

Hybrid Images

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Abstract

The current study aimed to identify the different stages of image processing for the creation of hybrid images. The pre-processing phase of the images where they are cut, rescaled and aligned is highly important for the success of the method. Among the considerations that were taken into account, it is the correct application of Gaussian filters for the creation of high pass and low pass filters. The results obtained are coherent with those reported in the literature and conclusive with the proposed method.

1. Introduction

Hybrid images are composed images that generate two different interpretations depending on the viewing-distance. One of the most outstanding work regarding hybrid images, was published by Oliva and Torralba, in which it was illustrated the applied technique in order to get this double-perception image. The technique involves a superimposing of two different spatial scales to two different images. For this, the main algorithm consists in the enforcement of a low pass filter to an image, which contributes with the low-spatial scale; and a high pass filter applied to another image, which becomes the high spatial scale. The final result consists in the addition of these two different scales representations what causes a variant of the original versions of the images [1].

2. Methods

2.1. Image Edition

The original images were taken in outdoors location, and were not taken for this purpose, so they were subjected to different procedures to achieve the objective of this study. For the first picture, Juanita was pretending to hold something, so that is why her hand was focused (see Fig. 1). She was making a serious face and her head was totally orientated to the front. Also, she was standing and her face was clear. Regarding the modifications made to this picture, a contrast enhancement was applied to highlight

more her face, since her face was slightly blurred (see Fig. 2). Besides, the image was cropped to get just the face of Juanita. The modified version of Juanita's picture, was the base to align the images, so no further modifications were performed over this image.

For the second image, Johnatan was also making a serious face, simplifying the correct alignment of the images (see Fig. 3). In this case, he was seated and lying on a tree. His posture is relaxed and without tensions. His face was also clear and his head was totally orientated to the front. Although, the chosen images had similar face orientation for both cases, the image of Johnatan required some modifications in Photoshop so that the alignment was correct.

The two main parameters that were modified, was the rotation and the scale. They were not drastically change, but the result was improved by the fine alteration of these parameters. Figure 4 shows the final modified image of Johnatan, perhaps it is not completely clear the real alterations of the original image. Because of this, Fig. 5 shows a grid, by which is possible to determine the rotation of the original image. Moreover, this same figure shows the slight rescalement done to the image. Has showed on the orange circle, the image is completely align with the red perfect square, but blue cicle shows the subtle unalignment between the image and the red square, which is again, a perfect square. This rescalement was necessary to have a better version of the hybrid image. The final superposition of the image in Photoshop is shown in Fig. 7.

2.2. Image Filtering and Hybrid Image Creation

Both images were filtered with a Gaussian filter. For Juanita's image, the filter had a window size of 19×19 , and a standard deviation of $\sigma = 1$. In contrast, Johnatan's image had a filter window of 21×21 , and a standard deviation of $\sigma = 9$. Juanita's picture had the low pass filter, while Johnatan's had the high pass filter.

The low pass filter, was computed using Matlab image filter toolbox, and here was not modification regarding the enhancement of the filtering. On the other hand, for the high pass filter, it was enforced the high pass filter by applying a normal low pass filter, and subtracting the original image

to the resultant low pass. Also, the it was subtracted the minimum value of the three channel and divided the result by the difference between the maximum and minimum value of each channel. This normalization was performed to improve the method by avoiding negative results. Finally, the sum of the images was done to have the final hybrid image.

2.3. Pyramid Creation

For the creation of the pyramid, it was implemented a function. The pyramid is a 5 scales pyramid. The first scale, determine the size of the invisible rectangle where the pyramid will lay, so it is performed a white padding in this stage. Then, for the creation of the pyramid, a resize was performed in order to make the original hybrid image smaller, to see the real effect of the technique. Finally, the concatenation of the images is done to visualize the final pyramid. The actual visualization of the pyramid method, was retrieved from internet.¹

```

1 %gaussian pyramid, first entry is
  assumed to be original image
2 pyr_gauss1{1,i+1} = im2double(
  imresize(imfilter((pyr_gauss1{i}),
  ,ker , 'same') ,0.5 , 'bilinear'));
3 %Computing laplacian pyramid as L(
  x)=I-f(I), f: low pass filter ,
  I: original image. The image is
  resampled for correct size
4 pyr_lap1{1,i} = pyr_gauss1{i}-
  im2double(imresize(
  pyr_gauss1{i+1}) ,2 , 'bilinear');
5 %normalization of each level of
  the laplacian pyramid for
  avoiding negative values.
  Generally x\in R^n\times m, min
  (x)\in n g(x)=(x-min(x))/(max(x)
  )-min(x))
6 I \in [0,255] \rightarrow \in
  [0,1]
7 pyr_lap1{1,i} = (pyr_lap1{1,i}-
  min(min(pyr_lap1{1,i})))./
  max(max(pyr_lap1{1,i}))-min(
  min(pyr_lap1{1,i})) );

```

2.4. Pyramid Blending Creation

A short pre-processing stage consisted in the concatenation of the images used for the pyramid blending. After that, a Matlab function was implemented for the creation of the pyramid blending. For the Gaussian part, it was performed a

¹The code for the visualization of the pyramid was retrieved from Project 1: Image Filtering and Hybrid Images <http://cs.brown.edu/courses/cs143/proj1/>

normal Gaussian filter over the image, with a bilinear resize interpolation, so that the dimensions of the images could be controlled. For Laplacian pyramid, it was applied a resize function over the image and its result was subtracted to the Gaussian first level that just was turned out from the past step. The result is normalized to avoid the negative values. This same process is carried out several times to compose a pyramid blending. Finally, the Gaussian Pyramid up is made, followed by the addition of the corresponding Laplacian Pyramid.

