Digital Image Processing Report

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Exercise 1: Implement the following processes: 1) read the cameraman image, 2) calculate negative image, 3) add a constant value of 50, 4) apply gamma intensity transform with γ [0, 2.0] with a step of 0.4. Report your observations with respect to contrast stretching.

Processes:

1. **Read the Cameraman Image:** The input image `cameraman.tif` was read and converted to double precision.
2. **Calculate the Negative Image:** The negative transformation was calculated by subtracting the pixel values from 1.
3. **Add a Constant Value:** A constant value of 50 was added to the pixel intensities, ensuring the values remained within the valid range of [0, 1].
4. **Gamma Intensity Transformation:** Gamma transformations were applied with $\gamma \in [0, 2.0]$, using a step size of 0.4.

Observations:

- **Negative Image:** The grayscale intensities were inverted, enhancing the visual distinction between bright and dark regions.
- **Gamma Transformations:**
  - $\gamma < 1$: Enhanced darker regions, stretching the contrast in shadows.
  - $\gamma = 1$: Retained the original intensity distribution.
  - $\gamma > 1$: Emphasized brighter regions, improving contrast in highlights.

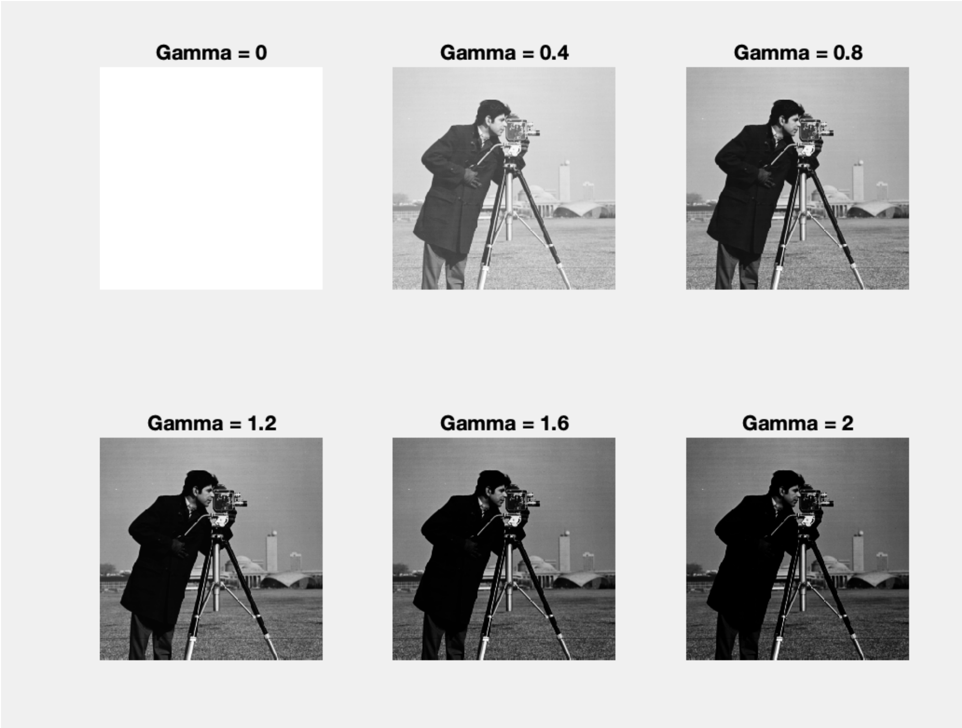


Figure 1: Gamma Transformed Images for Different γ Values

Exercise 2: Write the mathematical expression for the above piecewise linear contrast stretching function

The piecewise linear contrast stretching function can be mathematically expressed as:

$$f(x) = \frac{(x - a_i) \cdot (b_{i+1} - b_i)}{a_{i+1} - a_i} + b_i, \quad \text{for } x \in [a_i, a_{i+1}] \tag{1}$$

Explanation:

- x: Input intensity value within the range $[a_i, a_{i+1}]$.
- a_i, a_{i+1}: Boundary intensities of the input range.
- b_i, b_{i+1}: Corresponding mapped boundary intensities of the output range.

