

Homework 09

Histogram Matching: Built-in and Custom Implementations

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1 Introduction

Histogram matching (also called histogram specification) is a technique in digital image processing where the intensity distribution of a source image is transformed so that it matches the histogram of a reference image. In this assignment we explore three methods:

1. Built-in function from the `scikit-image` library
2. Custom method 1: CDF-based LUT with argmin search
3. Custom method 2: CDF-based LUT with interpolation

Code Link

The full code implementation is available here: [Click here for the code](#)

2 Applying Built-in Function

The built-in method uses the function `exposure.match_histograms()` from `scikit-image`. This function computes the cumulative distribution function (CDF) of both source and reference images, and remaps pixel values accordingly. It works for both grayscale and multi-channel images.

3 Applying Two Custom Functions

Custom Method 1: CDF–Argmin LUT

For each source graylevel, we compute its CDF value and find the reference graylevel whose CDF value is closest. This builds a look-up table (LUT), which is applied to remap all pixels of the source image.

Custom Method 2: CDF–Interpolation LUT

Instead of argmin search, we directly interpolate using `numpy.interp` to map source CDF values into the reference CDF domain. This produces a smoother mapping and avoids staircase

artifacts.

4 Analyzing the Results

The results of both custom methods are compared with the built-in method. We analyze:

- Visual similarity of the matched image to the reference
- Alignment of histograms (source vs. matched vs. reference)
- Smoothness of intensity mapping (argmin may produce banding; interpolation is smoother)

5 Observing Effect of Source Contrast

We study the effect of histogram matching when the **source image** has low, normal, or high contrast.

- Low contrast source → matched image expands its tonal range
- High contrast source → matched image compresses tonal extremes
- Normal contrast source → only minor tonal shifts occur

6 Observing Effect of Reference Contrast

We also vary the **reference image contrast**:

- Low contrast reference → matched image becomes low contrast
- High contrast reference → matched image becomes highly stretched
- Normal contrast reference → matched image balanced

7 Results: Nine Contrast Combinations

Below we present the nine combinations of source (low, normal, high) and reference (low, normal, high). Each output image corresponds to one case.

8 Conclusion

We demonstrated histogram matching using a built-in library and two custom implementations. The analysis shows:

- All three methods align source histograms with reference histograms
- The interpolation-based custom method produces smoother mappings
- Source and reference contrast both strongly influence the matched image

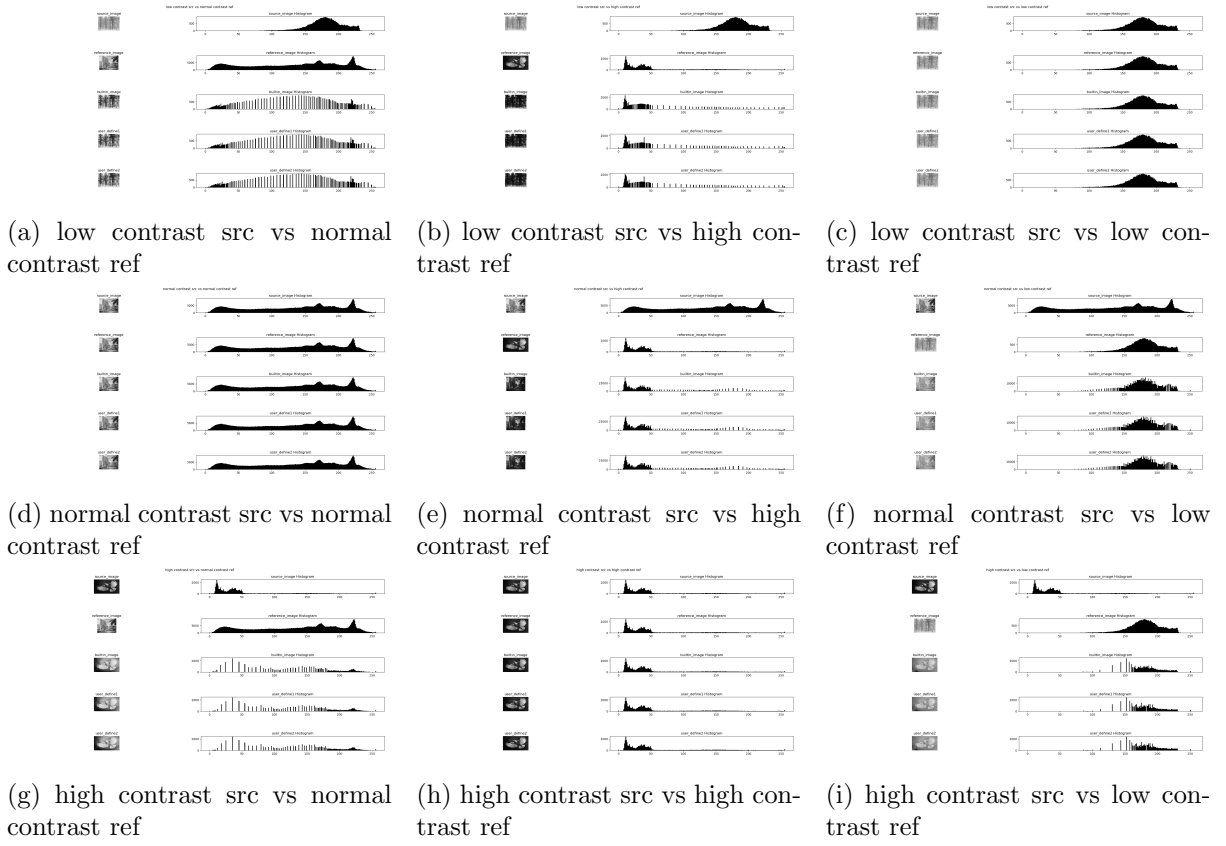


Figure 1: Histogram matching outputs across all nine source-reference contrast combinations.