Segmentation and Clustering (Part 3)

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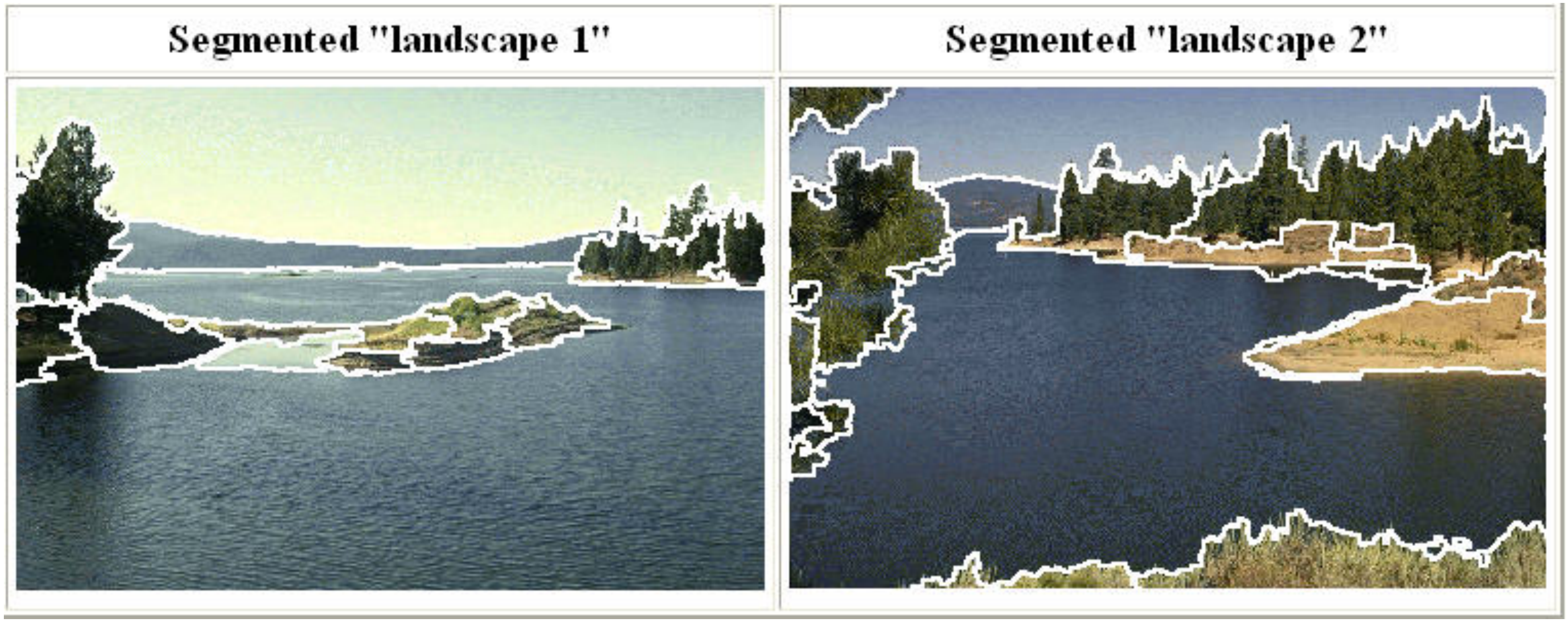
This Lecture

- Segmentation and grouping
  - Gestalt principles
  - Image segmentation
- Segmentation as clustering
  - k-Means
  - Feature spaces
- Probabilistic clustering
  - Mixture of Gaussians, EM
- **Model-free clustering**
  - Mean-Shift clustering
- Graph theoretic segmentation
  - Normalised cuts

