Ahmedabad University

ECE501 : Digital Image Processing

9 - Hybrid Multi-Frequency Image Illusion

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Abstract

This project examines the formation and optimization of hybrid images- visual illusion that combines the low frequencies of one picture and the high frequencies of the other picture. The hybrid images were initially built with the help of Gaussian filtering to combine low-frequency and high-frequency in the spatial domain. This method was then subsequently expanded by Laplacian pyramid fusion to achieve the multi-scale decomposition and recombination and then a frequency domain method was used with Haar wavelet decomposition to blend coarse and detail coefficients. These methods were evaluated with regard to perceptual behavior with different viewing distances and these trade-offs showed unique spatial- and frequency-domain fusion. It follows on these observations that the next step should develop an adaptive hybrid-image system that will be able to automatically adjust its parameters, i.e., the Gaussian blur sigma, wavelet depth, and structural-detail weighting, depending on the characteristics of the input images such as contrast, gradient magnitude and density of edges. This is aimed at generating perceptually constant, and visually consistent hybrids without human intervention to better balance low- and high-frequency information to maximize hybrid illusions.

Contents

1 What We Have Done

This week, we implemented a complete hybrid-image pipeline using three multiresolution techniques, Gaussian blurring, Laplacian pyramid fusion, and wavelet-based fusion. First, we loaded and resized two images and came up with a baseline hybrid through Gaussian filtering to add low-frequency details of one image and high-frequency details of the other image. We then applied this method by making both Gaussian and Laplacian pyramids to break the images into multi-scale detail layers and fused them layer-by-layer with structural information of one image and fine details of the other before reassembly to form a hybrid. Then we considered a more developed frequency-domain approach based on Haar wavelet decomposition, where we independently added coarse (low-frequency) and detail (high-frequency) coefficients in creating wavelet-based hybrids. Finally, we simulated viewing at different distances to show how these hybrids shift perceptually-appearing like one image up close and another when viewed from far away. Overall, the study enabled us to be able to compare spatial-domain and wavelet-domain fusion approaches, analyzing their visual merits and drawbacks, and learning how multiresolution analysis can have an effect on hybrid image perception.

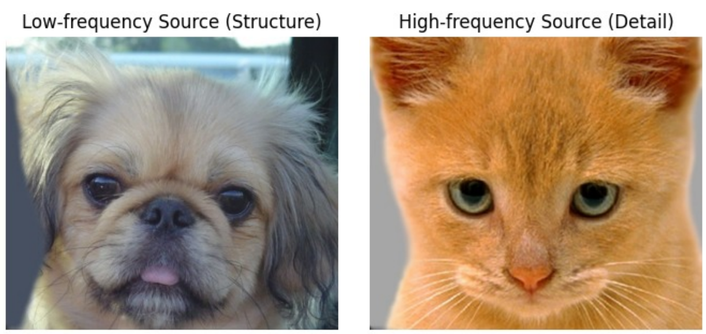

Figure 1: Initial images

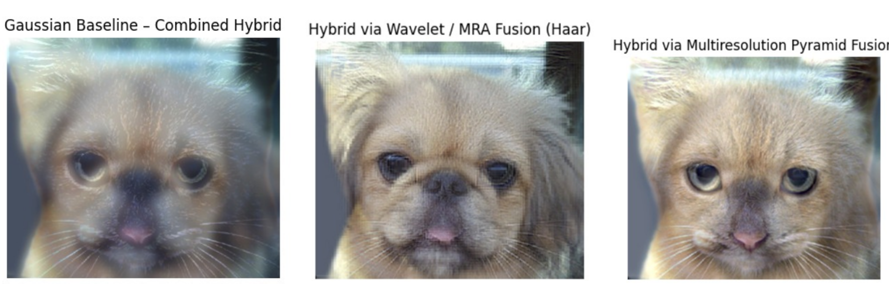

Figure 2: Output images.

2 What We Aspire to Do

Moving ahead, we intend to automate our hybrid multi-frequency image pipeline in such a way that it can adapt its parameters to the characteristics of its input images. To accomplish this, we will extract basic image statistics including gradient magnitude, edge density and global contrast to determine the frequency composition of each source image. Based on these measurements, the system will be able to automatically optimize important fusion parameters such as Gaussian blur sigma, wavelet decomposition depth, and structural/detail weighting coefficients (w_struct, w_detail), without the need for manual adjustment.

The objective of this automation is to enable the algorithm to intelligently determine the optimal balance between low-frequency structure and high-frequency detail for producing the most visually coherent hybrid illusion. Following implementation, we will evaluate the adaptive framework across multiple image pairs and assess the resulting hybrids in terms of visual stability, perceptual separation across viewing distances, and overall quality of the illusion.

References

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