Developing a Method for Generating Colour Palette from Landscape Images

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ABSTRACT

In the design process, particularly in landscape, architecture and urban design, colour is a vital element and usually appears in the entire design procedure. Designers generally use a specific colour palette to clarify their ideas or colourize their plans. Moreover, landscape is one of the most significant inspirations for designers; in light of the specific colour matching in landscape, designers can build a colour palette to indicate the theme of their plan. For instance, the typical landscape view with red bricks, green lawn and blue sky as well as the white cloud in the United Kingdom. This suggests that a colour palette derived from landscape can represent particular characteristic features of a place, which can relate to the themes and emotions of the designers. Landscape designers have been working on colour palette generation based on subjective colour assessment. The aim of this study is to develop an objective method to automatically generate colour palettes from landscape images using clustering analysis. A group of landscape images are captured and used as reference database. Clustering methods were applied to those landscape images in both RGB and CIELAB colour spaces. There is some evidence that the clusters that result from CIELAB colour representation are more robust than those that result from RGB colour representation.

KEYWORDS: colour palette, colour imaging, landscape

INTRODUCTION

In nature, the existence of similar and complementary colour arrangements is common. In landscapes, where there is a wide range of colours and colour combinations, this is particularly so, with the yellows, oranges and reds found during sunrise and the complementary blue sky or ocean with the yellowish sunrise. There is abundant colour variation in different regions, which results from various combinations of rock types, vegetation, local architecture materials and soil [1].

Using colour is a particularly creative component of the design process; it often appears throughout the entire design procedure [2]. Colour is thought to influence people's feelings and there are many theories (and much evidence) that support the idea that colour affects human emotion [3]. Colour can therefore play a central role in the visual landscape experience [4] and designers can use this explicitly in design. Designers generally use colour palettes according to the basic rules of colour harmony. However, they also often research and identify specific colours or colour combinations discovered in the characteristics of local landscapes.

This work is concerned with the automatic extraction of key colours in landscapes and the use of those colours to generate a colour palette that represents the colorimetric characteristics of the landscape and could be used in design. A typical application would be to generate a colour palette for use in a building where the architects would like the colours to be consistent with the local landscape and its character. One approach to this would be to segment the image in terms of colour. Unfortunately, there is no universal theory on colour image segmentation and methods that have been used tend to be *ad hoc* [5]. Cluster analysis is often used and one study of its use found that Pillar K-means clustering provided better results than either K-means or Fuzzy C-means clustering [6] although there was no conclusive finding on the relative merits of three colour spaces (RGB, CIELAB or HSV) in which to perform the cluster analysis. A different study, however, concluded that K-means is fast and efficient and segments images by colour in a way that is close to human perceptions [7]. Two recent studies have found that for K-means clustering the use of CIELAB and HSV colour spaces gave better results than RGB [8, 9]. Note, however, that our interest is not exactly in image segmentation but in the extraction of the most common colours in the images.

EXPERIMENTAL

A series of 21 images were captured of an urban landscape during a single day in July at approximately 20-minute intervals between 3pm and 10pm. Figure 1 shows four of these images. The images were captured using a Pentax KP Digital SLR camera mounted on a tripod with a Pentax smc DFA 50mm f/2.8 macro lens. The white-balance was fixed at 6000K and but the shutter speed was adjusted automatically based on the exposure (without the auto-exposure the camera would not be able to capture the dynamic range of the temporal scene).

Figure 1: Four of the 21 images captured at 15:17, 17:17, 19:37 and 21:57.

A LX1010BS lux metre was placed near to the camera and used to measure the illuminance of the ambient sky at the same time that the digital images were captured (see Figure 2). The lux measurements were captured for later analysis but are not used in this paper.