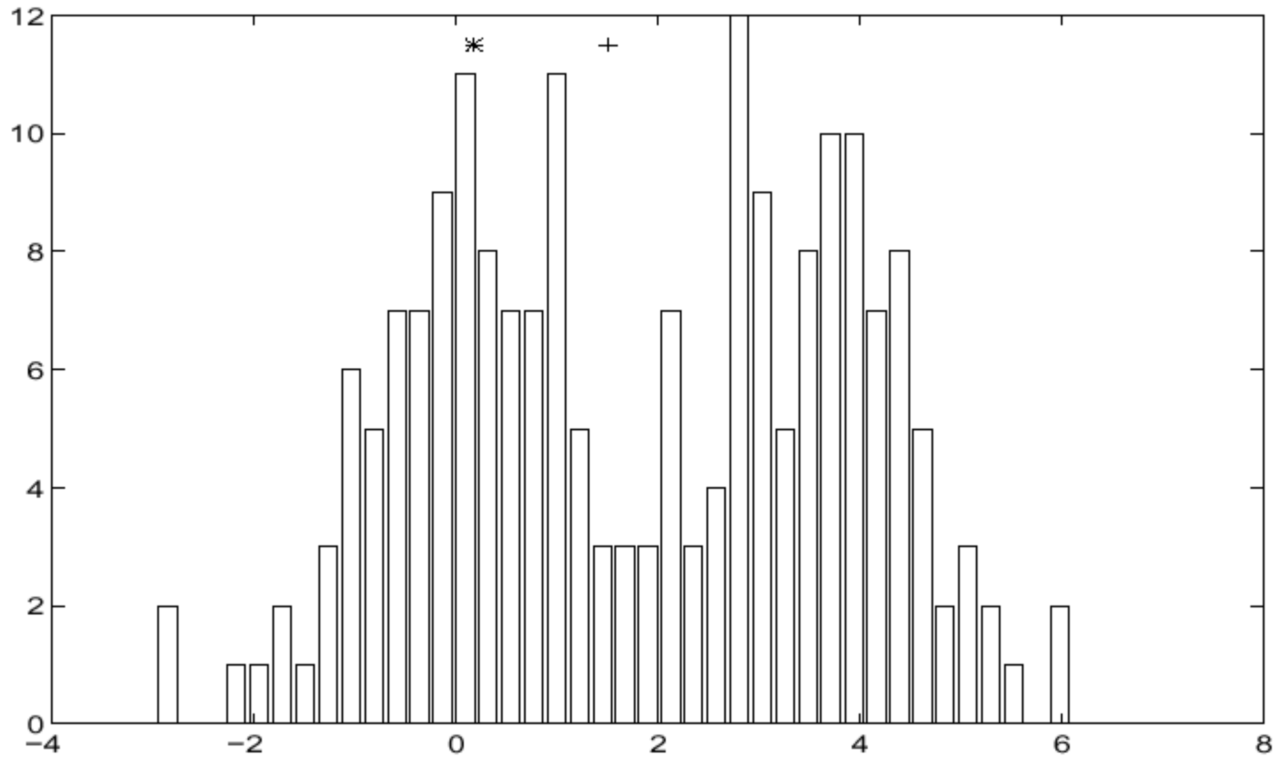
Mean-Shift Segmentation

- **An advanced and versatile technique for clustering-based segmentation**



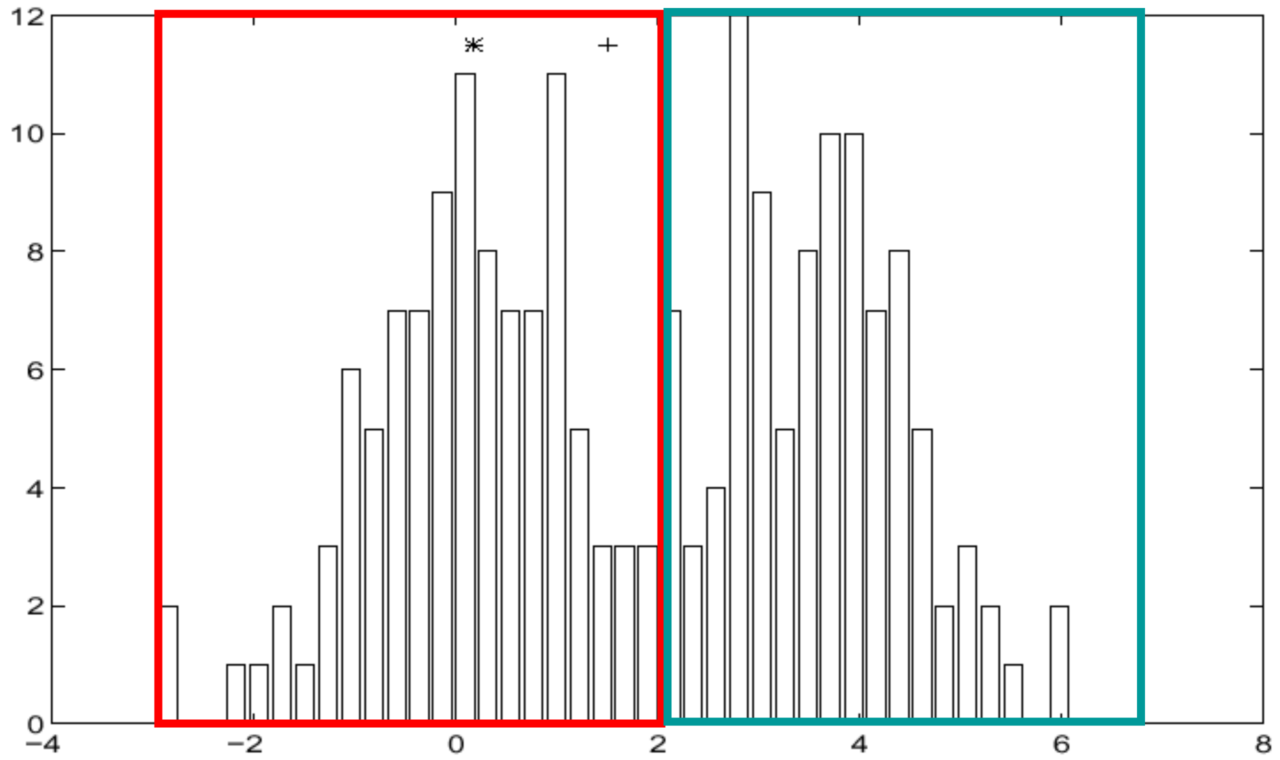
D. Comaniciu and P. Meer, [Mean Shift: A Robust Approach toward Feature Space Analysis](), PAMI 2002.

