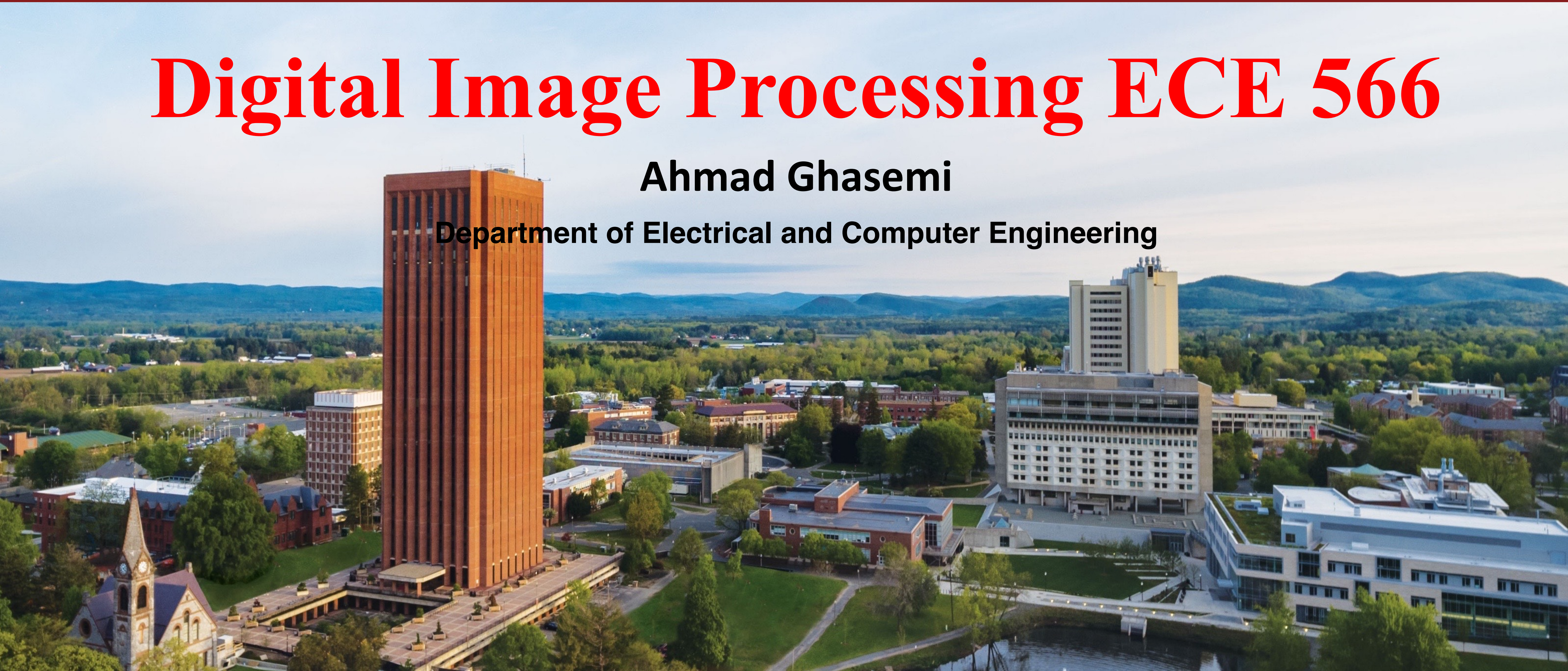
University *of* Massachusetts Amherst

# Digital Image Processing ECE 566


**Ahmad Ghasemi**

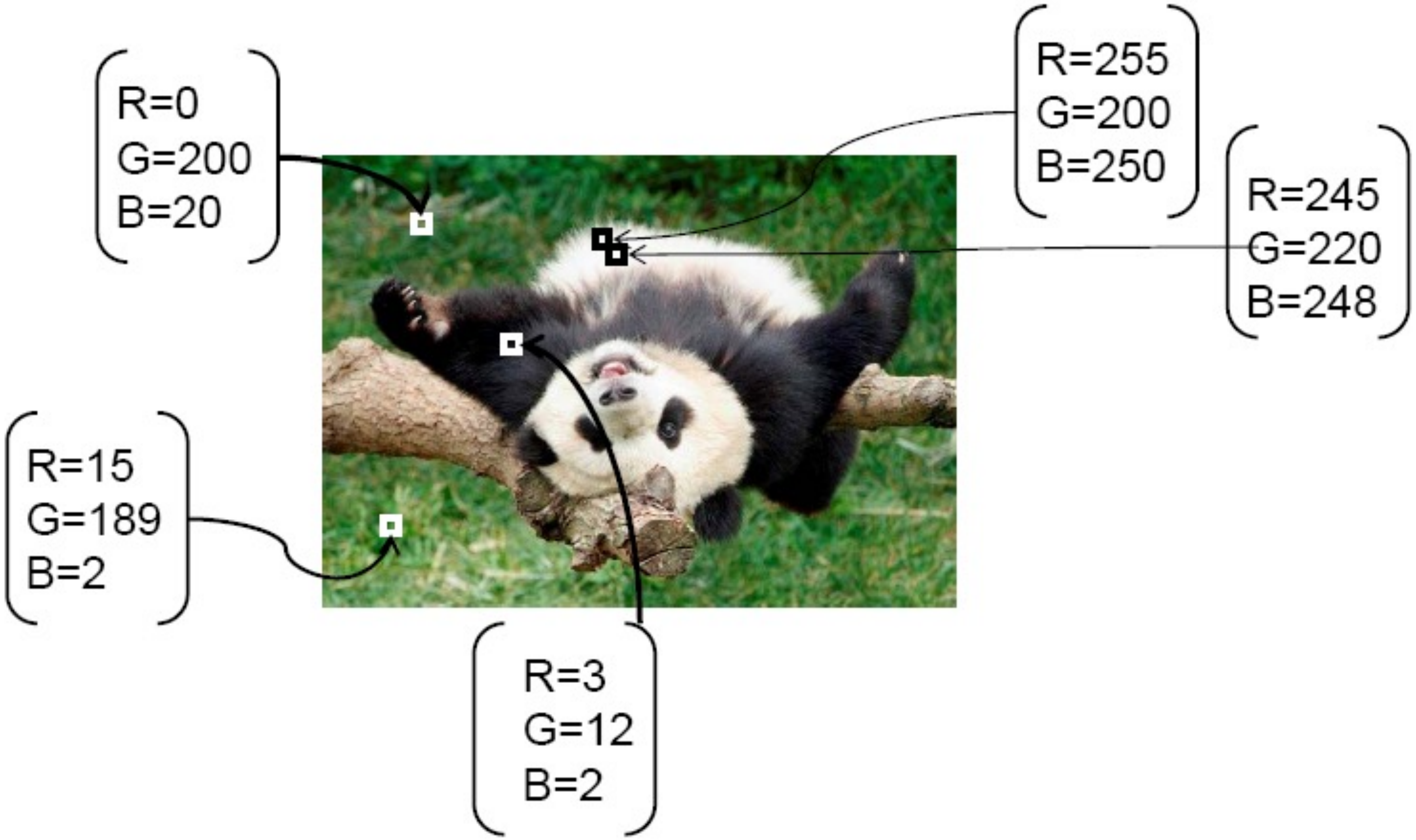
**Department of Electrical and Computer Engineering**

