

Computer Vision

Project 1

Hybrid Image Formation

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1. Hybrid images:

Hybrid images are images with two interpretations. The interpretation changes with viewing distance. With two suitable images these can be created. One of the superimposing images has to be in low frequency, while the other has to be in high frequency (which will be generated by applying appropriate filters).

2. Filter Implementation:

We have constructed a linear filter function. This uses the basic idea of convolution. Let the image be I and the filter be F , the convolution between the image and the filter is defined as

$$I(x,y) * F = \sum_{i=-N}^N \sum_{j=-M}^M I(x-i, y-j) F(i, j)$$

3. Parameters:

The function takes two parameters as input:

Image: Any image to be filtered

Filter: A filter of size $n \times m$ (where n may equal m), n and m both being odd

4. Handling Color:

We need to determine whether the image we have is a color image or a grayscale image. We can check this through the shape of the image matrix. If the dimension is 3 then it is a color image, else, it is a grayscale image.

5. Padding:

Now, the image needs to be padded. The amount of padding depends on the filter dimensions. Padding is done to prevent loss of information, as when we convolve the filter and the image, the edge pixels are not processed and thus are not included in the output and data loss takes place.

6. Convolution:

Next we perform convolution. We need to slide the flipped filter over our padded image matrix and perform element-wise multiplication between the two. Then we need to take the summation of the products and assign them to the pixels to be processed one by one.

7. Return Array:

We then return the convolved array as our output and we have our filtered image which is of the same resolution as the input image.

8. Filtering algorithm:

- Step 1:** The filter function takes the image and the filter as input.
- Step 2:** The image is padded (reflection padding).
- Step 3:** The filter is then flipped horizontally and vertically.
- Step 4:** The flipped filter is then run over all the channels of the padded image. And then the channels are merged together to get the original output.
- Step 5:** The output is taken without the padded portion of the filtered image.

