Hybrid images

Maria Camila Escobar
Universidad de los Andes
Bogotá D.C, Colombia
mc.escobar11@uniandes.edu.co

Laura Gongas
Universidad de los Andes
Bogotá D.C, Colombia
l.gongas10@uniandes.edu.co

1. Introduction

An image pyramid is a collection of images obtained from an original image that is repeatedly downsampled [2]. The most common pyramids are Gaussian and Laplacian. The first one is used to reduce size of images while the second one is helpful for the reconstruction of an upsampled image from an image in a lower level of the pyramid [2].

Gaussian pyramids are computed by convolving the original image with a Gaussian filter [1]. This kernel is a low pass filter and therefore the resulting image is a smoothed version of the previous one. To control the cut-off frequency, the σ parameter is used[1].Then, the Laplacian is calculated as the difference between the original image and the filtered one. Consequently, band pass filtered images are produced in the Laplacian pyramid [1].

The objective of this practice is to apply the concepts of image pyramids to hybrid and blended images. A hybrid image combines the low spatial frequencies of one image and the high spatial frequencies of another image. Therefore, a picture which changes interpretation at different viewing distances is produced [3].

2. Materials and methods

The images that were used to develop this laboratory can be seen in figure 1 and 2. Figure 1 was taken by Camila and it includes her and her mother. The original picture is a RGB representation in format jpg and size 2592 x 1994. On the other hand, Figure 2 consists of Laura and her cousin. The image's format is jpeg in the RGB color space and its size is 1280 x 962.

Figure 1. Image used for the laboratory

Figure 2. Image used for the laboratory

The original images were modified in order to achieve better results at the hybrid and the blended images. First, the images were cut so that there would only be one person.Then, the images were rescaled for a better fit. The output images can be seen in figures 3 and 4 .

Figure 3. Modified image for the hybrid image formation

Figure 4. Modified image for the blending

2.1. Hybrid image

First of all, both images were put in gray scale so that the merge between the two of them would be more believable.Afterwards we applied a gaussian filter to the image that was going to represent the low frequencies, the parameters of this gaussian filter were a window of [30 30] and a σ of 20. In order to extract the high frequencies from the other image we first created a gaussian filter with a window of [50 50] and a σ of 50, then we applied the filter and subtracted it from the original. Finally both images were added to create the hybrid image.

```
%A gaussian filter is created
filtro=fspecial('gaussian',[30 30], 20)
    ;
%The filter is applied to extract low
    frequencies from im1
filtrada1= imfilter(im1,filtro);
%Another gaussian filter is created
filtro2=fspecial('gaussian',[50 50],
    50);
%The high frequencies from im2 are
    extracted
filtrada2=im2-imfilter(im2,filtro2);
%Both images are added to create the
    hybrid image
final1=filtrada2+filtrada1;
```

In order to approximate how the image would look from different distances we used the matlab command *impyramid* to created a gaussian pyramid with 5 levels.

2.2. Blended image

To obtain a blended image of both halves illustrated in Figure4 we employed Gaussian and Laplacian pyramids. As shown in the following algorithm, the image produced by the concatenation of the half images was reduced using a Gaussian pyramid. In each level of the pyramid, the corresponding image of the Laplacian pyramid was calculated as the difference between that level in the Gaussian pyramid (”imagen”) and the expanded image of the upper level of the Gaussian pyramid (”resta”).

```
% Reduction of image with gaussian
    pyramid
for i=1:30
        reducida=impyramid(imagen,'
    reduce');
        resta=imresize(reducida,size(
    imagen));
        l{i}={imagen-resta};
        imagen=reducida;
end
```

Subsequently, the reduced image resultant of the previous step was expanded with the Gaussian pyramid (”expandida”) and added to the corresponding Laplacian level. This steps were repeated 30 times in order to obtain a better blending result.

```
% Laplacian pyramid reconstruction:
    addition of the corresponding
    Laplacian pyramid
for i=30:-1:1
        expandida=impyramid(reducida,'
    expand');
        expandida=imresize(expandida,
    size(cell2mat(l{i})));
        expandida=expandida+ cell2mat(l
    {i});
        reducida=expandida;
end
```

3. Results

3.1. Hybrid image

The final hybrid image can be seen in figure 5 and the gaussian pyramid for a better visualization of the hybrid effect in figure 6.