# Segmentation using clustering

- K-Means
- Mean-shift

# Feature Space

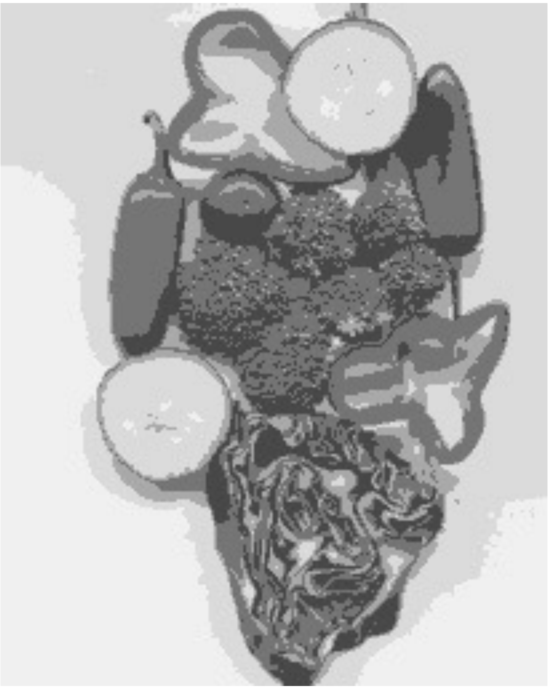



Source: K. Grauman

# K-Means Clustering Using Intensity & Color Alone

Image

Clusters on intensity



Clusters on color

# K-Means Clustering: Pros and Cons

- Pros
  - Simple and fast
  - Easy to implement

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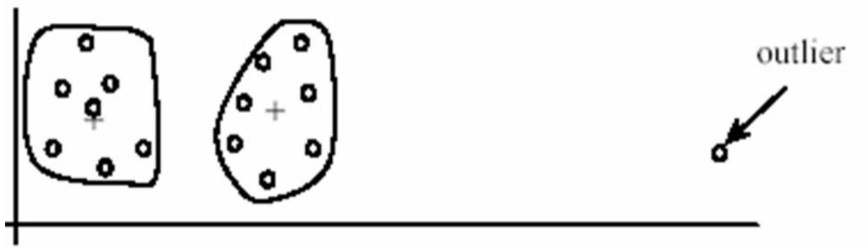
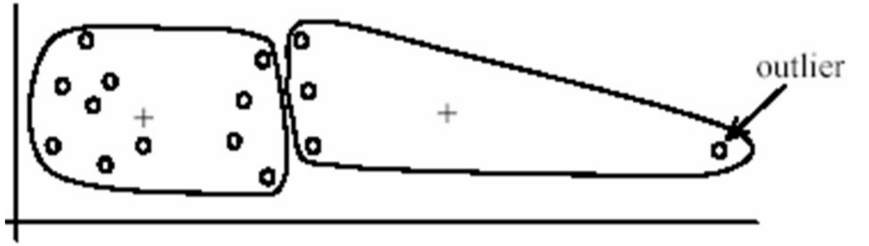
- Pros
  - Simple and fast
  - Easy to implement

- Cons
  - Need to choose K
  - Sensitive to outliers

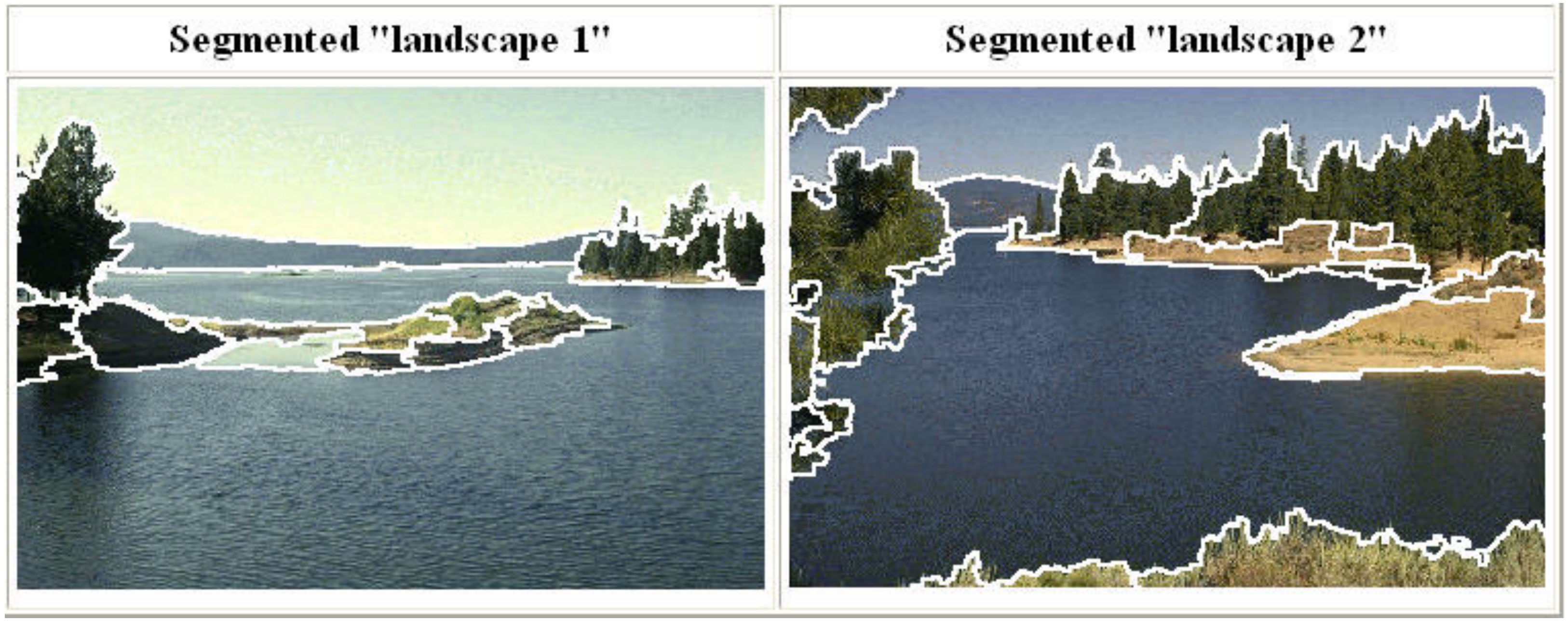



(B): Ideal clusters



# Mean Shift Segmentation

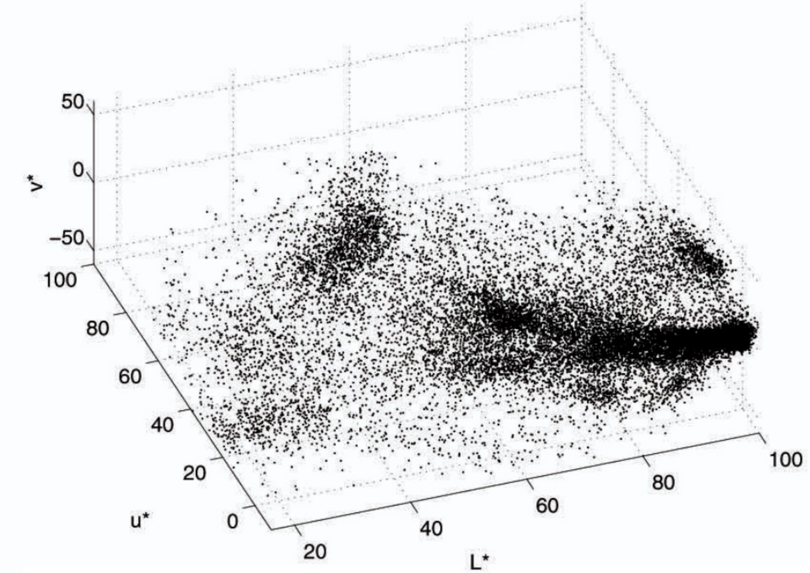
A Versatile technique for clustering-based segmentation

