

Real-world implementation is essential in computer vision. This first homework will help you gain familiarity with MATLAB programming environment. You are asked to implement three simple vision algorithms below. Your code must be clearly structured and well-commented.

Gray-scale images each pixel has a single intensity on [0:255].

Post the code and resulting images when the exercise asks you to generate some new image.

1. **Matlab Warmup** You are given a image http://cs.gmu.edu/~kosecka/cs482/images/notes_color.jpg. Do the following in Matlab, while avoiding to use loops:

- Load the above image and resize the image by factor of 4 (use help `resize`);
- Create a new gray level image (help `rgb2gray`);
- Display histogram of gray level image intensities with 20 bins. (help `hist` or `imhist`);
- Create binary image by setting all the pixels which have intensity greater than 125 to 255 and less than 125 to 0. (help `find`) Use the histogram of the gray level image to choose (by hand) better threshold to make the notes in the binary image readable;
- Create a negative of the obtained gray level image;
- Create color image of the same size as original resized binary image, but make the notes appear red. This can be achieved by setting the red channel to its maximal value, while making blue and green channel 0. The white color pixel has values [255, 255, 255].

2. **Histogram Equalization** Often, we encounter an image whose dynamic range (ie: contrast) is compressed (see Figure 2). For example, in an 8-bit gray-scale image, only a narrow range of the 256 possible intensity values might be used. In that case, an image can contain a significant amount of detail that is not apparent visually. One approach for enhancing detail is called histogram equalization. It is straightforward to perform. First, we generate a histogram H of the intensities in the image. Specifically, we have one bin for each intensity 0-255. The value in each bin is the number of pixels in the image with that intensity. Second, we normalize the histogram such that the sum of the 256 values in bins 0-255 is 255. Third, we generate a second histogram H' where $H'[i] = \sum_{0 \leq j \leq i} H[j]$ for all $0 \leq i \leq 255$. Finally, `destination_image[x, y] = H'[source_image[x, y]]`. Implement the transform on the image <http://cs.gmu.edu/~kosecka/cs682/images/landsat.jpg>. Submit your result as a PNG and the source code you used to generate it. An example of histogram equalization (on a different image) is at the end of this document. FAQ: It is helpful to keep floating-point precision until you write the new image in the last step. Otherwise, integer rounding will throw you off.

3. **Contrast Stretching** Another approach to detail enhancement in the face of dynamic range compression is contrast stretching. Contrast stretching is even easier than histogram equalization: `destination_image[x, y] = (source_image[x, y] - image_min)*255/(image_max - image_min)` where `image_min` and `image_max` are the minimum and maximum intensity values present in the image. Implement the transform on the image <http://cs.gmu.edu/~kosecka/cs682/images/landsat.jpg>. Submit your result as a PNG and the source code you used to generate it.

4. **Rigid Body Transformations** Consider rigid body transformations in the plane. Draw a right triangle defined by three points $A = (2, 1), B = (4, 1), C = (4, 6)$.

- Consider a rotation matrix

$$T_1 = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix}$$

- a. What is the determinant of the matrix ?
 - b. Apply the rotation matrix to the triangle and show the result.
 - Consider transformation matrix
$$T_2 = \begin{bmatrix} \sin \theta & \cos \theta \\ \cos \theta & -\sin \theta \end{bmatrix}$$
- a. What is the determinant of the matrix ?
- b. Apply the transformation matrix to the triangle and show the result. Is T_2 rigid body transformation (i.e. can you move the triangle from initial position to the final without leaving the plane ? What is the difference between T_1 and T_2 , how are the results different?
5. **Rigid body transformations composition** Suppose that you are given the relative displacement between the coordinate frame $\{1\}$ and $\{2\}$, $g_{21} = (R_{21}, T_{21})$ expressed in the frame $\{1\}$ and relative displacement between the frame $\{3\}$ and the frame $\{2\}$ expressed in the frame $\{3\}$, and denoted by $g_{23} = (R_{23}, T_{23})$. What is the relative displacement g_{31} , between the frame $\{1\}$ and frame $\{3\}$ expressed in the frame $\{1\}$? a) Draw a figure; and write g_{31} in terms of given transformations/displacements. b) Write down explicitly what is the rotational and translational part of g_{31} , in terms of given rotations R_{ij} and $T'_{ij}s$.

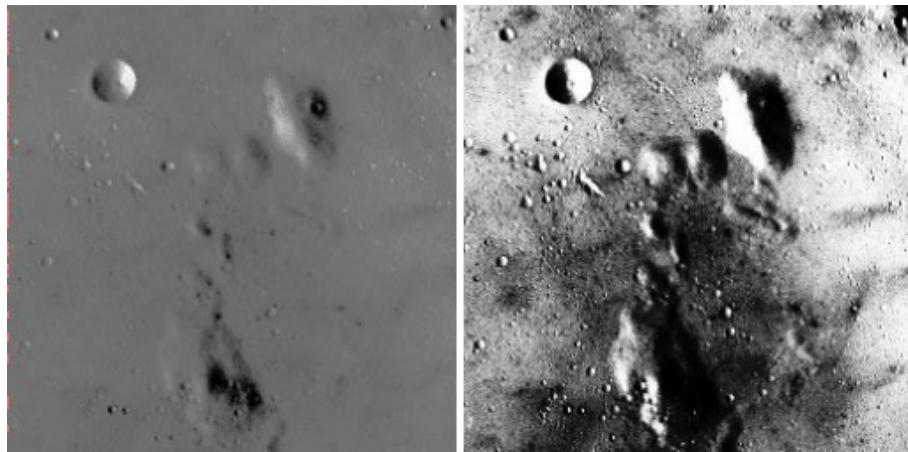


Figure 1: Histogram equalization: before and after