Principles and Applications of Digital Image Processing

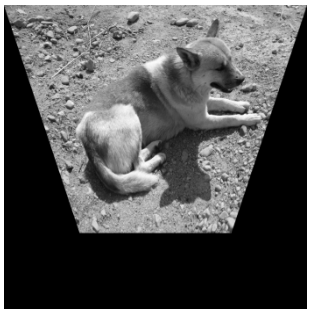
【Fall, 2024】

Homework 6

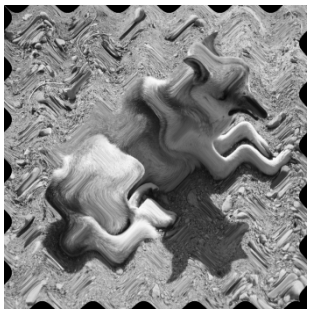
Part 1: (30%) Geometric Transformation

Design a computer program for geometric transformation of an image. Try to find the optimal geometric transformation to obtain the warped images shown below. Describe your approach as clearly as possible and show the resulting images. You may also challenge yourself by designing an interactive interface for more flexible geometric transformation.

Original Image



Trapezoidal Transformation



Wavy Transformation

Circular Transformation

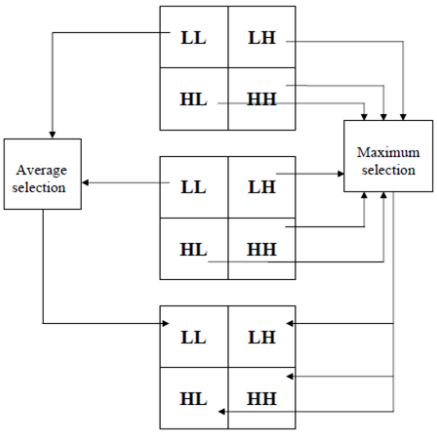
Part 2: (30%) Image Fusion Using Wavelet Transform

The algorithm of image fusion using DWT is described in the following steps:

1. The size of images to be fused needs to be the same size and the resolution needs to be of power of two.
2. The two dimensional Discrete Wavelet Transform (DWT) should be applied to the resized images.
3. Fusion rule: The most used image fusion rule using wavelet transform is maximum selection, by comparing the DWT coefficients of the two (or more) images and select the maximum. While the lowpass subband is an approximation of the input image, the three detail subbands convey information about the detail parts in horizontal, vertical and diagonal directions. Different merging procedures will be applied to approximation and detail subbands. Lowpass subband will be merged

using simple averaging operations since they both contain approximations of the source images, and the maximum selection rule is applied to detail subbands, as shown in the following figure.

4. After selecting the fused low frequency and high frequency bands, fused image is reconstructed using the inverse DWT from on the subbands determined in step 3.



Implement an image fusion program applying the DWT method as described above.

1. Test your program with the image sets provided in this homework and image sets you wish to test.
2. Quantitatively and qualitatively compare and discuss the effect of the image fusion results using different scales of decomposition.

Part 3: (40%) Superpixel-based Regional Segmentation

You are given a digital image and your task is to perform regional segmentation using a superpixel method. Superpixels are compact, perceptually meaningful regions that can be used as an intermediate step for more advanced image processing tasks. Your goal is to group similar pixels together to form these superpixels and segment the image into regions.

1. Choose an image of your preference (or use the accompanied sample image).
2. Implement a superpixel algorithm using Simple Linear Iterative Clustering (SLIC) described in Section 10.5 of the textbook).
3. Tune the algorithm's parameters (e.g., number of superpixels) for the best segmentation results. You may need to experiment with different parameter settings.
4. Carry out superpixel segmentation on the chosen image and display the resulting superpixel regions. Ensure that you superimpose these regions onto the original image for visual representation, akin to the illustration in Figure 10.51 of the textbook.
5. Provide a written explanation of the superpixel algorithm you used, the chosen parameters, and the results of your segmentation. Discuss the strengths and weaknesses of your method.
6. Compare and contrast your superpixel-based segmentation with a traditional method, such as K-means clustering, in terms of computational efficiency and quality of segmentation.

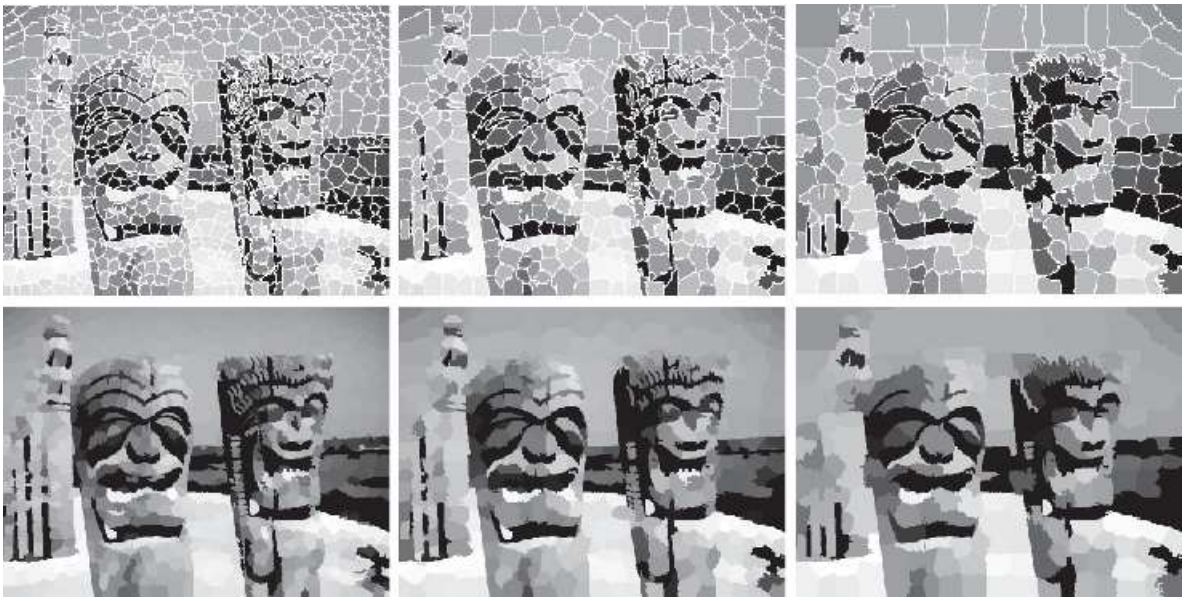


FIGURE 10.51 Top row: Results of using 1,000, 500, and 250 superpixels in the representation of Fig. 10.50(a). As before, the boundaries between superpixels are superimposed on the images for reference. Bottom row: Superpixel images.

Notes:

1. Please submit your programs and report to the AUTOLAB course website before **Nov. 27 (2:20PM).**

2. Late submission will have a penalty of 10% discount per day of your homework total score toward a maximum of 50% discount. No late submission over five days will be accepted.