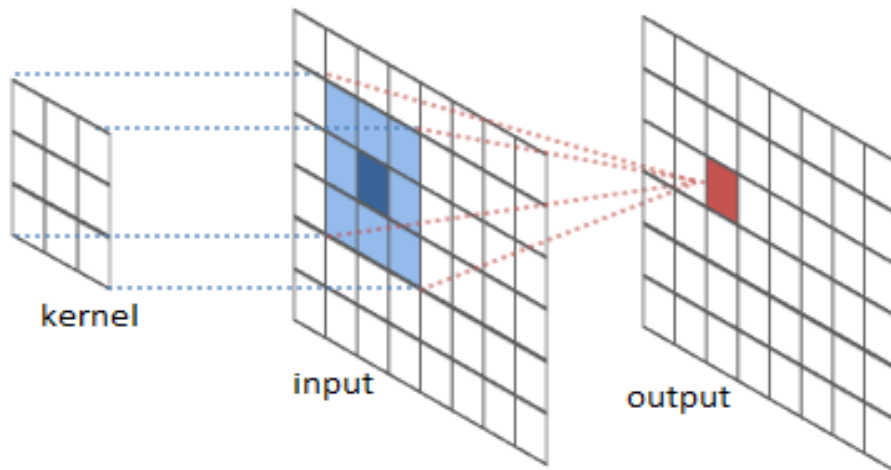


Image Source: <https://jeanvitor.com/wp-content/uploads/2017/07/6zX2c.png>

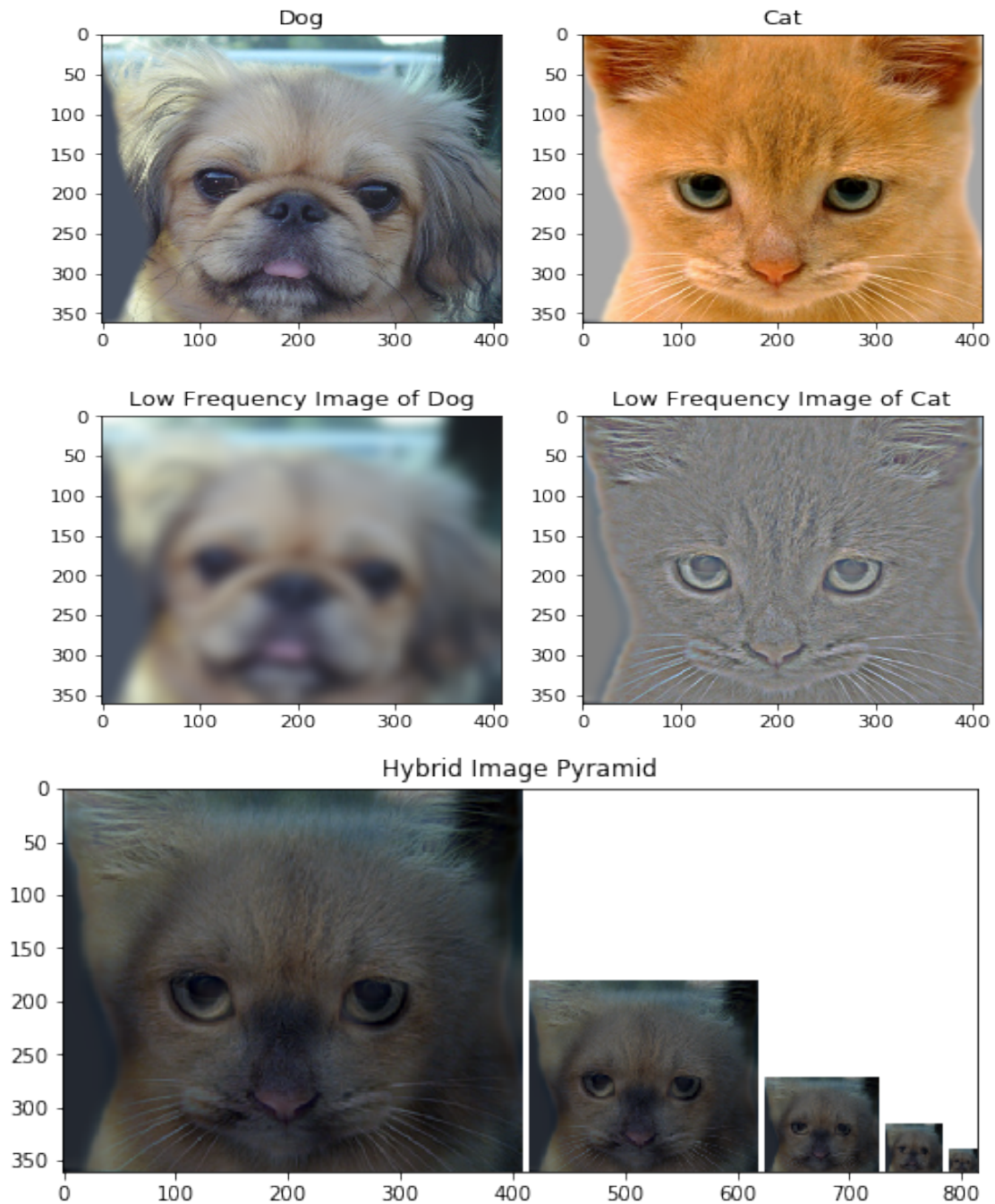
9. Hybrid image creation algorithm:

- Step 1:** Low frequency image of one of the images is created by applying a Gaussian Kernel using the filter function.
- Step 2:** To obtain the High frequency image from the other image ,the low frequency component is subtracted from the original image.
- Step 3:** The Hybrid image is obtained by adding the low frequency and high frequency images scaled by half to keep the pixel intensities within limits.