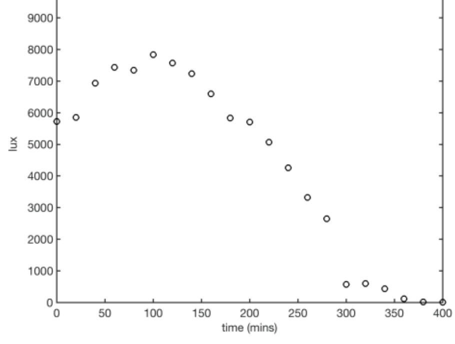

Figure 2: Lux measurements taken at the same time as the digital images (the time is expressed as mins after 15:17, the time at which the first image was captured).

Each of the images were converted from sRGB to CIELAB colour coordinates at each pixel using standard methods [10]. Both sRGB and CIELAB images were processed using MATLAB's *kmeans* command that uses K-means clustering to extract clusters or centroids. A total of 8 centroids were extracted with 10 replicates each time (in which the initial centroids were randomly selected and after which the replicate with lowest error was returned; error in this sense is the distance of the pixels from the centroids). The centroids were ranked according to the populations of the clusters that they represented and the first two of these centroids were selected as being representative of the image.

RESULTS AND DISCUSSION

Figure 3 shows representative colour centroids for two of the images from the series using either sRGB and CIELAB representations. Informally there is a good degree of visual correspondence between the colours in Figure 3 and the two images they represent from Figure 1 but a psychophysical study will be required to better evaluate this.

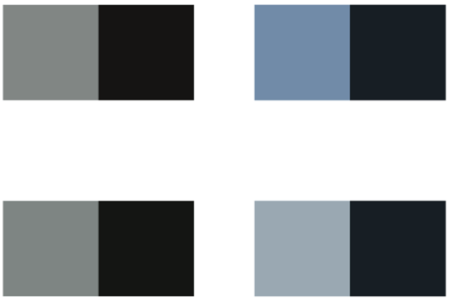

Figure 3: Representative colours for the 15:17 (left) and 21:57 (right) images extracted using RGB (upper row) and CIELAB (lower row) images.

The robustness of the colour-extraction method was assessed by repeated the analysis 6 times. The mean colour difference between the six repeats is then used as a measure of robustness (if the mean DE is zero it means that exactly the same colours are extracted each time). Table 1 shows the mean CIELAB DE for the colours extracted for the four images shown in Figure 1.

Table 1: Colour differences between repeated centroid extractions

	Image 15:17	**Image 17:17**	**Image 19:37**	**Image 21:57**
RGB	8.5	16.4	27.8	15.3
CIELAB	2.0	19.8	18.9	16.9

The colour differences for repeat assessments for Image 15:17 are quite small ($\Delta E = 2.0$ for CIELAB representation) which indicates that the first two components that were extracted from the image were quite stable. However, the colour differences for repeat assessments for some other images is much larger (for example, for Image 21:57 $\Delta E = 16.9$ for CIELAB representation). The most likely reason for this is for Image 15:17, for example, the first two components are dominant and have much greater population than the third component; on the other hand, for Image 21:57, the populations of the first two components are similar to that of the third component which means that when repeated with a different random starting point the second and third component, for example, may flip in order of population. This raises the important question of how many centroids should be extracted for a given image and whether this can be automatically determined for each image. The data in Table 1 are only for four images; however, there is some indication that the use of CIELAB colour leads to more stable estimates of the centroids than does the use of RGB colour space. This tentative finding needs to be explore more using a greater number of images and with images having greater variety.

CONCLUSION

Clustering analysis using K-means is usually used for image segmentation. However, there is evidence that it can be used as a method of automatically extracting key colours from an image. For landscape images this raises the potential that an automatic method could be employed to extract the colour characterization of the landscape images (either for a single image or for a group of related images). In this study both RGB and CIELAB colour representations were used and there was some evidence (albeit based on a small number of images) that more robust extraction of colour clusters occurs with CIELAB colour space and this is consistent with some other published work in image segmentation [8-9]. However, a number of important questions remain. In particular, there is the question of how many colour clusters or centroids should be automatically extracted from an image to form a colour characterization; what effect does this number have on the robustness of the clustering and on the agreement with any visual analysis?

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