3. Results

The low pass filter was applied to Juanita's picture, as shown in right lower quadrant of Fig. 8. For high pass filter, it was applied first a low pass filter, with different parameters than the last one, as shown in left upper quadrant of Fig. 8. After that, the subtraction of the original image and the low pass filter was performed as shown in right upper quadrant of Fig. 8. The final hybrid image is shown in Fig. 8 at the left lower quadrant. The pyramid of the hybrid image is shown in Fig. 9. In addition, the blending pyramid result is shown in Fig. 10.

4. Discussion

According to the results, it is possible to say that the interpretation of an image hidden on a hybrid image will be clear or not depending on the viewing-distance of the viewer. It was clear that the editing and transformation process that should be carried out over the images that will compose a hybrid image, is the most important phase of the creation of the resultant image. The success of a hybrid image relies on the right alignment of the images. Perhaps, it is also important the correct election of the window either for the low pass image and the high pass image, this factor improves the effect of the hybrid image, and actually defines the impact over the viewer by the correct interpretation of the image. Regarding the pyramid blending, it is possible to say that the method is really useful and comprehensive when there is a right alignment of the images. This is why the professional design software tools are used to pre-processing the images, such as Photoshop.

5. Conclusions

The effect of the hybrid images is directly related to the correct use of the tools. The creation of the filters is a process that depends on the original image, and its parameters must be chosen through trial and error to achieve an optimal result. The formation of Gaussian and Laplacian pyramids allow the visualization of hybrid images, and this process can be carried out by using functions already known in software such as Matlab.

References

- [1] A. Oliva, A. Torralba, and P. G. Schyns, “Hybrid images,” *ACM Transactions on Graphics, ACM SIGGRAPH*, vol. 25, no. 3.

Appendices

A. Images



Figure 1: Original picture of Juanita



Figure 2: Modified picture of Juanita



Figure 3: Original picture of Johnatan



Figure 4: Modified picture of Johnatan

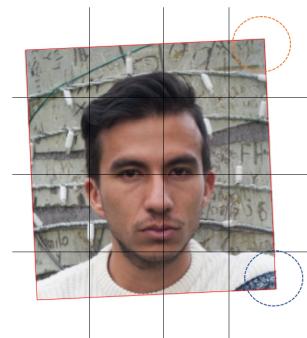


Figure 5: Edition process of Johnatan’s picture



Figure 6: Final picture of Johnatan

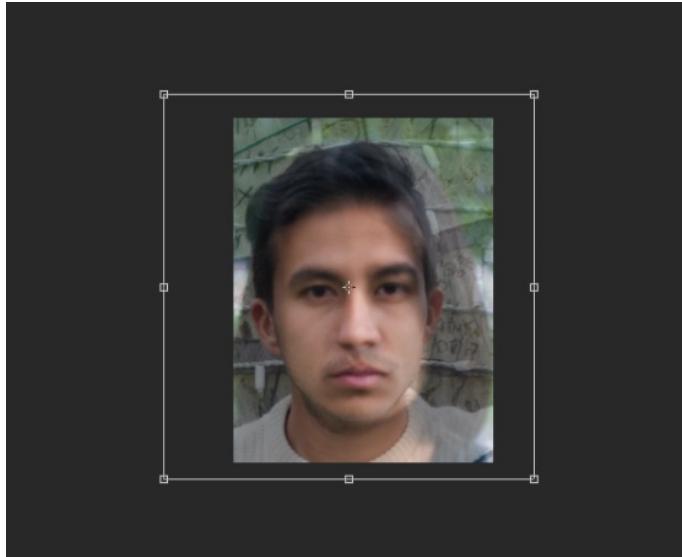


Figure 7: Final superposition of the images

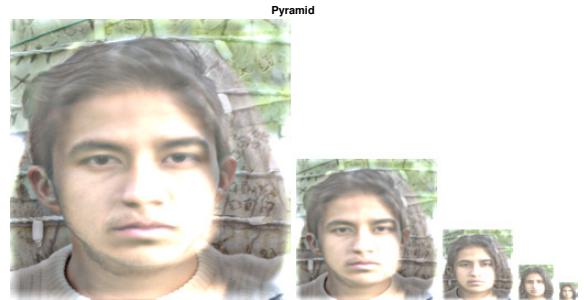


Figure 9: Final Pyramid of the hybrid image

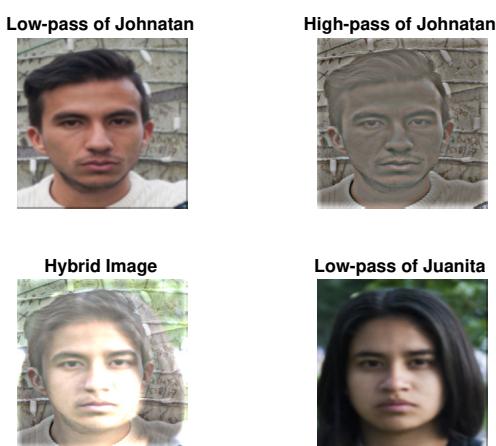


Figure 8: Filters over the images and the hybrid image



Figure 10: Pyramid Blending