Computational Color Design Process Towards Aesthetic Community Revitalization

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This study describes the digital color design process using emotional words. The design process proposed in this paper consists of three steps: color scheme selection, color arrangement, and design evaluation. The application of the color design process is to design the landscape of the village. It is much more complicated to assign colors to already existing buildings in a village than to a single building. The originality of this study is that the design process suggests a solution to solve this complex color design problem using numerical evaluation of the generated design. A case study was developed to show the potential of the proposed digital color design process. Through the case study, the utility and potential of the digital design process were demonstrated.

**Keywords:** Design process, Color scheme, Color composition, Color arrangement, Landscape, Color design

**INTRODUCTION**

Nowadays as fisher village in Korea has been declined continuously, and young generation has gone away from a village. In this current situation, Korean government recently has enacted a landscape law in 2013 to establish a landscape plan for the cities and villages where a population exceeding 100,000 (Lee, 2016).

Finding identity of cities or villages is one of the applicable methods to regenerate the places. These days, the locality and placeness of cities or villages are quite vague. The cities or villages need to improve its inherent characteristics to bring vitality to people by identifying its locality and placeless. Even though local governments, therefore, have promoted the preservation, management, and landscape planning of their local landscape, most identities of the cities and villages are still vague and practically unable to meet the criteria for application and management of design guidelines.

This paper claims that designing color is one of the methods to vitalize cities or villages (Chiesura, A., 2004). Colorscape is a feature of an area of the place, its color scheme, and how they integrate with nature and human-made features. Therefore, as the landscape keeps a wide spectrum of meaning from a general perspective to a distinct geographical definition (Makhzoumi J. & Pungetti G., 1999), colorscape also includes wide range of perspectives: the ecosystem services of urban areas, public psychological health (Wolch et al., 2014), and physical activities of urban population, particularly the elders (Wang, 2014). Moreover, colorscape is a decisive factor that affects human to recognize environment (Zheng, 2006).

As mentioned above, although color reflects the quality of humans’ lives taking an urban colorscape
and images, it has controvertible issues because of its relatively perceived subjective characteristics and its complexity to regulate a method to design (Birren, F. 1978 & Mahnke, F. H. 1996). Most of the colors in cities or villages do not exist isolated and combine more than two colors. Moreover, they are described by a set of three attributes: hue, value (brightness), and saturation (chroma) establishing relationships with each other. Taking all of them into account, it is hard to design colors to meet people’s preferences. For this reason, currently colors of the cities and villages are very inconsistent and grey which diminishes the image of the places and reduces the liveliness of it. This does not only lower the vitality of the cities but also affects the quality of humans’ lives. Furthermore, the complex color design would rather stress people out.

Against this background, this paper aims to develop a color design process for designers to design colors and stimulate cities or villages by the colors. The preference for color is very subjective and so-called well-designed color refers to designs with high preference (Lilia R., 2015), therefore, it is hard to design colors. However, color is an important element that allows people to determine their impressions when they perceive cities or villages as a visual element (Olguntürk, N., & Demirkan, H., 2011). At the present time when various computer programs have been developed, devising a method, a data-based color design process by flow work, will be helpful for designers to design colors of cities or villages.

EMOTION-BASED COLOR DESIGN
One of the most difficult tasks in color design is how to choose the appropriate color among the many colors that already exist in the world. Using color palette is one method to solve these problems for designers and architects (McLachlan, F. 2012). A color palette, a collection of colors, refers to the full range of colors that can be used in architectural and landscape color design. In other words, the color palette is a set of colors that are used most often among the many colors so that designers can quickly determine the colors during the design process.

For example, Eisenman presented a color palette consisting of 755 colors. This color palette will surely help designers choose colors. However, because the number of colors contained in the color palette is many, designers may still have difficulty in selecting colors. However, in order to solve the difficulty for designers to choose colors, the number of colors in the color palette cannot be reduced. This is because if the number of colors is reduced in the color palette, designers will have a narrower range of colors to choose from and it may not allow designers even to have the colors they want. In traditional color design methods, how to create a palette with the appropriate number of colors has always been an issue in color design field. However, a method using digital color will provide a clue to solve this problem, because digital color can be quickly retrieved from a computer. Yet, even if it is possible to express a lot of colors using digital color, it still needs one’s own color palette depending on the field. The color palette used in fashion and the color palette used in architecture should be different. In the color design pursuing beauty, the more important issue than the color palette seems to be the problem of how to make the color scheme by combining the colors included in the color palette.

