# Region Growing and Clustering for Segmentation

**Dr. Debdoot Sheet**
Assistant Professor
Department of Electrical Engineering
Indian Institute of Technology Kharagpur

www.facweb.iitkgp.ernet.in/~debdoot/

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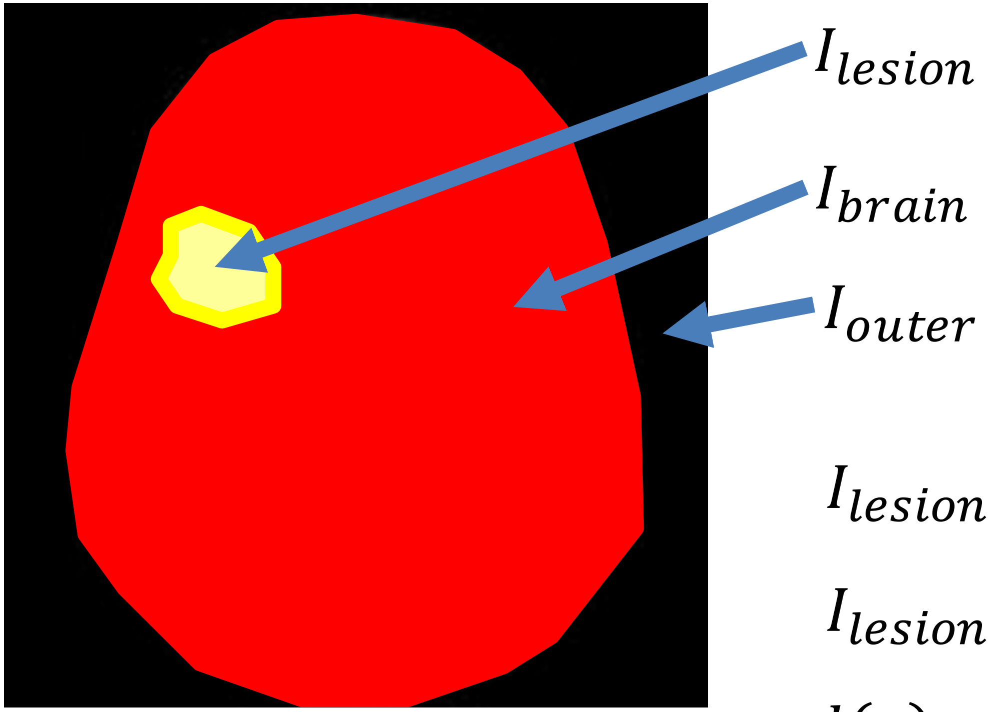
# Defining Segmentation



