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CS 445 - Project 1: Hybrid Images

Complete the claimed points and sections below.

Total Points Claimed

[130] / 130

1. Hybrid image main result
 - a. Main result and description [45] / 45
 - b. FFT images of main result [15] / 15
2. Hybrid images: two additional results [10] / 10
3. Image enhancement tasks (3rd is B&W)
 - a. Contrast enhancement [10] / 10
 - b. Color enhancement [10] / 10
 - c. Color shift [10] / 10
4. Quality of results / report [10] / 10
5. Color Hybrid Image w/ explanation (B&W) [5] / 5
6. Gaussian / Laplacian Pyramids (B&W) [15] / 15

1. Hybrid image main result

- The original images and their Fourier transformed results

Image 1



FFT Image 1

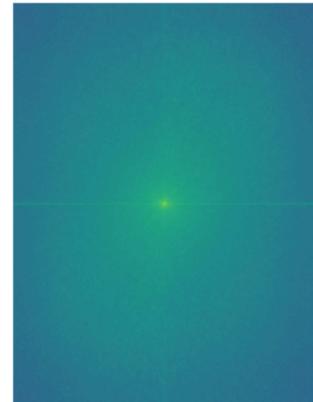
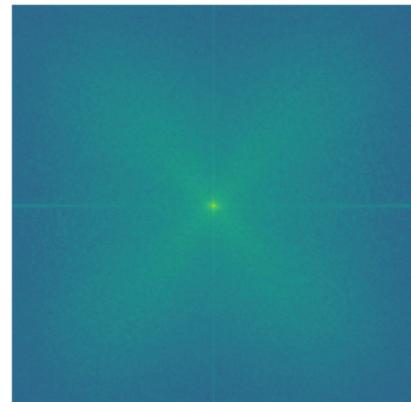


Image 2



FFT Image 2



- The filtered input images and their Fourier transformed results

Image 1



FFT Image 1

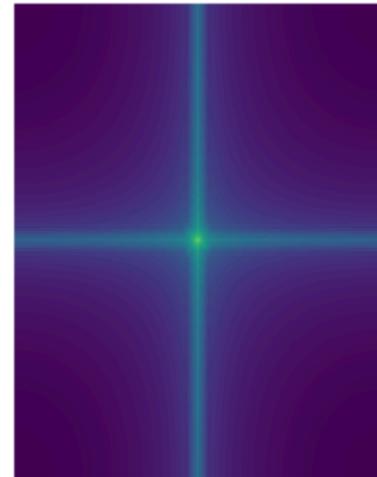
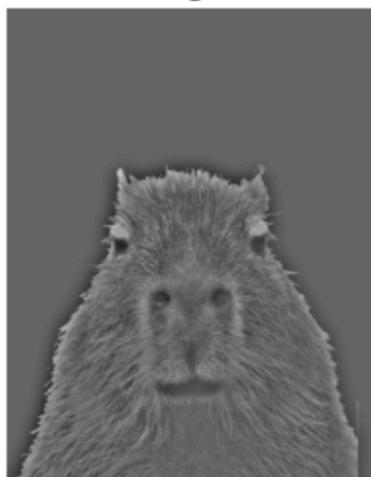


Image 2



FFT Image 2

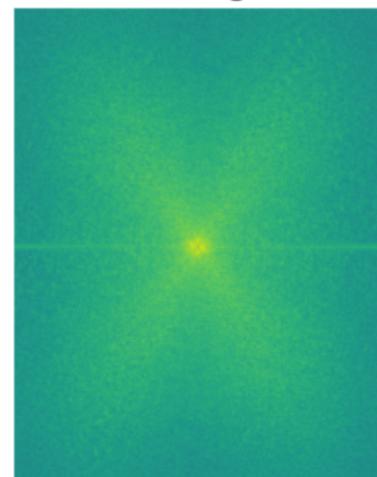


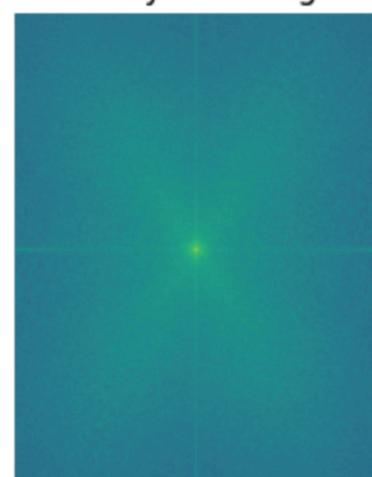
Image 1 is low-pass filtered while Image 2 is high-pass filtered.