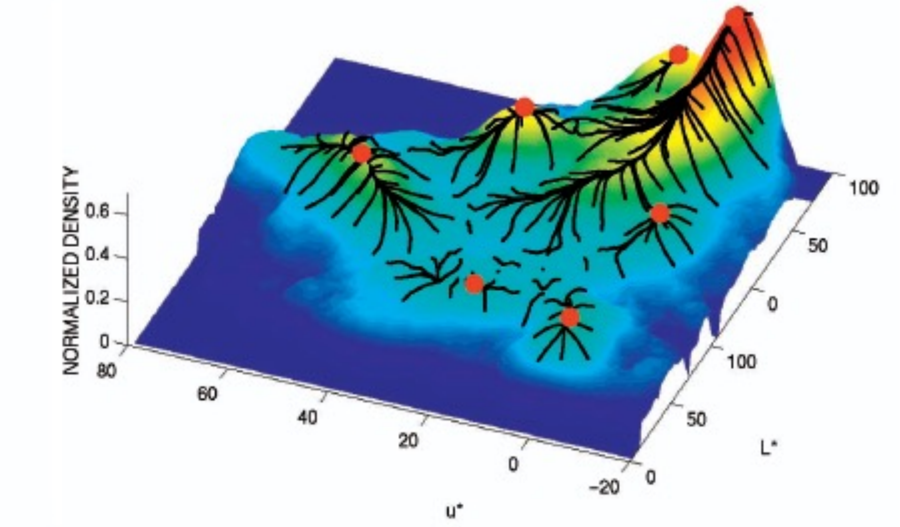


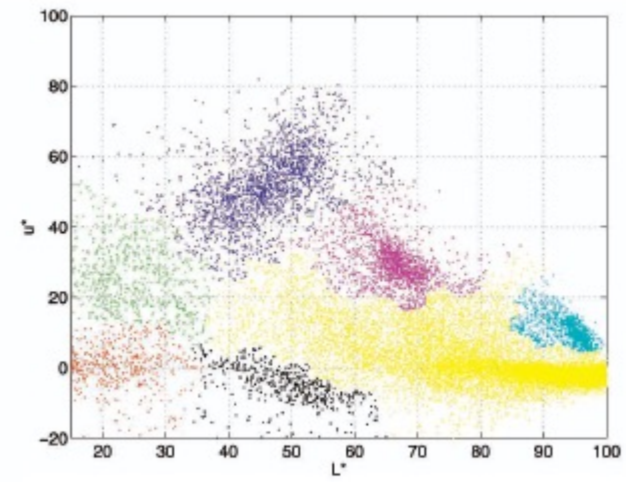

D. Comaniciu and P. Meer, Mean Shift: A Robust Approach toward Feature Space Analysis, PAMI 2002.

# Mean Shift Segmentation

It seeks *modes* or local maxima of density in the feature space.






IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 24, NO. 5, MAY 2002

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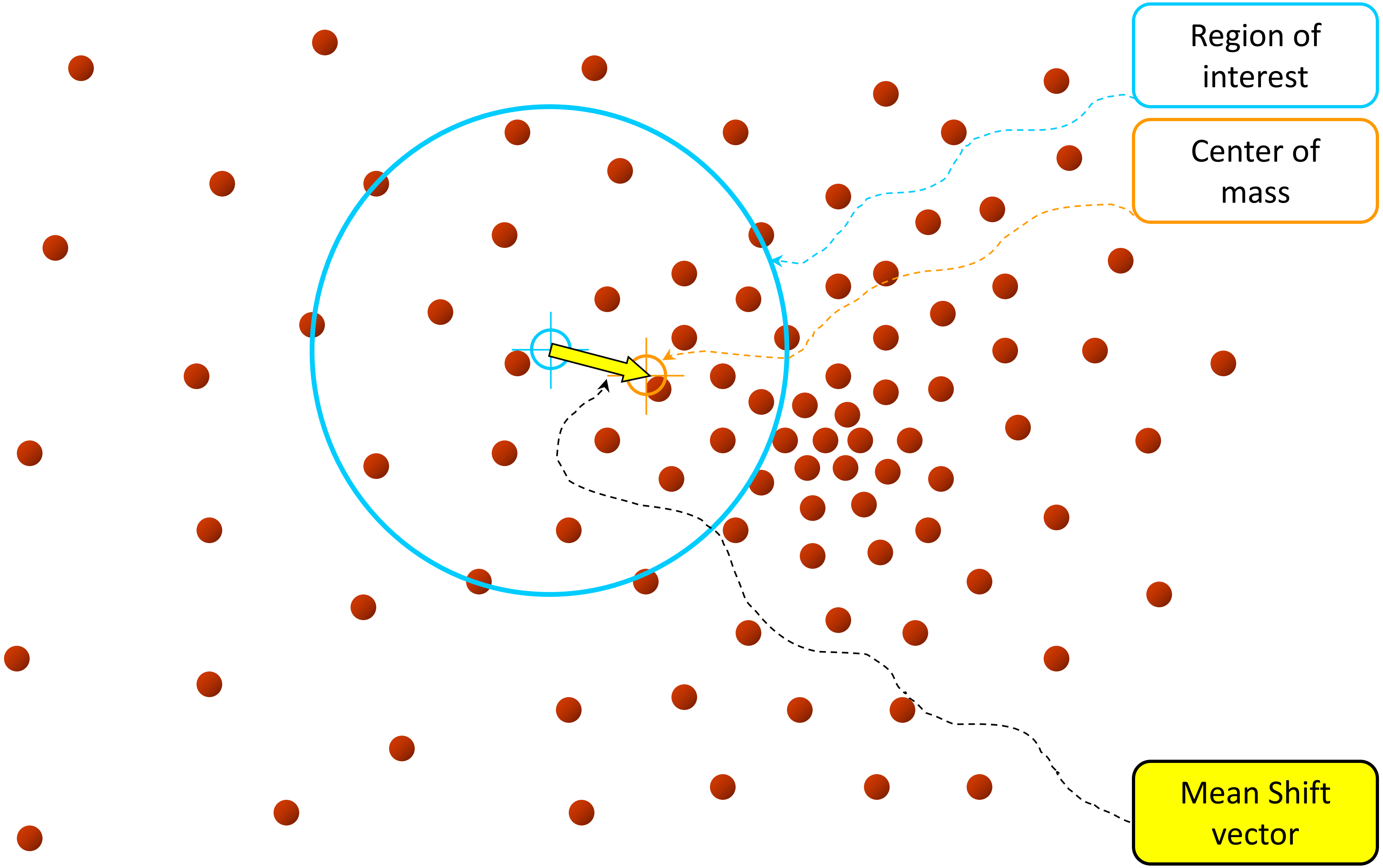