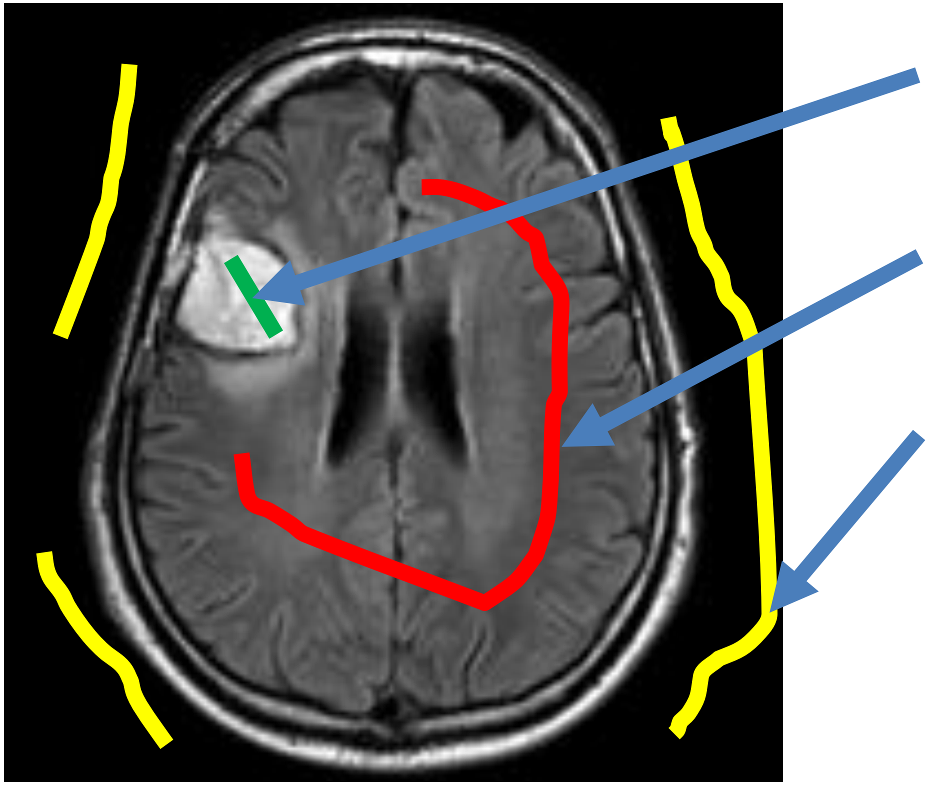

$$I_{lesion} \cup I_{brain} \cup I_{outer} = I$$

$$I_{lesion} \cap I_{brain} \cap I_{outer} = \emptyset$$

$$l(\mathbf{x}) = \omega$$

$$\omega \in \Omega = \{lesion, brain, outer\}$$

# Seeds as Initial Estimate

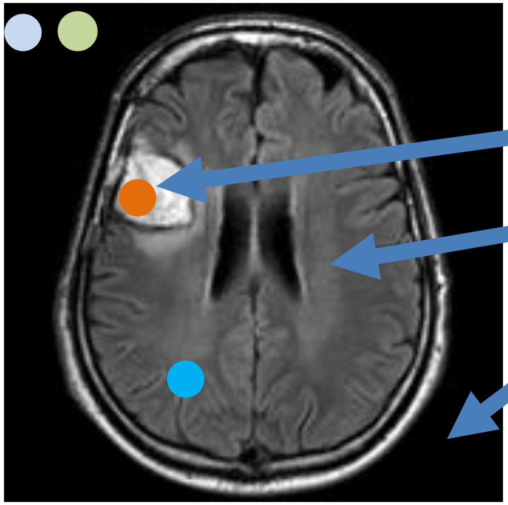


$$S_{lesion} = \{\mathbf{x}\} \subset I_{lesion}$$

$$S_{brain} = \{\mathbf{x}\} \subset I_{brain}$$

$$S_{outer} = \{\mathbf{x}\} \subset I_{outer}$$

# Distance Measure



$S_1$

$S_2$

$S_3$

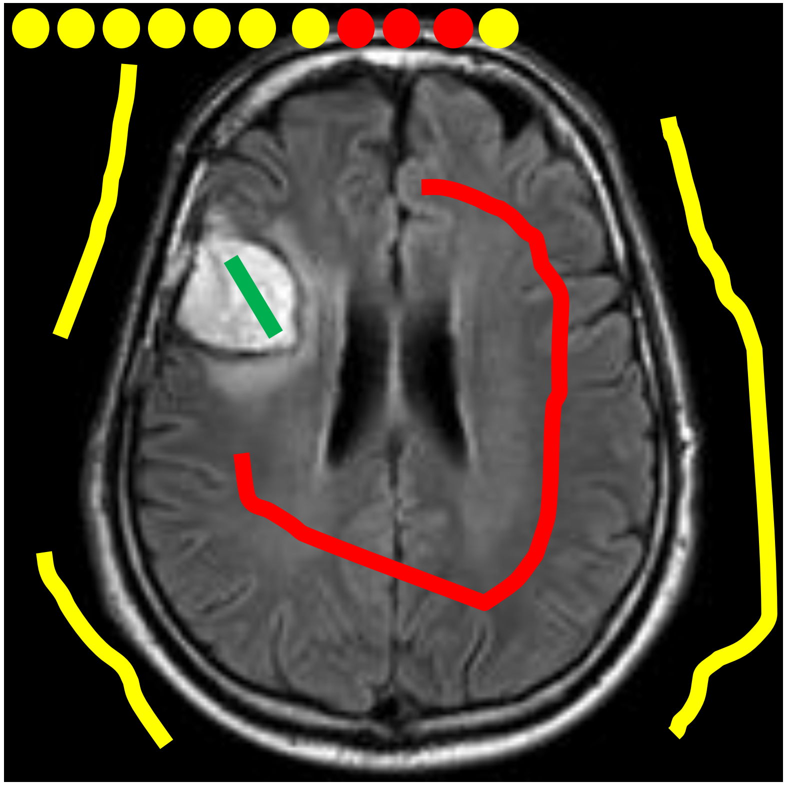
Euclidean distance

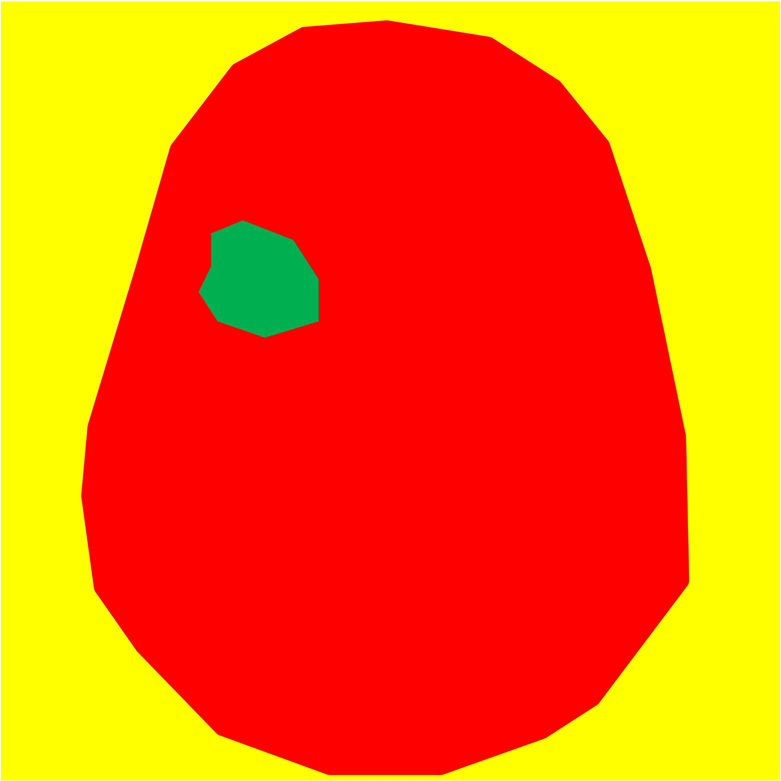
$$d(\boldsymbol{\alpha}, \boldsymbol{\beta}) = \|\boldsymbol{\alpha} - \boldsymbol{\beta}\|$$
$$= \sqrt[2]{(\alpha_1 - \beta_1)^2 + (\alpha_2 - \beta_2)^2 + (\alpha_3 - \beta_3)^2}$$

$$l(\mathbf{x}) = \operatorname{argmin}(\{d(\mathbf{i}(\mathbf{x}), \boldsymbol{\beta})\})$$