- The hybrid image and its Fourier transformed result

Hybrid Image

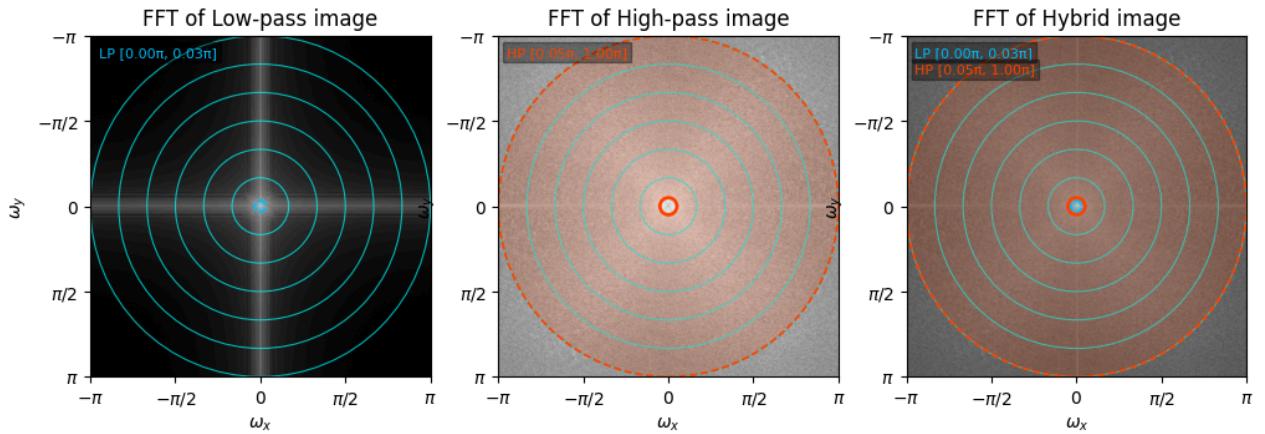


FFT Hybrid Image



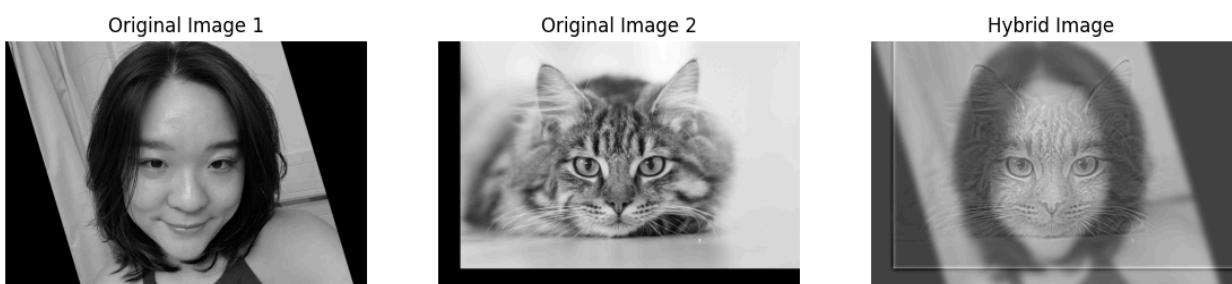
- Explanation

The hybrid image was generated by applying a low-pass filter to Image 1 and a high-pass filter to Image 2, and then combining the results by addition. A Gaussian filter with $\sigma = 8$ was used for low-pass filtering, while a Laplacian filter with $\sigma = 10$ was applied for high-pass filtering. The specific values of σ were selected based on the frequency-domain visualizations shown in the following figures.



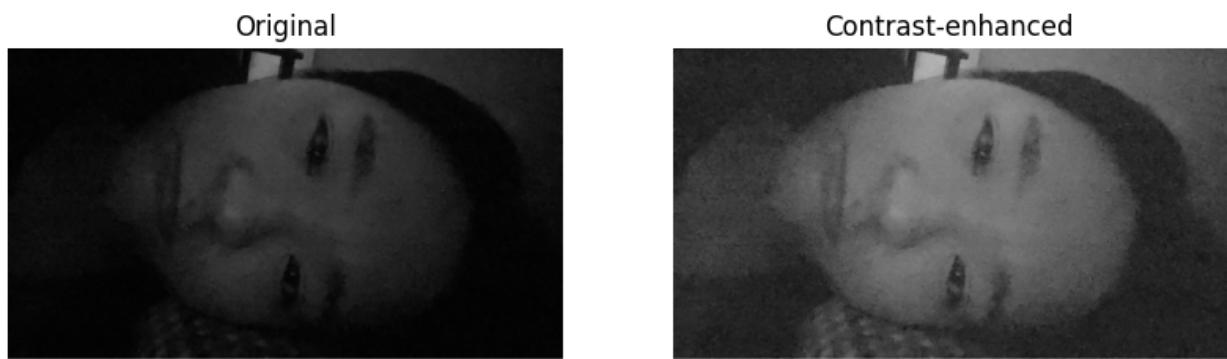
The figures were generated by removing portions of the signals where the power dropped below 50% of the original signal (corresponding to -3 dB), and by highlighting the regions where the magnitude remained above this threshold. From the charts, it can be observed that the two images occupy distinct, non-overlapping frequency ranges. Thus, the hybrid image provides unambiguous interpretation when viewing from different distances.

