Hybrid Images

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Abstract

Hybrid images are the sum of two previously filtered images, one of them using a low-pass and the other one a high-pass filter. By doing so, an image with low frequency components can be seen when looking from a long distance and high frequency components from the other image can be seen when looking closer. Images should be carefully chosen as their alignment, color and information must be similar enough to mix properly and give rise to different interpretations.

1. Introduction

The operation of filtering is associated with processing in frequency domain, in which different frequency components are preserved or rejected. Based on the cutoff frequency, the filter can produce a different response in the resultant image. For instance, if the low frequencies are preserved, the filter is low-pass type, while if the high frequencies are kept, it is known as a high-pass filter. Image filtering is applied directly to the image with a window or kernel that limits the region of the image that will be modified by some operations with the pixels within it. The new filtered image is obtained by covering all the pixels of the original image with the kernel and performing the respective operation. This operation is defined by the convolution or correlation operator, in which a weight is assigned to each pixel within the kernel, and then the sum of the product of the each weight and the intensity is normalized to define the new intensity of the central pixel [1]. The weights within the kernel can have a Gaussian distribution, known as Gaussian filter. Two important parameters define the effect of the filter: the size of the kernel and the variance of the normal distribution. The last one is important in the scale notion because it determines the structures that are preserved after filtering. In addition, since this distribution is symmetric, there would be no difference between filtering with convolution or correlation operator.

As it was mentioned before, the resulting image depends on the type of the filter that was applied. Low-pass filters remove high frequency components, which leads to a smoothed version of the original image. On the other hand, high-pass filters remove low frequency components, and preserve small details that can be seen up close. The results of the filters mentioned before would be on different spatial scales, and the superimposing of these images is known as *hybrid images*, in which there are two different interpretations can be perceived by changing the viewing distance [2]. The low spatial scale image is obtained by filtering one image with a low-pass filter, and the high spatial scale image by filtering the other image with a high-pass filter.

2. Materials and Methods

The images selected were a couple of pets related to the authors. Both animals are looking to the front, have similar ear and head shape and both frontal legs are shown. One of them is a gray cat called Gandalf, with size 2560x1920x3, and the other one is a white dog called Goku, whose image has a size of 1280x720x3. Both images are displayed in figures 1 and 2. The image of the cat has a dark background and the animal is gray; the only light-colored part is the lower part of the blanket. The cat occupies most of the image and there is not a big background. On the other hand, the image of the dog is mostly white: the animal itself and the whole background has either white or light colors. In the upper and lower part there is a considerable amount of background left, although the pet is centered.

Although the image of the cat is bigger in dimensions, the image of the dog must be cut to remove the excessive background in the upper and lower part, and a little bit of the lateral background so as to align both images to fit only the animals. After several trials we found the perfect alignment for both images.

Afterwards, filters were applied taking into account the color of the images. As their hue are almost opposite, we chose to use the image of the dog as the one to leave only high frequencies, so as to make it dark enough to mix it with the cat image by keeping only the high frequency features. This was accomplished by filtering the image of the dog

with a low pass Gaussian filter with σ=40 and size of 25x25, and subtracting the result to the original image. The image of the cat was low filtered using the same Gaussian filter and only low frequency features were left. It is paramount to note that features of the Gaussian filtered were selected after trying several values.

Finally, the image of the dog was rescaled to the size of the one of the cat, and the result of cropping and filtering both images were added up. The resulting image was shown in big size and in various scaled sizes, so as to imitate the effect of looking the image from a long distance.

