Chroma Keying

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1 Introduction : What is Chroma-keying ?

In movies, specially in sci-fi movies, we have seen many scenes in places which we even can't think in our dreams. Well this is all about **Chroma-keying**. The scenes are shot in a different background and those are fitted in the desired background. **Chroma Keying** is a visual effects and post-production technique widely used in various fields like film making, news-casting, video games etc. It involves combining the foreground of an image with the background of a different image, using colour hues. A green or blue screen is used in the foreground footage, which is replaced by a static background. Although chroma keying can be done with backgrounds of any colour that are uniform and distinct, but green and blue backgrounds are more commonly used because they differ most distinctly in hue from any human skin colour. We the students of B.Stat(Hons.) first year, as a part of our Statistical Methods 1 project, are going to work on finding an efficient algorithm for Chroma-keying.

2 Basic Target

Every image is a 2D collection of pixels, where each pixel represents a specific colour. Most common digital format to store colour is the RGB model, where the colour is stored in terms of the three primary components Red, Green, and Blue.
The task in chroma-keying is that given such an image, to classify every pixel as a background screen or a foreground component.

3 Hypothesis

The colour of the background is the colour which occurs maximum in the image. Thus the background colour is expected to be the mode. So if we make a histogram of the colours vs their frequency, the mode is expected to occur at a background colour.

4 First Algorithm

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Read the image
Separate the Red, Green, Blue components
Take individual mode for Red, Green and Blue to be the central tendency of the background
The pixels with RGB values similar to that central tendency will will be considered as background
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Fallacy in the First Approach

The main fallacy in the previous approach was that we tried to remove close neighbourhood of the mode by judging it through their RGB values. Now, two hues might be completely different to human eyes, yet have close RGB values. On the other hand, two shades of the same colour might have a significant difference in RGB values. So, while removing a close neighbourhood of the mode, some parts of the original picture also got removed as well as some section of the background persisted. As a result, we needed to have some measure of colour where two colours have close measure only if the colours are close according to human perception. This is why we chose the **HSV** colourspace.

HSV vs RGB

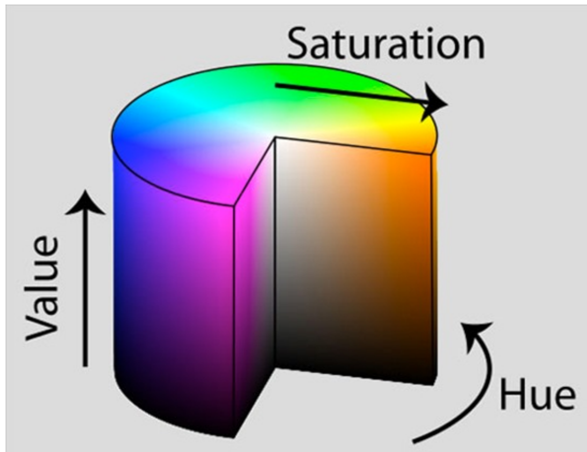

Figure 1: HSV Colour Scale

HSV is a colour model that is quite close to human perception of colour. H stands for Hue and is measured in a circular scale with Red at 0°(or 360°), Green at 120°, Blue at 240°. S stands for saturation, it is measured from 0 to 1.0 where 0 is complete grayscale and 1 is complete saturated colour. V, also measured from 0 to 1.0, stands for Value. Less V means darker(blackish tendency) and more V means brighter(whitish tendency). Clearly, this is closer to human perception of colour as similar shades of a particular colour have same H value. Also, in cases of minor changes in external lighting (such as pale shadows,etc.), hue values vary relatively lesser than RGB values. Similarly two colours having a significant difference in HSV values, must be different.

Data Analysis

The following plots are an example from our collection of samples:

