CULTURAL DIFFERENCE IN COLOUR USAGES FOR BUILDING FAÇADES FOCUSING ON THEME PARK BUILDINGS

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Abstract. The notion of globalisation has become widely spread in various fields, and accordingly, it is increasingly more important to take account of indigenous culture characteristics in each field. An aspect of achieving globalisation, globalization with local consideration, is to consider the difference of colour usage between distinct cultures. This study suggests an approach to investigate the colour difference between eastern and western cultures with the case analysis of building façade colours in Disneyland Paris and Tokyo Disneyland. We analysed cultural colour usage characteristics and derived tendencies for both Paris and Tokyo Disneyland building façade colours. To do this, we use image based k-means clustering algorithm and CIELAB colour space distances to explore colour characteristics. Our analysis indicates an overall colour usage tendency that Paris uses more green and bluish colours and Tokyo uses more red and yellowish colours for building façades, based on CIELAB colour space values. The major motivation of this paper was to reflect the atmosphere and the mood of the space that can be easily felt but not readily expressible into a cultural colour palette. Eventually, by finding the characteristics of perceived colours, we hope to create a colour recommendation system for different cultures based on cultural clues.

Keywords. Culture; colour usage; colour clustering; building façade; computational approach.

1. Introduction

Cultural background plays an integral role in one’s way of thinking and behaviour (Nisbett, 2003). According to Nisbett, different environments between eastern and western cultures generate different ability of perceiving and processing information in cultural groups—the cultural power. Hofstede
(1984) first tried to quantify the cultural difference as a form of cultural dimensions. This theory of culture quantification is widely adapted in various fields such as computer-human interaction and social and behavioural sciences (Ishak et al., 2012). Cultural differences can be related to visual design features such as colour preferences in culture groups (Kondratova and Goldfarb, 2009). Kondratova and Goldfarb suggested national colour palette that can be applied to design website interface. However, less work is concerned with architectural colour usage difference between cultures in physical spaces. This study attempts to quantify decisive arrangement of colour choices under the condition of equivalent Disney themes but different cultural circumstances: western and eastern. Disneyland is a representative example of the strategically designed theme parks in the world. Theme park is a place where a wide range of colours, but at the same time, only theme-related colours can be used for architectural façade design. In this condition, theme park designers certainly encounter the process of selecting proper colours for attractions, shops, and restaurants. Moreover, cultural characteristics should not be overlooked to meet glocalisation (Clavé, 2007). However, there has not yet been an extensive research regarding how designers should consider cultural differences in the process of selecting ideal colours. Theme park designers are known to design using concept images and choose colours from them. However, even though it is of same theme such as the Mickey Mouse theme or the Peter Pan theme, there are differences in the overall atmosphere that make up the thematic environment depending on the location where the theme park is situated.

In this paper, we explore ways to incorporate human perception for quantitatively extracting the colours used in theme parks with the aid of computers and compare how much the eastern and western architecture façade colours differ. To do this, we use k-means clustering algorithm (MacQueen, 1967) for image-based colour palette extraction first to guide the surveyors of selecting five representative colours. Then, we evaluated how much the perceived colours differ for eastern and western architecture façades on each axis of the CIELAB colour space, which are blue-yellow, green-red, and lightness. Eventually, by finding the characteristics of perceived colours in theme parks in different countries, we hope to create a colour recommendation system for façade colours or city colours for different cultures that is based on cultural clues.
2. Literature review

2.1. COLOUR PERCEPTION AND CIELAB COLOUR SPACE

The spectrum of colour is continuous; however, it is widely known that when humans perceive colours, they tend to group discriminable colours into a number of colour categories such as grouping into reds, blues, and greens (Bird et al., 2014; Clifford et al., 2010). Therefore, there is a tendency to merge similar colours or spatially adjacent fragments into one region.

CIELAB colour space is designed to approximate human vision and perception. CIE L* a* b* model (Robertson, 1977) is considered to be more similar to human vision because the way it is represented reflects how humans perceive colour difference. Figure 1 shows the CIELAB colour space. The lightness L*, represents black at L* = 0 and white at L* = 100. The colour channel a* axis represents red-green, with green at negative a* values and red at positive a* values. The b* axis represents blue-yellow, with blue at negative b* values and yellow at positive b* values.

![Image of CIE colour space](image)

Figure 1. CIE colour space.