Figure 2: woman stretching

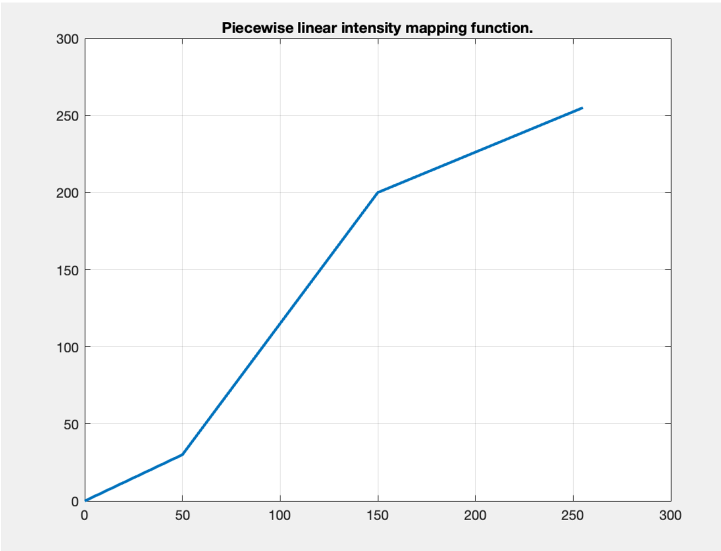


Figure 3: Piecewise Linear Mapping Function

Exercise 3: Repeat the bit-plane decomposition and reconstruction processes for the jetplane image. Describe the steps of this method, its implementation and the output: (Bit-Plane Decomposition and Reconstruction for Jetplane Image)

Introduction

Bit-plane slicing is a technique in image processing where the individual bits of the pixel intensities are analyzed separately. Each bit-plane represents a binary image corresponding to a specific bit position in the pixel intensity values. This technique is useful for image compression, watermarking, and analyzing the importance of individual bits in the representation of an image.

This report presents the steps for bit-plane slicing and reconstruction applied to the `pirate.tif.png` and `jetplane.png` images, along with observations on their outputs.

Steps for Bit-Plane Slicing

1. Read and Display the Image:

- The `pirate.tif.png` image was read and converted to double precision to facilitate numerical computations.
- The original image was displayed using MATLAB.

2. Display Help for Modulus Function:

- The `mod` function was used to extract specific bits from the pixel intensities.
- Its functionality was reviewed using the `help mod` command.

3. Extract Bit-Planes:

- Each bit-plane was extracted by iteratively dividing the pixel intensities and taking the modulus with 2.
- This resulted in 8 bit-planes (I_0 to I_7), with I_7 being the most significant bit (MSB) and I_0 being the least significant bit (LSB).

4. Reconstruct the Image:

- The image was reconstructed using different combinations of the most significant bit-planes.
- Three reconstructions were performed:
  1. Using I_7 only.
  2. Using I_7 and I_6.
  3. Using I_7, I_6, and I_5.

