Assignment 1
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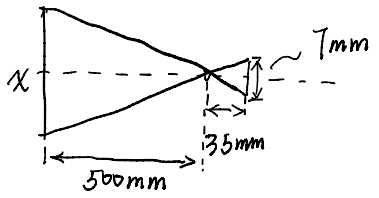
1.



$$\frac{x}{500} = \frac{7}{35}$$

$$x = 100mm$$

So there are $\frac{1024}{100} = 10$ lines per mm

number of line pairs per mm = 5 lp/mm

2.

$$\begin{bmatrix} Cx & 0 & 0 \\ 0 & Cy & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ tx & ty & 1 \end{bmatrix} = \begin{bmatrix} 0.25 & 0.433 & 0 \\ -0.2598 & 0.15 & 0 \\ 50 & 75 & 1 \end{bmatrix}$$

$$\begin{bmatrix} Cx\cos\theta & Cx\sin\theta & 0 \\ -Cy\sin\theta & Cy\cos\theta & 0 \\ tx & ty & 1 \end{bmatrix} = \begin{bmatrix} 0.25 & 0.433 & 0 \\ -0.2598 & 0.15 & 0 \\ 50 & 75 & 1 \end{bmatrix}$$

$$\tan\theta = \frac{Cx\sin\theta}{Cx\cos\theta} = \frac{0.433}{0.25} = 1.732$$

∴ Rotation Angle $\theta = 60°$

Scaling: $Cx = \frac{0.25}{\cos 60°} = 0.5$

$Cy = \frac{0.15}{\cos 60°} = 0.3$

translation: $tx = 50$

$ty = 75$

3. $P_r(r) = \begin{cases} 2-2r, & 0 \le r \le 1 \\ 0, & \text{otherwise} \end{cases}$, $P_z(z) = \begin{cases} 2r, & 0 \le r \le 1 \\ 0, & \text{otherwise} \end{cases}$

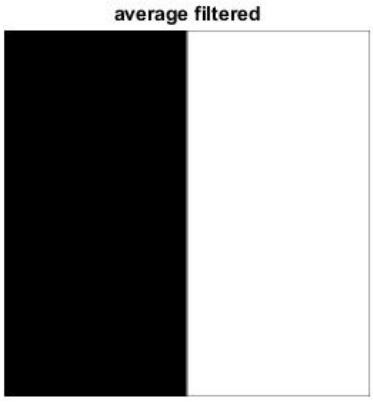
∴ $S = T(r) = \int_0^r P_r(w)\,dw = 2r - r^2$

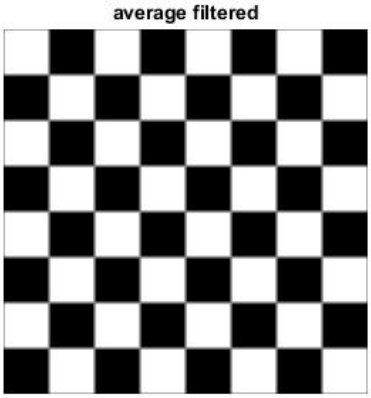
$S = G(z) = \int_0^z P_z(w)\,dw = z^2$

∴ $z = G^{-1}(s) = \sqrt{s} = \sqrt{2r - r^2}$

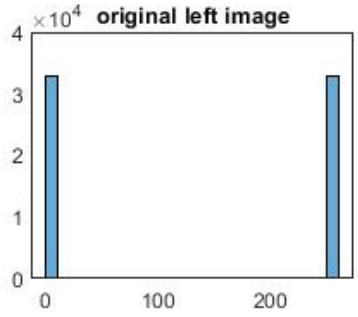
4.