Slide by Y. Ukrainitz & B. Sarel

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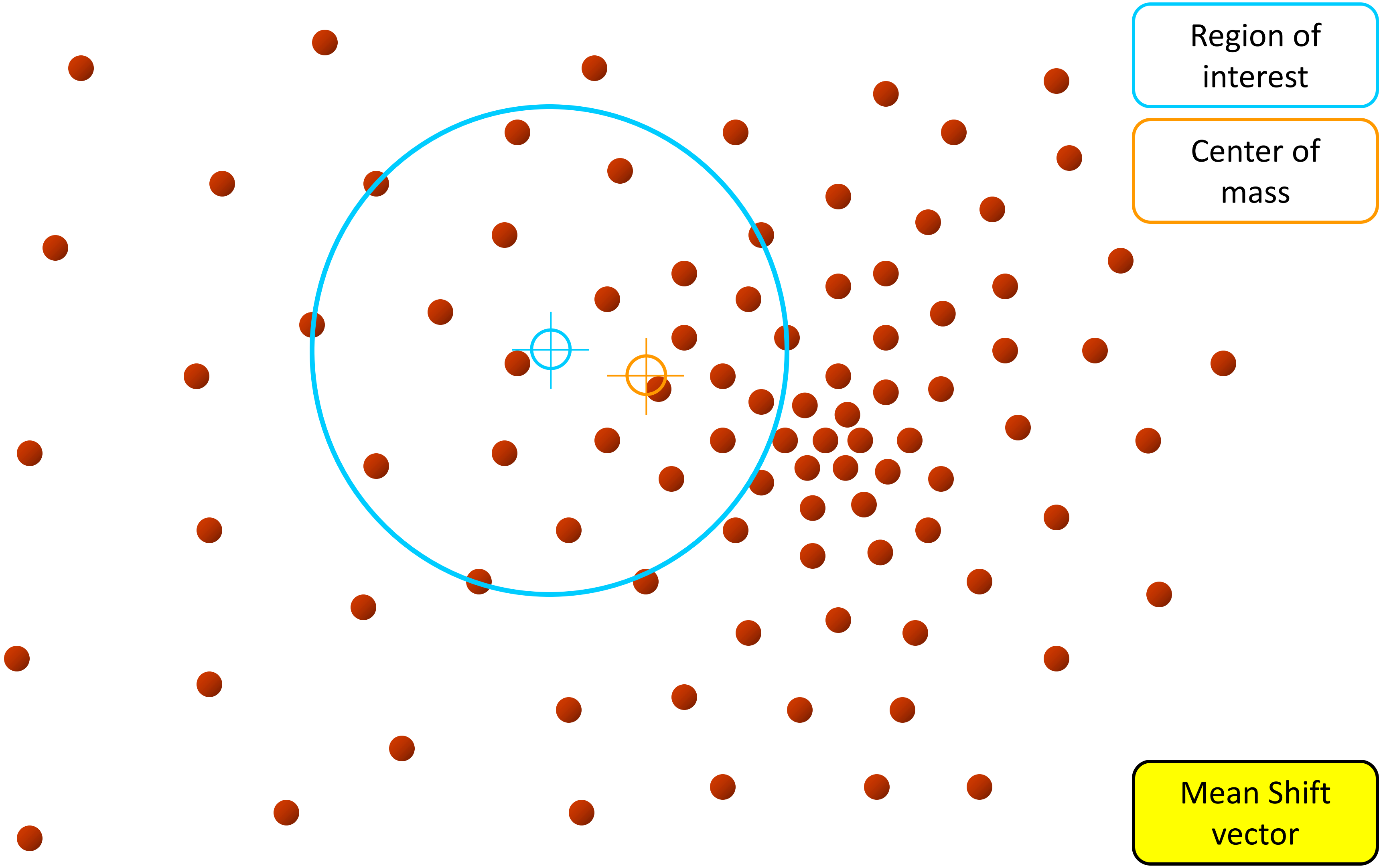

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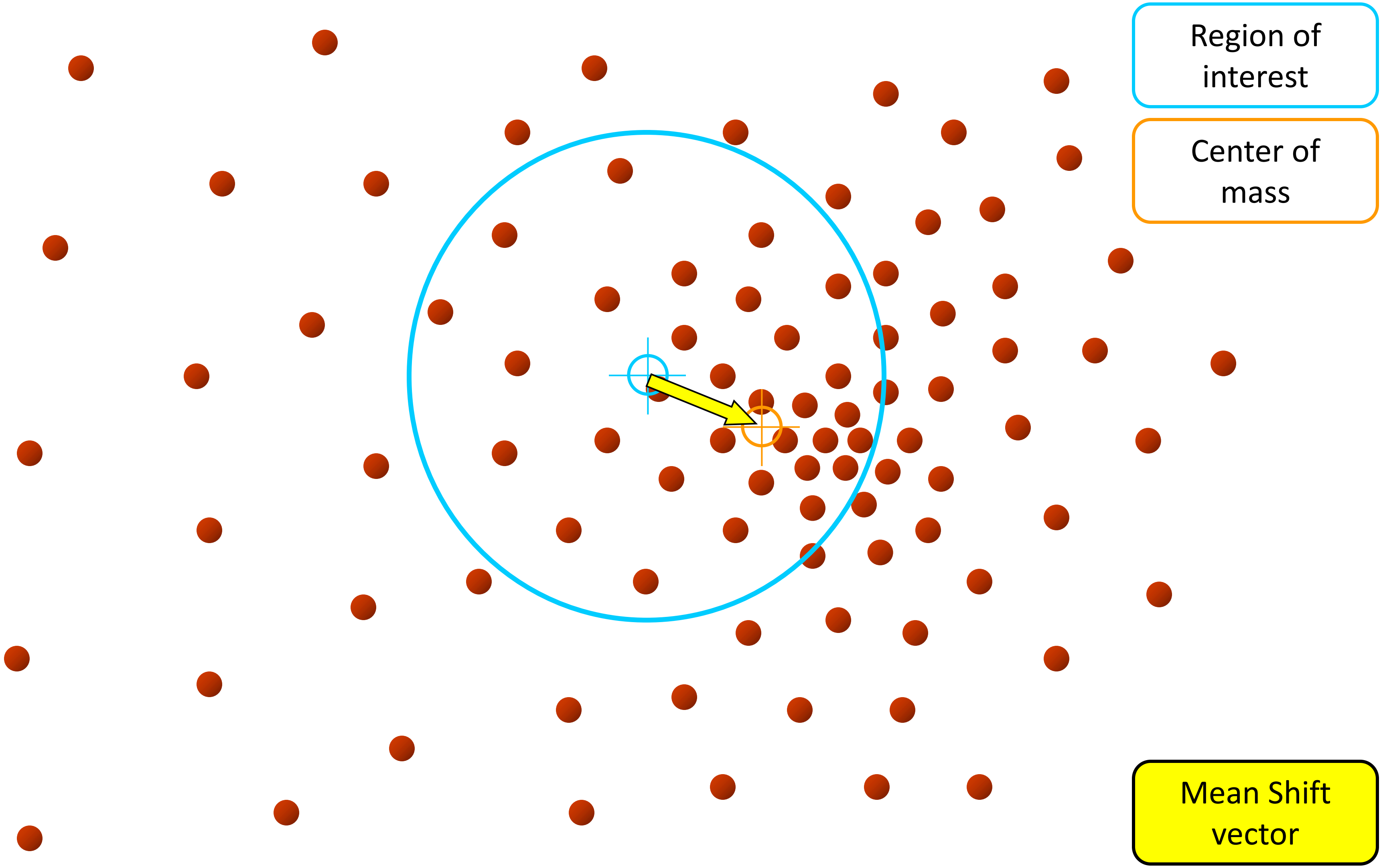




