Color Harmonization

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Daniel Cohen-Or, Olga Sorkine, Ran Gal, Tommer Leyvand, and Ying-Qing Xu. Color harmonization. *ACM Transactions on Graphics (Proceedings of ACM SIGGRAPH)*, 25(3):624–630, 2006

The goal of this paper is to find a set of aethestically pleasing colours to apply to an image. This process, called colour harmonization, involves quantifying the harmony within a given image and apply a new colour scheme that maximizes the harmony while minimizing the overall change in colour. In other studies, it has been suggested that within the colour wheel, there are eight different templates for harmony. Based on this concept, we can define the harmony within an image by the closest distance between its colour scheme to any of these templates. First, construct a hue histogram for the input image. Then for each template, since it can be reflected and rotated, we find the orientation that best matches the hue histogram. Finally, pick the template with the optimal orientation that best fits our image. This two-step optimization process returns the best harmonious colour scheme for the recolouring.

There are many ways to apply the recolouring, the simplest being a linear contraction of the original colours so that they fit within the sectors of the target template. If preserving the original colours is not an issue, one may choose to experiment with different target templates to produce many colour-harmonized results. Using this simple recolouring method, however, has its drawbacks. One possible problem is that a contiguous region within an image may be split into two different colours after recolouring. This occurs when the original colours within the region lie approximately half way between two sectors of the target template. As a result, the algorithm recolours part of the region using the first sector and the rest using the second sector. To avoid this spatial incoherence, we introduce an energy function that measures the amount of shifting done during recolouring as well as the difference in hue between neighbouring pixels. The aim is to find a harmonious colour scheme that minimizes both these quantities. Then to apply this new colour scheme, instead of linearly contracting the colours, we use a upside-down Gaussian distribution weighted based on colour saturation. This is more effective because hues that are already inside a template sector change very little while hues outside change more. Also, weighing the colour shift based on saturation means that colours with high saturation are not allowed to shift too much. This limits how much change is applied to the original image after recolouring.

The authors of the paper implemented their algorithm along with several extra features to enhance the final recoloured image. One feature is being able to "scribble" on a recoloured image where wrong colours have been applied, and the algorithm will reassign the region the colour from the other direction of the colour wheel instead. This is useful when the program incorrectly identifies segments within an image. Another feature is that, given two superimposed images corresponding to the foreground and background, the program can apply the colour scheme from one to the other.

Some practical applications of this colour harmonization technique include poster design, interior design, fashion design, etc. Basically, presented with any abstract art form, this algorithm can give it aesthetically pleasing colours. The program even allows the user the flexibility of choosing their own colour scheme to be applied to image, thus bypassing the harmonization step. Currently, the method does not always provide satisfactory results when realistic images, such as scenery photographs and human portraits, are given, because certain objects need to retain their original colours. One extension mentioned in the paper is being able to choose certain colours to fix while varying other colours. However, this alone may not be sufficient because, for example, given an image with a blue sky in the background and a person wearing a blue shirt in the foreground, we want to tell the program to keep the sky's colour fixed while allowing the shirt's colour to vary according to the harmonization. This may be done by extending the scribble feature, but to fully automate the process, it may be necessary to incorporate some segmentation techniques.

For certain results presented in the paper, it is unclear whether the colour harmonization actually improved the aesthetics of the image. As the algorithm does not take into account the amount of colour variation within the original image, often the harmonization simply removes any outlying colours, leaving the image with a narrow range of colours and thus looking artificial. To fix this, the preservation of colour variance should be added as an optimization constraint for the colour harmonization. As for images with separate foregrounds and backgrounds, to avoid too much colour matching, it may help to assign one sector of the harmony template to the foreground and another sector to the background, or vice versa. An extension on this idea would be to relate spatially contiguous regions to contiguous regions within the colour wheel.