Lab 4: Hybrids

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1. Introduction

Gaussian pyramids can be useful for optimizing disk space without losing significant information. Gaussian pyramids give the possibility of observing low frequencies in high resolution, and high frequencies in low resolution [1]. This knowledge has been previously used by artists as Salvador Dali in its famous painting of Gala and Abraham Lincoln.

What Dali taught us is that one can create hybrid images if tonalities and spatiality allow it. For creating a good hybrid both images have to correspond in the previous two factors for having the visual impact desired.

Anyway, making hybrids is not always of interest. Sometimes one might want to identify the details that are lost between each Gaussian level. For accomplishing this objective, one can use the Laplacian Pyramid. Additionally, Laplacian Pyramid can be used if one wants to recover the original resolution [1].

Finally, if one wants to check the symmetry of two images, merging can be useful. Again, Laplacian Pyramid can be used for recovering the initial information.

2. Materials and methods

The original images are Cristian Martinez Borja (soccer player) [Fig. 1] and myself [Fig. 2]. Borja is a black person. In the photo he is wearing a black t-shirt with a Pepsi logo in the middle of it. The photo has a bright background. The original resolution of the photo is 507x1000 in RGB. The image format is JPG.

I'm a Hispanic person (my skin is way lighter than Borja's). In the photo I'm wearing a blue shirt with a black jacket. The photo has a blue background. The original resolution of the photo is 472x346 in RGB. The image format is JPG.

The first step was cropping both images for them to be aligned and of the same size. The idea was that Borja's upper head matched with my hair. In this way, most of the parts of both heads correspond. After doing the cropping and the alignment, both images had a resolution of 400x300 in RGB and JPG format.

As described at the beginning of this section, Borja's skin is darker than mine. That's why I divided by 1.2 for obtaining a darker image. The divisor was obtained empirically after comparing results when doing the hybrid.

Two methods were proposed for obtaining the initial hybrid. The first method was filtering both images with the same kernel size (50) and the same sigma (20). The second method was filtering each image with different parameters. Borja's image was filtered with a window of 6x6 and a sigma of 10, while the image of myself was filtered with a window of 80x80 and a sigma of 80.

After doing this, the hybrid was created. Borja's image will be seen from far away (as it keeps low frequencies), and the image of myself will be seen from a near view (as it keeps high frequencies).

After obtaining the initial image, the Gaussian pyramid was built. As a first approach, the Gaussian pyramid was built using an average filter (because of its ease of implementation). The kernel was of 2x2 and each pixel had the same weight (see this code at downsampling.mat). The second approach was a Gaussian kernel of 3x3 and a sigma of 0.5 (see this code at downsampling2.mat). Five levels were taken into account for visualizing the hybrid at different resolutions.

For doing the blending, 5 levels of the Gaussian pyramid were taken into account. First each image was down sampled individually. After that, merging was made between corresponding images in the same level. Later, the Laplacian pyramid was built using upsampling.mat. The result obtained from the function was subtracted by the previous resolution merged image.

Finally, the level chosen dor starting the blending was the fourth one. From there, upsamplings and sums with its corresponding Laplacian level were performed. This process was repeated until the original resolution was achieved.

3. Results

After doing the cropping of the images, both heads were of the same size. Most of the anatomical parts of one image matched in the other one [Fig. 3].

The darkening of the image was efficient. The image of myself was dark enough for merging with Borja at a low resolution, but light enough for being recognizable in high resolution. As stated before, the divisor was determined by try and failure. Borja's image detail is lower than my image. That's why I decided that each image had to be filtered with a different gaussian kernel. By doing this, one obtained a highly blurred image of myself and a less blurred image of Borja. As a final result, Borja was easier to recognize at low resolutions. The hybrid obtained by individual filtering can be seen in Fig. 4.

Building the Gaussian pyramid with average filtering was a fast method. However, the result shown in low resolution (seen from far away) wasn't the best. On the contrary, the pyramid built using a Gaussian filter showed better results in low resolution [Fig. 5]. The final choice was to use a Gaussian filter, and its results at different scales can be seen in Fig. 6. However, the result at low resolutions isn't the best. One of the possible causes of this can be the big differences in the background tonalities. For further processes, one can modify the background in a pre-processing phase. Other noise factor can be my blue shirt that contrasts with Borja's black t-shirt. This noise might be more difficult to handle.

Moving on, when building the blending the asymmetry of the images was noticeable. Borja's head is smaller than mine, so there are some mismatches. The most recognizable mismatches are his smile and my ears. Also, Borja's head is tilt, he is a bit turned to a side, while I'm straight looking the cam. The previous mentioned factors made that the merging looked asymmetrical (Borja's smile a bit upper than my lips and Borja's nose not focused on the center of the image) [Fig. 7].

