Making hybrid images

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Abstract

This paper describes a technique for creating hybrid images. To obtain these interesting images the discrete Fourier transform and Gauss filter are used. Auxiliary video containing a set of frames helps in getting hybrid image. Each video frame displays a possible hybrid image with new settings. In this paper, three sets of images were tested.

1 INTRODUCTION

In the early 16th century, Leonardo da Vinci painted one of the most enigmatic painting in the history of humanity. The title of this painting is Mona Lisa. The striking result is that when you look directly at Mona Lisas smile, it seems to disappear. But when you look at the background your peripherals see a smiling face. This painting is a kind of hybrid image, which will discussed in this paper.

A hybrid image is an image that is perceived in one of two different ways, depending on viewing distance, based on the way humans process visual input. A technique for creating hybrid images exhibiting this optical illusion was developed by Aude Oliva and Philippe G. Schyns. Hybrid images combine the low spatial frequencies of one picture with the high spatial frequencies of another picture, producing an image with an interpretation that changes with viewing distance.

The most famous hybrid image is Marilyn Einstein (Figure 1).

If you look at this image from up close, you will see the face of Albert Einstein. And, if you move 2 meters away and look again, you will see the beautiful Marilyn Monroe. In this paper, we will take a look at how to create these amazing images.

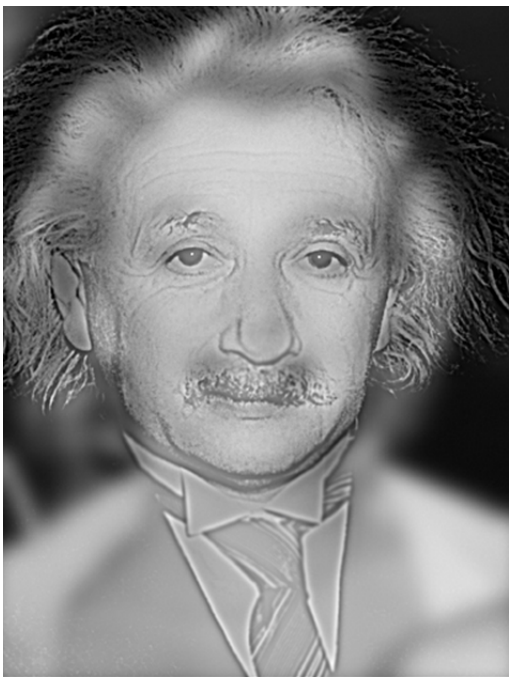


Figure 1: Marilyn Einstein

2 METHODOLOGY

A hybrid image is obtained by combining two images, one filtered with a low-pass filter and the second one filtered with a high-pass filter [1]. These filters based on the idea of Fourier analysis.

The Fourier transform is used to decompose an image into its sine and cosine components. The output of the transformation represents the image in frequency domain. Building blocks that are used in Fourier transform are as follows:

$$e^{2\pi ikx} \tag{1}$$

An image in frequency domain is a linear combination of such Fourier coefficients.

Constructing hybrid images is one particularly nice example of manipulating the Fourier spectrum of two images, and then combining them back into a single image. An image in frequency domain may be presented like follows:

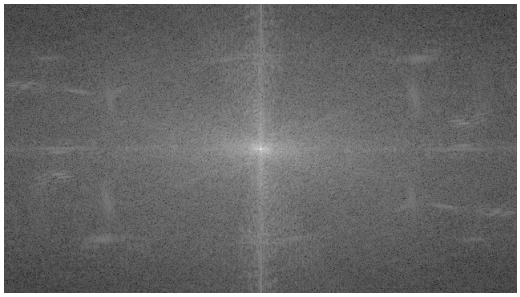


Figure 2: Image in frequency domain

Each dot in this grid corresponds to how intense the Fourier coefficient is. The points that are closer to the origin correspond informally to the smooth changes in the image. These are called "low frequency" coefficients. And points that are further away correspond to sharp changes and edges, and are likewise called "high frequency" components. Combining images with different coefficients, you can create hybrid image. It needs to use a filter to obtain low or high image frequencies. The most common filter is the Gaussian filter:

