Hybrid image illusion using convolutional filtering

Introduction

Human eye's perception depends strongly on the distance between the object and the observer. If the distance was small, the eye start focusing more on the sharp details of the image (high frequency),however at the far away distances, the eye is only capable of detecting sooth variations (low frequency).In this project we are trying to use that phenomena to create an illusion by making hybrid image, which gets its low frequency content from an image and its high frequency content from another one.

Implementation of the convolutional filter

This function is used to perform convolution operation over RGB and gray scale image . It has two types of padding (zeros and mirror).It takes only odd shaped kernel,and returns the output in the form of an image with the same size as the input image

```python
def my_imfilter(image, kernel,mode ='zeros'):
  # get the kernel dimesnsions in kh and kw
  kh,kw=kernel.shape
  # get the hight and width only as the third dimension may exist or
    not
  ih=image.shape[0]
  iw=image.shape[1]
  # get the number of dimsensions for both the kernel and the image
  kdim=kernel.ndim
  idim=image.ndim

  assert kdim == 2 , "kernel dimensions must be exaxctly two"
  assert idim == 2 or idim ==3 , "image dimensions must be exaxctly
    two or three"
  assert (kh%2) !=0 and (kw%2) !=0 , "all kernel dimensions must be
    odd"
  # this foarmula calculates how many rows do i need to put so that i
    can make proper padding
  hpad=(kh-1)//2
  wpad=(kw-1)//2

  filtered_image = np.zeros_like(image)

  if mode=='zeros':
    md='constant'
  elif mode=='reflect':
    md='reflect'
  else:
    raise  Exception('the mode {} is not defined \n "zeros" and "
    reflect are available"'.format(x))
  # change the padding function according to the input image
  if idim==2:
    paddedImg=np.pad(image,[(hpad,hpad),(wpad,wpad)],mode=md)
```

```
    else:
        paddedImg=np.pad(image,[(hpad,hpad),(wpad,wpad),(0,0)],mode='constant')
        dim_No=image.shape[2]
    # apply convolution over the number of channels
    for dim in range(0,dim_No):
        for i in range(0,ih):
            for j in range(0,iw):
                # multiply the kernel with the cropped part of the image and then sum the result

                cropped=paddedImg[i:i+kh,j:j+kw,dim]
                filtered_image[i,j,dim]=np.sum(np.multiply(kernel,cropped))

    return filtered_image
```

A Result

1. Result 1 was a total failure, because...
2. Result 2 (Figure 1, left) was surprising, because...
3. Result 3 (Figure 1, right) blew my socks off, because...

Figure 1: *Left:* My result was spectacular. *Right:* Curious.

My results are summarized in Table 1.

Condition	Time (seconds)
Test 1	1
Test 2	1000

Table 1: Stunning revelation about the efficiency of my code.

Generation of Hybrid Image

In this part we are trying to add a low-pass filtered image and then add it to a high-pass filtered image of the same shape. This was implemented using 2 ways of filtering the first used the spatial convolution of the filter and the latter was done in frequency domain. The good thing of the frequency domain thing is that the convolution becomes a normal multiplication.

The kernel used is a Gaussian kernel with size 15x15 and $\sigma = 10$. This is how the low-pass filtered image was obtained and the high-filtered images was obtained by subtracting the low frequencies from the original image and this kept only high frequencies.

Here is a code snippet of the function implemented 2 times one with spatial convolution and the second using FFT-based convolution

```

def gen_hybrid_image(image1, image2, cutoff_frequency):

  assert image1.shape == image2.shape

  ksize = 15
  sigma = cutoff_frequency


  # Here I do outer product of 2 gaussian vectors to get 2D kernel
  x = np.arange(-ksize//2, ksize//2+1)
  gx = np.exp(-(x)**2/(2*sigma**2))
  g = np.outer(gx, gx)
  g /= np.sum(g)
  kernel = g



  # Your code here:
  # looping over the channels of the image to apply the gaussian kernel
  low_frequencies = np.zeros(image1.shape, dtype=np.float32)

  for i in range(image1.shape[2]):
  low_frequencies[:,:,i] = correlate2d(image1[:,:,i], kernel, 'same') # Replace with your implementation

  # (2) Remove the low frequencies from image2. The easiest way to do this is to
  #     subtract a blurred version of image2 from the original version of image2.
  #     This will give you an image centered at zero with negative values.

  low_frequencies2 = np.zeros(image2.shape, dtype=np.float32)

  for i in range(image1.shape[2]):
  low_frequencies2[:,:,i] = correlate2d(image2[:,:,i], kernel,'same')