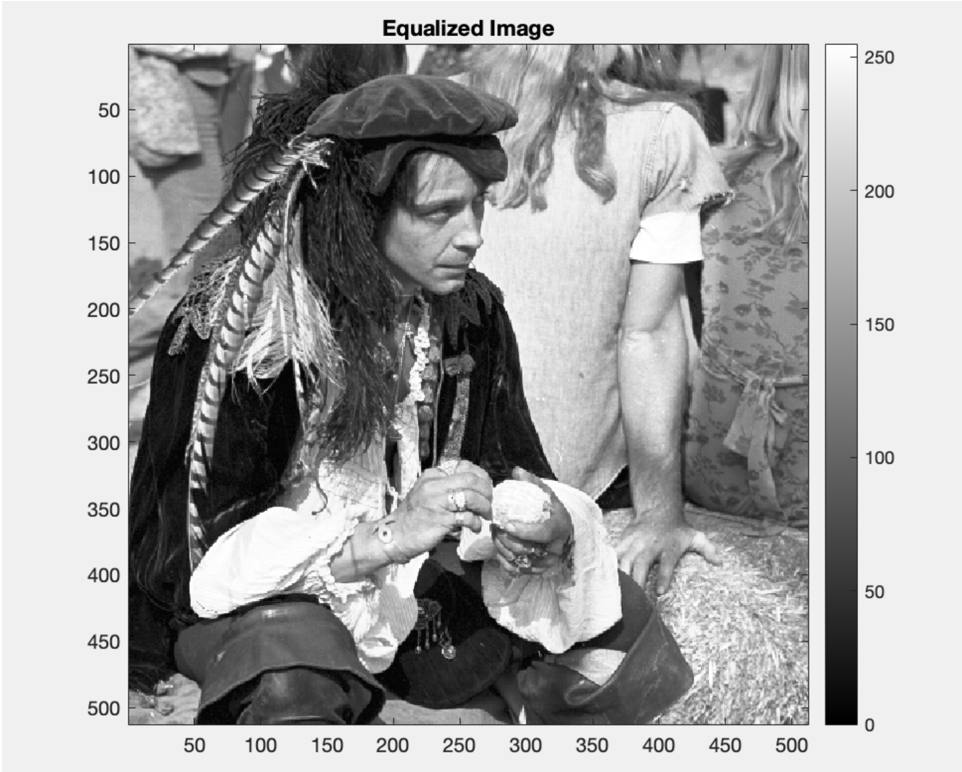


Figure 4: Equalized Pirate Image

Application to Jetplane Image

Steps:

1. The `jetplane.png` image was read and processed in the same manner as `pirate.tif.png`.
2. Bit-planes were extracted, and the image was reconstructed using selected significant bit-planes.
3. The results were displayed to compare the contributions of different bit-planes.

Observations

Bit-Planes:

- Lower bit-planes (I_0 to I_3) primarily captured noise or minor details.
- Higher bit-planes (I_6 and I_7) contained most of the significant details of the image.

Reconstruction:

- Reconstructing with I_7 alone produced a low-detail image that retained the primary structure.
- Adding more significant bit-planes (e.g., I_7, I_6, I_5) improved the detail and visual quality of the reconstructed image.
- Similar behavior was observed for both `pirate.tif.png` and `jetplane.png` images.

