ECSE 4540 Image Processing

HW 2

Feb 4, 2018
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%% ===================================2.1======================================
```

Main Function

```
%% 1a
im1a=ones(1,500)'*0*ones(1,125);
im1b=ones(1,500)'*128*ones(1,125);
im1c=ones(1,500)'*255*ones(1,250);
im1 =horzcat(im1a,im1b,im1c);
imshow(im1,[0,255]);
%% 1b
im2a=ones(1,125)'*0*ones(1,500);
im2b=ones(1,125)'*128*ones(1,500);
im2c=ones(1,250)'*255*ones(1,500);
im2 =vertcat(im2a,im2b,im2c);
imshow(im2,[0,255]);
%% 1c
im3 = zeros(500,500);
im3(:,1:250)=128;
im3(1:250,:)=255;
imshow(im3,[0,255]);
%% 1d
im4 = zeros(500,500);
im4(1:250,:)=128;
im4(:,1:250)=255;
imshow(im4,[0,255]);
```

Matlab Result

1a

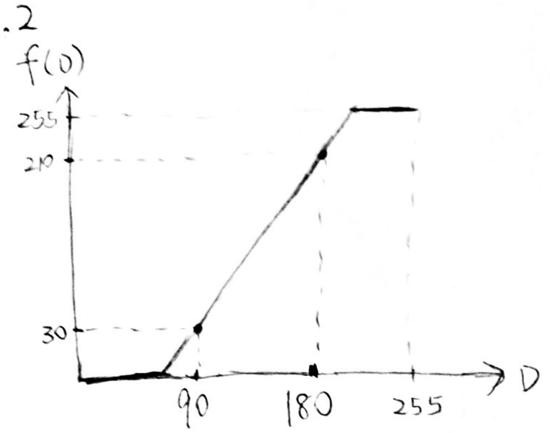
1b

1c

1d

If each of these images were blurred using an averaging filter, histograms would become **different** since the edges have different length and different color combination in different *p(D)* configuration. For example, If one initially has black and white, white and grey edge, after the filter, the resulting histogram would be different than one has grey and black, black and white edge.

2.2



$$\begin{cases} 30 = k \cdot 90 + b \\ 210 = k \cdot 180 + b \end{cases}$$

$$\Rightarrow \begin{cases} k = 2 \\ b = -150 \end{cases}$$

$$f(D) = 2 \cdot D - 150$$

largest mapped to 0:

$$0 = 2D - 150 \Rightarrow \boxed{D = 75}$$

Smallest mapped to 255:

$$255 = 2D - 150 \Rightarrow D = 202.5 = \boxed{203}$$

2.3

$$\text{Total \# of pixels} = \sum_{n=0}^{255} (2n+1) = \frac{[(2(0)+1) + (2(255)+1)]\,256}{2}$$

$$= (1+510) \cdot 128 = 65408$$

$$h(D) = \frac{2 \cdot D + 1}{65408}$$

$$f(100) = \int_0^{100} \frac{2 \cdot x + 1}{65408}\,dx$$

% of pixels have intensity 100 or less

$$= 0.154415$$

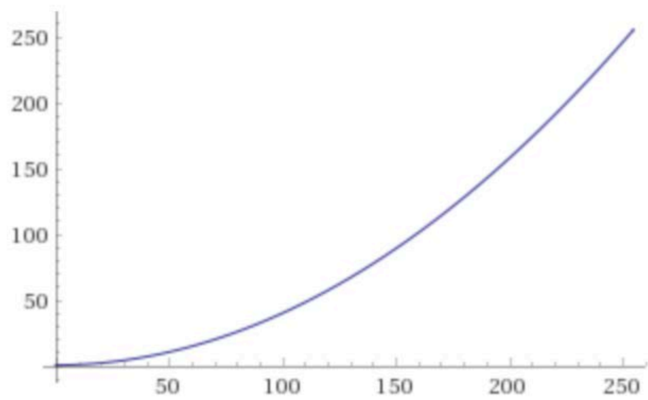
$$255 \cdot f(100) = 39.37 = \boxed{39}$$

New intesity mapped from 100

$$F(D) = 255 \cdot \int \frac{2 \cdot D + 1}{65408}\,dD$$

$$\approx 0.003899(D^2 + D)$$

$$\boxed{F(D) = 0.003899 \cdot (D^2 + D)}$$



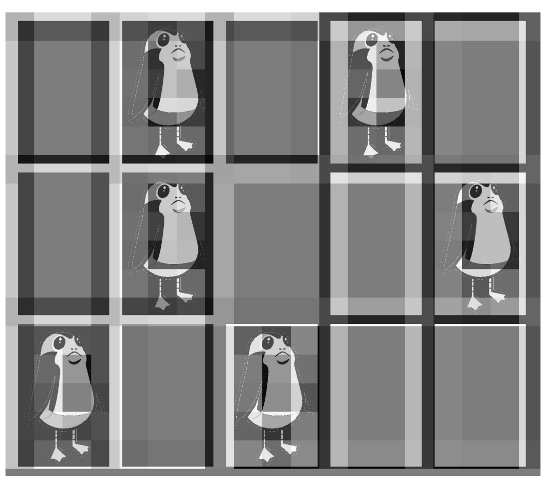
```
%% ==================================2.4=====================================
```

Main Function

```
%% 4a
im4 = imread('mystery2.png');