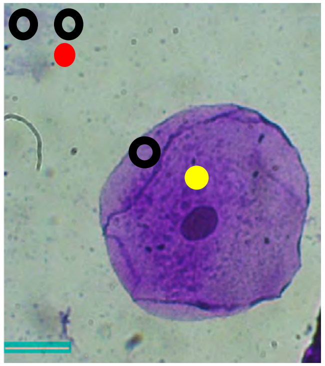
| | $S_1 = (\mathbf{a})$ | $S_2 = (\mathbf{b})$ | $S_3 = (\mathbf{c})$ | $l(\mathbf{x})$ |
|---|---|---|---|---|
| $\mathbf{i}(\mathbf{x}_1)$ | $d(\mathbf{i}(\mathbf{x}_1), \mathbf{a})$ | $d(\mathbf{i}(\mathbf{x}_1), \mathbf{b})$ | $d(\mathbf{i}(\mathbf{x}_1), \mathbf{c})$ | 3 |
| $\mathbf{i}(\mathbf{x}_2)$ | $d(\mathbf{i}(\mathbf{x}_2), \mathbf{a})$ | $d(\mathbf{i}(\mathbf{x}_2), \mathbf{b})$ | $d(\mathbf{i}(\mathbf{x}_2), \mathbf{c})$ | 3 |
| $\mathbf{i}(\mathbf{x}_k)$ | $d(\mathbf{i}(\mathbf{x}_k), \mathbf{a})$ | $d(\mathbf{i}(\mathbf{x}_k), \mathbf{b})$ | $d(\mathbf{i}(\mathbf{x}_k), \mathbf{c})$ | 1 |
| $\mathbf{i}(\mathbf{x}_m)$ | $d(\mathbf{i}(\mathbf{x}_m), \mathbf{a})$ | $d(\mathbf{i}(\mathbf{x}_m), \mathbf{b})$ | $d(\mathbf{i}(\mathbf{x}_m), \mathbf{c})$ | 2 |

