

IPCV Practical No : 3

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Aim

To study and implement Histogram Modeling techniques (Equalization, Stretching, and Specification) for image enhancement.

Requirements

- Python 3.x
- OpenCV (cv2)
- NumPy (numpy)
- Matplotlib (matplotlib.pyplot)
- Input grayscale or color image

Theory

Histogram and Image Histogram

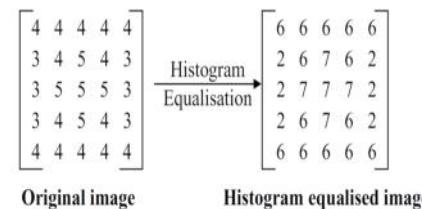
- A **histogram** is a graphical representation of the distribution of pixel intensity values in an image.
- For grayscale images, intensity values range from **0 (black)** to **255 (white)**.
- The histogram indicates **how many pixels belong to each intensity level**.

Histogram Analysis

- If histogram is **centered on the left** → Image is **dark**.
- If histogram is **centered on the right** → Image is **bright/white**.
- If histogram is **narrow and centered** → **Low contrast image** (fewer gray levels).
- If histogram is **evenly distributed across full range** → **High contrast image**.

Histogram Equalization

- **Histogram equalization** is an image processing technique that adjusts the pixel values of an image to enhance its contrast and visibility
- There are two types of histogram equalization:
 - **Global histogram equalization**: Enhances the contrast of the entire image
 - **Local histogram equalization**: Enhances details in an image by applying different transformations to the same gray level at different locations in the image



Applications of Histogram Equalization

- **Medical Imaging**: Enhances X-rays, MRIs, CT scans for better diagnosis.
- **Satellite and Remote Sensing**: Improves visibility of Earth surface details.
- **Computer Vision**: Enhances contrast for object detection and recognition.
- **Photography & Editing**: Adjusts brightness and contrast in under/overexposed images.
- **Historical Image Restoration**: Improves old/damaged photo readability.
- **Astronomy**: Highlights details in celestial objects.

Histogram Stretching

- Also called **contrast stretching**.
- Linearly spreads intensity values over the full range [0–255].
- Example: If values are between 80–120, stretching expands them to 0–255.
- Improves **visual contrast** but is linear (unlike equalization which is nonlinear).

Histogram Specification (Matching)

- Adjusts histogram of one image so it matches a **reference image's histogram**.
- Works like equalization, but instead of making histogram flat, it makes it resemble the **target histogram**.

Use Cases

- Matching photo tones in a dataset for uniformity.
- Medical imaging: Normalizing brightness/contrast across scans.
- Photography/Cinematography: Ensuring consistent "style" between shots.

Steps for Histogram Specification

1. Compute histogram & CDF of input image.
2. Compute histogram & CDF of reference/target image.
3. For each input pixel intensity:
 - Map using its own CDF.
 - Find the closest matching intensity in target CDF.

- o Replace with matched value.

Steps to Perform

1. Import cv2, numpy, and matplotlib.
2. Load an input image and convert it to grayscale.
3. Plot original image and histogram.
4. Apply **Histogram Equalization** (cv2.equalizeHist()) and plot histogram.
5. Apply **Histogram Stretching** (linear normalization).
6. Perform **Histogram Specification** with a reference image.
7. Compare results (original vs processed images and histograms).

Expected Output

- **Original Image & Histogram:** May show low contrast or biased distribution.
- **Equalized Image & Histogram:** Spread over full range [0–255], better contrast.
- **Stretched Image & Histogram:** Linearly expanded range, improved contrast.
- **Histogram Matched Image:** Tone and contrast similar to reference image.

Conclusion

- Histogram gives valuable insight into brightness, contrast, and distribution of image pixels.
- **Histogram Equalization** enhances contrast non-linearly and is useful in many domains like medical imaging, satellite processing, and astronomy.
- **Histogram Stretching** linearly expands pixel range, improving visual contrast.
- **Histogram Specification** modifies an image's histogram to match another image, useful in medical imaging and style matching.
- Thus, **Histogram Modeling** (Equalization, Stretching, and Specification) is a key image enhancement technique in digital image processing.