IT523: Digital Image Processing
Lab - 2: Histogram Equalization & Spatial Filtering

Read Help for: `imhist`, `histeq`, `conv`, `convn`, `pinv`.

1. Write a MATLAB function `mybitplane.m` that extracts all 8 bit planes of any input gray scale image I. Show the original image and all bit planes using subplot command. Now use the binary image `daiict.bmp` as a watermark and replace the i^{th} bit plane of the image `lena.jpg` and reconstruct the gray scale image J_i for $1 \leq i \leq 8$. Show each J_i using subplot and comment on the reconstructed image J_i.

2. Write a program `my_histeq.m` that applies histogram equalization on any input gray scale image. The user may specify the number of bins N over which you need to carry out histogram equalization. Compare your result with that of `histeq.m`.

3. Implement `my2Dconv.m` that takes two 2D arrays h and f as an input and outputs $y = h * f$ as the output. Assume that the image is zero(black) outside the domain.

4. Let us derive some popular convolution masks. We can denote the image over a 3×3 neighborhood centered at the origin by

$$\begin{bmatrix} f(-1,-1) & f(-1,0) & f(-1,1) \\ f(0,-1) & f(0,0) & f(0,1) \\ f(1,-1) & f(1,0) & f(1,1) \end{bmatrix}$$

   Assume that the above given gray values are actually the recorded height of a plane using a noisy measurement device (at those points). The equation of the actual plane is given as

$$g(x,y) = a + bx + cy.$$

   We can write $f(x,y) = g(x,y) + \eta(x,y)$.
   For every 3×3 neighborhood, we can estimate the values of the parameters a, b, c using the given 9 measurements using the least square method. We can collect the 9 height observations into a column vector F and similarly the original height values into a column vector G, and write

$$F = G + \eta = X\beta + \eta \tag{1}$$

   where $\beta = (a,b,c)^t$ and η are column vectors and X is a 9×3 matrix.

   (a) Solve the following least square problem

$$\beta^* = \text{argmin}_\beta \left(||F - X\beta||^2 \right)$$

   by differentiating $||F - X\beta||^2$ with respect to β and setting the differential to zero. You can use MATLAB for computation.

(b) Arrange the solution as three 3×3 convolution masks.

(c) Solve the above questions if errors are weighted according to the following pattern:

$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

(d) Convolve the image `lena.jpg` with the six masks derived and show the results and comment on them.

Submission instructions

1. Write a report with answers, plots and figures (under corresponding question number), only in LaTeX.

2. Name your report as `Id_No_Lab2.pdf`. Submit only a single zip file per group (named `ID_No_Lab1`) containing following files and folder: `mybitplane.m`, `myhisteq.m`, `my2Dconv.m` and `Report_IDno` (containing `IDno_Lab2.tex` and other required files for compilation, for example image files.) on `courses.daiict.ac.in`. Email submissions will **not** be accepted under any circumstances.

3. Your report and code should contain names and Id numbers of your group members. In the report title specify what software/language/tool you have used to write codes: MATLAB/C++ OpenCV/C++ CImg/Octave.

4. Do not include codes in the report and comment your code properly.

5. **Submission deadline: 21:00 hrs, Tuesday,** 4^{th} **February, 2014**. The deadline on the Moodle webpage behaves as a random variable, so make sure you submit well in advance.