Homework 6: Review of Image Processing Operations

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Abstract

This report presents the implementation and analysis of various image processing operations, including geometric transformations and edge detection. The tasks involved applying transformations such as translation, cropping, scaling, flipping, rotation, and filling on test images, as well as computing and displaying image gradients, gradient magnitudes, orientations, and histograms of gradient orientations at different scales.

Introduction

The ability to manipulate and analyze images through geometric transformations and edge detection is fundamental for applications in image registration, object detection, and machine learning. This report details the implementation of these operations using Python and discusses the outcomes and insights gained from these exercises.

Experiment

Part A: Geometric Image Transformations

The first part of the assignment focused on geometric transformations. The implemented operations included:

- Translation
- Crop and Scale
- Vertical Flip
- Horizontal Flip
- Rotation
- Fill

Each operation was applied to a test image using specified parameters.

Part B: Edge Detection and Histogram of Gradient Orientations

The second part dealt with edge detection and gradient analysis. The tasks included:

- Computing and displaying image gradients (Ix, Iy)
- Calculating gradient magnitude (M)
- Computing gradient orientation (θ)
- Generating a histogram of gradient orientations

These tasks were executed at two different scales to observe the variation in image details and structures.

Test Image:

Results

Part A: Geometric Image Transformations

Translation

Crop & Scale

Vertical Flip

Horizontal Flip

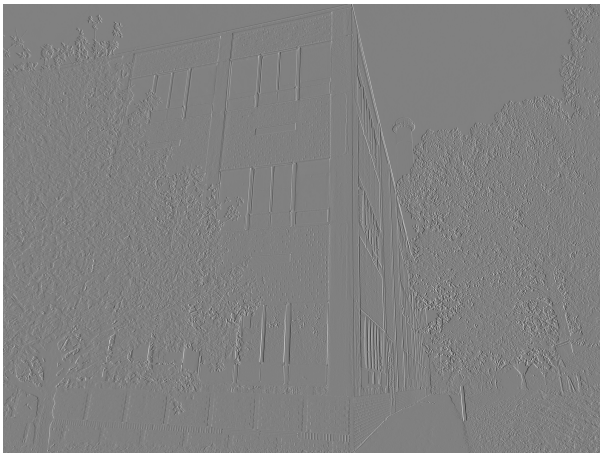
Rotation

Fill

Part B: Edge Detection and Histogram of Gradient Orientations

Images are shown with a Sobel kernel size of 3 on the left and 11 on the right.

Image Gradient in X (Ix)



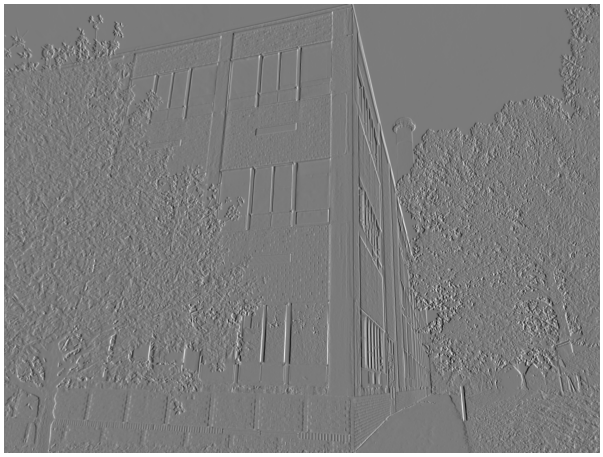
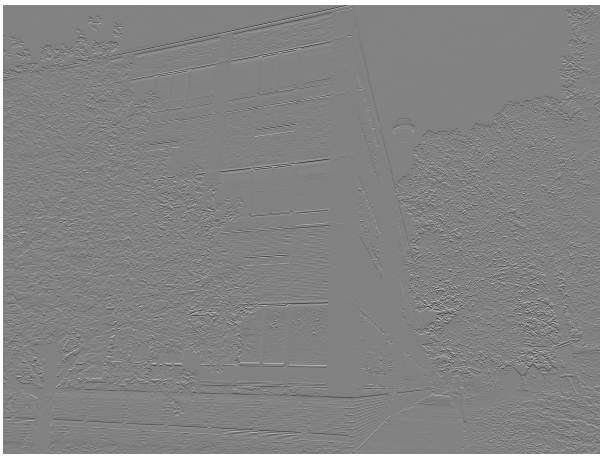
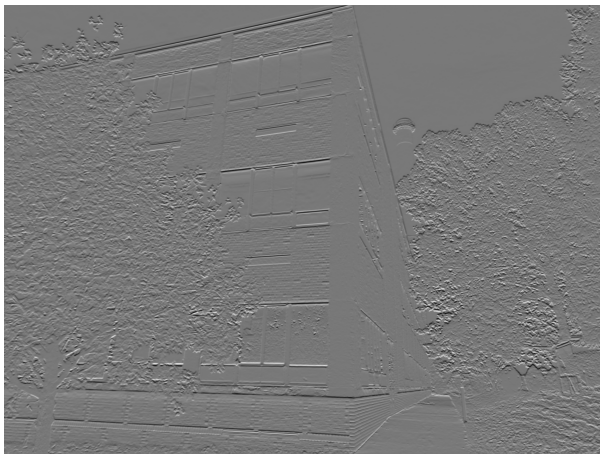