Figures

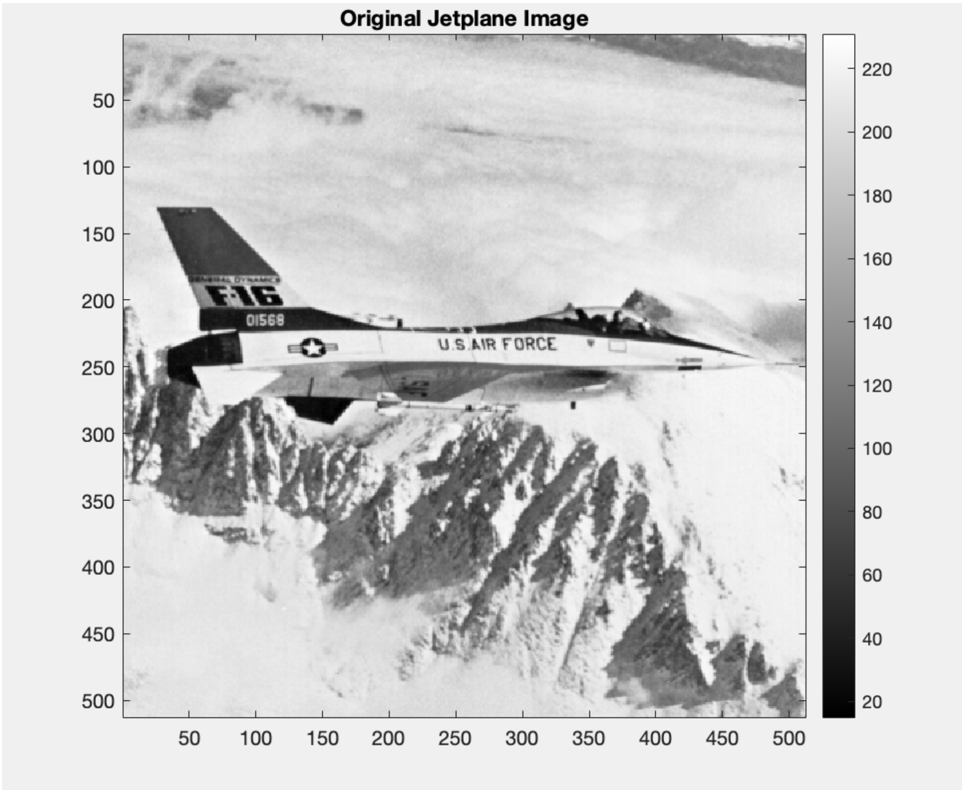


Figure 5: Original Jetplane

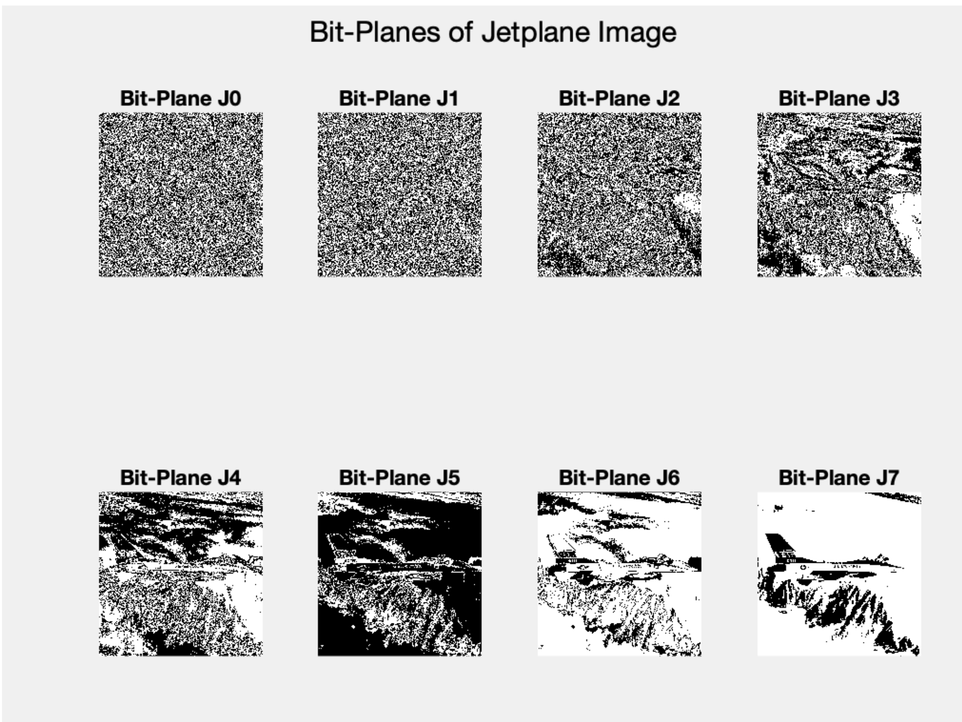


Figure 6: Bit-Planes of the Jetplane Image (J_0 to J_7)