10. Examples of Hybrid Images created using the method explained above:-

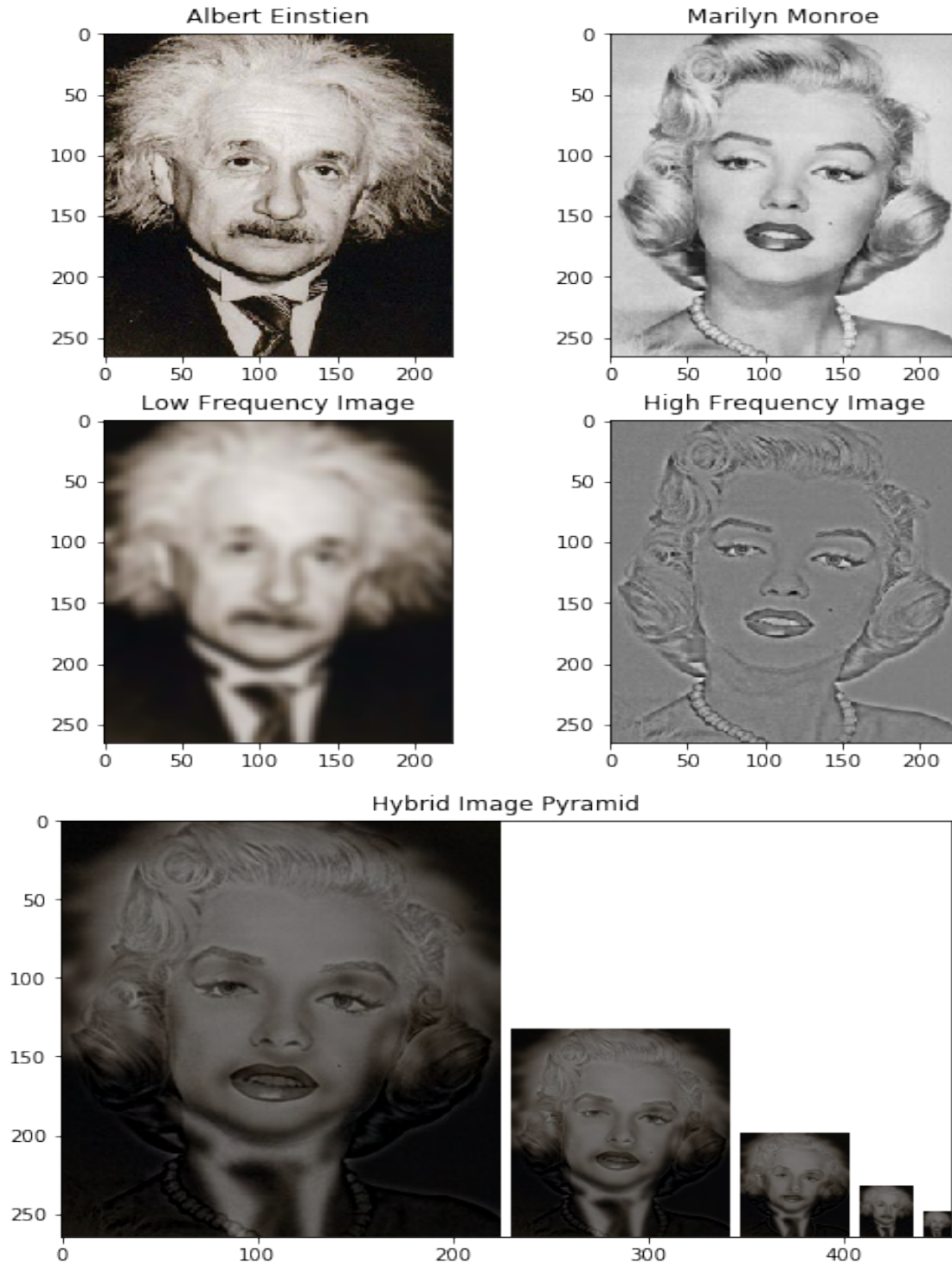
