VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI - 590018

A MINI PROJECT ASSIGNMENT REPORT

on

"High-Pass Filtering: Enhancing Edges in Images"

A report submitted in partial fulfillment in

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

7th Semester

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Accredited by NAAC with A+ Grade

Shobhavana Campus, MIJAR-574225, Moodbidri, D.K., Karnataka

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CERTIFICATE

This is to certify that assignment work for the course **"Basic Digital Image Processing (21EC753)"** has been successfully completed and report submitted A.Y 2023-24. It is certified that all corrections/suggestions indicated Presentation session have been incorporated in the report and deposited in the department library.

The assignment was evaluated and group members marks as indicated below

SI	USN	NAME	Presentation Skill (5)	Report (10)	Subject Knowledge (5)	Total Marks(20M)
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CHAPTER 1

INTRODUCTION

Image processing is a vital domain in computer vision, where enhancing the visual quality of images plays a significant role in various applications such as medical imaging, security, and photography. One popular technique in this field is high-pass filtering, which focuses on emphasizing the edges and fine details of an image. Edges in an image represent significant transitions in intensity, often marking the boundaries of objects, making them crucial for tasks like object detection and pattern recognition. High-pass filters work by removing the low-frequency components (smooth variations) of an image while preserving or enhancing the high-frequency components (sharp transitions).

This project explores the implementation of high-pass filtering to enhance edges in grayscale images. Using a predefined convolution kernel, the high-pass filter accentuates the details of the image, making edges more pronounced. Additionally, by blending the filtered image with the original, we create an enhanced output that highlights important features without losing the overall image structure. This report delves into the methodology, implementation, and applications of high-pass filtering in edge enhancement, showcasing its significance in improving image quality for practical use cases.

CHAPTER 2

WORKING PRINCIPLE

High-pass filtering is a fundamental technique in image processing that focuses on enhancing the edges and fine details of an image. This chapter provides a detailed explanation of the working principle of high-pass filtering, including its methodology, implementation, and practical applications.

2.1 Introduction to High-Pass Filtering

- High-pass filtering is a technique used in image processing to enhance sharp transitions in intensity, such as edges and fine details.
- It removes low-frequency components (smooth variations) from an image while retaining high-frequency components (sharp changes).
- The technique is widely used in applications such as edge detection, object recognition, and image sharpening.

2.2 Kernel Design for High-Pass Filtering

A convolution kernel is a small matrix used to filter images by emphasizing or suppressing certain features.

For high-pass filtering:

- Common kernels include matrices where the center value is significantly higher than the surrounding negative values (e.g., Laplacian kernel).
- Here is the example kernel in proper matrix form:

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

- The high positive value in the center emphasizes intensity differences in neighboring pixels.

2.3 Convolution Process

Convolution is the operation where the kernel is slid over the image to compute new pixel values.

Steps:

- Place the kernel at a specific pixel position in the image.
- Multiply each kernel value with the corresponding pixel value under it.
- Sum all these multiplications to compute the new pixel value.
- Repeat this process for all pixels in the image.

Result:

- Areas with rapid intensity changes (e.g., edges) produce high values, highlighting those features.

2.4 Edge Enhancement

High-pass filtering highlights edges, but further enhancement is often required for better visualization.

Enhancement process:

- Blend the high-pass filtered image with the original image using a weighted sum.
- **Formula:** TextEnhancedImage=alpha times TextOriginalImage + beta times TextFilteredImage
- α and β are weights that control the contribution of each image.

Benefits:

- Preserves the overall structure of the image while enhancing sharp transitions.

2.5 Applications of High-Pass Filtering

- **Edge Detection**: Identifies boundaries of objects in images for tasks like segmentation and pattern recognition.
- **Image Sharpening**: Improves the clarity of images by enhancing details and edges.
- **Medical Imaging**: Highlights critical features in X-rays, CT scans, and MRIs for better diagnosis.

CHAPTER 3

METHODOLOGY

3.1 Image Acquisition

Objective: To obtain input images for processing.

