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. We had already worked on the selection of appropriate image pairs and the creation of a simple implementation pipeline, which consisted of image alignment, image frequency filters and fusion. The cutoff frequency and filter size were experimentally adjusted to give information on the effect of the parameters on perceptual balance and clarity. Based on our previous experiments on image alignment, filtering, frequency-based fusion, we have added Gaussian and Laplacian pyramids, Difference of Gaussians (DoG) to perform an experiment on the representation of image details at various levels. We also tried running our codes on new set of images to try a work on a code that can be applicable to multiple different images. We have tried experimenting on hybrid formula of wavelet based using Haar transform has shown that it has a lot of potential to control the frequency separation and improve the perceptual clarity. In the future, we want to extend it to other wavelet bases and the fusion of coefficients across color channels optimized and how the perceptual transition varies with viewing distance is checked.

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1 What We Have Done

This week, we started applying the idea of viewing images at multiple levels of detail, known as multiresolution analysis (MRA), to our hybrid image work. We explored how images can be broken down into different layers of detail using simpler tools like Gaussian and Laplacian pyramids. By adjusting the blur level (the Gaussian σ value), we observed how it changes the mix between smooth (low-frequency) and detailed (high-frequency) parts of an image. We also tried the Difference of Gaussians (DoG) method to highlight the finer details and compared its results with those obtained from the Laplacian pyramid. We noticed that pyramid fusion builds hybrids that look right because it blends images the way the human eye perceives detail at multiple resolutions, whereas wavelet fusion is more mathematical so it analyzes frequencies precisely, but doesn't always reconstruct visually smooth results.

In addition, we began initial experiments with wavelet-based image blending using the Haar transform. In this approach, we separately handled the smooth and detailed parts of two images and combined them to create hybrid results. Our early findings suggest that blending in the wavelet domain gives better control over how much detail is preserved at different scales and can help us fine-tune the visual balance more systematically in future stages.

2 What We Aspire to Do

Moving forward, we plan to further analyze the difference between the two methods by comparing the computational behavior and visual outcomes of pyramid- and wavelet-based multiresolution fusion.

Our next step is to refine the pyramid fusion method by optimizing the blending weights across frequency levels and RGB channels to enhance perceptual balance between the near-view and far-view identities. In parallel, we will continue experimenting with different wavelet families such as Daubechies and Symlets to understand how filter characteristics influence visual sharpness and texture continuity.

We also intend to perform scale-dependent perception tests to quantify how the hybrid image transitions between its two identities with changing viewing distance. Finally, we will document and compare the results from the Gaussian, DoG, pyramid, and wavelet methods using both visual inspection and numerical quality measures to identify which technique provides the most stable and perceptually accurate hybrid illusions.

An important focus going forward will be on automating the hybrid image generation process by developing an adaptive parameter selection framework. This system will analyze image characteristics such as frequency content, contrast, and alignment to automatically determine suitable filter sizes, blending ratios, and decomposition levels, minimizing manual tuning.

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