A color scheme is a combination of colors created by the principle of color harmony. Harmony is a combination of individuals with the aesthetic consideration. Color harmony represents a satisfying balance or unity of colors. Combinations of colors that exist in harmony are pleasing human through the eyes. The human brain distinguishes the visual interest and the sense of order created by the harmony and forms a dynamic equilibrium. The principle of color harmony generally accepted by colorists is monochromatic harmony, analogous harmonies, complementary harmonies, a split-complementary color scheme, and a triad color scheme. Monochromatic harmony uses various values (tints, tones, and shades) within the same color family. Analogous harmonies are based on three or more colors that sit side-by-side on the color wheel. Complementary
colors (or Direct Complementary) are those that appear opposite each other on the color wheel. A split-complementary color scheme results from one color paired with two colors on either side of the original color’s direct complement creating a scheme containing three colors. Triad color schemes are three colors equally spaced from one another, creating an equilateral triangle on the color wheel.

The above-mentioned color harmony certainly plays an important role in creating scenery that gives aesthetic pleasure for people (Birren, F. 1978). It is also conceptually clear. However, it is not easy to proceed with an actual color design process since it is difficult to find a color scheme that fully reflects the principle of color harmony. This paper claims that one of the solutions to this problem is a digital color design approach.

According to the principle of color harmony, the color code can be found by a variety of digital design methods that produce a color scheme. Figure 1 shows an example of a program that generates a color scheme (Tiger Color). The name of the program is the Colorimpact. As shown in Figure 1, a color scheme can be created by clicking a point on the color wheel on the left side and dragging it to the dot on the color wheel on the center. When the color scheme is created, the principle of color harmonization is considered. Another way to create a color scheme is creating a color palette from existing images and then drag the colors to the color palette. Conventional images can be various images such as buildings, natural scenery, and people surrounding the buildings. An image can be used that contains the desired design style. This method is suitable for creating landscapes that harmonize the colors with surroundings.

Using this design method, it is possible to find various color schemes. However, the color scheme derived by this method should not contain only the visual harmony of colors. In addition to this, it should contain emotional meaning to provide people with aesthetic pleasure (Manav, B. 2017). In this sense, this study argues that color design approach using emotional words should be accepted to design concept. Figure 2 is an example of color schemes associated with emotional words used in the case studies (Eisenman L. 2000 & Itten, J. 2001). These color schemes were proposed by Eisenman. The numbers shown at the bottom of Figure 2 are Pantone color codes. The Pantone color codes need to be converted to RGB color model using the ‘Find a Pantone Color’ program on the official website of Pantone. This is because Pantone color code can be expressed in color by the value of RGB.
In addition, color schemes are not developed using the computer program described above in this paper because it is difficult to create a color scheme associated with emotional words. Instead of that, therefore, color schemes already made were used. This paper focuses on developing a color design process rather than developing color schemes.

**AESTHETIC VILLAGE FOR REVITALIZATION TOWARDS COLORSCAPE**

The design concept is very important in any design project. However, a design concept has a broader meaning because it includes everything related to solving a design problem. Therefore, it is necessary to narrow down the meaning of the design concept. However, this study dealt with the concept of color design expressed by emotional words related to beauty. The color design concept can be expressed as a group of architects such as modernism or postmodernism and described in terms of styles such as Parisian style, Roman style, New York style and Seoul style (Anter, K. F. & Billger, M. 2010). It can also be explained by the concept of emotional words such as romantic, classical, or unique. There can be various ways for design concepts. In this study, the design with color schemes using emotional words was explored. The color design using emotional words is a design approach that can create the characteristics of the villages and consequently the identity of the village (Linton, H. 1999).

For example, beautiful landscapes can be created effectively using color schemes. Moreover, the beautiful scenery created should ensure the unity of color. The unity of color, such as the unity of value, the unity of chroma, and the unity of tone, creates a pleasant landscape. The unity of tone in landscape design is more important than anything else for aesthetic scenery. Once the design concept is established, the designer must find the color scheme associated with the design concept. Once the color code is set up, the next step is to apply a color scheme to each building. Generally, in order to make the color design to the villages, it is efficient to apply the color schemes to each zone after dividing the villages into several color zones rather than coloring all the buildings with different colors. A color zone means an area using a color scheme of the same design concept.