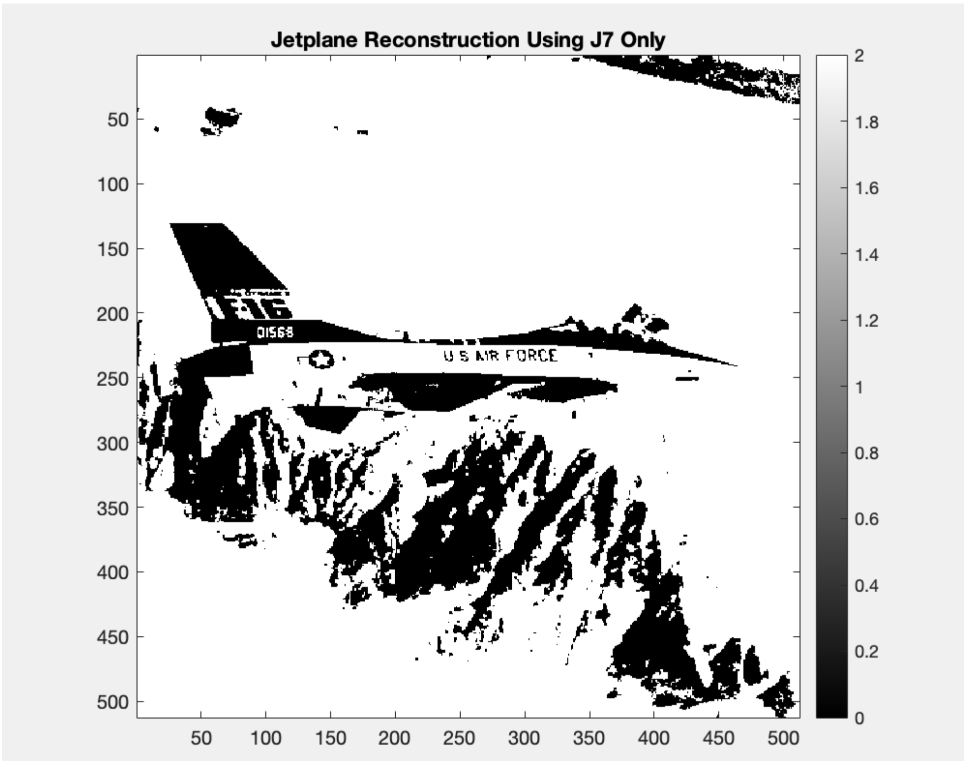
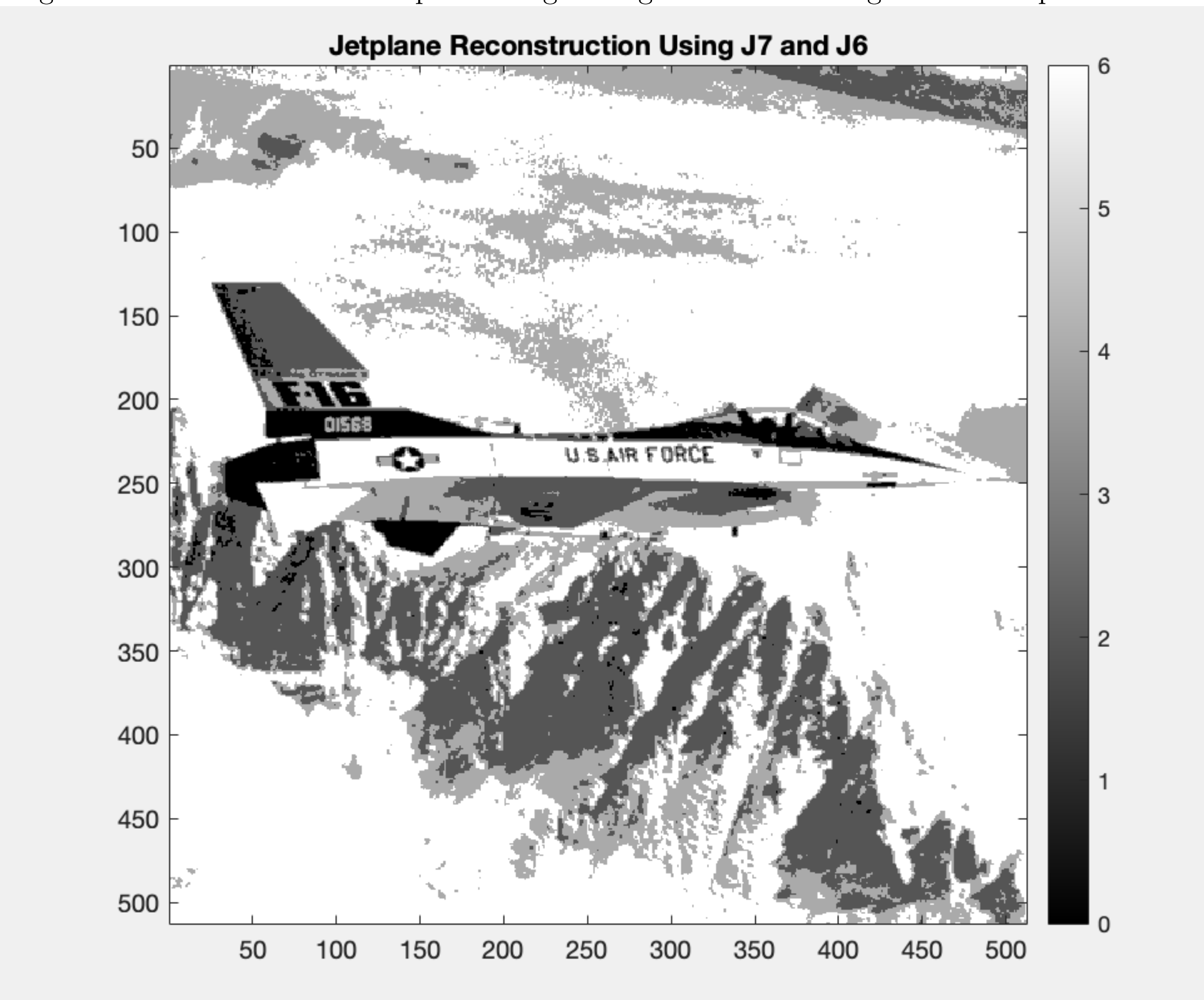