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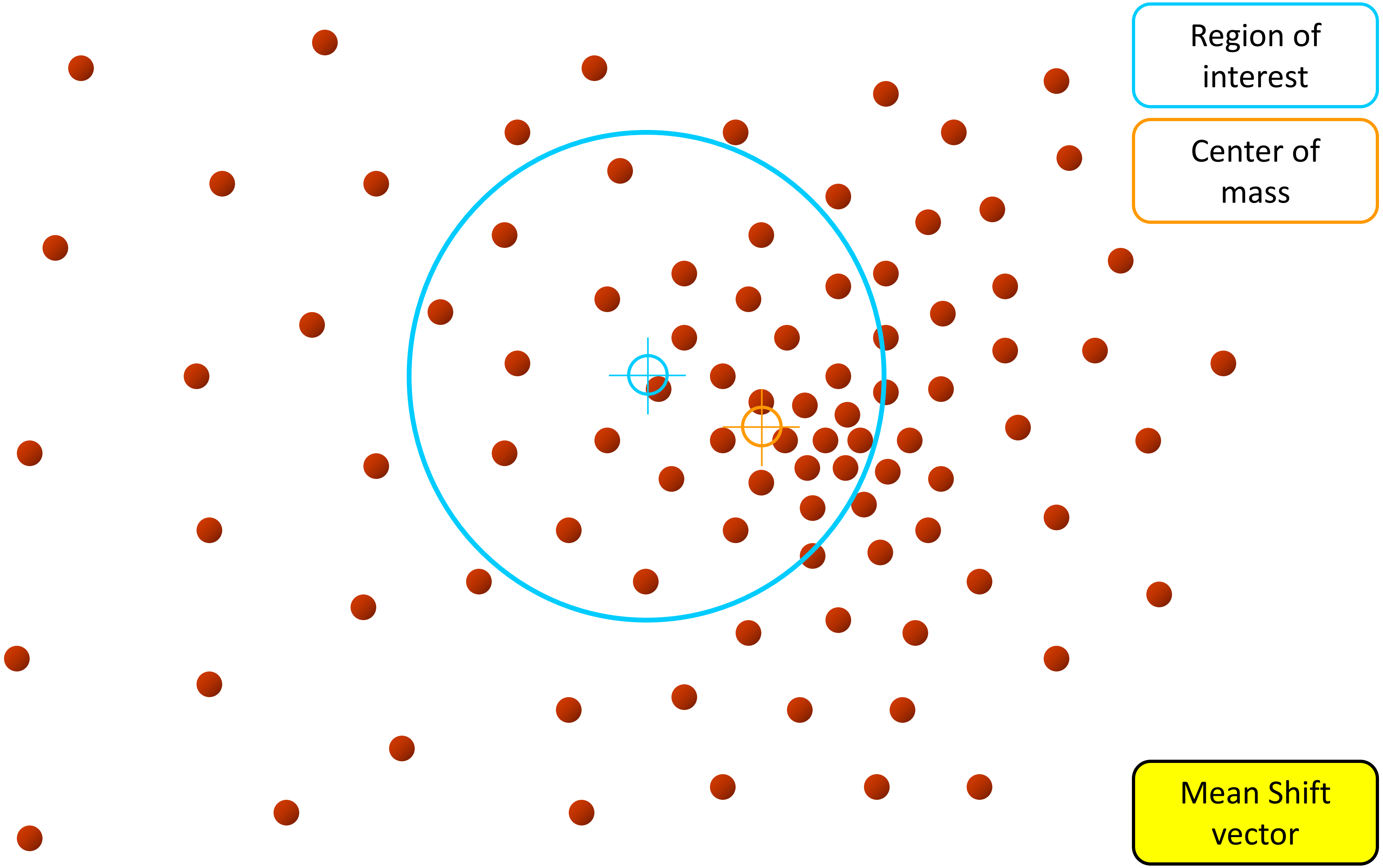

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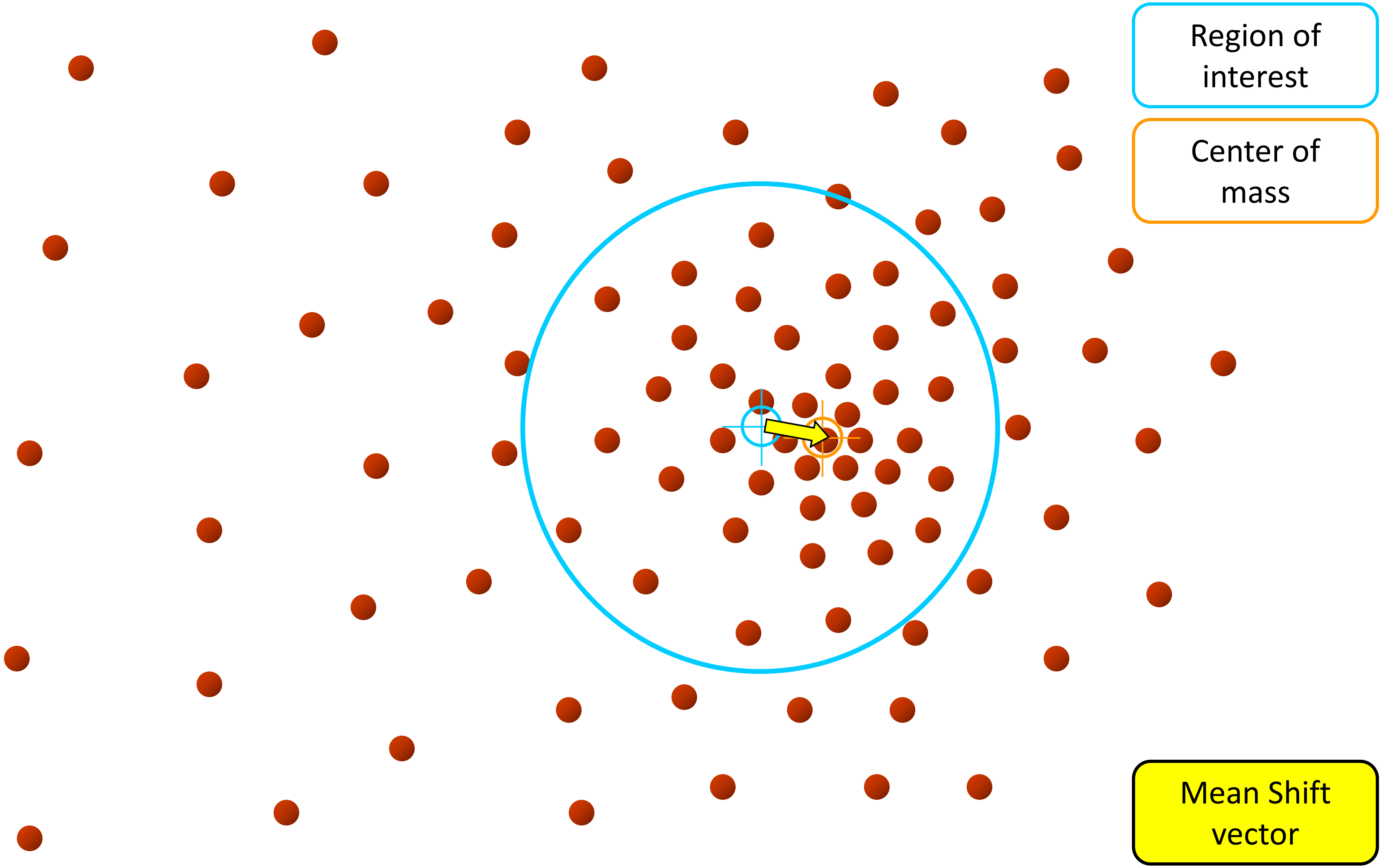




