CS270 Digital Image processing
Homework 1
Due date: Oct 9th, 2018

1. Suppose that a flat area is illuminated by a light source with intensity distribution

$$i(x,y) = K \cdot 10^{-(x^2+y^2)^{\frac{1}{2}}}$$

If the reflectance characteristic of the area is

$$r(x,y) = \frac{1}{x^2+y^2}$$

What is the value of *K* that would yield an image intensity of 1 at (*x*=6, *y*=8)?

2. There are one thousand 1024*768 images with 256 gray levels.
   (1) calculate the capacity (megabyte) that is required to store these images
   (2) A common measure of transmission for digital data is the ***baud rate***, defined as the number of bits transmitted per second. Generally, transmission is accomplished in packets consisting of a start bit, a byte of information, and a stop bit. Calculate the time that is required to transmit these 1000 images at 9600 baud.

   **Note: 1byte = 8 bits**

3. A CCD camera chip of dimensions 14*14mm, and having 2048*2048 elements, is focused on a square flat area, located 0.5m away. What is the spatial resolution that this camera will be able to resolve? The camera is equipped with a 35-mm lens. (Hint: Model the image process as in Fig 2.3).

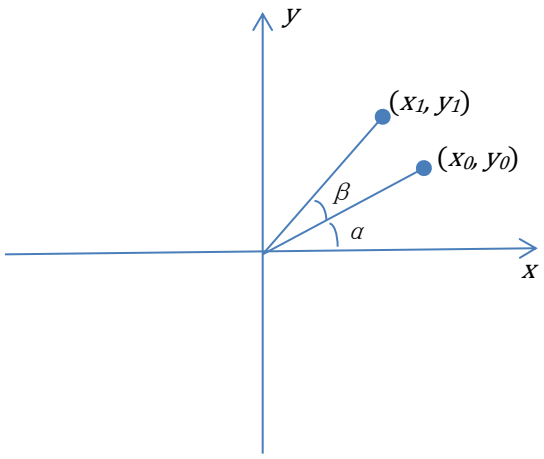
4. V ={1,2,3}, mark the shortest 4-, 8-, m-path between P and Q, and calculate $D_4$, $D_8$, $D_m$ from P to Q respectively.

| | | | | |
|---|---|---|---|---|
| 5 | 2 | 2 | 1 | (Q)2 |
| 2 | 3 | 6 | 3 | 6 |
| 1 | 0 | 3 | 2 | 5 |
| (P)3 | 2 | 4 | 5 | 2 |
| 1 | 5 | 3 | 4 | 0 |

5. Derive the rotation operation equation

$$\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \begin{bmatrix} cos\beta & -sin\beta & 0 \\ sin\beta & cos\beta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_0 \\ y_0 \\ 1 \end{bmatrix}$$

according to the figure as below



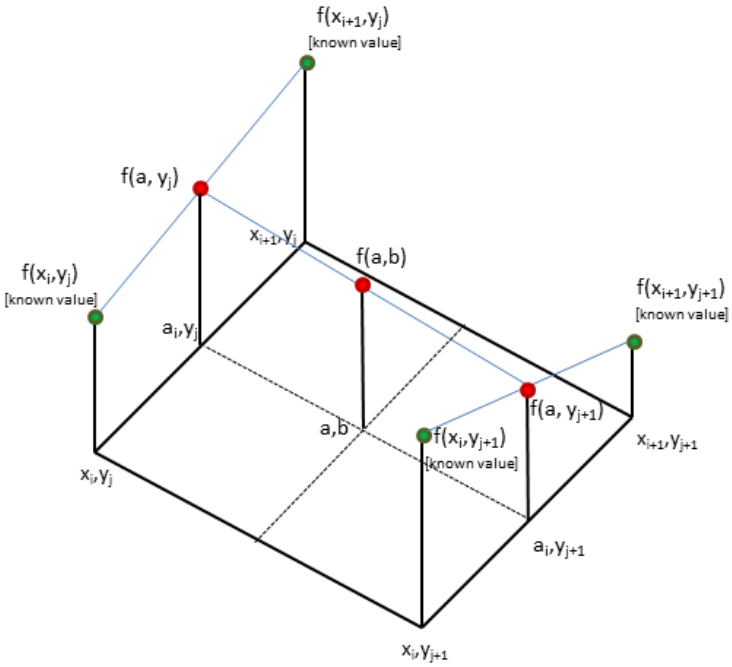

6. Let the original image is $f(x,y)$, the transformed image is $g(x,y)$. If rotate $f$ counter-clockwise 30 degrees around the pixel $f(2,2)$ to get $g$, then
   Forward mapping is $g = T \cdot f$
   Inverse mapping is $f = T^c \cdot g$
   Derive the transformation matrix $T$ and $T^c$

7. Find the bilinear interpolation value of $f(a,b)$ using 4 nearest neighbours as shown in the figure. Denote:

$$f_{00} = f(x_i,y_j) \quad f_{10} = f(x_{i+1},y_j) \quad f_{01} = f(x_i,y_{j+1}) \quad f_{11} = f(x_{i+1},y_{j+1}),$$

$$x_{i+1}=x_1 \quad x_i=x_0 \quad y_{j+1}=y_1 \quad y_j=y_0 \quad x_{i+1}-x_i=1 \quad y_{j+1}-y_j=1$$

   Use $f_{00}, f_{10}, f_{01}, f_{11}, x_1, x_0, y_1, y_0$ to describe $f(a,b)$




8. If the image in Problem 6, $f(x,y) = \begin{bmatrix} 0 & 8 & 10 & 5 & 8 & 7 \\ 1 & 5 & 7 & 8 & 10 & 6 \\ 5 & 4 & 2 & 11 & 9 & 8 \\ 3 & 6 & 2 & 3 & 5 & 9 \\ 2 & 3 & 6 & 9 & 12 & 11 \\ 1 & 4 & 0 & 15 & 13 & 14 \end{bmatrix}$ $(0 \le x, y \le 5)$, use the method in Problem 6&7, calculate the gray value of *g*(3,3).