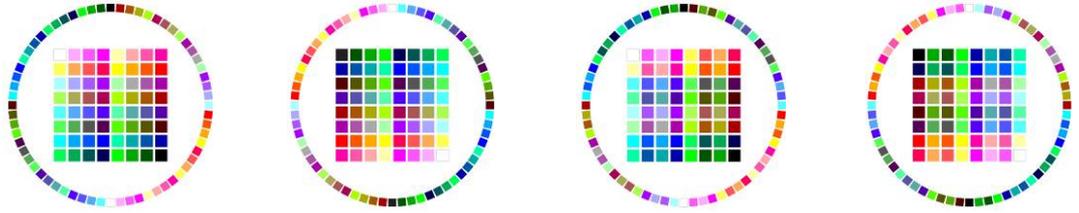
Pattern1. RBG /1,-1/T/-3,255   Pattern2. RBG /1,-1/T/3,255   Pattern3. RBG /1,-1/B/-3,255   Pattern4. RBG /1,-1/B/3,255
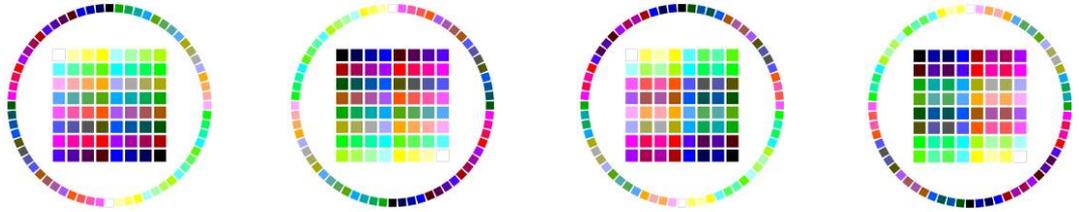
Pattern1. GRB /1,-1/T/-3,255   Pattern2. GRB /1,-1/T/3,255   Pattern3. GRB /1,-1/B/-3,255   Pattern4. GRB /1,-1/B/3,255

Pattern1. GBR /1,-1/T/-3,255   Pattern2. GBR /1,-1/T/3,255   Pattern3. GBR /1,-1/B/-3,255   Pattern4. GBR /1,-1/B/3,255

Pattern1. BRG /1,-1/T/-3,255   Pattern2. BRG /1,-1/T/3,255   Pattern3. BRG /1,-1/B/-3,255   Pattern4. BRG /1,-1/B/3,255

Pattern1. BGR /1,-1/T/-3,255   Pattern2. BGR /1,-1/T/3,255   Pattern3. BGR /1,-1/B/-3,255   Pattern4. BGR /1,-1/B/3,255
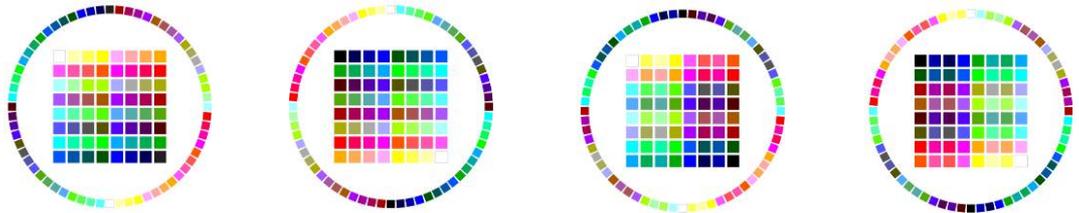
Table. 2 Color systems corresponded to 24 cases of

Bok-Hee-Seon-Cheon-64-Gwae-Bang-Wond-Do(伏羲先天 64 卦方原圖)(24 cases, color)

2.2 The property of extracted color system

By creating 24 color systems of the Book of Changes and analyzing the results, the research has found following facts.

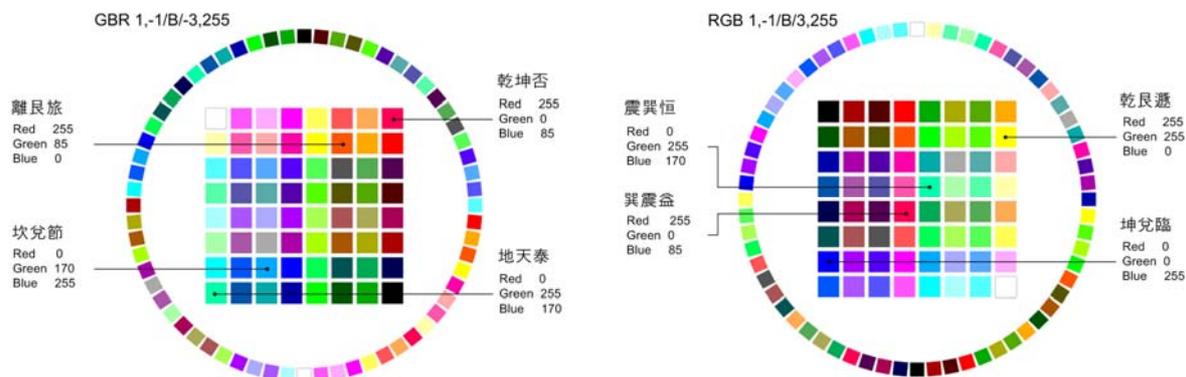**(1) Analysis on color system by 64 hexagram layouts from the Book of Changes**

