

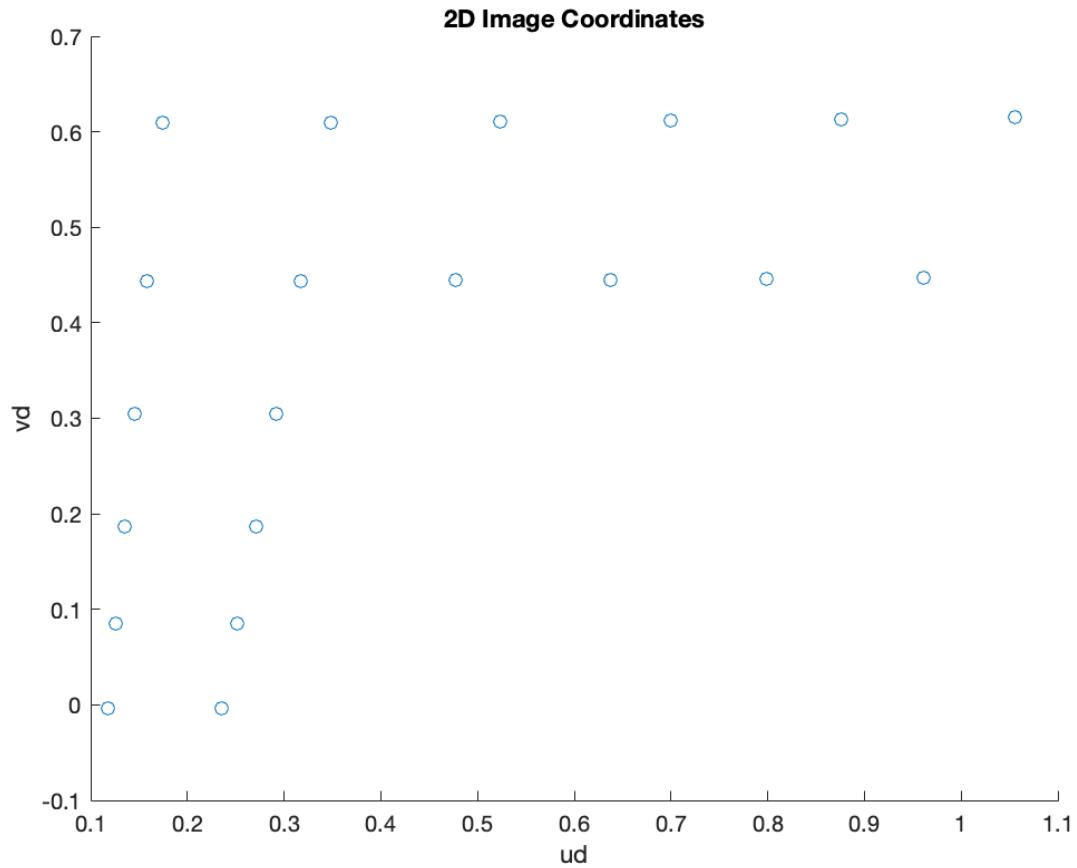
HW4

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1. Camera Model and Calibration

a)



b)

