Image Processing - Exercise 3

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Introduction

The exercise aimed at developing an algorithm for blending two images using a black and white mask and Gaussian and Laplacian pyramids to achieve seamless integration. Additionally, the task involved creating a hybrid image that presents differently at close and far distances, utilizing the same pyramidal techniques for manipulating frequency components.

Algorithm

In this task I wrote two algorithms:

1. Blending Images:
   The algorithm involves generating Gaussian and Laplacian pyramids for both input images to break them down into multi-scale representations. A Gaussian pyramid for the mask is also created to guide the blending process. At each level of the pyramid, the corresponding portions of the two images are blended according to the mask, allowing for seamless transition between them. This blended pyramid is then reconstructed to form the final image, ensuring a smooth blend that respects the spatial coherence of both source images.
2. Hybrid Image:
   Creating a hybrid image employs Gaussian and Laplacian pyramids to separate the high-frequency details from one image and the low-frequency background from another. By carefully choosing a cutoff level, the algorithm combines these frequencies to create a new image that reveals one image when viewed up close and another when viewed from a distance.

Implementation Details

The implementation details of each algorithm:

1. Blending Images Implementation:
   Mask Creation: The mask was designed using Photopea, an online photo editing tool, to manually define areas of blend between the two images.

Loading and Resizing: Load the first image, second image, and mask. Resize them to ensure identical dimensions. I used OpenCV (cv2) for image reading (cv2.imread) and resizing (cv2.resize).
Mask Preparation: Convert the mask to grayscale (if not already) and normalize its values between 0 (transparent) and 1 (opaque) using OpenCV.
Generating Gaussian Pyramid for Mask: Create a Gaussian pyramid for the mask to facilitate multi-scale blending. I used OpenCV's cv2.pyrDown for downsampling.
Creating Laplacian Pyramids for Images: Generate Laplacian pyramids for both images to capture and manipulate details at various scales. I used OpenCV's cv2.pyrUp for upsampling and cv2.subtract to create Laplacian pyramids.
Blending Pyramids: Blend the corresponding levels of the Laplacian pyramids using the Gaussian pyramid of the mask as weights.
Reconstructing the Blended Image: Reconstruct the image from the blended Laplacian pyramid. Begin with the topmost layer of the blended Laplacian pyramid (the smallest image). For each level, upsample the current image to match the next level's size and then add it to the corresponding level of the pyramid. I used OpenCV's cv2.pyrUp for upsampling and cv2.add for adding layers of the pyramid.
Saving the Blended Image: Save the final blended image to a file. I used OpenCV (cv2.imwrite).

Hyper-parameters: Opting for 6 levels in Gaussian and Laplacian pyramids strikes a balance between capturing detail and maintaining computational efficiency, avoiding the pitfalls of too few or too many levels.
Challenges: Achieving a seamless blend involved fine-tuning mask creation and pyramid levels for optimal smoothness and detail preservation. This was tackled by testing various levels, aiming for the right balance between detailed representation and blending quality.

2. Hybrid Image Implementation:
Image Preparation: Load and resize the first and second images for consistency. I used OpenCV for image loading and resizing.
Generating Gaussian and Laplacian Pyramids: Create Gaussian pyramids for both images and then convert them into Laplacian pyramids. I used OpenCV for image loading and resizing.
Combining Pyramids for Hybrid Image: Combine the Laplacian pyramids, taking low-frequency components from one image and high-frequency components from the other.
Reconstructing the Hybrid Image: Use the combined pyramid to reconstruct the hybrid image. I used OpenCV for pyramid reconstruction.

Final Adjustments and Saving: Optionally convert to grayscale and save the hybrid image using OpenCV.

Hyper-parameters: Choosing 6 pyramid levels and a cutoff of 3 strategically balances detail and the perceptual impact of the hybrid images. This setup ensures that one image is prominent at close view due to high-frequency details preserved below the cutoff, while the other image, represented by low-frequency details above the cutoff, becomes visible from a distance.

Challenges: Balancing the visibility of both images in the hybrid image was difficult, especially determining the right cutoff level. This was solved through trial and error, adjusting the cutoff to ensure both images contribute visible details.

The difference between the algorithms was that the blending algorithm combines two images with a mask, adjusting the blend per pixel, while the hybrid algorithm merges images at different frequencies for varying perceptions with distance. The key difference is their approach: blending adjusts based on spatial variance, and hybrid utilizes a frequency cutoff for dual-viewing effects.

Blending Images Results

I opted for blending an image of Barcelona by night with Van Gogh's "The Starry Night," creating a custom black and white mask for the Barcelona image to guide the blending process effectively. The rightmost image is the result.



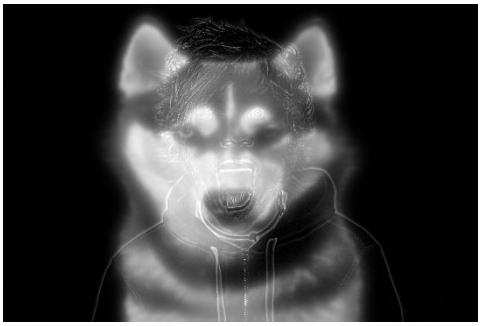

During the task I got intermediate results of unsuccessful blending between images. In left, an inadequate mask, leading to unwanted blended areas. Conversely, in right, choosing too few pyramid levels (only 1 level) resulted in stark, unblended overlays, lacking smooth transition between images.


Pyramids Results

In the Gaussian pyramid, the Barcelona image blurs and shrinks across levels, highlighting broader structures as fine details diminish. The Laplacian pyramid captures contrasting details, with lower levels nearly dark, suggesting minimal change, and higher levels emphasizing sharp features and edges, reflecting the image's textural complexity.

Hybrid Image Results

I've selected two distinct images for creating a hybrid image: one featuring a dog and another capturing the likeness of singer-songwriter Ed Sheeran.
Upon close examination, the image distinctly reveals Ed Sheeran's features, whereas from a distance, the visual transitions to clearly depict a dog.



Conclusion

The use of Gaussian and Laplacian pyramids was instrumental in both blending and hybrid image tasks. These pyramids enabled us to manipulate images on a multi-scale level—Gaussian for smooth transitions in blending and Laplacian for emphasizing details in hybrid images. They demonstrate how control over different frequency contents can lead to sophisticated visual outcomes, seamlessly merging two images or presenting one subject up close and another from afar.