Figure 7: Reconstruction of Jetplane Image Using the Most Significant Bit-Planes

Figure 8: Reconstruction of Jetplane Image Using the two Most Significant Bit_planes



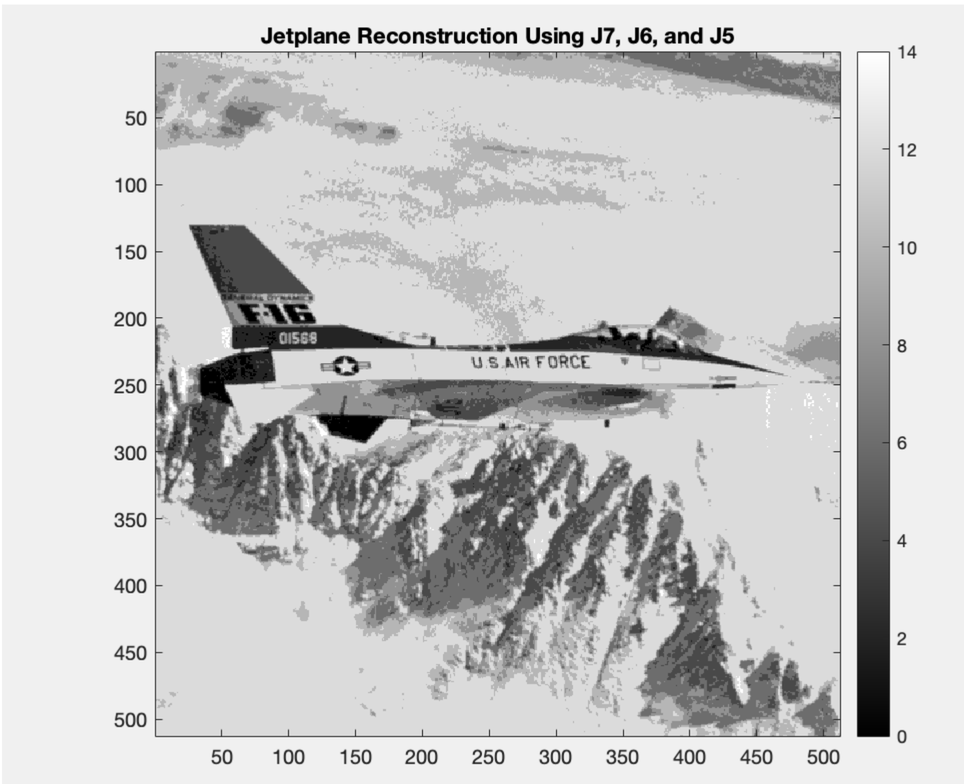


Figure 9: Reconstruction of Jetplance using (J_5 to J_7

Conclusion

Bit-plane slicing is an effective technique for analyzing the contribution of individual bits to an image. The results demonstrate that higher bit-planes contribute significantly to image detail, while lower bit-planes primarily capture noise. Reconstructing images using significant bit-planes improves visual quality and retains important features.