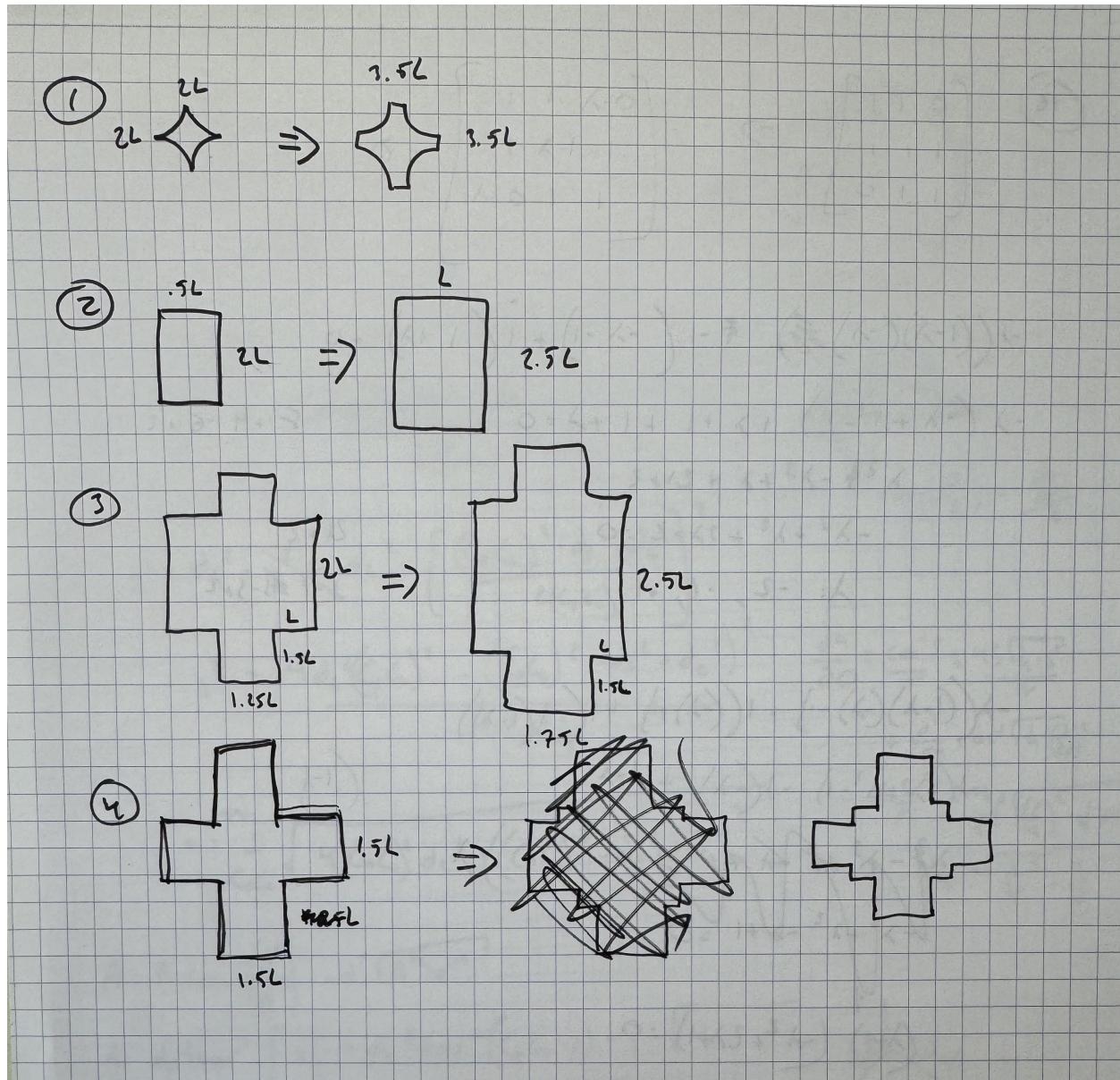
$$f = 1.3$$

$$[R] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -\frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \\ 0 & -\frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} \end{bmatrix}$$