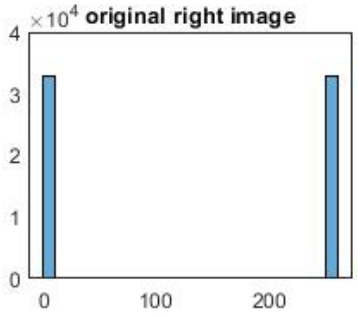
a) No. They're not equal. Because of the padding around the original image, new intensities are introduced, which are between the white and dark.
b) The filtered images are as follows:

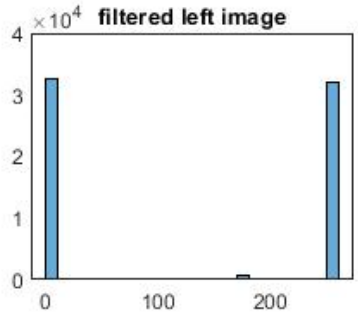


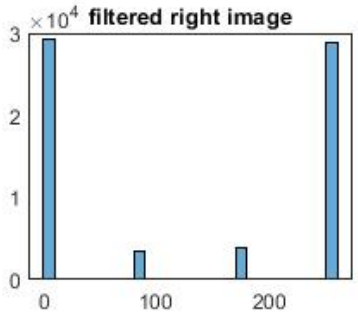


And their histograms:









Please see the code in Appendix.

5.

	z_2	
z_4	z_5	z_6
	z_8	

Pixel neighborhood

	d_2	
d_4		d_6
	d_8	

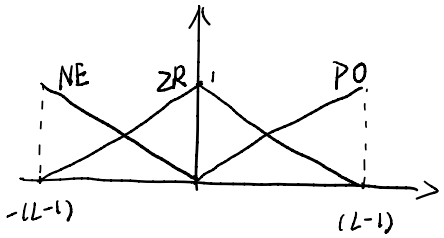
Intensity difference

$d_i = z_i - z_5$

If d_2 is NE AND d_4 is NE AND d_6 is NE AND d_8 is NE THEN make it brighter ($V<0$)

If d_2 is PO AND d_4 is PO AND d_6 is PO AND d_8 is PO THEN make it darker ($V>0$)

ELSE keep it ($V=0$)



Membership function

If

	NE	
NE	z_5	NE
	NE	

THEN brighter

Rule 1

If

	PO	
PO	z_5	PO
	PO	

THEN darker

Rule 2

ELSE $z_5 \rightarrow z_5$

Appendix:

MATLAB Code for Q4

```
% Generate black&white image
height = 256;
width = 256;

img1 = zeros(height, width);
for i = 1:height
    for j = 1:width
        if j > 256/2
            img1(i,j) = 255;
        end
    end
end
figure
imshow(img1,[]);

n = 8;
img2 = zeros(height, width);
flag = 1;
for i = 1:height
    for j = 1:width
        if flag > 0
            img2(i, j) = 255;
        end
        if mod(j, int8(width/n)) == 0
            flag = -flag;
        end
    end
    if mod(i, int8(height/n)) == 0
        flag = -flag;
    end
end
figure
imshow(img2,[]);

% 3x3 average filter
figure
kernel = 1/9*[1,1,1;1,1,1;1,1,1];
img3 = sfilter(kernel, img1);
imshow(img3,[]);
title('average filtered')
img4 = sfilter(kernel, img2);
imshow(img4,[]);
title('average filtered')

figure
subplot(2,2,1);
histogram(img1);
title('original left image');
subplot(2,2,2);
histogram(img2);
title('original right image');
subplot(2,2,3);
```

```
histogram(img3);
title('filtered left image');
subplot(2,2,4);
histogram(img4);
title('filtered right image');
function output = sfilter(w, f)
%SFILTER spatial filter
%   take an image and the kernel as inputs
%   and return the filtered image

[M, N] = size(f);
[m, n] = size(w);
a = (m-1)/2;
b = (n-1)/2;
output = zeros(M,N);
% size of zero-padding image
Sv = M+m-1;
Sh = N+n-1;
f_pad = zeros(Sv, Sh);
for i = 1:M
   for j = 1:N
      f_pad(i+a,j+b) = f(i,j);
   end
end

for i = 1:M
   for j = 1:N
       for k = 1:m
           for l = 1:n
               % correlation
               output(i,j) = output(i,j)+ w(k,l)*f_pad(i+k-1, j+l-1);
                % convolution
%                output(i,j) = output(i,j)+ w(k,l)*f_pad(i+m-k, j+n-
l);
           end
       end
   end
end

end
```