Figure. 3 The sum total of RGB values of hexagrams from the Book of Changes
which are symmetrical from a center point

- The sum total of a diagonal line of RGB is equal in any cases: In 24 cases as they are all seen from <figure 4>, RGB's case of 1, -1/B/-3, and 255, the sum total of RGB value of "Cheon-ji-bi (乾坤否, as Korean)" and RGB value of "Ji-cheon-tae (地天泰, as Korean)" is respectively 255,255, and 255. From the case of RGB 1, -1/B/3, and 255, sum of RGB value of "Noe-poong-hang (震巽恒, as Korean)" and RGB value of "Poong-noe-ik (巽震益, as Korean)" is respectively 255, 255, and 255.

- There is no identical array: For 24 cases there are no repeating and similar arrays. For 24 cases all extracted independent 64 different colors exist in same, but there is no type with similar arrays.

- When it has different arrays 1: It has difference between black and white of "Joong-ji-gon (重地坤, as Korean (color on top left))" and "Joong-cheon-geon (重天乾, as Korean (color on right bottom))" (difference between 3=255 and -3=255). As it is shown from <figure 4> the color table on the top's "Joong-ji-gon" is white, "Joong-cheon-geon" is black. The color table on the bottom's "Joong-ji-gon" is black, and as "Joong-cheon-geon" is white, it will change by the different method of applying 3 to 255 or -3 to 255.

- When it has different arrays 2: Do colors on the sides gradually change or repeat bright and dark values? When it starts the value of hexagrams from the Book of Changes from the top (T), color differences with next colors of the same row changes gradually, but when it starts from the bottom, colors become brighter and become darker. In other words, pattern 1 and 2 have gradual changes towards colors next to it, and pattern 3 and 4 change with the repetition of being brighter and darker.

- When it has different arrays 3: It has an arrangement of brightness and darkness by the different rows (difference in substituting RGB value). As it is seen from <Table 3> from all 4 patterns RGB, GRB, and BGR have remarkable brightness difference in different rows. In opposition to this, RGB, GBR, and BRG don't have significant differences in brightness by different rows.

(2) Development of color solids by solid models from the Book of Changes

It was not easy to visually select the most appropriate color system from 24 different color systems arranged by illogical composition, production of repeating values, and similar patterns. Therefore, for extracting the most appropriate color system from 24 cases, I applied general properties of yin and yang and the Book of Changes (yin is dark and yang is bright/ yin is cold and yang is warm/ yin and yang is circulating) and the result was reduced into 6 cases. Based on those 6 cases, color solids have been created.
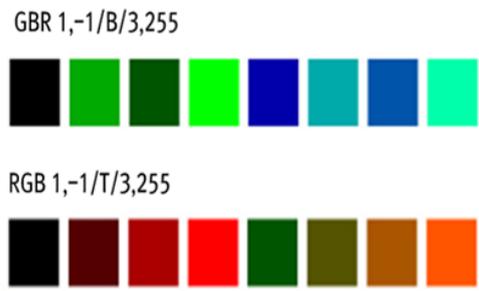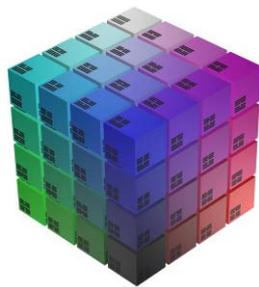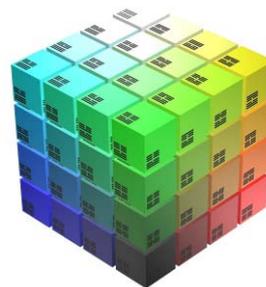
GBR 1,−1/B/3,255

RGB 1,−1/T/3,255

Figure. 4 Difference in each color of 65 hexagrams color system from the Book of Changes

(Substituting number values from the top and the bottom)

Pattern2 RGB / 1,-1/T/3,255/XYZ   Pattern2 RBG / 1,-1/T/3,255/XYZ
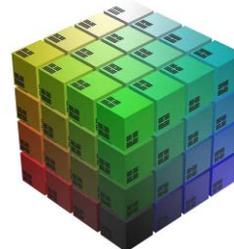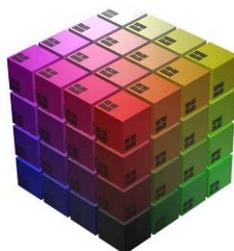

Pattern2 GRB / 1,-1/T/3,255/XYZ   Pattern2 GBR / 1,-1/T/3,255/XYZ

Pattern2 BRG / 1,-1/T/3,255/XYZ   Pattern2 BGR / 1,-1/T/3,255/XYZ

Table. 3 Color solids from the Book of Changes (6 cases) / Corresponding pattern 2 and XYZ coordinates

(3) Analysis on properties of color solids from the Book of Changes

Six properties of color solids from the Book of Changes can be found as following.