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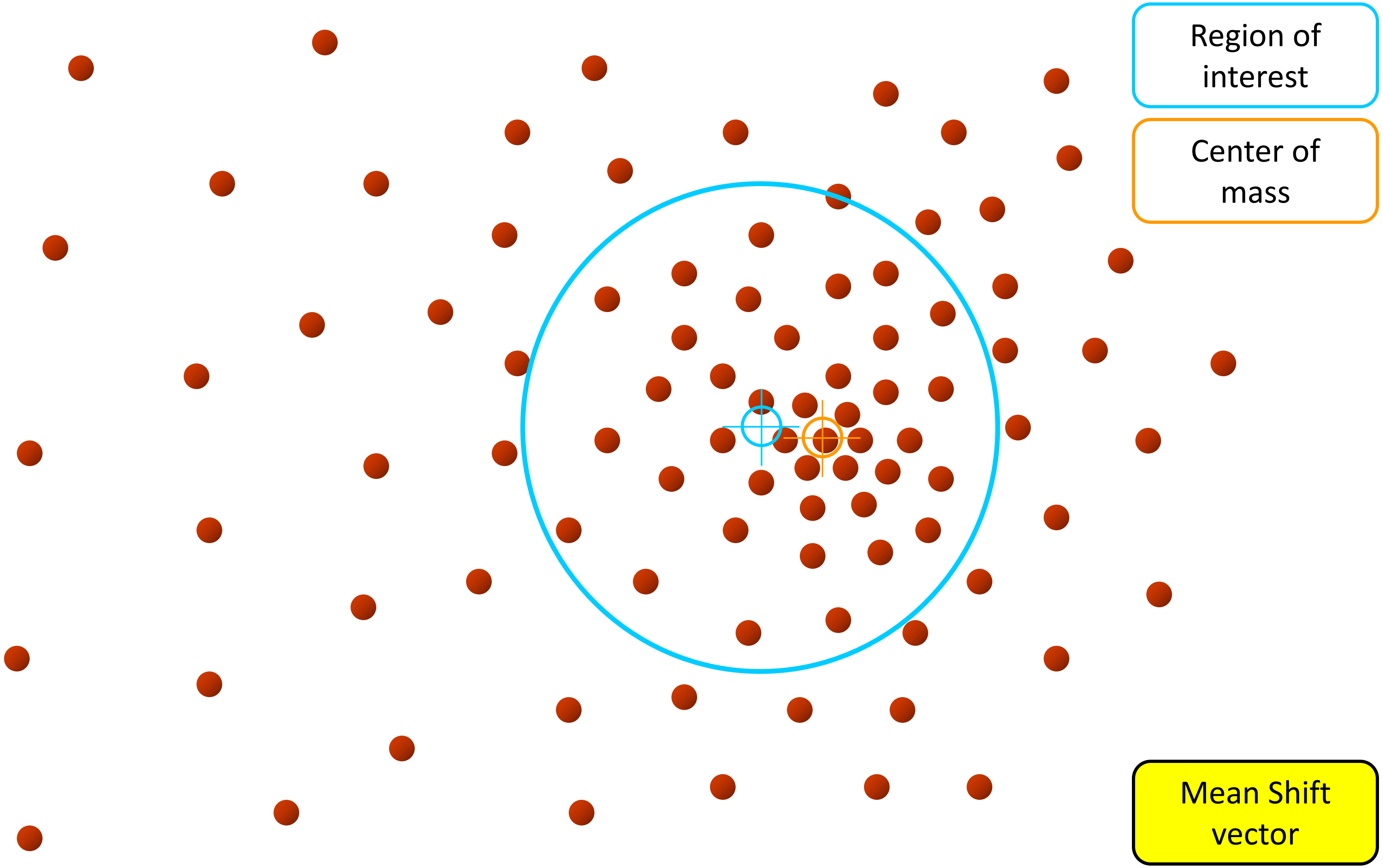




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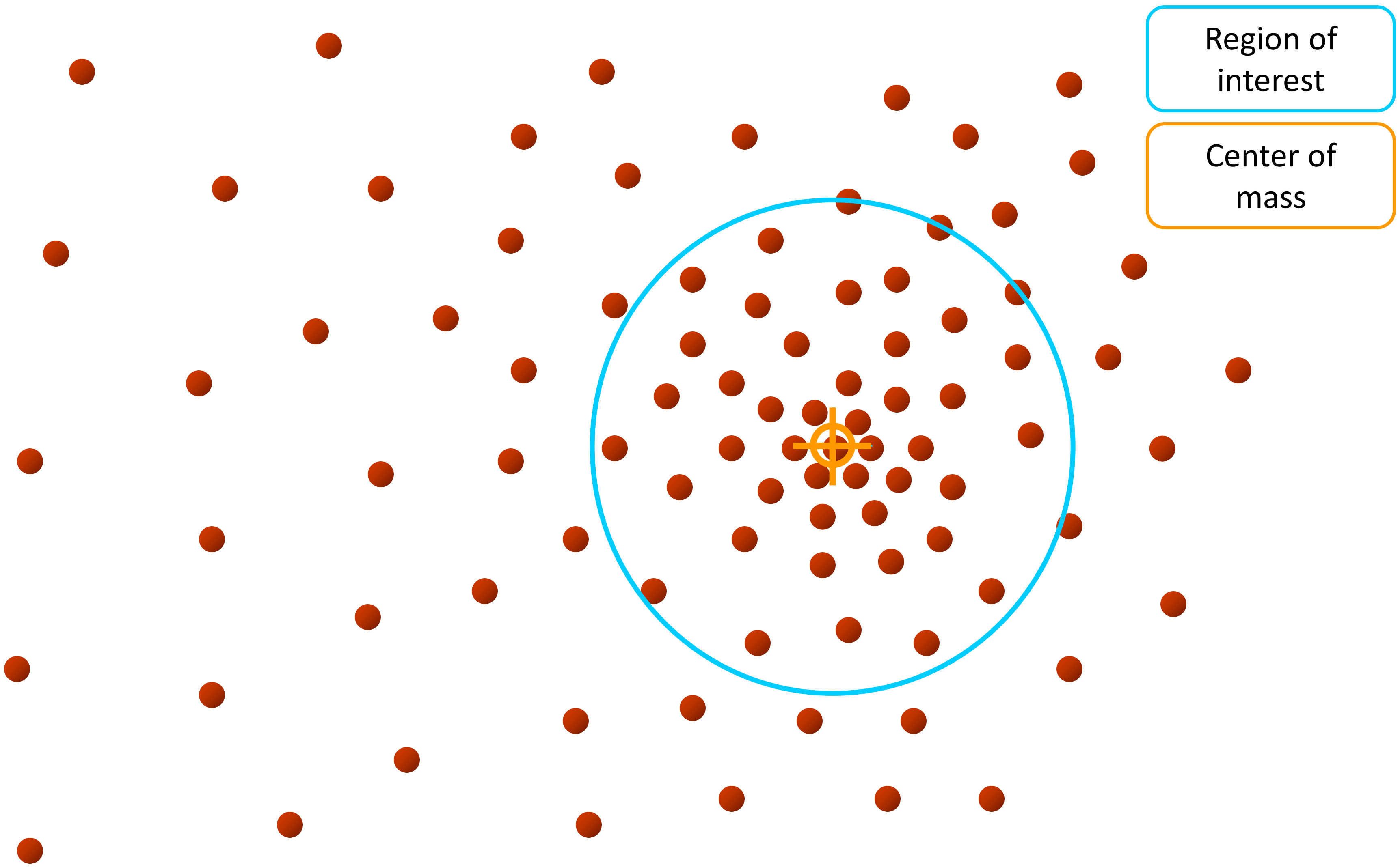