This study deals with a color scheme consisting of three colors. These three colors are the dominant color, complementary color, and accent color. How to determine these three colors in the landscape of the village is an important research issue. This is because the landscape image of the village is influenced by the ratio of them. For example, 70% of the dominant color, 20% of the complementary color, and 10% of the accent color are able to be applied, or they can change the ratio to 60% of dominant color, 35% of complementary color and 5% of accent color. Using the digital color design, it is possible to create color schemes to automatically adjust this ratio. Therefore, by exploring color design with infinite alternatives, the possibility of finding a good design is increased.

**COLOR DESIGN PROCESS**

The disadvantage of traditional color design is that only a few people with design talent are likely to draw good designs. Another problem with this method is that most of the work is done by hand, so only a few design alternatives are considered and the final design is decided. In order to improve the quality of color design, it is necessary to search for many designs and then to decide the quality of the design that is searched. It is also necessary to utilize a systematic design process that is easy to use and incorporates the principles of color harmony (Pile, J. F. 1997 & Poore, J. 1994). It is obvious that color is a powerful design element for attracting people. Although the color is an important design element that affects people’s emotions, few architects deal with color in detail.

Why do so many architects hesitate to use color? Perhaps it is because of the intensive focus on form-centered design education and lack of education on color design. In addition, color cannot be objectified because it is perceived subjectively by individuals.
Thinking that there is no correct answer to good color design is one of the reasons to avoid color design. However, designing colors can be trained, and using appropriate color design methodologies can produce good results. From this point of view, this study describes the color design process using emotional words. As shown in Figure 3, the computational color design process consists of three steps: color scheme selection, color arrangement, and color evaluation.

The first step, color scheme selection in the design process, is the stage to select the appropriate color schemes in the stored color scheme database. The choice of color scheme is found by the search term of emotional words. The second step, color arrangement (Serra, J. et al., 2012; Serra, J. 2013; Unver, R. & Ozturk, L. D. 2002), is to apply the selected color schemes to the buildings in each zone. It is very important at this stage to decide on which color zones and which buildings to apply the selected color scheme (Swirnoff, L. 2003). The third step, color evaluation, pursues an objective and numerical analysis of color quality. This step is to find the average value
of value, chroma on the scenery of the village created through the design process. In this step, the difference values of value, chroma, and tone between the color zones are calculated. Through these analysis results, the designer can finally decide the design that is suitable for the intention of the design.

**CASE STUDY**

**Target Village**

Figure 4 is a three-dimensional model to demonstrate the proposed computer color design process in this study. As shown in Figure 4, the target villages consist of the residential zone, commercial zone, and public zone. The residential zone has zone codes of H1, H2, H3, H4, the commercial zone has zone code of C1, and the public zone has zone code of P1. The four residential zones have design concepts of spring, summer, autumn, and winter, and the corresponding emotional words of the concept are romantic, cool, luscious, serene, respectively. The commercial zone and the public zone do not have a seasonal design concept but have only emotional words: capricious, unique, and classic. The village consists of a total of 1,448 buildings, and assigning the colors of these buildings is a design problem. Therefore, it is assumed that buildings included in the same zone code have the same emotional word.

**Color design process**

Figure 5 shows the example of the color design process that the H1 zone code of the residential zone is selected. It specifies the building color of the building number 232-619 contained in H1. How to select one color scheme at a time and then designate it to apply to several buildings can be a research issue, but in this study, it is assumed that one color scheme is selected and ten building colors are selected. Thereafter, it is assumed that the ratio of the dominant color, complementary color, and accent color composing the coloring code in the ratio of 7:2:1. This ratio can be changed by using parametric design. However, in this paper, these colors were applied in the ratio of 7:2:1. As shown in Table 1, the emotion code of the H1 zone is Serene. Therefore, one Serene color schemes need to be determined among various color schemes in Serene. If there are several color schemes corresponding to Serene, the color scheme will be determined randomly.

