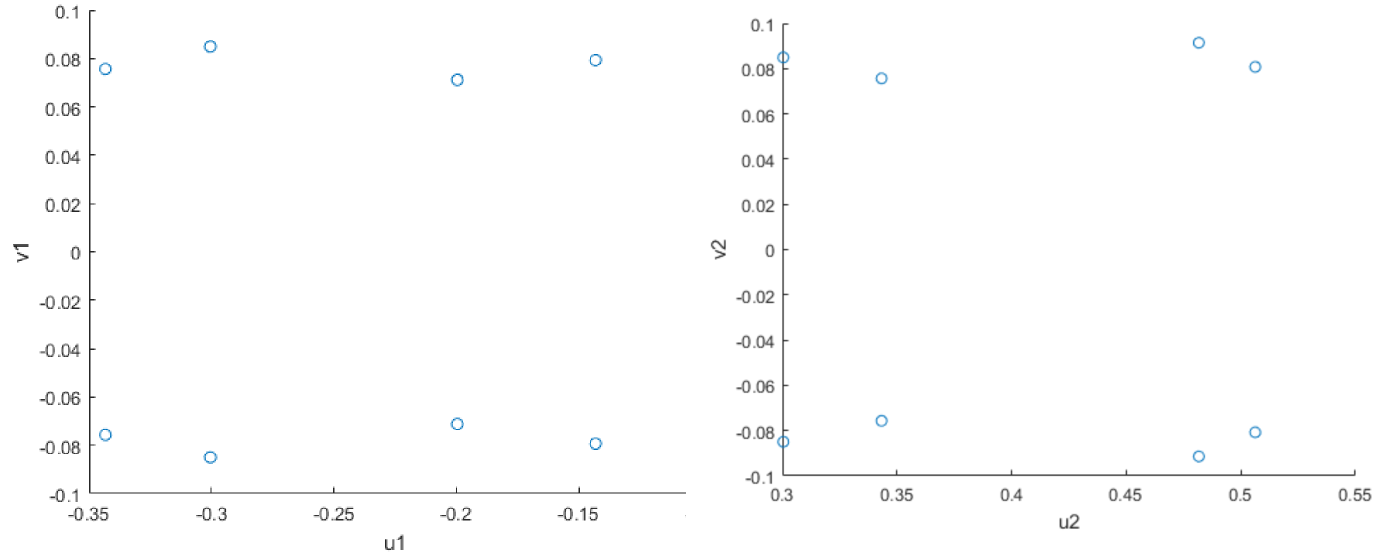
Arpit Patel

Homework 4

1- a) Camera Model




```
u1 =

   -0.3433   -0.1996   -0.1996   -0.3433   -0.3004   -0.1431   -0.1431   -0.3004


v1 =

    0.0757    0.0712   -0.0712   -0.0757    0.0850    0.0793   -0.0793   -0.0850


u2 =

    0.3433    0.5063    0.5063    0.3433    0.3004    0.4817    0.4817    0.3004


v2 =

    0.0757    0.0808   -0.0808   -0.0757    0.0850    0.0914   -0.0914   -0.0850
```