2. Hybrid image additional results



3. Image enhancement tasks (2 required, 3 for B&W)

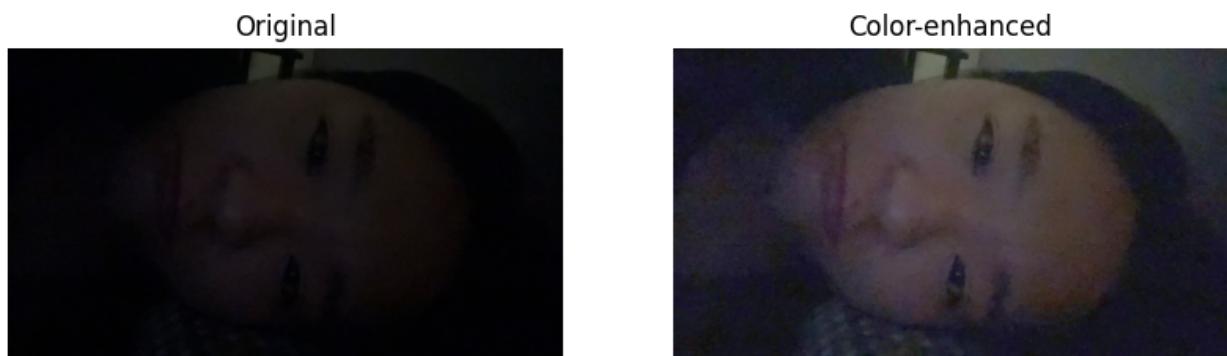
- Contrast Enhancement



- **Explanation**

The image was first converted to the gray scale and then contrast-enhanced using γ correction ($I_{out} = I_{in}^{\gamma}$). γ correction was selected over other algorithms due to the low exposure of this image. By setting $\gamma = 0.5$, the Gamma correction mapped the dark pixels to brighter values, improved the overall exposure of the image, and enhanced the visibility of the face in the image.

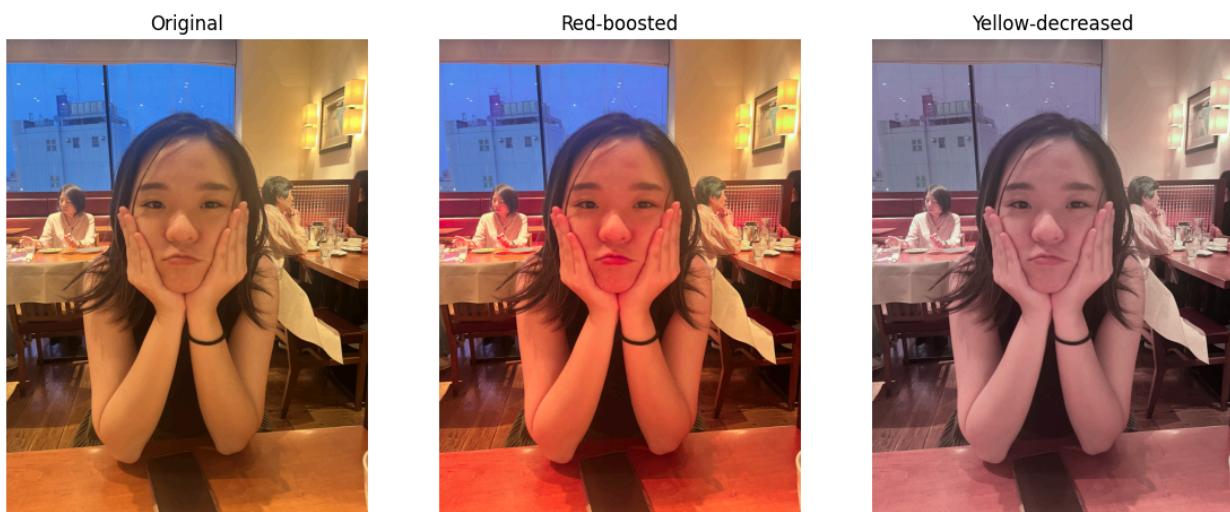
- **Color Enhancement**



- **Explanation**

HSV color space was used in this enhancement. The image was first converted to HSV color space with H (hue), S (saturation), and V (brightness value) channels extracted. The V value was modified with γ correction with $\gamma = 0.5$ to enhance the overall exposure of the image. The S value, on the other hand, was decreased by 35% to bring down the vibrance. The adjustments above enhance the picture's color, enabling the face in the picture to be visible.