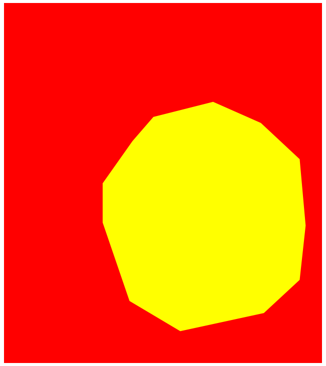
# Region Growing Segmentation





# Clustering for Segmentation

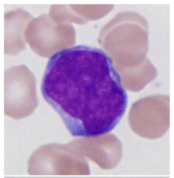




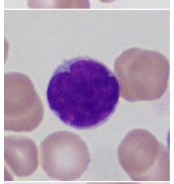
$$C_0 = (130, 240, 190) \quad C_1 = (245, 50, 210)$$

| Iter. | $\mathbf{c}(\mathbf{x})$ | $l(\mathbf{x})$ | $C_0$ | $C_1$ |
|---|---|---|---|---|
| 1. | (132,200,190) | 0 | (131,220,190) | (245,50,210) |
| 2. | (133,220,194) | 0 | (132,220,191) | (245,50,210) |
| … | | | | |
| … | | | | |
| *k* | (240,40,200) | 1 | (140,241,200) | (243,45,205) |
| … | | | | |
| … | | | | |

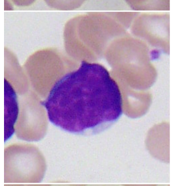
# Clustering for Classification



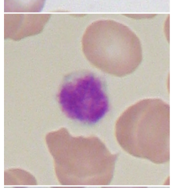
$$I_1 = \mathbf{x}_1 = \left\{x^{(1)}, x^{(2)}, x^{(3)}, \dots, x^{(d)}, \dots, x^{(D)}\right\}_1$$



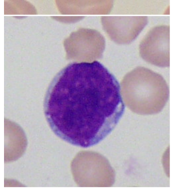
$$I_2 = \mathbf{x}_2 = \left\{x^{(1)}, x^{(2)}, x^{(3)}, \dots, x^{(d)}, \dots, x^{(D)}\right\}_2$$



$$I_3 = \mathbf{x}_3 = \left\{x^{(1)}, x^{(2)}, x^{(3)}, \dots, x^{(d)}, \dots, x^{(D)}\right\}_3$$



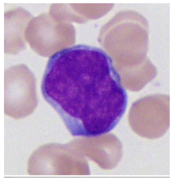
$$I_4 = \mathbf{x}_4 = \left\{x^{(1)}, x^{(2)}, x^{(3)}, \dots, x^{(d)}, \dots, x^{(D)}\right\}_4$$



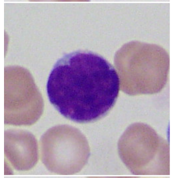
$$I_n = \mathbf{x}_n = \left\{x^{(1)}, x^{(2)}, x^{(3)}, \dots, x^{(d)}, \dots, x^{(D)}\right\}_n$$

# Clustering for Classification

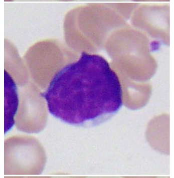
$\mathbf{C}_0$



$I_1 = \mathbf{x}_1 \quad \mathbf{C}_0 = \mathbf{x}_1$

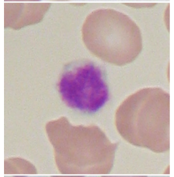


$I_2 = \mathbf{x}_2 \quad d(\mathbf{C}_0, \mathbf{x}_2) \; d(\mathbf{C}_1, \mathbf{x}_2) \quad l(\mathbf{x}_2) \quad Update: \mathbf{C}_{l(\mathbf{x}_2)}$

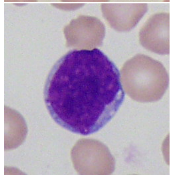


$I_3 = \mathbf{x}_3 \quad d(\mathbf{C}_0, \mathbf{x}_3) \; d(\mathbf{C}_1, \mathbf{x}_3) \quad l(\mathbf{x}_3) \quad Update: \mathbf{C}_{l(\mathbf{x}_3)}$

$\mathbf{C}_1$



$I_4 = \mathbf{x}_4 \quad \mathbf{C}_1 = \mathbf{x}_4$



$I_k = \mathbf{x}_k \quad d(\mathbf{C}_0, \mathbf{x}_k) \; d(\mathbf{C}_1, \mathbf{x}_k) \quad l(\mathbf{x}_k) \quad Update: \mathbf{C}_{l(\mathbf{x}_k)}$

# Take home message

- K.D. Toennies, “Classification and Clustering”, *Guide to Medical Image Analysis*, Springer-Verlag London Limited 2012.