b) Stereo Vision

```
XYZ =

   -0.0000    1.0000    1.0000   -0.0000    0.0000    1.0000    1.0000   -0.0000
    0.0000   -0.0000    1.0000    1.0000   -0.0000    0.0000    1.0000    1.0000
    0.0000   -0.0000   -0.0000    0.0000    1.0000    1.0000    1.0000    1.0000
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

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c) Pose Estimation

R =

0.8660	0.0000	0.5000
-0.0000	-1.0000	-0.0000
0.5000	0.0000	-0.8660

T =

-2.2680
0.5000
7.9282

2- Neural network

a)

2 (a)

$$\Delta W_{qp} = W_{qp}^{k+1} - W_{qp}^{k} = -\alpha \frac{\partial E_p}{\partial W_{qp}}$$

where, $\frac{\partial E_p}{\partial W_{qp}} = \frac{\partial E_q}{\partial I_q} \cdot \frac{\partial I_q}{\partial W_{qp}} \rightarrow (1)$

where $\frac{\partial I_q}{\partial W_{qp}} = \frac{\partial}{\partial W_{qp}}\left(\sum_{p=1}^{N_p} W_{qp} O_p\right) \rightarrow (2)$ $= \frac{\partial}{\partial W_{qp}}[W_{q1}O_1 + \cdots + W_{qN_p}O_{N_p}]$

$\frac{\partial E_q}{\partial O_q} = -(r_q - O_q) \rightarrow (11)$

$\frac{\partial O_q}{\partial I_q} = O_q(1-O_q) \rightarrow (12)$

$\frac{\partial I_q}{\partial W_{qp}} = O_p \rightarrow (6)$

$O_q = h(I_q) \rightarrow (7)$

$I_q = \sum W_{qp} O_p \rightarrow (8)$

$I_p = \sum W_{pj} O_j \rightarrow (9)$

$O_j = \frac{\partial I_p}{\partial W_{pj}} \rightarrow (10)$

$\frac{\partial E_q}{\partial I_q} = \frac{\partial E_q}{\partial O_q} \cdot \frac{\partial O_q}{\partial I_q} \rightarrow (3)$

where $\frac{\partial E_q}{\partial O_q} = [(r_1 - O_1)^2 + (r_2 - O_2)^2 + \cdots + (r_{N_q} - O_{N_p})^2] \rightarrow (4) = \frac{1}{2}\frac{\partial}{\partial O_q}\left[\sum_{q=1}^{N_p}(r_q - O_q)^2\right]$

&

where $\frac{\partial O_q}{\partial I_q} = \frac{\partial}{\partial I_q}[h_q(I_q)] = h'(I_q) \rightarrow (5) = y' = \frac{d}{ds}\left(\frac{1}{1+e^{-s}}\right) = O_q(1-O_q)$

$$\Rightarrow \boxed{\delta_q = (r_q - O_q)\, h'_q(I_q) = -\frac{\partial E_q}{\partial O_q} \frac{\partial O_q}{\partial I_q}}$$

Using the above equations

$$\boxed{\begin{aligned} \Delta W_{qp} &= \alpha(r_p - O_q)\, h'(I_q)\, O_p = \alpha(r_p - O_q)\, h(I_q)\, h(1 - I_q) O_p \\ W_{qp}^{new} &= W_{qp}^{old} + \Delta W_{qp} \end{aligned}}$$

Similarly

$$\Delta W_{pj} = -\alpha \frac{\partial E}{\partial W_{pj}} = -\alpha \frac{\partial E}{\partial O_p} \frac{\partial O_p}{\partial I_p} \frac{\partial I_p}{\partial W_{pj}}$$

where $\frac{\partial E}{\partial O_p} = \frac{\partial}{\partial O_p}\left[\frac{1}{2}(r_q - O_q)^2\right] = -(r_q - O_q)\frac{\partial O_q}{\partial I_q}\frac{\partial I_q}{\partial O_p} = -\frac{1}{2}(r_q - O_p)(1 - O_q^2) W_{qp}$

$= -\delta_q W_{qp}$

$\frac{\partial O_p}{\partial I_p} = O_p(1 - O_p)$; $I_p = \sum W_{pj} O_j$; $\frac{\partial I_p}{\partial W_{pj}} = O_j$

$$\Delta W_{pj} = -\alpha \frac{\partial E}{\partial O_p} * \frac{\partial O_p}{\partial I_p} * \frac{\partial I_p}{\partial W_{pj}}$$

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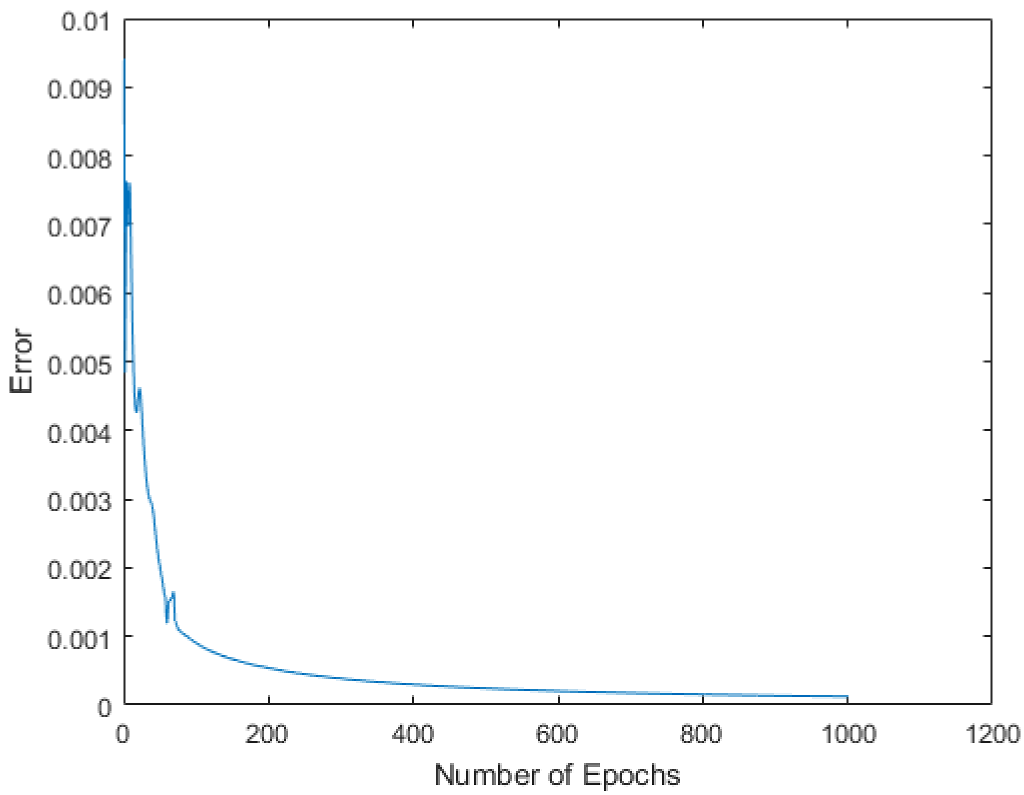
b) and c)