Figure 5. Final hybrid image

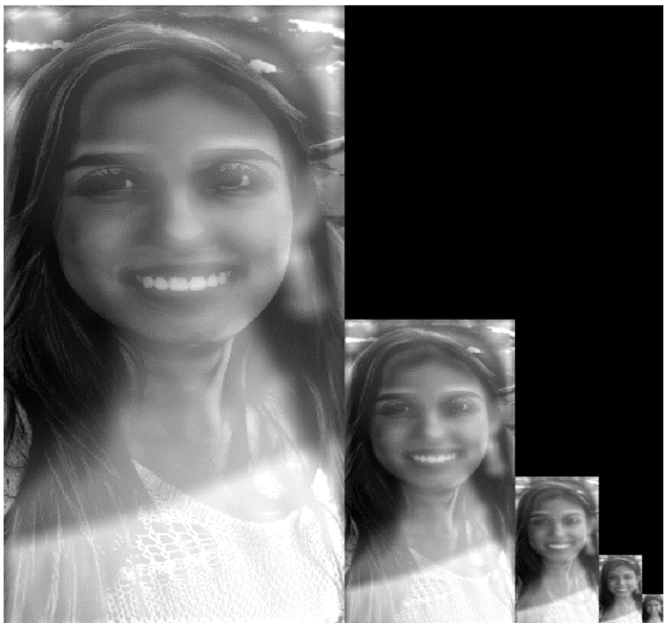

Figure 6. Gaussian pyramid with 5 scales of the hybrid image

3.2. Blended image

Figure 8 is the blending of the concatenated images (Figure 7) after 30 iterations of the proposed algorithm.

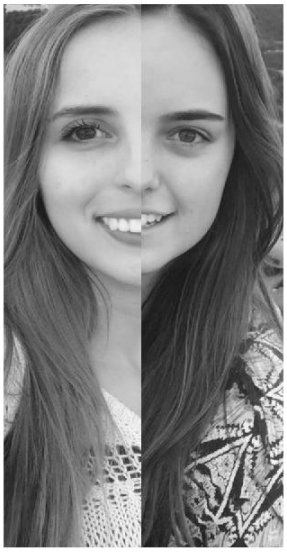

Figure 7. Concatenated halves of images in grayscale.

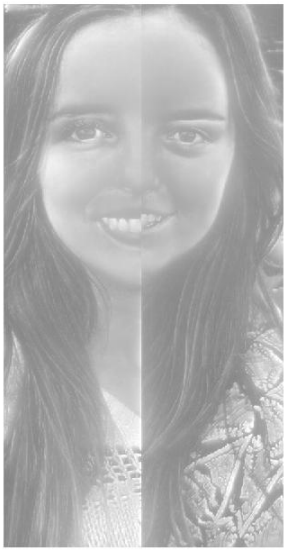

Figure 8. Blended image after 30 iterations of the proposed algorithm

4. Conclusions

Based on the methods used for the hybrid image formation we are able to conclude that the cut-off frequency plays an crucial role in the formation of the image. We tried with several cut-off frequencies and found that the best fit for the image were the ones we used. Additionally, by putting both images on gray scale we were able to achieve better results than in color, this is due to the differences in color schemes of the original images.

On the other hand, by the elaboration of the blended image we were able to identify the levels of the gaussian pyramid that gave the best output image. Initially we tried with 10 levels but we found that this was not enough to smooth the edges between both images. We then proceeded to add more levels until we found that at 30 levels the image had smoother edges.

Lastly, it was possible to observe that gaussian filters have a low-pass effect on the images, leaving only the details that change slowly in space. Whereas the laplacian pyramid left the high frequencies of each image. The mixture of these two filters can be used for different purposes, whether it is to smooth a blended picture without losing details or to create a complete different picture with a hidden optical illusion.

References

[1] Gaussian and laplacian pyramids, 2002. Available at `https://www.cs.utah.edu/~arul/report/node12.html`.

[2] Image pyramids, 2018. Available at `https://docs.opencv.org/2.4/doc/tutorials/imgproc/pyramids/pyramids.html`.

[3] A. Oliva, A. Torralba, and P. Schyns. Hybrid images. *ACM Siggraph*, 25(3):527–530, 2006.