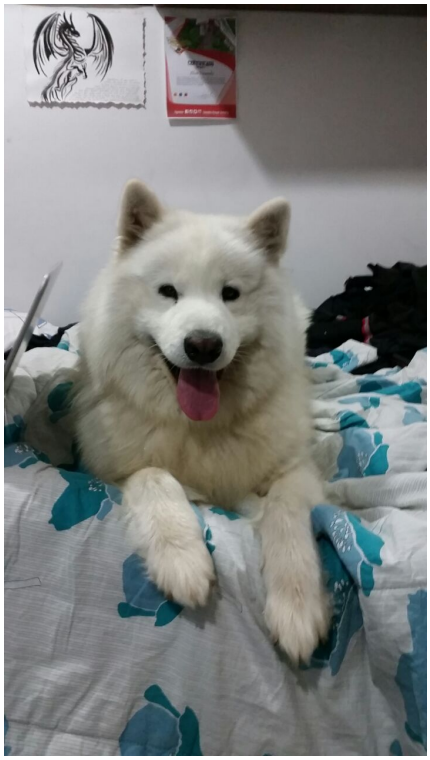

Figure 1. Image of Goku, the dog

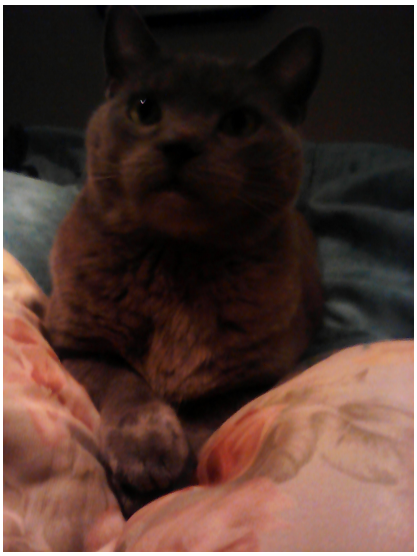

Figure 2. Image of Gandalf, the gray cat

The code developed to perform the operations previously described is shown.

```
%Imagenes Hibridas
gfrente=imread('gfrente.jpg'); %
    cargo la imagen del gato
gokuf1=imread('gokuf1.jpeg'); %cargo
     la imagen del perro
ker=fspecial('gaussian',25,40); %
    creo el kernel gaussiano para
    usarlo como filtro pasabajas
l1=gokuf1; %renombro la imagen del
    perro
g1=gfrente; %renombro la imagen del
    gato
l1=l1(290:end-120,70:end-70,:); %
    recortamos el fondo de la imagen
    del perro para que quede con la
    misma alineacion que el gato
lf1=imfilter(l1,ker); %filtro la
    imagen del perro con un pasabajas
lhf=mat2gray(l1-lf1); %resto la
    imagen del perro filtrada a la
    original para dejar solo
    frecuencias altas y reescalarlas
    entre 0 y 1
gf1=imfilter(g1,ker); %ahora filtro
    la imagen del gato con un
    pasabajas
lhf=imresize(lhf,[size(gf1,1) size(
    gf1,2)]); %reescalo la imagen del
     perro al tamano de la del gato
gf1=mat2gray(gf1); %reescalo los
    valores de intensidad del gato a
```

```
    valores entre 0 y 1
if1=gf1+lhf; %sumo el perro y el
    gato despues de filtrarlos
if1=mat2gray(if1); %reescalo el
    resultado a valores de 0 a 1
%reescalo la imagen a escalas mas
    pequenas para ver las bajas
    frecuencias, como si la viera
    lejos
ipq1=imresize(if1,0.5);
ipq2=imresize(if1,0.25);
ipq3=imresize(if1,0.125);
ipq4=imresize(if1,0.07);
figure();
imshow(if1,[0 1]); %muestro la
    imagen resultante en el tamano
    grande
%completo las imagenes con unos para
     poderlas plotear juntas
u1=ones(size(if1,1),size(ipq1,2),3);
u1(1:size(ipq1,1),1:size(ipq1,2),:)=
    ipq1;
u2=ones(size(if1,1),size(ipq2,2),3);
u2(1:size(ipq2,1),1:size(ipq2,2),:)=
    ipq2;
u3=ones(size(if1,1),size(ipq3,2),3);
u3(1:size(ipq3,1),1:size(ipq3,2),:)=
    ipq3;
u4=ones(size(if1,1),size(ipq4,2),3);
u4(1:size(ipq4,1),1:size(ipq4,2),:)=
    ipq4;
pqfinal=[if1 u1 u2 u3 u4];
figure();
imshow(pqfinal,[0 1]); %mostrar
    imagen mas pequena
```

3. Results

The result of cutting the image of the dog can be seen in figure 3, in which a good alignment is noticeable.