- There is no similar color solid.

- All six properties have natural composition of color tones, and all six properties have white and black on opposite apex.

- The total sum of RGB from two color tones which are symmetrical with solid center axis is 255: As it is similar to the color system which is based on "Bok-Hee-Seon-Cheon-64-Gwae-Bang-Won-Do (伏羲先天64卦方原圖, as Korean)" the total sum of RGB of colors from color solids which is symmetrical from the center is always 255.

- In any cases 8 vertex contains RGB (primary colors of light tones), CMY (primary colors of color tones), and white and black: In any cases the types of color from 8 vertexes are white, black, red, green, blue, cyan, magenta, and yellow.

- Primary colors of light tones, primary colors of color tones, and black have the composition of two regular tetrahedrons which are included in a regular hexadron: In any cases black has a regular hexadron structure linked to cyan, magenta, and yellow (primary color of color tones). White has a regular tetrahedron structure linked to red, green, and blue (primary colors of light tones).
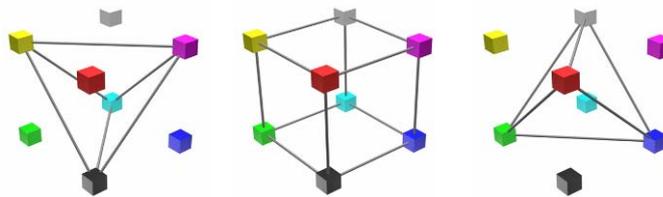

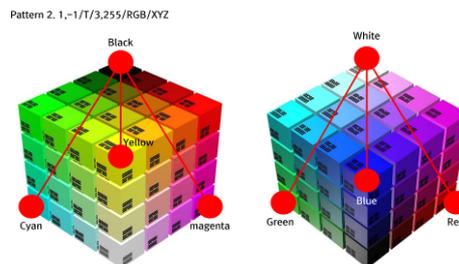Figure. 5 Two regular tetrahedrons within a regular hexahedron

Figure. 6 Composition of regular tetrahedrons containing black/CMY, and white/RGB within the color solid from the Book of Changes (1,-1/T/3,255/RGB/XYZ)

3. Research synthesis and conclusion

3.1 Research synthesis

The most appropriate cases of color system using the principle of the Book of Changes create following results.

- The appropriate numeric values for transforming hexagram layouts from the Book of Changes into numbers can be yang "+1", and yin "-1".

- To transform hexagram layouts from the Book of Changes into numbers which has more than "2 Hyo" it is right to apply in the order of 1, 2, 4, 8, 16, 32 from "upper Hyo."

- From the results which are acquired by transforming into number values while grouping hexagrams from the Book of Changes into "2 Hyo," it is right to correspond with the maximum value of 3 to 255 which is the

maximum value of RGB corresponding value. However, it didn't find out how each value of groups from "1ˢᵗ Hyo/ 2ⁿᵈ Hyo" which are acquired by grouping hexagrams from the Book of Changes into "2 Hyo," groups of "3ʳᵈ Hyo/ 4ᵗʰ Hyo", and "5ᵗʰ Hyo/ upper Hyo" is corresponded to the color of red, green, and blue.

3.2 Further researches

1) Further research within the system and boundary of the research

This research wasn't able to completely extract the color system corresponding to the principle of the Book of Changes into one final result. Since it didn't find the accurate solutions for the following two cases, the problem will be left for the future research.

- Identification of substitution orders of numbers for transforming hexagrams from the Book of Changes into number values: From hexagrams from the Book of Changes which are composed with more than 2 "Hyo", it relocated white and black of "Joong-cheon-geon" and "Joong-ji-gon" either by corresponding number values of 1, 2, and 4 from the top("6 hyo") or corresponding number values of 1, 2, and 4 from the bottom("1 hyo").

- Identification of RGB, RBG, GRB, GBR, BRG, and BGR: From the process of corresponding values which were grouped as the value of "2 Hyo" to RGB composition, it relocated the colors, but it didn't find out which one from 6 cases is the most appropriate.

2) Developing usefulness of color systems

The development of color system using the Book of Changes is not simply for extracting colors which settle down specified hexagrams from the Book of Changes. Since the ultimate purpose of the research is not about application principle and sensible application of individuals which were developed from the East, but about application of colors using theory and meaning of the Book of Changes, application systems for colors need to be developed after completing the color system. In other word, development colors and the meaning of colors, circulation of colors, complementary colors, similar colors, and mixed colors should be developed with the application rules from the Book of Changes. And this will be possible with the development of the most optimized color system.

Examples Citations

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