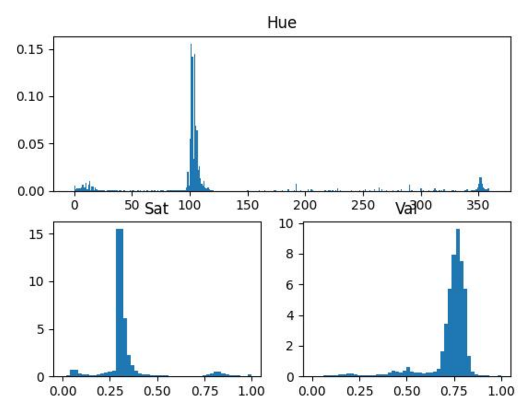

Figure 2: Histograms of Hue, Saturation and Value

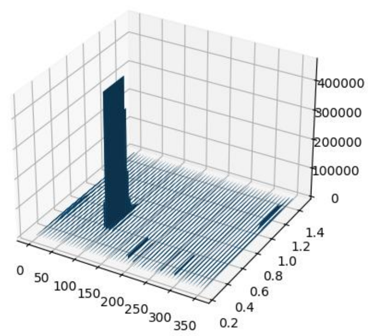

Figure 3: 3D plot showing Hue vs. Saturation vs. Frequency

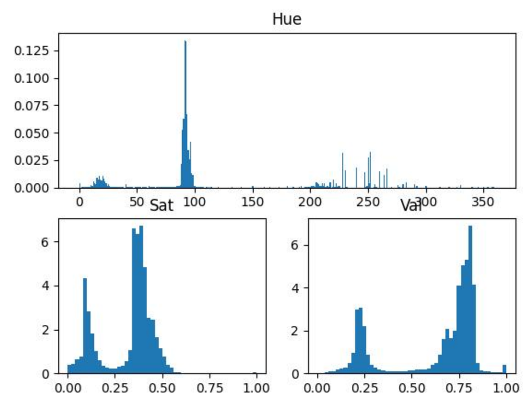

Figure 4: Histograms of Hue, Saturation and Value

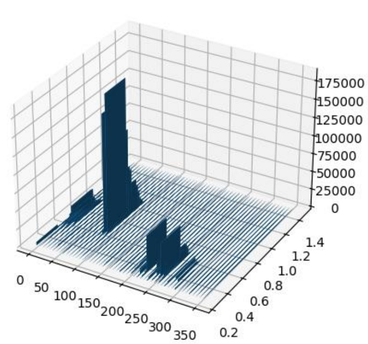

Figure 5: 3D plot showing Hue vs. Saturation vs. Frequency for Fig. 3

We observed the following:

- The hue values are concentrated around a certain point which is in the range of hue value for green. It corroborates our assumptions that the background hue has maximum frequency. The other hue values are due to the foreground and other than some minor peaks, they are scattered without any significant pattern.

- The “value” and “saturation” form a unimodal distribution in case of Fig. 1. Although, In certain samples(Fig. 3 for example), the secondary peak is also significant, they might even follow a bimodal distribution. This might be a cause of error if we give strict restrictions on S and V. So these conditions are relatively relaxed than H (but not ignored).
- In all cases, however, the hue, saturation and value labels with maximum frequency are clustered around a small neighbourhood around one (sometimes two) values. This value is the mode of the data.
- Based on this insight, our algorithm tries to remove the mode along with a certain neighbourhood around the modal value from the image to generate output image.

Note: The 2D plots show the relative frequency density of each value whereas the 3D plots show the frequency of (Hue, Saturation) tuple.

Revised Algorithm

Read the image
Convert every pixel from RGB scale to HSV scale
Take mode for Hue, Saturation and Value to be the central tendency of background
Remove the pixels with HSV values that are “similar” to the mode

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Note: The range of variation in the components that is called “similar” in our algorithm is determined by hard estimates from the histograms and the computerized trials. We allow $\pm 30\ Hue,\ \pm 0.8\ Sat,\ \pm 0.3\ Val$ variation around the modal values.

5 Results

Accuracy

We checked the accuracy of our algorithm by comparing it with a popular, widely used algorithm available for chroma-keying. We compared the pixels of each picture obtained by our algorithm vs the well-known algorithm and gave the measure as,

$$\textbf{accuracy} = 1 - \frac{\text{(No. of mismatched pixels)}}{\text{(total no. of pixels)}}.$$

The accuracy of each image in our sample has been computed using the previous formula and is presented in a compiled form in the Excel Sheet. There are two types of error in the output:

1. **Type I** The error caused by accidentally removing foreground pixels.
2. **Type II** The error caused by accidentally NOT removing the background pixels from original image

Our algorithm had an average accuracy of 95.39% .

Output Files

The output files have been included in the shared folder, along with the samples.

6 Conclusion

Our algorithm has showcased it’s effectiveness in replacing a green background colour with a different background.The algorithm’s success lies in it’s ability to differentiate a background colour from a foreground colour. However, it’s crucial to acknowledge the algorithm’s dependency on various factors such as lighting conditions, individual type of image provided, etc which has impacted its performance. Future enhancements could focus on refining the algorithm’s adaptability to varying environmental conditions. Overall, this project has provided us valuable insights into the complexities and potential advancements within chroma keying technology.

7 Bibliography

We made use of the following resources:

- *https://www.remove.bg* This site was used to generate the "perfect" output images against which we measured the accuracy of our algorithm.

- *https://en.wikipedia.org/wiki/Chroma-key* We got Fig. 1 as well as general information about Chroma Keying from this site.

8 Acknowledgements

We would like to express our sincere gratitude to all of the dedicated team members for their collaborative efforts and commitment in successfully completing this statistics project on chroma-keying. Each member's unique skills and contributions played a crucial role in the development and implementation of the algorithm. Additionally, our heartfelt thanks go to **Prof. Arnab Chakraborty** for his guidance and valuable insights throughout the project. This endeavor has been a rewarding learning experience, and we appreciate the support received from our peers , our parents and the academic community of ISI Kolkata.