- **Sources:**
  - Pre-captured images from datasets or personal collections.
  - Images captured using cameras or other devices.
- **File Format**:
  - Common formats like .jpg, .png, or .bmp are supported for input.
  - Post-surgery recovery monitoring.
  - Early detection of health anomalies.
- **Pre-processing**: Convert images to grayscale if they are in RGB or other color formats, as high-pass filtering is generally applied to single-channel images.

3.2 Kernel Design

Purpose: To define a convolution matrix for filtering the image.

Design Principles:

- High-pass kernels are designed to detect intensity changes by emphasizing differences between neighboring pixels.
- **Types of Kernels**:
  - **Laplacian Kernel:** Detects edges in all directions (horizontal, vertical, and diagonal.
  - **Sobel Kernels**: Used for detecting edges specifically in horizontal or vertical directions.
- **Implementation**:
  - The kernel is stored as a 2D matrix in code and applied using convolution operations.

3.3 Image Convolution

Overview: Convolution is the process of applying the kernel to the image to generate the filtered result.

- **Steps**:
    - **Kernel Overlay**: Adjust automatically based on patient movements, reducing the risk of bedsores and improving comfort.
    - **Pixel Multiplication**: Allow remote monitoring and control of patient ventilation parameters.
    - **Summation**: Deliver precise medication dosages and alert staff to potential errors.
    - **Pixel Replacement:** Replace the original pixel value with the computed value.
    - **Sliding the Kernel**: Move the kernel to the next pixel and repeat the process.
- **Result**:
    - The output is an image where sharp intensity changes (edges) are enhanced, while smoother areas are suppressed.

3.4 Edge Enhancement

Objective: To improve the visibility of edges without distorting the original image.

- **Steps**:
    - Blend the high-pass filtered image with the original image using a weighted combination.
    - Adjust the weights to control the strength of enhancement.
    - Ensure that the final image retains structural details while highlighting edges.

3.5 Workflow Summary

- **Step 1: Load the input image in grayscale format.**
- **Step 2: Define the high-pass filter kernel.**
- **Step 3: Apply convolution to the image using the kernel.**
- **Step 4: Blend the high-pass filtered image with the original image for enhancement.**
- **Step 5: Display the original, filtered, and enhanced images for comparison.**

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CHAPTER 4

IMPLEMENTATION IN SCILAB

This chapter describes the implementation of high-pass filtering in **Scilab 5.5.2 (64-bit)**. The process includes setting up the environment, writing the code, executing it, and analyzing the outputs. The methodology discussed earlier is applied programmatically, and the corresponding results are captured.

4.1 Environment Setup

- Scilab Version: The project was implemented using Scilab 5.5.2 (64-bit), a powerful open-source software for numerical computation.
- Image Processing Toolbox: The SIVP toolbox was installed and loaded for handling image-related operations.
    - Installation command: atomsInstall("SIVP");
    - Loading command: atomsLoad("SIVP");
- System Configuration: The implementation was conducted on a computer with adequate memory to process large images.

4.2 Steps of Implementation

1. **Image Loading:**
    - The input image (boloor.jpg) was loaded into Scilab using the imread function.
    - Conversion to grayscale was performed using rgb2gray.
2. **Defining the High-Pass Filter Kernel**:
    - A convolution kernel was defined to enhance edges by emphasizing intensity differences.

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

    - Kernel matrix:

3. **Applying the Convolution**:
    - The high-pass filter was applied using the imfilter function, resulting in a filtered image that highlights the edges.
4. **Enhancing the Image**:
    - The original grayscale image was blended with the filtered image to enhance edges while retaining structural details.
    - Formula used: Enhanced Image=α×Original Image+β×Filtered Image
    - Values of α\alphaα and β\betaβ were set to 0.5.
5. **Displaying and Saving Outputs:**
    - Three outputs were displayed in separate figures:
        1. Original Image
        2. High- Pass Filtered Image
        3. Enhanced Image
    - The filtered and enhanced images were saved using imwrite.