In the initial level of merging (4th level) there were enough details for knowing who was who 8. After performing the blending pyramid, one obtained an image almost identical to the original (as one expected) 9. What one is doing is summing the upsampling with its Laplacian. That in fact returns the original image of a given level.

4. Conclusions

Spatial and tonality are extremely important when comparing two images, or in this case, when creating hybrids of them. Big fluctuations in this two factors between two images can lead to bad results when creating an hybrid.

Data obtaining can play a crucial role in image processing. A subtle tilt or change of orientation can make image processing way more difficult.

Gaussian and Laplacian pyramids are useful for obtaining information about details of a given image. Specially, Gaussian pyramid can be useful for optimizing disk space.

Merging and blending can be useful for identifying symmetry and how important the details are in a given image. Worth noting that Gaussian and Laplacian pyramids are needed for creating blendings.

References

[1] Arbelaez, P. *04-Filters*. Universidad de Los Andes. 2018.

5. Images and snippets

Figure 1. First original image. Cristian Martinez Borja (soccer player).

Figure 2. Second original image. Myself (Jhony Mejia).

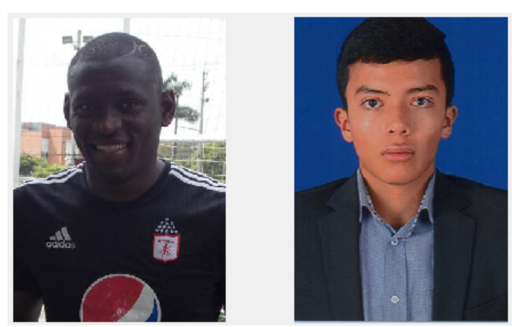

Figure 3. Images cropped and aligned (430x300 in RGB).

Figure 4. Final hybrid at full resolution.

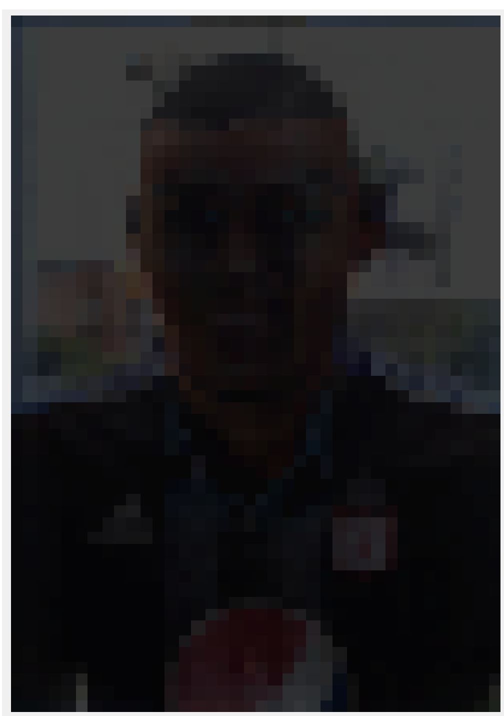

Figure 5. Final hybrid at the 4th level of a Gaussian pyramid.

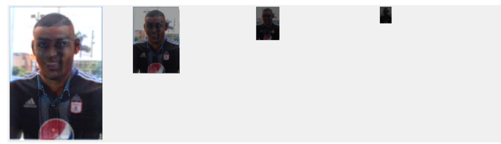

Figure 6. Gaussian pyramid of 5 levels.

Figure 7. Original merging.

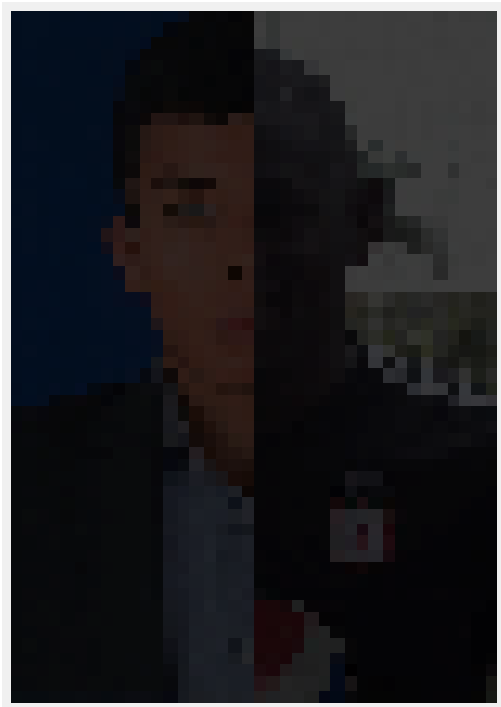

Figure 8. Merging on the fourth level of a Gaussian Pyramid.

Figure 9. Final blending starting from the 4th level of a Gaussian Pyramid.