- **Color Shift**



- **Explanation**

LAB color space was used to manipulate the color of the image. The image was first converted to the LAB color space, with lightness and chroma channels extracted. For the red-boosted image, the A chroma channel (which controls the red-green axis) was used with all the values centered to the neutral gray (A - 128), amplified by a factor of 1.8, and shifted back to the [0, 255] range. The yellow-decreased image was generated through the same procedure, but applied to the B chroma channel (which controls the blue–yellow axis) with a scaling factor of 0.3 instead of 1.8.

4. Quality of results and report

Nothing extra to include.

5. Color hybrid result (B&W)

- **The original Images**

Original Low-frequency Image



Original High-frequency Image



- **The hybrid images of the original images with different frequencies colored**

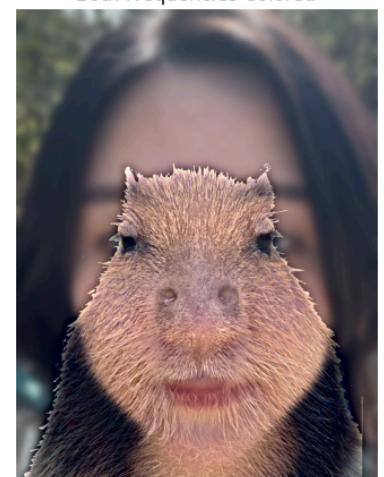
Low Frequency Colored



High Frequency Colored



Both Frequencies Colored

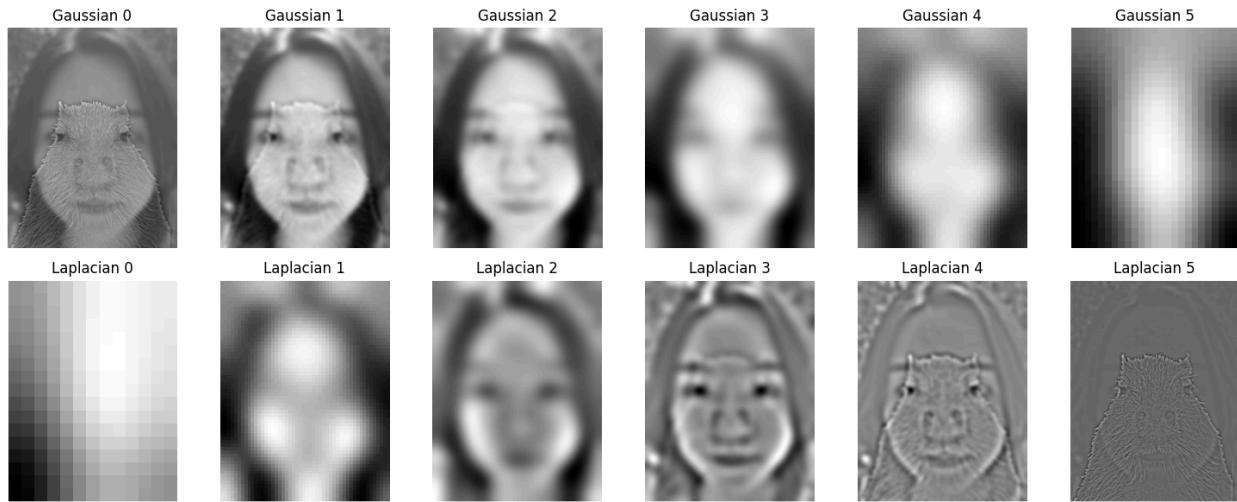


- **Explanation**

To create hybrid images with different frequencies colored, the LAB color space was used. The two aligned input images were first converted into LAB, and their lightness and chroma channels were extracted. The lightness channels were then combined using the hybrid image method. Next, the resulting hybrid L channel was merged with the chroma channels of the image corresponding to the frequency that was chosen to retain

color. In the case where both frequencies were colored, the chroma channels from the two images were first blended together and then merged with the hybrid L channel to produce the final hybrid image.

6. Gaussian and Laplacian Pyramids (B&W)



- The Laplacian pyramid is reversed to demonstrate the up-sampling process better.

Acknowledgments / Attribution

- ChatGPT conversation on Fourier domain visualization with annulus under Cartesian coordinates: [link](#)
- Capybara image: [link](#)
- Cat image: [link](#)
- Gopher image: [link](#)