Exercise 4: Effects of Division and Inversion on Intensity Histogram

Explanation:

- **Division:** Division reduces the intensity values, compressing the histogram toward lower intensities. This operation lowers contrast as the range of pixel values narrows.
- **Inversion:** Inversion flips the intensity values, reversing the histogram along the intensity axis. Bright regions become dark, and dark regions become bright.

Exercise 5: Histogram Equalization of Cameraman Image

Steps:

1. The histogram, PDF, and CDF of the original cameraman image were calculated.
2. An intensity mapping function was generated using the CDF.
3. The equalized image was created by applying the mapping.
4. The histogram, PDF, and CDF of the equalized image were calculated for verification.

Observations:

- The original histogram had a narrow range, indicating low contrast.
- Equalization redistributed intensities across the full range, improving contrast.
- The output PDF may not be perfectly uniform due to the discrete nature of intensity levels and image-specific distributions.

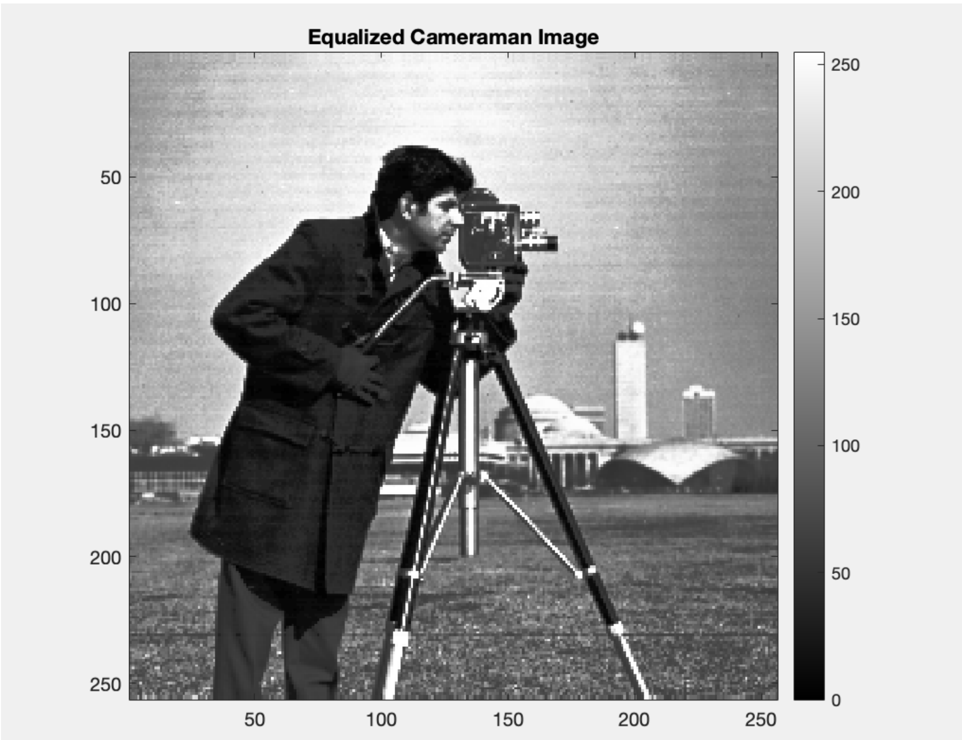


Figure 10: Equalization for Cameraman Image

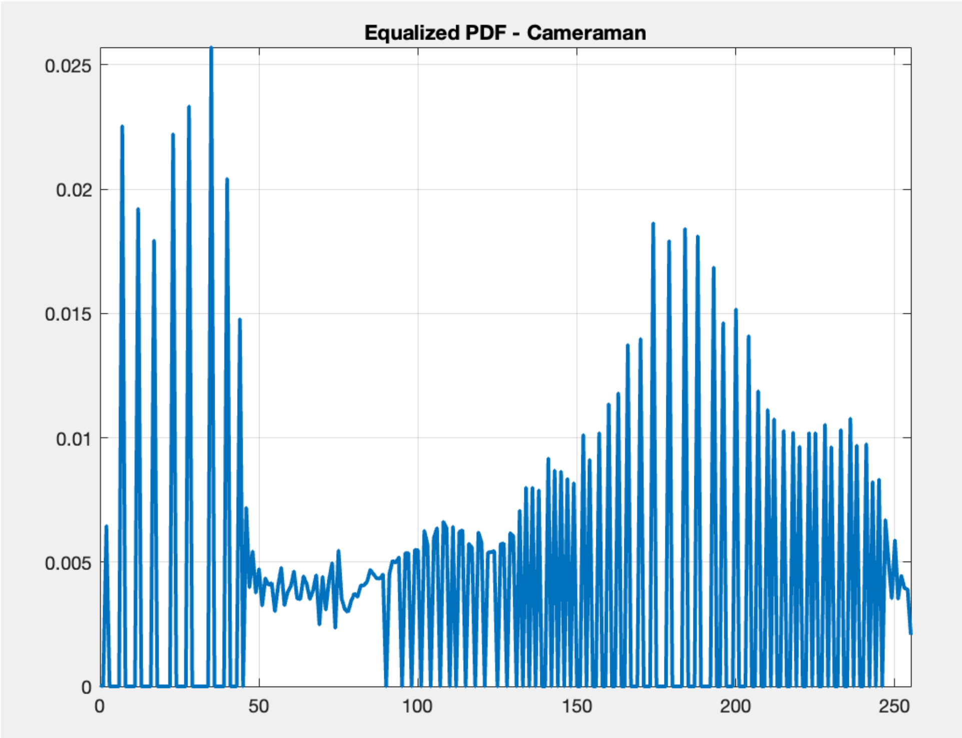


Figure 11: Histogram Equalization

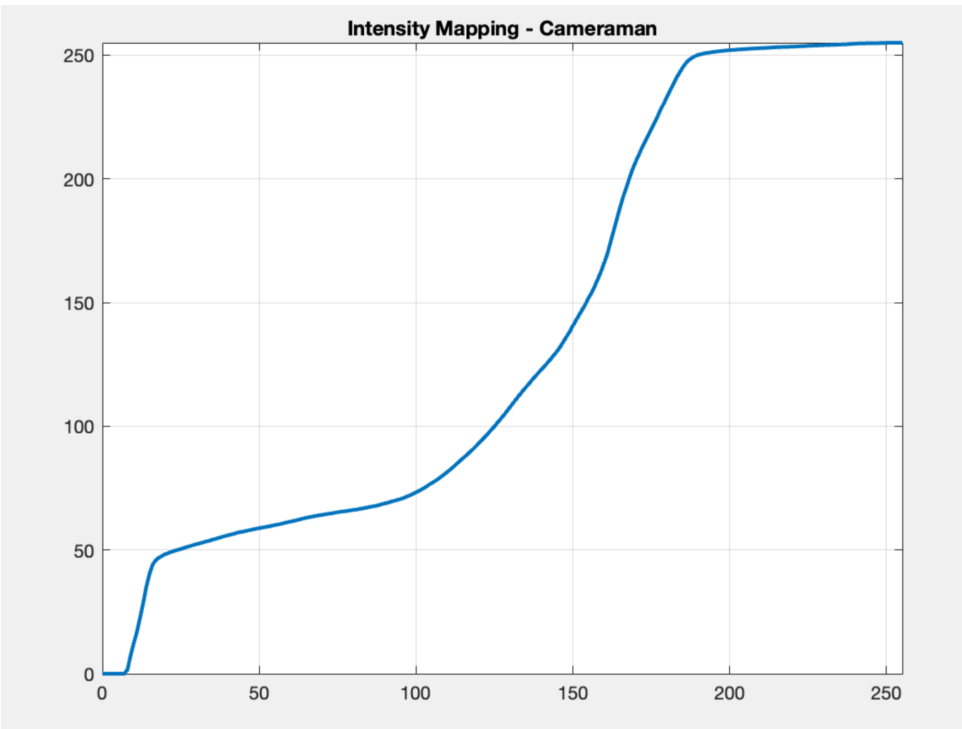


Figure 12: Intensity Mapping