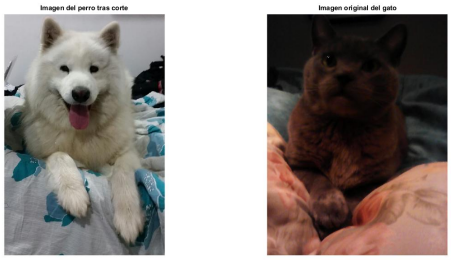

Figure 3. Image of Gandalf, the gray cat

The hybrid image obtained is shown in figure 4 in full size, in which a good alignment can be seen. The same image different scales is shown in pyramid of figure 5, simulating the view of the image from a long distance. The animal that can be seen better in figure 4 is the dog, as we preserved the high frequency features of this image. Contrastingly, the animal that can bee better appreciated in the smaller scales of figure 5 is the cat, as low frequency features were the ones we kept from this image.

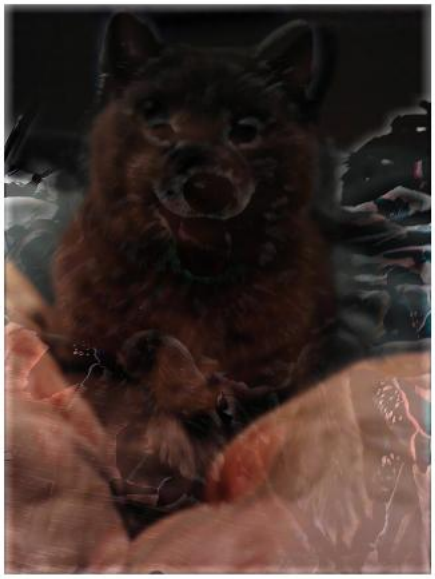

Figure 4. Result of the hybrid image in big size

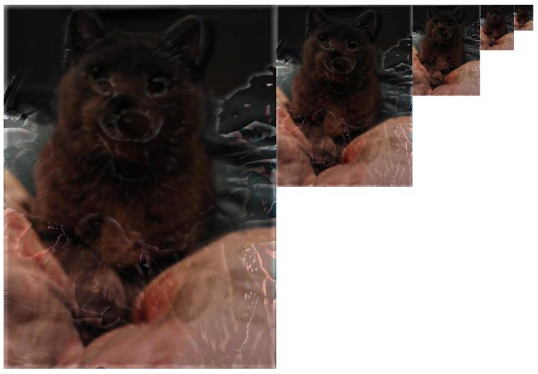

Figure 5. Pyramid with 5 scales to simulate the effect of distance.

4. Conclusions

- Hybrid images are the sum of two processed images in which we keep only low frequency features from one of them and high frequency features from the other.
- High frequency features can be better seen from a close view whereas low frequency features are better observed when looking from a long distance.
- The parameters of the low pass filter used to process both images must be carefully chosen according to the particular characteristics of the images being processed, and the scale of the structures that want to be preserved.
- The selection of the images chosen to build a hybrid image must be made carefully. Many attempts were made in this trial and we found that having similar characteristics in both pets such as size, position, shape and alignment are fundamental.
- Using images with similar colors could have facilitated the task, although choosing wisely which image to filter with low pass and which one with high pass according to both tonalities, was fundamental to obtain a good result in the hybrid image created.

References

[1] Digital image processing, R. González, P. Woods. 3rd Ed., Prentice Hall, 2008.

[2] A. Oliva, A. Torralba & P. Schyns. Hybrid images. Association for Computer Machinery, 2006.