CHAPTER 5

ANALYSIS OF RESULTS

5.1 Observations

1. Edge Detection:

The high-pass filtered image successfully highlighted sharp transitions in intensity, such as object boundaries and texture details.

2. Enhanced Image:

The edge-enhanced image retained the structural details of the original image while improving the visibility of important features.

3. Computational Efficiency:

The implementation in Scilab was efficient, with processing times suitable for typical image sizes (e.g., 512x512 pixels). Larger images required resizing or increased stack size.

5.2 Output Results

1) 

Figure 1 Original Image: A representation of the input image.

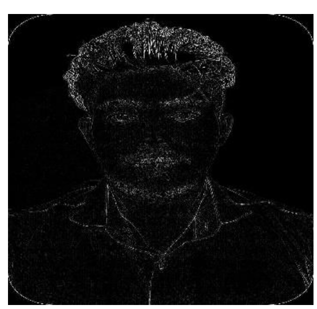
2) 

Figure 2 High-Pass Filtered Image: An image highlighting the edges, with most low-frequency details removed.

3) Enhanced Image: A blend of the original and filtered images, enhancing the visibility of edges while retaining overall structure.

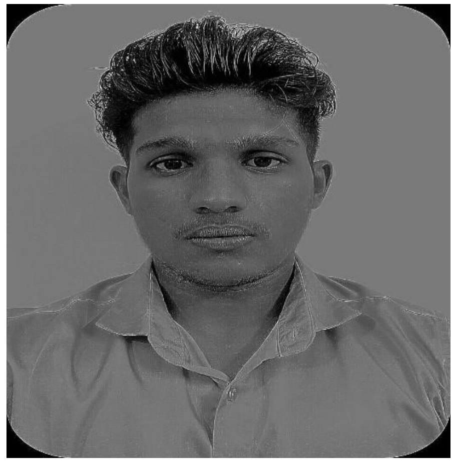


Figure 3 Enhanced Image: A blend of the original and filtered images, enhancing the visibility of edges while retaining overall structure

5.3 Advantages:

1) Enhances edges effectively without requiring advanced preprocessing.
2) Simple and intuitive implementation using Scilab's built-in functions.
3) Customizable blending coefficients (α and β) allow control over the enhancement effect.

5.4 Limitations

1) High-pass filtering can amplify noise in images, especially in regions with uniform intensity.
2) The quality of results depends on the choice of kernel and blending weights.
3) Processing large images may require adjustments to memory allocation (stack size).

CHAPTER 6

CONCLUSION & FUTURE ENHANCEMENT

The implementation of high-pass filtering in Scilab has proven to be an effective method for enhancing edges in images by emphasizing sharp transitions in intensity. By applying a well-defined convolution kernel, the technique successfully highlights critical features such as boundaries and texture details, which are often obscured in the original image. The blending of the high-pass filtered image with the original grayscale image has further enhanced the visual quality, providing a balanced outcome that retains structural details while improving edge visibility. This project demonstrates the utility of Scilab as a powerful tool for image processing, particularly in scenarios requiring simplicity, flexibility, and computational efficiency. The outputs validate the practical relevance of high-pass filtering in fields such as medical imaging, satellite imagery, and computer vision, where feature extraction and image clarity are crucial.

Looking ahead, there is significant potential to expand the scope of this project. Advanced filtering techniques, such as Gaussian-based high-pass filters or frequency domain filtering, could be integrated to achieve more refined results. Automating the selection of kernel parameters and blending coefficients would make the system adaptive to diverse image types, minimizing user intervention. Furthermore, extending the implementation to support multi-channel processing for color images would enhance its versatility and applicability in real-world scenarios. Combining high-pass filtering with other image enhancement techniques, such as histogram equalization or noise reduction, could also improve the overall quality and robustness of the results. These enhancements would make the technique more efficient and reliable for modern applications, ensuring its relevance in evolving technological landscapes.