```

```



    high_frequencies = image2 - low_frequencies2 # Replace with your implementation


    # print(np.sum(high_frequencies<0))

    # (3) Combine the high frequencies and low frequencies

    hybrid_image = low_frequencies/2 + high_frequencies/2 # Replace with your implementation

    high_frequencies = np.clip(high_frequencies,-1.0,1.0)
    hybrid_image = np.clip(hybrid_image,0,1)

    # np.clip(low_frequencies,0,1)
    # np.clip(high_frequencies,0,1)
    # np.clip(hybrid_image,0,1)
    return low_frequencies, high_frequencies, hybrid_image
```

```
def gen_hybrid_image_fft(image1, image2, cutoff_frequency):
    assert image1.shape == image2.shape

    ksize = 15
    sigma = cutoff_frequency

    x = np.arange(-ksize//2, ksize//2+1)
    gx = np.exp(-(x)**2/(2*sigma**2))
    g = np.outer(gx, gx)
    g /= np.sum(g)
    kernel = g


    # Applyingthe fft convolution on each channel
    low_freqs = np.zeros(image1.shape)
    for i in range(image1.shape[2]):
    low_freqs[:,:,i] = fft_convolve(image1[:,:,i], kernel)



    low_freqs2 = np.zeros(image2.shape)
    for i in range(image1.shape[2]):
    low_freqs2[:,:,i] = fft_convolve(image2[:,:,i], kernel)


    # getting only high freqs of image2
    high_freqs = image2 - low_freqs2


    # combining the low freqs and high freqs
    hybrid_image = low_freqs/2 + high_freqs/2 # Replace with your implementation

    high_freqs = np.clip(high_freqs,-1.0,0.5)
    hybrid_image = np.clip(hybrid_image,0,1)

    return low_freqs, high_freqs, hybrid_image
```

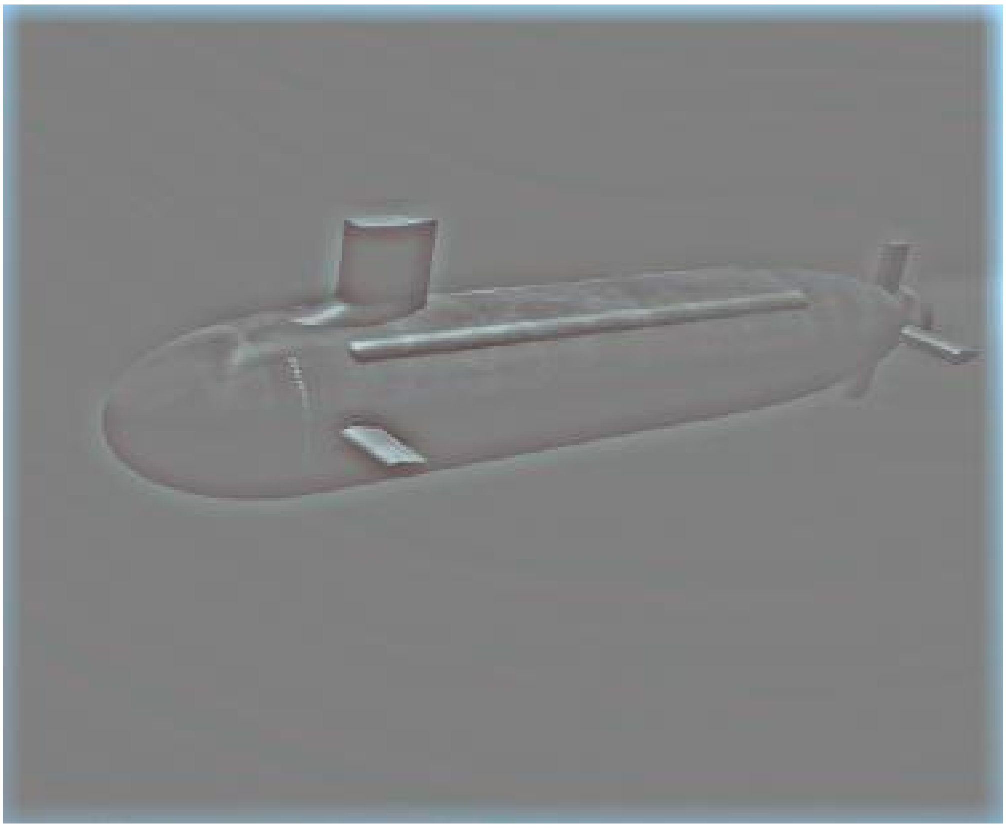
1 Results

The code worked perfectly in both spatial and FFT-based convolution.

Here are the 2 images I used:

low Frequencies

High Frequncies



Both added together

And here it is on different scales