```
Oq1 =          Oq2 =          Oq3 =          Oq4 =

    0.9964         0.0020         0.0004         0.0044
    0.0069         0.9803         0.0118         0.0003
    0.0003         0.0083         0.9778         0.0078
    0.0012         0.0006         0.0250         0.9973
```

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3- a) <u>ACC</u>

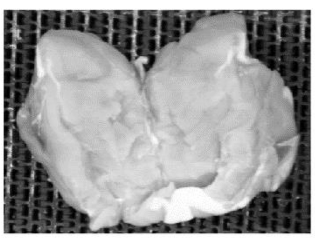
$$h = G_{\sigma c} * R + G_{\sigma s} * (R - G)$$

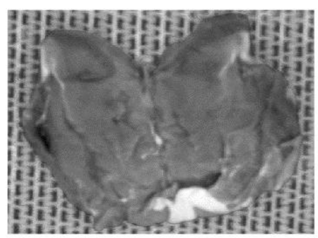
$$h = G_{\sigma c} * R + G_{\sigma s} * (R - G) + G_{\sigma s}(R - R)$$

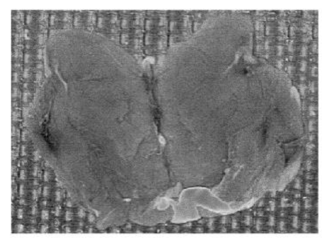
$$h = [G_{\sigma c} - G_{\sigma s}] * R + G_{\sigma s} * (2R - G)$$

$$h = DoG * R + G_{\sigma s} * (2R - G)$$

b) <u>PCA</u>





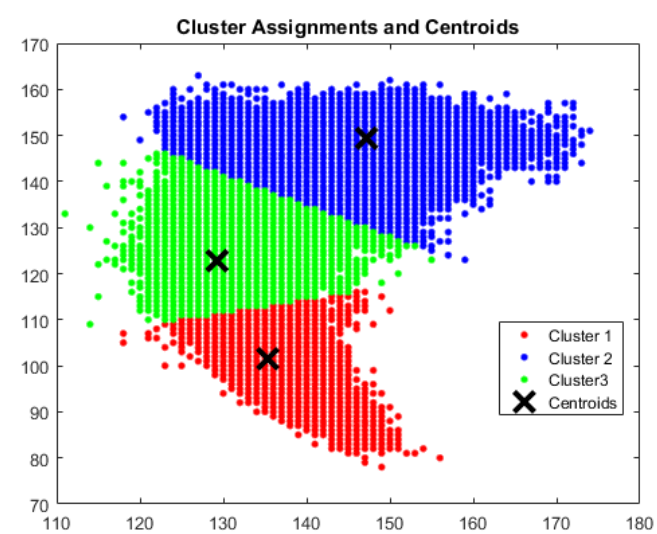


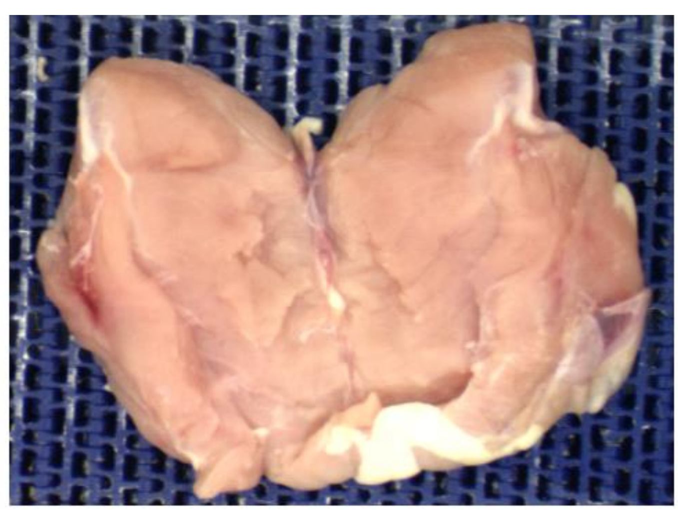
```
C =

