Ahmedabad
University

ECE501 : Digital Image Processing

9 - Hybrid Multi-Frequency Image Illusion

Course Instructor: Dr. Mehul Raval
Group Number: 8
Group Members: Aashaka Ashara
Bansari Jani
Manasvi Gondalia
Aaryan Sheth

Abstract

This project is dedicated to the generation of hybrid images by the wavelet based image fusion techniques. Two source images were employed - one providing the low frequency structural information of the scene and the other providing the high frequency detail information - to generate the perceptually blended hybrid image. Although the algorithm implemented was able to combine the inputs successfully, the generated images had undesired artifacts and did not have the desired perceptual balance between coarse and fine details. This indicates the need for refinement in the choice of wavelet, decomposition levels and the fusion strategy.

In the next phase, the study will be extended to assess factors that affect the perceptual quality of hybrid images. The work will include color image fusion based on different color spaces (RGB, YCbCr and Lab) and multi-resolutions analysis using different values of Gaussian standard deviation and Difference of Gaussian (DoG) features for the enhanced extraction of details. Further experiments will be conducted to optimize parameters such as wavelet basis choice, decomposition depth, and relative scaling of input images. Additionally, perceptual effects associated with viewing distance will be analyzed for better understanding the effectiveness of how low frequency and high frequency components interact in human visual perception. The aim is to create a stronger and more perceptually consistent hybrid image synthesis framework.

Contents

1 What We Have Done **4**

2 What We Aspire to Do **5**

1 What We Have Done

In this week of the project, we tried to design and implemented an automated code for generation of a hybrid image by using two source images through the wavelet-based image fusion techniques. The first two images were given as inputs, one of them as the low frequency (base) part and the other as the high frequency (details) part. The goal was to generate a hybrid image that keeps the coarse structure of one image but adds fine details from the other image to generate a perceptually blended image automatically and that the code works for any set of images.

The implemented code was able to take the two input images and give the output image, as we can see from the below. However, the hybrid image that was produced did not match the expected visual outcome. Despite several changes to the algorithm parameters, including changes in the levels of decomposition, factors of scaling and types of filters, the resulting image still was not up to the mark and did not show the intended balance between the two input images. Further refinement of the wavelet selection and fusion strategy is needed in order to achieve the expected hybridization effect.

While Multiresolution pyramid fusion did give better results than wavelet hybrid images for both the cases, the output for second set of images is still not perfect and we still have a lot to improve in the automation process.

Figure 1: First set of initial images

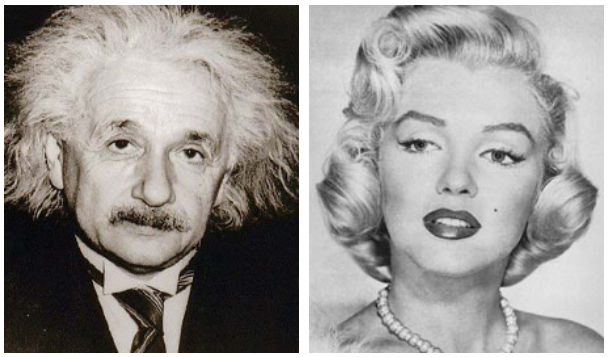

Figure 2: Second set of initial images

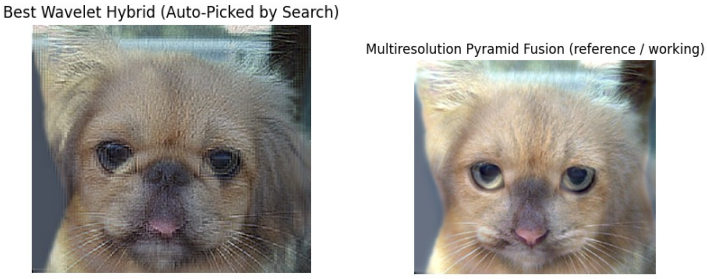

Figure 3: Output for first set of images

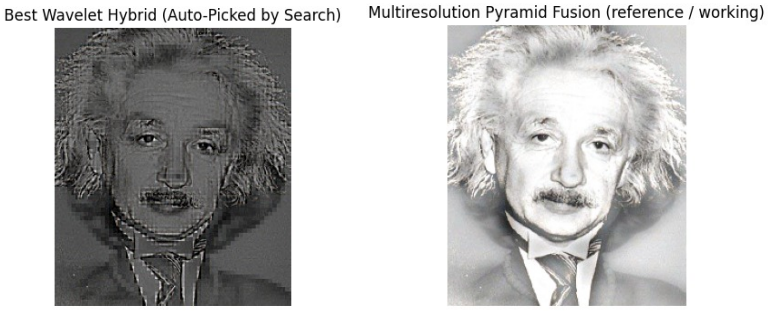

Figure 4: Output for second set of images

2 What We Aspire to Do

In the next step of the project, we want to extend the implementation and the evaluation of several factors that affect the perceptual quality of hybrid images.
The first step is to apply the technique to color images, rather than grayscale, either by processing each of the RGB channels separately or by using other color spaces such as YCbCr or Lab in order to better preserve the luminance and chromatic content. A multi-resolution analysis will be performed by trying different values of the Gaussian standard deviation. sigma) to investigate the impact of different levels of image defocus on image fusion. The Difference of Gaussian (DoG) feature will also be investigated to improve the feature extraction at high frequency before performing the fusion using wavelet-based fusion or pyramid-based fusion. Another important factor of the analysis will be the perception of the viewing distance, since hybrid images tend to favor high frequency structures when viewed from short range, and low frequency structures when viewed from long range. Secondly, several parameters such as the choice of wavelet basis, decomposition depth, filter bandwidth, and relative scaling of the input images will be optimized in order to obtain more balanced results. Finally, it will be examined to identify the importance of various image features, highlighting the importance of low-frequency information associated with global structure and form and how the high-frequency content gives the detail and edges that provide a perceptual experience for the viewer.

References

[1] GeeksforGeeks, "Image pyramid using opencv — python," https://www.geeksforgeeks.org/python/image-pyramid-using-opencv-python/, 2025, last updated: 11 Aug 2025.

[2] A. Oliva and P. G. Schyns, "Hybrid image illusion," in *The Oxford Compendium of Visual Illusions*, pp. 763–766. [Online]. Available: http://olivalab.mit.edu/Papers/Oliva-Schyns_Hybrid-Image-Illusion-Chapter.pdf

[3] A. Oliva, A. Torralba, P. G. Schyns, and A. for Computing Machinery, "Hybrid images," Tech. Rep., 2006. [Online]. Available: https://dellaert.github.io/19F-4476/misc/oliva-siggraph-2006.pdf

[4] M. A.-M. M. Salem, "Multiresolution image analysis," in *Multiresolution Image Segmentation*, 2008. [Online]. Available: https://www.researchgate.net/publication/264129683_Multiresolution_Image_Analysis

[5] P. Sripian and Y. Yamaguchi, "Hybrid image of three contents," *Visual Computing for Industry Biomedicine and Art*, vol. 3, no. 1, 2 2020. [Online]. Available: https://pmc.ncbi.nlm.nih.gov/articles/PMC7099537/

[6] "View of Hybrid motion illusions as examples of perceptual conflict — Journal of Illusion." [Online]. Available: https://journalofillusion.net/index.php/joi/article/view/7084/13847