10.1 Example 1: Cat vs Dog

Cut_off_frequency=7



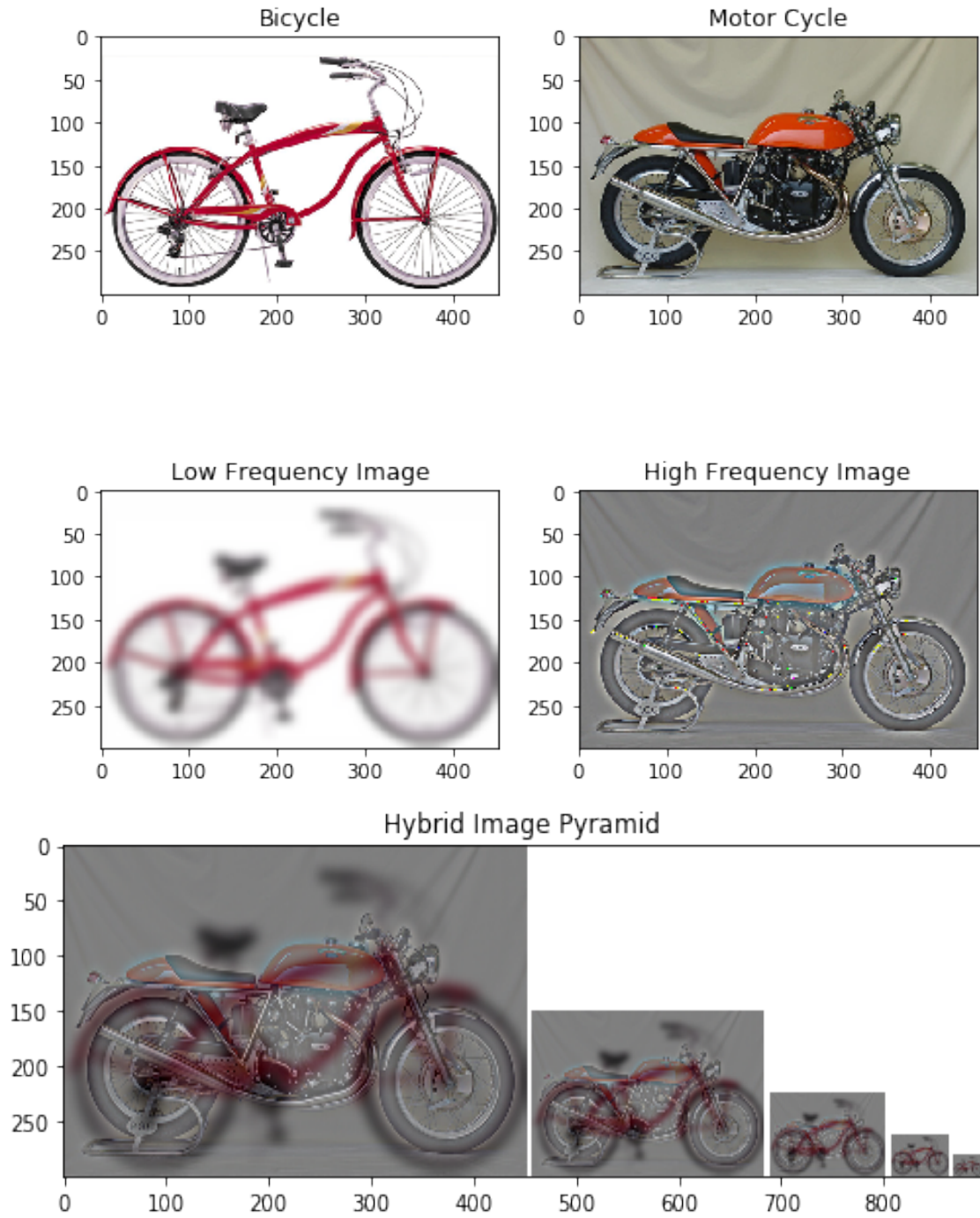
10.2 Example 2:Einstein vs Marilyn Monroe