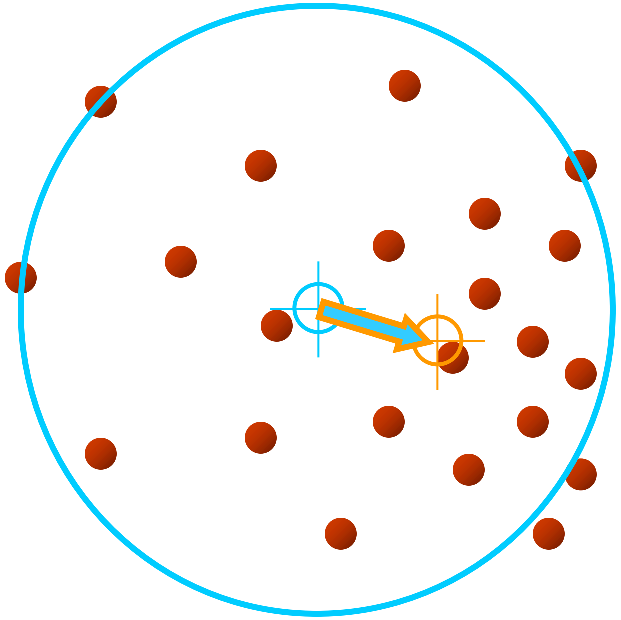
# Computing the Mean Shift

Simple Mean Shift procedure:

- Compute mean shift vector

- Move the Kernel window by **m(x)**

$$\mathbf{m}(\mathbf{x}) = \left[ \frac{\sum_{i=1}^{n} \mathbf{x}_i g\left( \frac{\|\mathbf{x} - \mathbf{x}_i\|^2}{h} \right)}{\sum_{i=1}^{n} g\left( \frac{\|\mathbf{x} - \mathbf{x}_i\|^2}{h} \right)} - \mathbf{x} \right]$$



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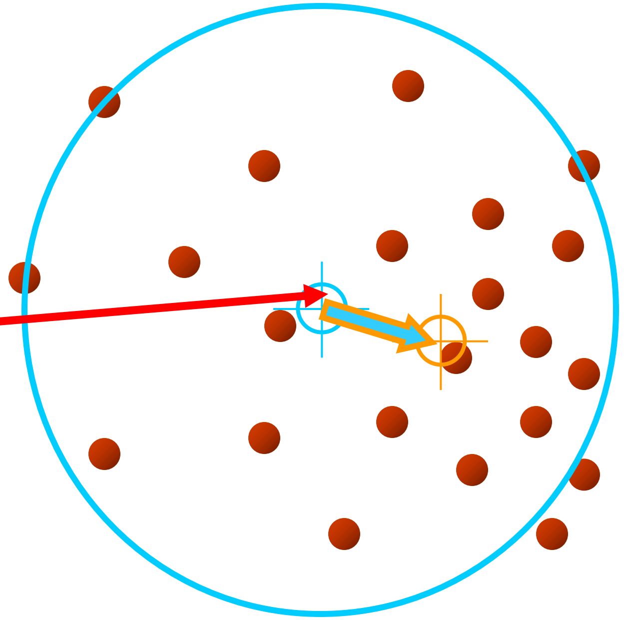

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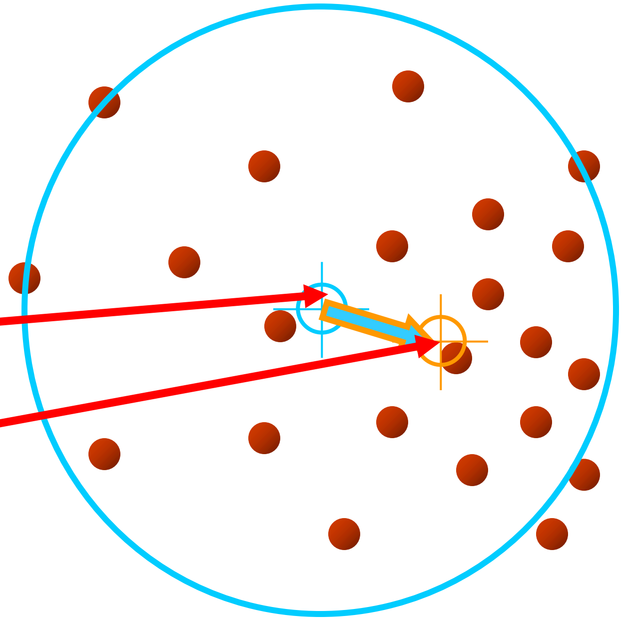

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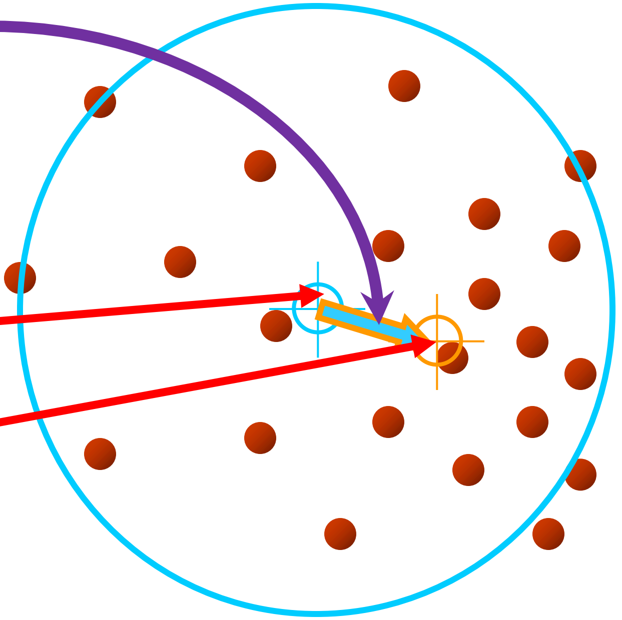
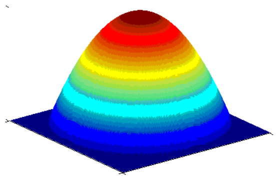


# Computing the Mean Shift

- Epanechnikov Kernel

$$K_E(\mathbf{x}) = \begin{cases} c\left(1-\|\mathbf{x}\|^2\right) & \|\mathbf{x}\| \le 1 \\ 0 & \text{otherwise} \end{cases}$$



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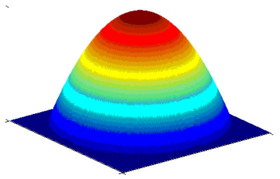
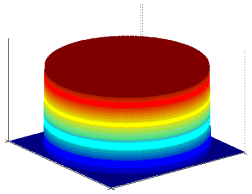


- Uniform Kernel

$$K_U(\mathbf{x}) = \begin{cases} c & \|\mathbf{x}\| \le 1 \\ 0 & \text{otherwise} \end{cases}$$



# Computing the Mean Shift

$$\mathbf{m}(\mathbf{x}) = \left[ \frac{\sum_{i=1}^{n} \mathbf{x}_i g\left( \frac{\left\| \mathbf{x} - \mathbf{x}_i \right\|^2}{h} \right)}{\sum_{i=1}^{n} g\left( \frac{\left\| \mathbf{x} - \mathbf{x}_i \right\|^2}{h} \right)} - \mathbf{x} \right]$$

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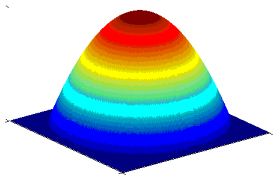