out = histeq(im4);
imshow(out);
%% 4b
bs = @(block_struct) histeq(block_struct.data);
out2 = blockproc(im4, [80 80], bs);
imshow(out2);
```

Matlab Result

4a



4b

The local histogram equalization gives us a much clearer output than the global histogram equalization. Global histogram equalization focuses on the whole picture and tries to even out the color pixels distribution, which also included the non-desire, content such as the edges around the penguins. On the other hand, Local histogram equalization will only focus on the desire areas thus we get what we want to see.

2.5

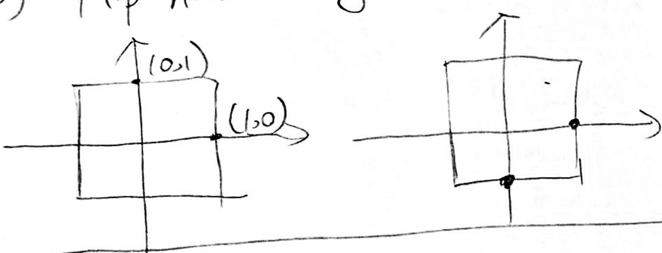
a) Clockwise $\theta = 30°$

$$\begin{bmatrix}1\\0\end{bmatrix} \rightarrow \begin{bmatrix}\cos 30°\\-\sin 30°\end{bmatrix}$$

$$\begin{bmatrix}0\\1\end{bmatrix} \rightarrow \begin{bmatrix}\sin 30°\\\cos 30°\end{bmatrix}$$

$$\boxed{\begin{bmatrix}x'\\y'\end{bmatrix} = \begin{bmatrix}\cos 30° & \sin 30°\\-\sin 30° & \cos 30°\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix}}$$

b) Flip horizontally



$$\begin{bmatrix}1\\0\end{bmatrix} \rightarrow \begin{bmatrix}1\\0\end{bmatrix}$$

$$\begin{bmatrix}0\\1\end{bmatrix} \rightarrow \begin{bmatrix}0\\-1\end{bmatrix}$$

$$\boxed{\begin{bmatrix}x''\\y''\end{bmatrix} = \begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}\begin{bmatrix}x'\\y'\end{bmatrix}}$$

Together: $$\begin{bmatrix}x''\\y''\end{bmatrix} = \begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}\begin{bmatrix}\cos 30° & \sin 30°\\-\sin 30° & \cos 30°\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix}$$

$$= \begin{bmatrix}\cos 30° & \sin 30°\\-\sin 30° & -\cos 30°\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} = \boxed{\begin{bmatrix}\frac{\sqrt{3}}{2} & \frac{1}{2}\\\frac{1}{2} & -\frac{\sqrt{3}}{2}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix}}$$

If order switched: $$\begin{bmatrix}\cos 30° & \sin 30°\\-\sin 30° & \cos 30°\end{bmatrix}\cdot\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}$$

$$= \boxed{\begin{bmatrix}\frac{\sqrt{3}}{2} & -\frac{1}{2}\\-\frac{1}{2} & -\frac{\sqrt{3}}{2}\end{bmatrix}}$$

No, answers are not the same, different operation matrix than before switching order.