Cut_off_frequency=3



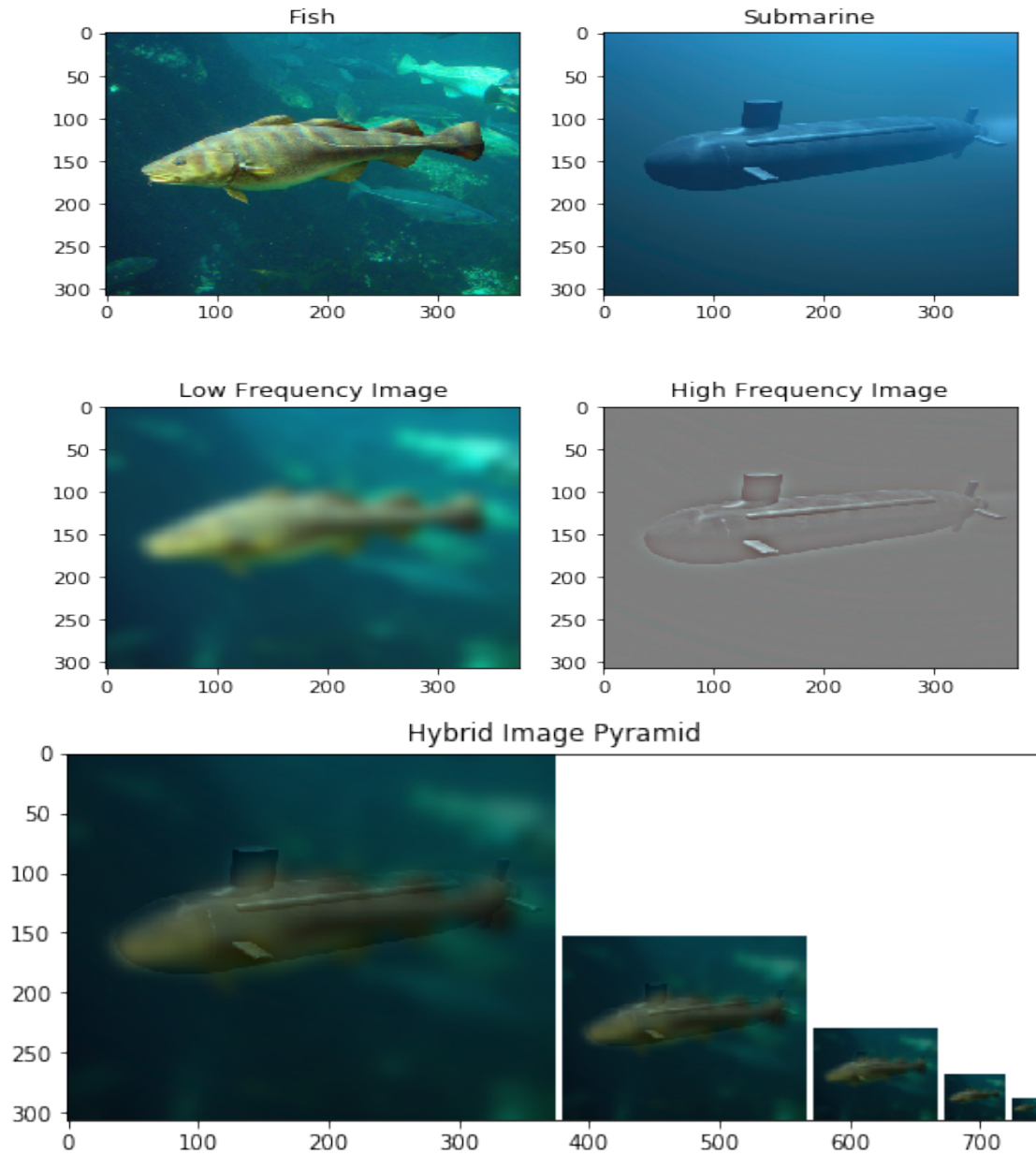
10.3 Example 3: Bicycle vs Motor Cycle

Cut_off_frequency=6



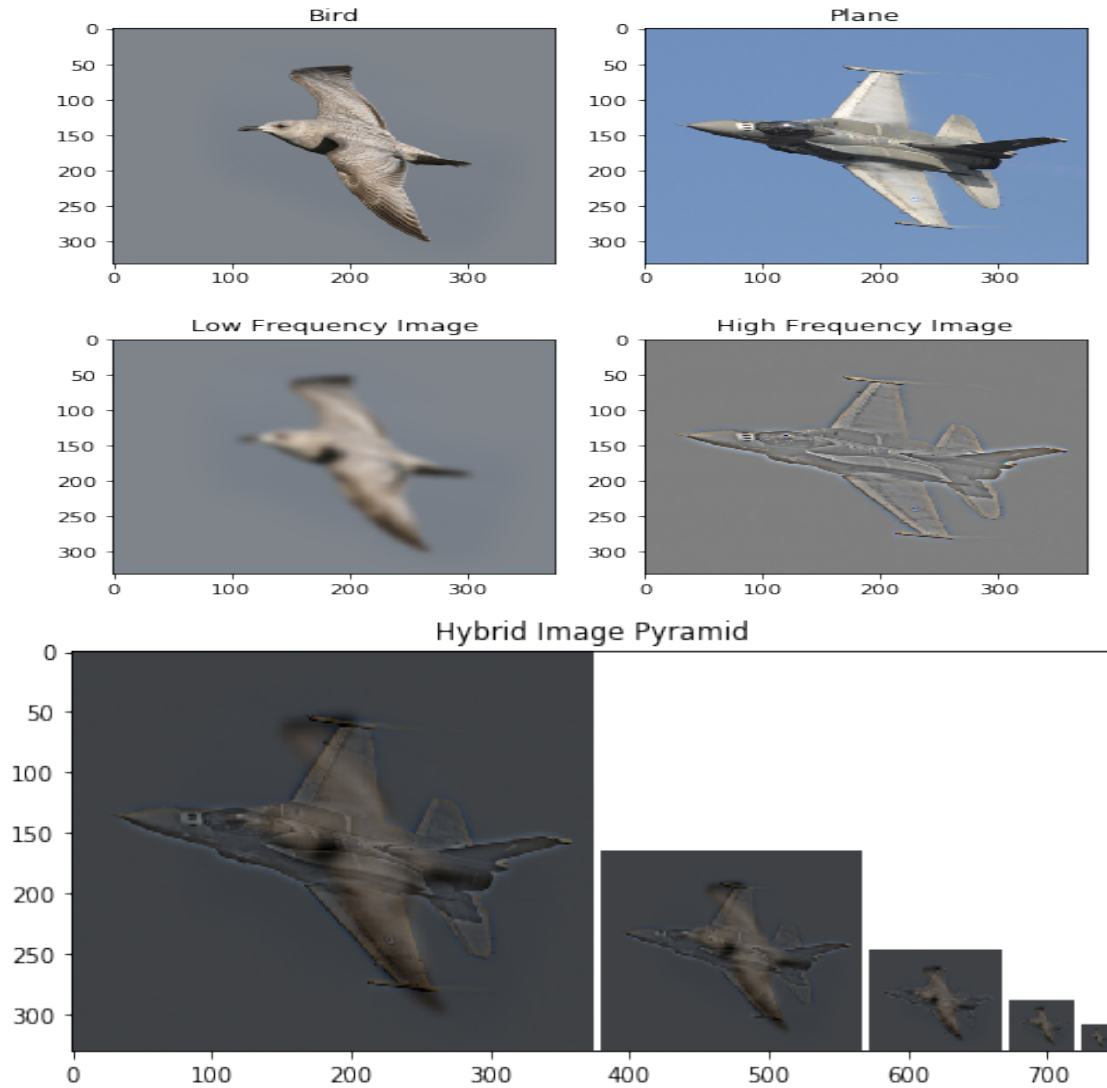
10.4 Example 4: Fish vs Submarine

Cut_off frequency=7



10.5 Example 5: Bird vs Plane

Cut_off frequency=4



11. Discussion:

While creating the filters for different images we need to specify different cut off frequencies. This has to be done to make the hybrid image work as expected, i.e. be interpreted differently with change in viewing distance. The algorithm while making the hybrid image divides the superimposed images by 2 to keep the pixel values within limits (so that no clipping takes place and we do not lose any detail).

12. References:

[1] Aude Olivia, Antonia Torralba, and Philippe. G. Schyns. *Hybrid images*.