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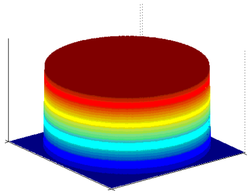
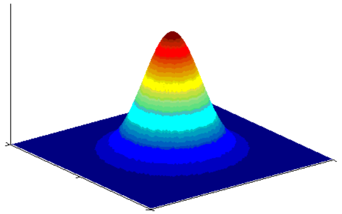
$$K_U(\mathbf{x}) = \begin{cases} c & \|\mathbf{x}\| \le 1 \\ 0 & \text{otherwise} \end{cases}$$



- Normal Kernel

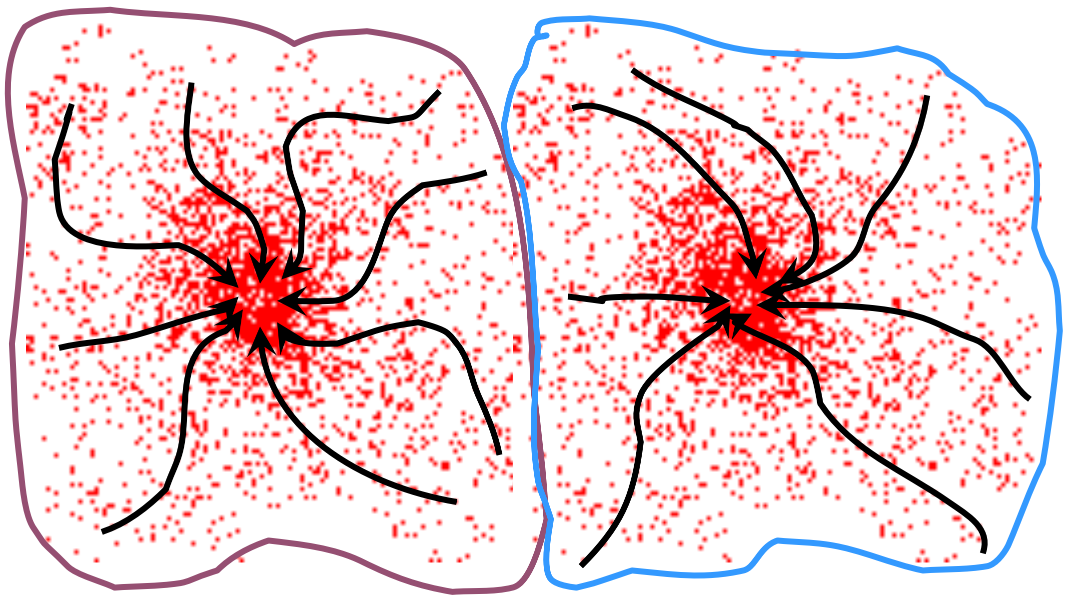
$$K_N(\mathbf{x}) = c \cdot \exp\left( -\frac{1}{2} \|\mathbf{x}\|^2 \right)$$



# Attraction Basin

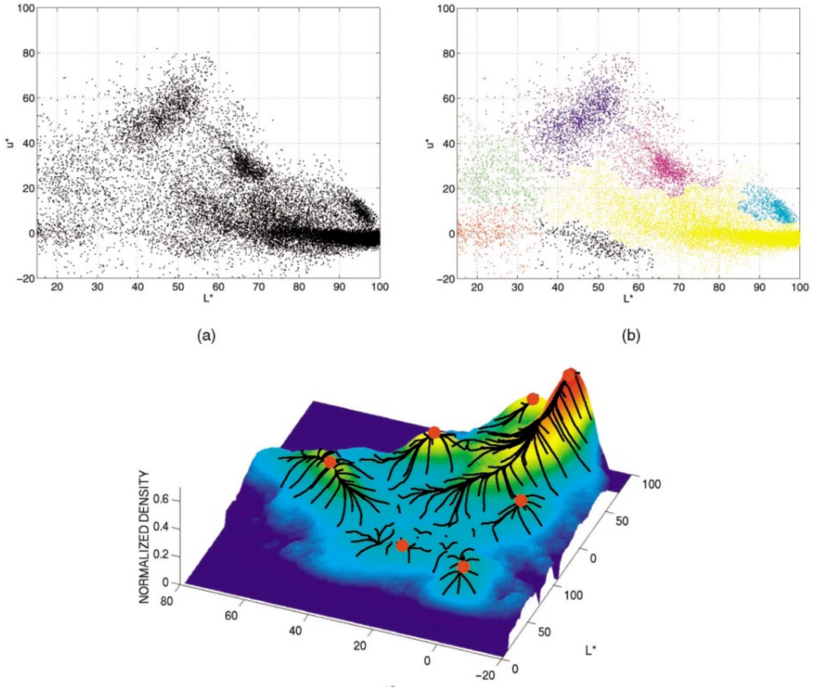
- **Cluster:** all data points in the attraction basin of a mode.

- **Attraction basin:** the region for which all trajectories lead to the same mode.

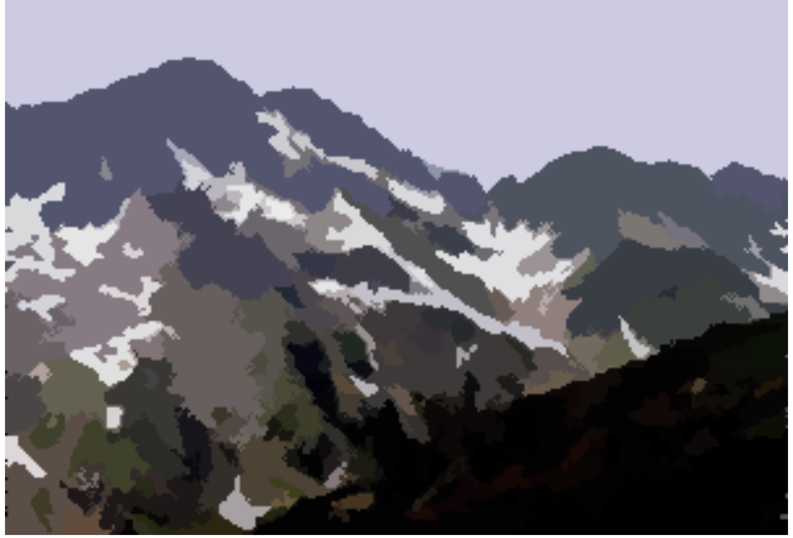


# Mean Shift Clustering/Segmentation

- Find features (color, gradients, texture, etc).
- Initialize windows at individual feature points.
- Perform mean shift for each window until convergence.
- Merge windows that end up near the same “peak” or mode.



# Mean shift segmentation results



http://www.caip.rutgers.edu/~comanici/MSPAMI/msPamiResults.html

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# Mean Shift: Pros and Cons

- Pros
  - Good general-purpose segmentation
  - Flexible in number and shape of regions
  - Robust to outliers
  - General mode-finding algorithm (useful for other problems such as finding most common surface normals)

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  - Good general-purpose segmentation
  - Flexible in number and shape of regions
  - Robust to outliers
  - General mode-finding algorithm (useful for other problems such as finding most common surface normals)

- Cons
  - Have to choose kernel size in advance
  - Not suitable for high-dimensional features

# Mean-shift reading

- Nicely written mean-shift explanation (with math)

http://saravananthirumuruganathan.wordpress.com/2010/04/01/introduction-to-mean-shift-algorithm/

  - Includes .m code for mean-shift clustering

- Mean-shift paper by Comaniciu and Meer

http://www.caip.rutgers.edu/~comanici/Papers/MsRobustApproach.pdf

- Adaptive mean shift in higher dimensions

*http://mis.hevra.haifa.ac.il/~ishimshoni/papers/chap9.pdf*