Image Gradient in Y (Iy)

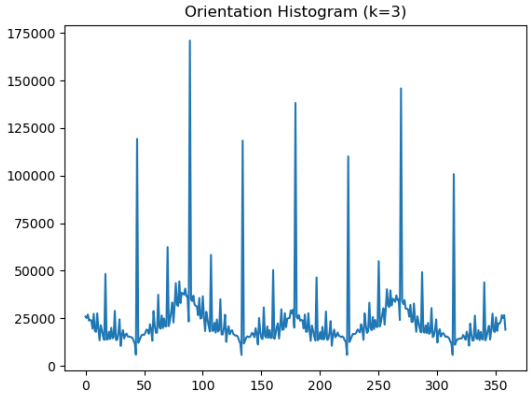


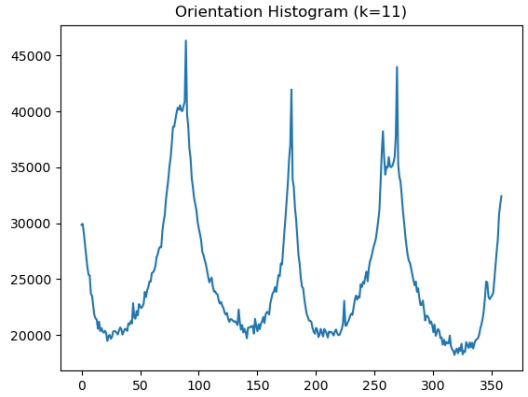


Gradient Magnitude (M)

Gradient Orientation (θ)

Histogram of Gradient Orientations





Discussion

The outcomes of the geometric transformations and edge detection operations provide valuable insights into the complexities and capabilities of image processing.

In geometric transformations, each operation distinctly altered the image. Translation shifted the image's position, revealing the impact of spatial displacement on visual perception. The crop and scale operation demonstrated how image resolution and detail can be manipulated. The vertical and horizontal flips showcased the effects of mirror transformations on image orientation. Rotation further emphasized the importance of angle in image interpretation. Lastly, the fill operation illustrated the potential for modifying image content.

In edge detection and gradient analysis, the use of different scales revealed varied levels of detail. At a smaller scale, finer details and subtle edges were more pronounced. Conversely, at

a larger scale, broader structures and more significant edges were highlighted. The computation of image gradients (Ix, Iy), gradient magnitude (M), and gradient orientation (θ) provided a comprehensive understanding of the image's edge and texture characteristics. The histogram of gradient orientations offered a quantitative view of edge directions.

Conclusion

This report has demonstrated the practical application and analysis of various image processing operations, including geometric transformations and edge detection. The geometric transformations showcased how different operations could significantly alter the perception and information content of an image. These transformations are fundamental in various image processing applications, from basic image editing to more complex tasks like automated image registration.

The edge detection, through gradient analysis and histogram generation, illustrated the importance of scale and orientation in understanding image structures. These operations are essential in many computer vision tasks, such as object recognition, scene understanding, and feature extraction.

In conclusion, the tasks performed in this assignment highlight the versatility and depth of image processing techniques. They underscore the essential role these operations play in both enhancing our understanding of visual data and their practical application in various fields, including computer vision, digital arts, medical imaging, and surveillance.