The Euclidian distance of two colours in CIELAB colour space is generally accepted as the difference between two colours. In this study, the colour distance between two colours is computed based on the CIELAB colour difference equation. The distance between any two-colour locations is typically expressed as,

\[ \Delta E^2 = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \]  

(1)

2.2. K-MEANS CLUSTERING

K-means clustering is a method commonly used to partition n observations into k groups according to the similarity between observations. It proceeds by selecting k initial cluster centres and then finds a partition such that the
mean squared error between the cluster centre and each point that belongs to the cluster is minimized. Formally, given a set of \( n \) observations \( X = \{ x_i \}, i = 1, 2, \ldots, n \), where each observation \( x_i \) is a \( d \)-dimensional real vector point to be clustered, k-means finds \( k \) cluster centres \( \{ m_j \}, j = 1, 2, \ldots, k \). The centre \( m_j \) of a cluster \( M_j \) is defined as the average of observations that belong to that cluster. Given the cluster centres, each observation \( x_i \) belongs to closest cluster, where the distance is defined against the cluster centres. K-means works by minimizing the sum of the squared error over all \( k \) clusters, given as follows:

\[
J(M) = \sum_{j=1}^{k} \sum_{x_i \in M_j} \left\| x_i - m_j \right\|^2,\]

where \( m_j \) is the mean of \( M_j \).

3. Methodology

3.1. DATA GATHERING

Building images used in this work are photographs taken at first hand in Paris Disneyland and Tokyo Disneyland with OLYMPUS PEN E-P1 and the size of each original image is 4032*3024. For the comparison of colour usage differences between eastern (Tokyo) and western (Paris) cultures, we have selected three pairs of equivalent Disney themed building images – Mickey Mouse, Peter Pan, and Pinocchio. We extracted clear building shapes from the image by eliminating obstructive factors such as sky, trees, and pedestrians.

3.2. MATLAB K-MEANS COLOUR CLUSTERING

We generated 20 theme colour swatches by running k-means clustering on the image in MATLAB (Gonzalez, 2004). Figure 2 shows the example of extracted 20 representative theme colours with three themed buildings that the colours were extracted from: Mickey Mouse theme, Peter Pan theme, and Pinocchio theme from top to below.

The CIELAB colour space is designed to approximate human vision and perception. To incorporate human colour perception, we used CIELAB colour space as our standard space. To this end, we converted every RGB pixel values into CIELAB values by conversion formula provided from a MATLAB library “rgb2lab”.
3.3. EXPERIMENTAL SETUP

We gathered human extracted theme colours from Amazon Mechanical Turk, which has been widely used in crowdsourcing graphical perception experiments (Heer and Bostock, 2010) and Google Forms survey: (https://www.google.com/forms/about/). We asked surveyors to select their ethnicity (either westerner or easterner at the end of the experiment). In total, we recruited 60 surveyors, including 30 westerners (United States, United Kingdom and Brazil) and 30 easterners (South Korea, India, Mongolia, Japan, China and Hong Kong). We wanted to know if westerners and easterners (as classified according to their nationality) perceive colours in different ways. Each experiment was paid $0.80 and the median time to complete the experiment (total six tasks) was 9.42 minutes.

We followed the experimental setting of Lin and Hanrahan (2013), and asked surveyors to select five theme colours from 20 colour swatches per image for total six images. Each task includes one image on the left and associated colour swatches on the right. They were asked to select five different colours that best describe the image. Figure 3 shows the experiment interface.
4. Results

4.1. DISTRIBUTION ON THE CIELAB SPACE AXES

To evaluate the perceived façade colour differences, we visualized extracted CIELAB colour values on a three-dimensional scatter plot. Tokyo and Paris Disneyland, the two different theme parks situated in eastern and western area showed different trend of façade colour usages. The distribution of points shows how much the colours differ. Figure 4 shows the overall L*, a*, b* values of Tokyo and Paris building façade colours.

![Figure 4. CIELAB three-dimensional scatter plot of Paris and Tokyo data (asterisk mark represents Paris, dot mark represents Tokyo).](image)

Figure 5 shows the projection of the Tokyo and Paris building façade colours onto L*, a* and b* axes of the CIELAB colour space. There is little difference in lightness between Paris and Tokyo. However, we found an overall tendency of using more green and blue colours in Paris façade and more red and yellow colours in Tokyo by looking at two-dimensional space.
Figure 5. Colour distribution of eastern and western architecture facades on each axis of the CIELAB colour space (L*: lightness, a*: green-red, b*: yellow-blue, asterisk mark represents Paris, dot mark represents Tokyo).