    0.1246    0.0861    0.0487
    0.0861    0.0634    0.0384
    0.0487    0.0384    0.0270
```

```
D =

    0.2067
    0.0076
    0.0007
```

```
V =

    0.7693    0.5495    0.3260
   -0.5338    0.2724    0.8005
   -0.3511    0.7898   -0.5029
```

c) <u>Image Segment</u>





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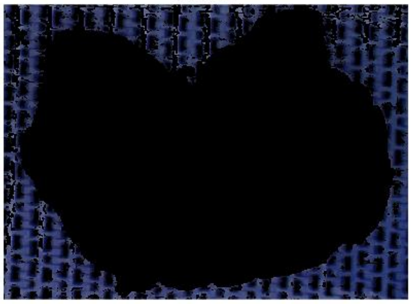
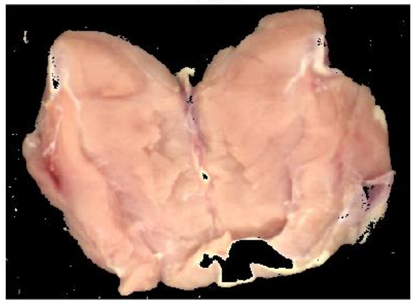
Cluster 1



Cluster 2



Cluster 3

4- a)

4 (a)

LHS $\Rightarrow$ $(A \bullet B)^c = ((A \oplus B) \ominus B)^c \rightarrow (1)$. $\Rightarrow$ from the definition of closing $(A \bullet B = (A \oplus B) \ominus B)$.

Using $(X \ominus Y)^c = X^c \oplus \hat{Y} \rightarrow (2)$

$\Rightarrow$ $(A \bullet B)^c = (A \oplus B)^c \oplus \hat{B}$ [Using (1) & (2), where $X = (A \oplus B)$, $Y = B$] $\rightarrow (4)$

where $(A \oplus B)^c = ((A^c)^c \oplus (\hat{B}))^c$.

Using (2), where $X = A^c$, $Y = \hat{B}$

$(A \oplus B)^c = ((A^c \ominus \hat{B})^c)^c = A^c \ominus \hat{B} \rightarrow (5)$

substituting (5) in (4).

$(A \bullet B)^c = (A^c \ominus \hat{B}) \oplus \hat{B}$

$= A^c \circ \hat{B}$

$=$ RHS

Hence Proved.

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b) Morphology

Erosion

Dilation

Difference=Dilation- Erosion