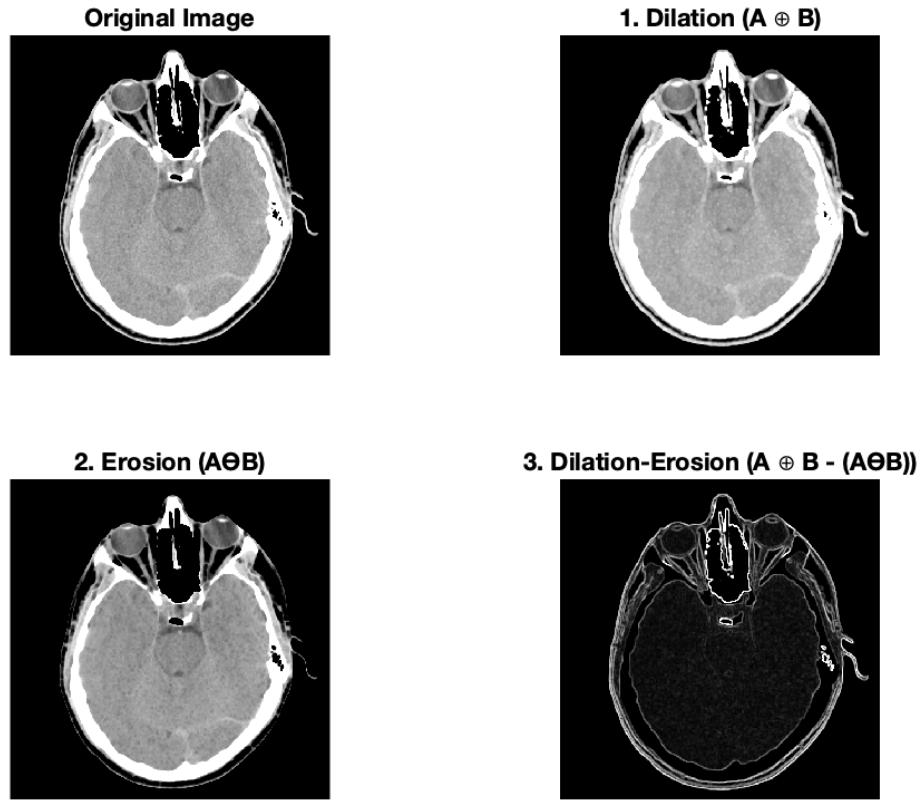
$$T = [3 \quad 3.5 \quad -7.5]$$

2. Morphology

a)



b)



3. Robot Eye-on-Hand Calibration

1)

$$Rc12 = \begin{bmatrix} -0.0958 & 0.9346 & -0.3425 \\ -0.8060 & -0.2747 & -0.5243 \\ -0.5841 & 0.2258 & 0.7797 \end{bmatrix}$$

$$Rc23 = \begin{bmatrix} 0.0041 & -0.2779 & 0.9606 \\ 0.4665 & 0.8502 & 0.2440 \\ -0.8845 & 0.4471 & 0.1331 \end{bmatrix}$$

$$Tc12 = \begin{bmatrix} 4.893 \\ 4.8245 \\ -1.9306 \end{bmatrix}$$

$$Tc23 = \begin{bmatrix} -4.4892 \\ -1.2969 \\ 8.5167 \end{bmatrix}$$

2)

$$\theta_{Rc12} = 107.1822$$

$$n_{Rc12} = \begin{bmatrix} 0.3926 \\ 0.1265 \\ -0.9110 \end{bmatrix}$$

$$\theta_{Rc23} = 90.3601$$

$$n_{Rc23} = \begin{bmatrix} 0.1016 \\ 0.9226 \\ 0.3722 \end{bmatrix}$$

$$\theta_{Rg12} = 107.1722$$

$$n_{Rg12} = \begin{bmatrix} -0.1268 \\ 0.3927 \\ -0.9109 \end{bmatrix}$$

$$\theta_{Rg23} = 90.3553$$

$$n_{Rg23} = \begin{bmatrix} -0.9225 \\ 0.1014 \\ 0.3723 \end{bmatrix}$$

3)

$$Pc12 = \begin{bmatrix} 0.6319 \\ 0.2035 \\ -1.4663 \end{bmatrix}$$

$$Pc23 = \begin{bmatrix} 0.1441 \\ 1.3088 \\ 0.5281 \end{bmatrix}$$

$$Pg12 = \begin{bmatrix} -0.2041 \\ 0.6320 \\ -1.4661 \end{bmatrix}$$

$$Pg23 = \begin{bmatrix} -1.3087 \\ 0.1438 \\ 0.5282 \end{bmatrix}$$

4)

$$Pcg = \begin{bmatrix} -0.0003 \\ -0.0001 \\ -1.4143 \end{bmatrix}$$

$$Rcg = \begin{bmatrix} -0.0002 & 1 & 0.0001 \\ -1 & -0.0002 & 0.0003 \\ 0.0003 & -0.0001 & 1 \end{bmatrix}$$

$$Tcg = \begin{bmatrix} -1.7696 \\ 6.1870 \\ 2.9136 \end{bmatrix}$$

4. Ellipse-Circle Correspondence

1)

$$O = [1.6739 \quad -0.6527 \quad 1.8853]$$

2)

$$(x - 1.6739)^2 + (y + 0.6527)^2 + (z - 1.8853)^2 - 7.5^2 = 0$$