EQ2330 – Image and Video Processing

Exercise #1: Point Operations

Most of the problems are taken from R. C. Gonzales and R.E. Woods. *Digital Image Processing*, (second ed.), Prentice Hall, Upper Saddle River, New Jersey, 2002.

Problems to be solved in the classroom

1. **Problem 2.7 and 2.8** Suppose that a flat area with center at (x_0, y_0) is illuminated by a light source with intensity distribution

$$i(x, y) = Ke^{-[(x-x_0)^2+(y-y_0)^2]}. \tag{1}$$

   Assume for simplicity that reflectance of the area is constant and equal to 1.0, and let $K = 255$. If the resulting image is digitalized with k bits of intensity resolution, and the eye can detect an abrupt change of eight shades of intensity between adjacent pixels, what value of k will cause visible false contouring? Sketch the image for $k = 2$.

2. **Problem 3.5** Explain why the discrete histogram equalization technique does not, in general yield a flat histogram.

3. **Problem 3.6** Suppose that a digital image is subject to histogram equalization. Show that second pass of histogram equalization will produce exactly the same result as the first pass.

4. **Problem 3.10** An image has the gray level PDF $p_r(r)$ shown in the following diagram (see figure 1). It is desired to transform the gray levels of this image so that they will have the specified $p_z(z)$ shown. Assume continuous quantities and find the transformation (in terms of r and z) that will accomplish this.

5. A gray level image has a histogram shown in Figure 2. You approximate the histogram with a continuous function.

$$h(x) = \begin{cases} \frac{exp(1-x)-1}{a} & 0 \leq x \leq 1 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

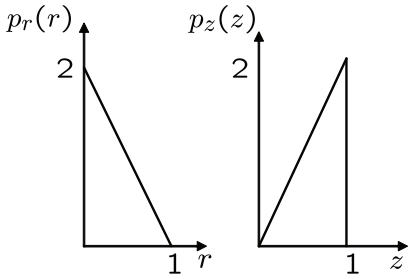

Figure 1: Histograms in Problem 3.10.

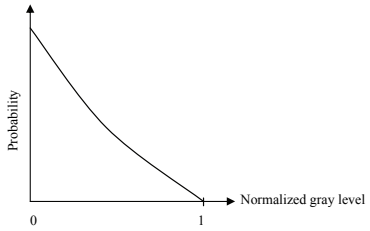

Figure 2: Gray level distribution.

(i) Describe the characteristics of the image.

(ii) What is the value of a that ensures that $h(x)$ is a probability density function?

(iii) It is desirable to transform the image such that the resulting image has a more uniform histogram. Derive a transformation that will accomplish the desired equalization for a continuous variable.

(iv) Sketch the transformation function and argue why it should have the indicated shape. *Note that it is possible to sketch and argue without having solved subproblem ii)*

(v) Assume that the image is digitalized with 256 gray levels, and you apply the discrete version of the histogram equalization method to it. Sketch the histogram of the equalized image. Explain the difference compared to the theoretical result obtained using the continuous version of the transform. State your assumptions.