Figure 6. CIELAB two-dimensional colour space result (left: a* b* relation, right: L* a* relation, middle: L* b* relation, asterisk mark represents Paris, dot mark represents Tokyo).

Figure 6 shows the result of two-dimensional relation between two axes of CIELAB colour space. It is recognizable that overall trend of Paris and Tokyo colour differs. The right graph of L* and a* relation, Tokyo building facade used more red (higher a* values) colours than Paris. On the contrary, Paris building facades tend to use more greenish (lower a* values) colours for architecture facade designs. According to the middle graph of L* and b* relation, Tokyo building facade used more yellowish (higher b* values) col-
ours than Paris. On the contrary, Paris building façades tend to use more bluish (lower $b^*$ values) colours for architecture façade designs.

4.2. INSIGHTS FROM RAW DATA

Extraction of 20 theme colours for each image is done by k-means clustering. For each image, we calculated the colour differences among 20 extracted theme colours using the colour difference equation given in (1). Figure 7 shows 20 x 20 CIELAB colour distance values for each image. According to the calculated colour differences, we could categorize the 20 colours into representative groups of similar colours. We enumerated distance values in an ascending order (lower distance values indicate the more similarity between two colours in human perception) and we found an interesting distance threshold that distinguishes representative colour groups in a way that resembles human colour categorization results. By grouping colours within a CIELAB distance of 15, five to seven theme colours categories are generated, which are reasonably similar to those of human results. For each human image, we obtained representative groups of similar colours.

Figure 7. CIELAB colour distance among the 20 representative colours (top: Paris Mickey Mouse, bottom: Tokyo Mickey Mouse).

Figure 8 shows the similarity result of five extracted theme colours of total six images. DT indicates the above computational distance threshold ap-
proach of colour grouping result, W indicates westerners’ and E indicates easterners’ results. We found an interesting insight that westerners tend to choose more theme colours from less salient parts such as back walls of the building, which is located one depth behind the closer salient parts.

![Building façade images and their associated five theme colours from distance threshold (DT) approach, westerners (W), and easterners (E). From above to below, Mickey Mouse theme, Peter Pan theme, and Pinocchio theme (left: Paris, right: Tokyo).](image)

**Figure 8.** Building façade images and their associated five theme colours from distance threshold (DT) approach, westerners (W), and easterners (E). From above to below, Mickey Mouse theme, Peter Pan theme, and Pinocchio theme (left: Paris, right: Tokyo).

### 5. Conclusion and expected contribution

This study suggests an approach to investigate the colour difference between eastern and western cultures with the case analysis of building façade colours in Disneyland Paris and Tokyo Disneyland. We analysed colour usage characteristics and derived tendencies for both Paris and Tokyo. To achieve this, we used image based k-means clustering and CIELAB colour space distances to explore cultural characteristics. We found a difference in the overall colour usage tendency of Paris and Tokyo. That is, Paris uses more green and bluish colours and Tokyo uses more red and yellowish colours for building façades. We also gained insight that westerners tend to focus broader areas such as back walls of the buildings than easterners. Therefore, by considering different tendencies in perception of physical space as well as colour perception, strategical suggestions can be made in the usage of building exterior colours. Based on these cultural clues, we anticipate glocal colour recommendation with local considerations to the theme park designers.

### 6. Discussion and future works

As a first phase of cultural colour study, we wanted to compare same thematic buildings in theme parks located in two different cultural environ-
ments, and the current work may seem to lack data. However, in the next phase, we will improve our approach using a broadened scope of data, such as expressing cultural differences using representative colour palettes of a whole theme park colours or city colours. In addition, it is challenging to get intact building images due to trees or pedestrians in the theme park. Therefore, we expect better results if there is a way to achieve unimpeded images of building façades. The major motivation behind this paper was to reflect the atmosphere and the mood of the space that can be easily felt but not readily expressible into a cultural colour palette. Eventually, by finding the characteristics of perceived colours, we hope to create a colour recommendation system for different cultures based on cultural clues.

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