2.6

$$x' = Ax + b$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} a & c \\ b & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} a & c \\ b & d \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix}$$

$$\begin{bmatrix} -1 \\ 0 \end{bmatrix} = \begin{bmatrix} a & c \\ b & d \end{bmatrix} \begin{bmatrix} -1 \\ 1 \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix}$$

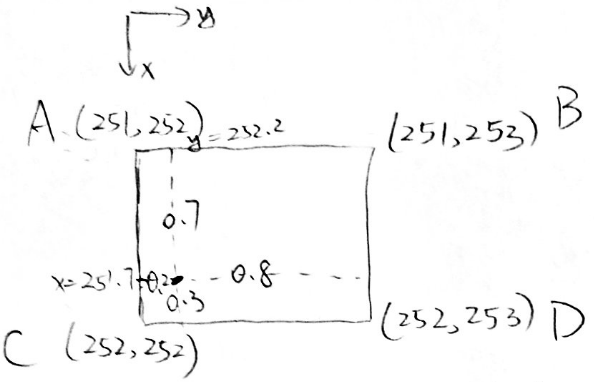
$$\begin{bmatrix} 2 \\ 0 \end{bmatrix} = \begin{bmatrix} a & c \\ b & d \end{bmatrix} \begin{bmatrix} 1 \\ -1 \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix}$$

$$\begin{cases} 0 = a + c + e \\ 1 = b + d + f \\ -1 = -a + c + e \\ 0 = -b + d + f \\ 2 = a - c + e \\ 0 = b - d + f \end{cases} \Rightarrow \text{Solve using calculator} \quad \begin{cases} a = \frac{1}{2} \\ b = \frac{1}{2} \\ c = -1 \\ d = \frac{1}{2} \\ e = \frac{1}{2} \\ f = 0 \end{cases}$$

$$\therefore A = \begin{bmatrix} a & c \\ b & d \end{bmatrix} = \boxed{\begin{bmatrix} \frac{1}{2} & -1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}}$$

$$b = \begin{bmatrix} e \\ f \end{bmatrix} = \boxed{\begin{bmatrix} \frac{1}{2} \\ 0 \end{bmatrix}}$$

2.7



$$I(251,252) = 255\, e^{-\left(\frac{(251-250)^2 + (252-250)^2}{10^2}\right)} = 243 \quad A$$

$$I(251,253) = 255\, e^{-\left(\frac{(251-250)^2 + (253-250)^2}{10^2}\right)} = 231 \quad B$$

$$I(252,252) = 255\, e^{-\left(\frac{(252-250)^2 + (252-250)^2}{10^2}\right)} = 235 \quad C$$

$$I(252,253) = 255\, e^{-\left(\frac{(252-250)^2 + (253-250)^2}{10^2}\right)} = 224 \quad D$$

Bilinear interpolation:

$$= 0.8 \cdot 0.3 \cdot A + 0.2 \cdot 0.3 \cdot B + 0.7 \cdot 0.8 \cdot C + 0.2 \cdot 0.7 \cdot D$$

$$= 0.24 \cdot 243 + 0.06 \cdot 231 + 0.56 \cdot 235 + 0.14 \cdot 224$$

$$= \boxed{235}$$