In step one, color schemes were set. In step two, seven buildings were assigned the dominant color, two buildings had a complementary color, and one
Table 1
Zone and emotional theme of village to apply

<table>
<thead>
<tr>
<th>Zone type</th>
<th>Zone code</th>
<th>Number of Buildings</th>
<th>Design Concept</th>
<th>Emotional Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential zone</td>
<td>H4</td>
<td>1069-1448</td>
<td>Summer</td>
<td>Cool</td>
</tr>
<tr>
<td></td>
<td>H3</td>
<td>1049-1068</td>
<td>Autumn</td>
<td>Luscious</td>
</tr>
<tr>
<td></td>
<td>H2</td>
<td>620-1048</td>
<td>Spring</td>
<td>Romantic</td>
</tr>
<tr>
<td></td>
<td>H1</td>
<td>232-619</td>
<td>Winter</td>
<td>Serene</td>
</tr>
<tr>
<td>Commercial zone</td>
<td>C1</td>
<td>40-231</td>
<td></td>
<td>Capricious, Unique</td>
</tr>
<tr>
<td>Public zone</td>
<td>P1</td>
<td>1-39</td>
<td></td>
<td>Classic</td>
</tr>
</tbody>
</table>

Figure 5
An example of color design process

building had accent color. In a similar way, by repeating the design process of the computer design the colors of all the zones were assigned. Finally, design alternatives by repeating the design process were produced. In step three, design evaluation proceeded. Table 2 shows averages values of value, chroma, and tone in each zone for three alternatives. These values cannot be obtained with the R, G, B color models. When converting the R, G, and B models to the Munsell model, the average values of value, chroma can be calculated. In this paper, Munsell Conversion Software 2018 was used to convert R, G, B into Munsell model.

Unlike value and chroma, tone cannot be expressed numerically. However, in this paper, the value of tone was expressed by a sum of the values of chroma and value. The values of tone itself were not meaningful because it was aimed at obtaining the difference values of tone rather than trying to obtain the values of tone itself. It is not possible to accurately define the sum of value and chroma as a tone, but it is possible to obtain the difference in tone. Table 3 shows the differences values of value and chroma and difference values between zones us-
Table 2
Mean values of value, chroma, and tone in the design

<table>
<thead>
<tr>
<th>Zone code</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>Chroma</td>
<td>Tone</td>
</tr>
<tr>
<td>H4</td>
<td>8.2</td>
<td>3.6</td>
<td>11.7</td>
</tr>
<tr>
<td>H3</td>
<td>7.5</td>
<td>5.8</td>
<td>13.3</td>
</tr>
<tr>
<td>H2</td>
<td>8.4</td>
<td>2.6</td>
<td>11.0</td>
</tr>
<tr>
<td>H1</td>
<td>7.6</td>
<td>7.0</td>
<td>14.5</td>
</tr>
<tr>
<td>C1</td>
<td>6.6</td>
<td>4.8</td>
<td>11.5</td>
</tr>
<tr>
<td>P1</td>
<td>8.3</td>
<td>0.2</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Figure 6
Munsell Conversion Software 2018

DISCUSSION
This study is worthy of the study because it suggests a method to do color design even if designers have no sense of color or talent. Another value is that it creates a myriad of design alternatives in a short period of time, stimulating the imagination of the designer and increasing the chances of deciding the quality of the design in various ways. The contribution of this paper is to present a color-based design strategy that does not require much more costly than other methods to activate a declining village.

Since the design result generated by this study is...
Table 3
Differences of values, chroma, and tone between zones

<table>
<thead>
<tr>
<th></th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of value</td>
<td>8.2</td>
<td>8.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Average of chroma</td>
<td>7.5</td>
<td>6.8</td>
<td>8.2</td>
</tr>
<tr>
<td>VD</td>
<td>8.4</td>
<td>8.6</td>
<td>8.2</td>
</tr>
<tr>
<td>CD</td>
<td>7.6</td>
<td>6.9</td>
<td>8.2</td>
</tr>
<tr>
<td>TD</td>
<td>6.6</td>
<td>7.4</td>
<td>5.8</td>
</tr>
</tbody>
</table>

VD: value difference between zones  
CD: chroma difference between zones  
TD: tone difference between zones

based on the color scheme with the harmonization of the colors, the color design with the beauty can be made. For the further research, if the color scheme is built in the database and various emotional vocabularies are added, the possibility of using the proposed design process will be higher. There is also a need to develop a way to create optimized solutions using genetic algorithms to create good design alternatives. It is also necessary to develop a more diverse and creative approach to color design using Knight's(1994) concept of color grammar rather than merely relying on color schemes. The final conclusion of this study is that the computer color design process can enhance the quality of color design and provide a tool for anyone to create a good color design.

ACKNOWLEDGEMENT
This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (NRF-2015R1D1A1A09061276)

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