$$g(x,y) = e^{-\frac{(x-a)^2+(y-b)^2}{2\sigma^2}} \tag{2}$$

If we are trying to get rid of high-frequency components we can just multiply the Fourier coefficients directly by the filter values $g(x,y)$, and if we are doing a high-pass filter we multiply by $1-g(x,y)$. If you increase sigma value for low-pass filter, you will get more blurred image. Otherwise, if you increase sigma value for high-pass filter, you will get more edges and shapes on image. Sigma value helps us to set the cut-off frequency. Hybrid image will be a composition of the filter results.

3 PRACTICAL RESULTS

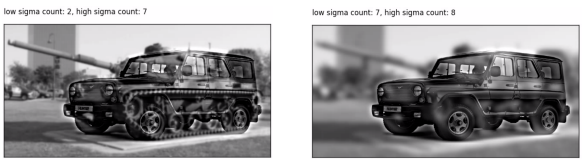
In this paper, three sets of images were used. Each set consists of two similar images, in which the main elements are aligned and have the almost same boundaries. These features help to make proper hybrid image. First image set is presented below.

Figure 3: Image 1

Figure 4: Image 2

To create the hybrid image it is required to write two functions to implement low-pass filter and high-pass filter. Both filter functions are based on SciPy library function $gaussian\_filter$. This function realizes the functionality from Methodology chapter.

Gaussian filter takes a sigma value as argument. However, it is hard to find proper sigma values to create hybrid image immediately. To facilitate the search of the required sigma values a video, which consists of a large set of hybrid image candidates, was created. Each image candidate includes the current sigma values for low-pass and high-pass filters. Watching video does not take a lot of time and allows you to choose the desired sigma values within a short time. Frames of the video are represented below.



(a) Frame 1 (b) Frame 2

Figure 5: Frames

There is a problem in finding sigma values this way. One image may overlap the another one anytime. It is due to image backgrounds, color intensities and edges. The common way to solve this problem is to swap images. One image from high-pass to low-pass and vice versa.

After making the right choice, you can plot the estimated hybrid image with a set of helper images before. Helper images consist of frequency domain images, which help us to make sure that image filtering was successful.

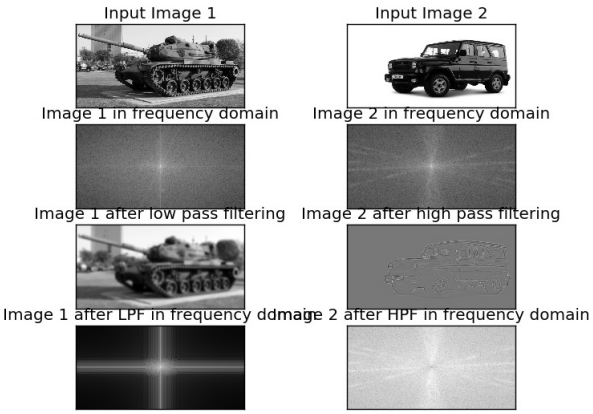


Figure 6: Helper images

Hybrid image for set 1 is represented below.

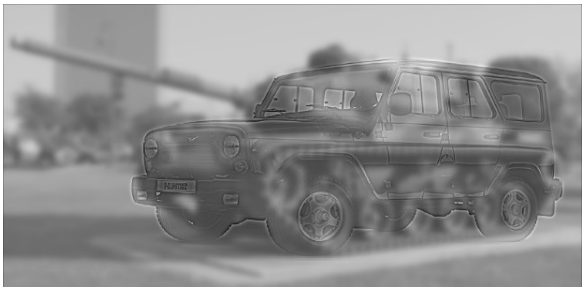


Figure 7: Hybrid image (set 1)

Obtained results allow to make sure that the technique of making hybrid image was implemented correctly.

References

[1] Oliva A., Torralba A., Schyns P.G. Hybrid Images.