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| **Technical Report on Palette-based Color Transfer** |
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Abstract

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Palette-based Color Transfer is an area of image processing that has great artistic merit. Manipulating 2D images using color transfer has merit in both photorealistic and non-photorealistic areas of image manipulation. This technical report will cover the implementation process used to create a functional Palette-based Color Transfer web interface. This model can automatically extract the color palette of an input image, which the user can then alter and produce a resulting output image using the user-selected color palette.

Introduction

For my final project, I have created a Palette-based Photo Recoloring web interface. This model can extract the pixels from a given image and automatically extract a palette matching the input image. The user can then select a new color palette by altering each palette color using a provided color picker. The user can generate a new image that reflects the user-selected color palette. This intuitive interface provides an alternative to editing extracted histograms as implemented in commercial image-editing software. This tool provides non-experts in the field with a fully-realized color editing tool using simple palette editing input. The implementation of this Color Transfer model was most influenced by the paper of Chang et al., which defines state-of-the-art methods of Palette-based Color Transfer which has influenced research in the field for years later.

Tools

Unlike many Computer Graphics and Computer Visualization projects, this web-based Palette editor was implemented entirely using JavaScript. To achieve the many linear algebra and other arithmetic calculations in this model, I employed the use of multiple JavaScript tools found on the web. The color picking interface was implemented using the colorPicker project of GitHub user PitPik[[1]](#footnote-1). Mathematical operations were performed using the math.js library[[2]](#footnote-2). K-Means clustering was performed using the clusterfck.js by GitHub user harthur[[3]](#footnote-3). The Radial Basis Function used to represent pixels as a combination of palette-entries uses rbf.js by GitHub user thibauts[[4]](#footnote-4).

For the purposes of the web interface, the user can select from a preset list of images. This is simply to allow users an easily selectable list of images to use when testing the model. The model is designed to work with any image that fits the canvas size, which in this case uses square images. The web interface allows for an intuitive way to transfer colors between images, as well as providing a challenge to implement the system completely in JavaScript.

User Interface

The user interface for this tool is simple, as I aimed to make an intuitive interface to allow as simple interaction between the user and the tool as I could allow. There is a dropdown menu provided at the top of the interface to select the image which the user would like to perform Color Transfer on. To save the technical debt of implementing image uploading, the web interface uses a pre-determined list of images.

To calculate the palette of the selected image, the user can select the “Calculate Palette” button. Before doing so, the user can select a palette size between 3 and 5. This dynamically calculates the image palette of the specified size from the input image in a process explained in the next section. To edit the palette, the user may click on the palette entry and open a color picker interface. The user then selects any desire color which will now be reflected as the palette. Once the user has selected their new palette, the user can select the “Transfer Colors” button and wait for the output image to be generated.

Automatic Palette Extraction

Automatically extracting the palette from an image is achieved using a modified version of the K-Means Clustering algorithm. The goal is to select k colors that are representative of the colors in the original image. The choice of k is selected by the user, with options ranging between 3 and 5 colors.

A simple implementation of this algorithm would be to take all the pixels in the image, use them as input into the K-Means algorithm and select the k resulting centroids. This, however, is computationally expensive and may result in colors that are like one another, without accounting for variability in the resulting palette.

In this implementation, pixels are assigned to a bin as a 3-dimensional histogram of size 16 x 16 x 16. Each dimension of the histogram represents a color channel in RGB space. Once all pixels have been assigned a bin, the mean color for each bin is computed in Lab color space. The means collected here will be the points used for calculating the K-Means centroids.

When using this method, the randomized initial centers will still result in a different palette generated for each calculation. Thus, to initialize centers optimally, the algorithm will find the k largest bins and use those values as the initial centers. This results in uniform palette output, as well as representative palette entries for the colors found most within the image.

Another deviation from simple K-Means clustering is that generally, the resulting palette will produce near-black colors, since images often have many dark colors. Changes in color are hard to distinguish qualitatively, thus making very dark palette entries less useful to the user in distinguishing the colors of an image. As such, k+1 means are calculated, with the extra center initialized around the color black. This forces an extra cluster to be centered around black, then the resulting palette entry can be ignored. Thus, a k-sized palette can be generated without very dark colors providing noise to the algorithm.

Luminance Mapping

Mapping luminance of a color to a natural value was a crucial part of making the output image look natural and true to the original, while still adhering to the updated palette. A method described in the paper by Chang et al. allows output luminance to be computed based on the luminance of the output palette. This function would gather the nearest 2 nearest colors to a pixel in the new palette. Then, the weighted combination of the luminance of these two colors would result in the output luminance for that pixel.

Perhaps due to the vague explanation of this luminance transfer function, I was unable to reproduce this function in a way that would result in a natural image. In each iteration of the function, the output luminance would be noticeably similar between pixels, losing a lot of the texture in the image. As such, I devised a different way to handle luminance.

In order to maintain the depth of the original image, all calculations performed on the pixel assumes the original pixel’s luminance. This not only allows for the image to maintain its original depth, but it also allows the user to enter any color value for the output palette. In the paper by Chang et al., the UI restricted the user to stay within a luminance range between of the current palette color and of the color with the next highest luminance. By assuming to keep the original luminance value, all colors are mapped to the luminance that best represents the semantics of the scene, as well.

This treatment of luminance also benefits colors which are unaffected by the change in palette. Using the more complex luminance transfer function, colors unaffected by the palette change would also see a change in luminance, due to the weight between closest palette entries resulting in a different luminance from the original value. Thus, this method results in unchanged colors to be unaffected, further integrating the changed colors into the original scene semantics.

Color Transfer

Transferring colors between palettes requires a combination of the luminance mapping described above and a function that changes the hue of the pixel values. This calculation takes only into account the a and b values within Lab color space, as the luminance component is determined via the mapping of luminance described above.

To explain this transfer function, we can first view the function within the scope of a single color, . Assume the original palette color is and the new value of the corresponding palette color is . Let us also say that the pixel is and the desired output for the pixel will be .

Results

Results.

References

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1. <https://github.com/PitPik/colorPicker> [↑](#footnote-ref-1)
2. <http://mathjs.org/download.html> [↑](#footnote-ref-2)
3. <https://github.com/harthur/clusterfck> [↑](#footnote-ref-3)
4. <https://github.com/thibauts/rbf> [↑](#footnote-ref-4)