# Digital Image Processing

## HW1

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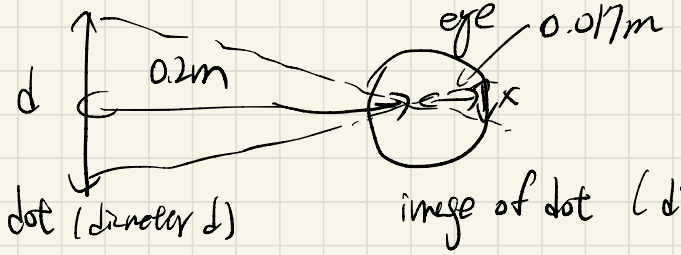
2.2.




$$\Rightarrow \frac{x}{0.017} = \frac{d}{0.2}$$

$$x = 0.085d$$

consider the foren as a square array with ~337000 elements

$\sqrt{337000} \cong 580$, assume elements are equally spaced

the length ($l$) of an element is

$$l \cong \frac{1.5}{580 \pm 579} \cong 1.3\,\mu m$$

so

$$x = 0.085d > 1.3\,\mu m$$

$$d > 15.3\,\mu m$$

the diameter of the smallest visible dot is ~15.3$\mu m$

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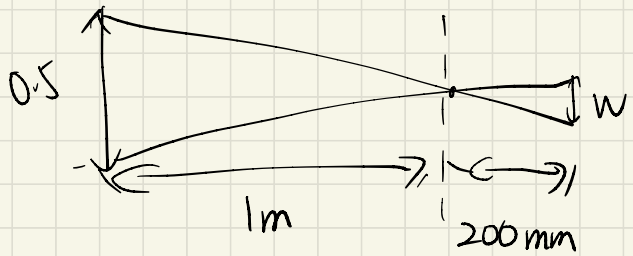
2.8.




$\frac{0.5\,m}{1m} = \frac{W}{200mm} \Rightarrow W = 100(mm)$ (width of the projected area)

to have 5 lp/mm,

suppose each line is x mm, $\frac{1}{2x} \geq 5 \Rightarrow x \leq 0.1(mm)$

consider the CCD is dxd


we get $x = \frac{w}{d} \leq 0.1$

$d \geq 100 \div 0.1 = 1000$

So the minimum dxd is $10^6$ with d = 1000

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2.36.

(a) scaling (S) and translation (T)

$$A_1 = T \cdot S = \begin{pmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} c_x & 0 & 0 \\ 0 & c_y & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} c_x & 0 & t_x \\ 0 & c_y & t_y \\ 0 & 0 & 1 \end{pmatrix}$$

$$A_1' = S \cdot T = \begin{pmatrix} c_x & 0 & 0 \\ 0 & c_y & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} c_x & 0 & c_x t_x \\ 0 & c_y & c_y t_y \\ 0 & 0 & 1 \end{pmatrix}$$

(b)

$$A_2 = R \cdot T \cdot S \qquad (R: \text{Rotation})$$

$$= \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} c_x & 0 & t_x \\ 0 & c_y & t_y \\ 0 & 0 & 1 \end{pmatrix}$$

$$= \begin{pmatrix} c_x\cos\theta & -c_y\sin\theta & \cos\theta t_x - \sin\theta t_y \\ c_x\sin\theta & c_y\cos\theta & \sin\theta t_x + \cos\theta t_y \\ 0 & 0 & 1 \end{pmatrix}$$

(c)

$$A_3 = R \cdot T \cdot S \cdot V \qquad (V: \text{Vertical Shear})$$

$$= \begin{pmatrix} c_x\cos\theta & s_v c_x\cos\theta - c_y\sin\theta & \cos\theta t_x - \sin\theta t_y \\ c_x\sin\theta & s_v c_x\sin\theta + c_y\cos\theta & \sin\theta t_x + \cos\theta t_y \\ 0 & 0 & 1 \end{pmatrix}$$

(d) Yes, in (a) $A_1 \neq A_1'$ (i.e. $[S,T] = ST - TS \neq 0$)