Finding Modes in a Histogram



- **How many modes are there?**
  - *Mode* = local maximum of the density of a given distribution
  - Easy to see, hard to compute

Finding Modes in a Histogram



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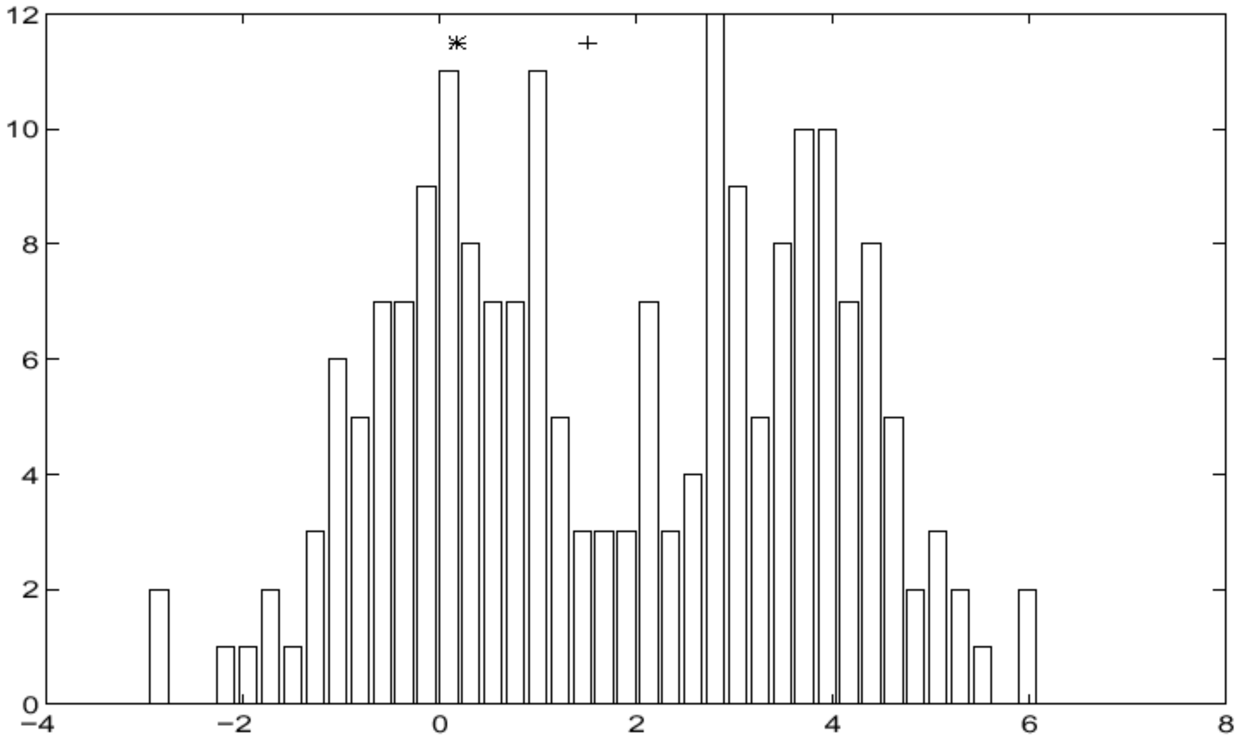
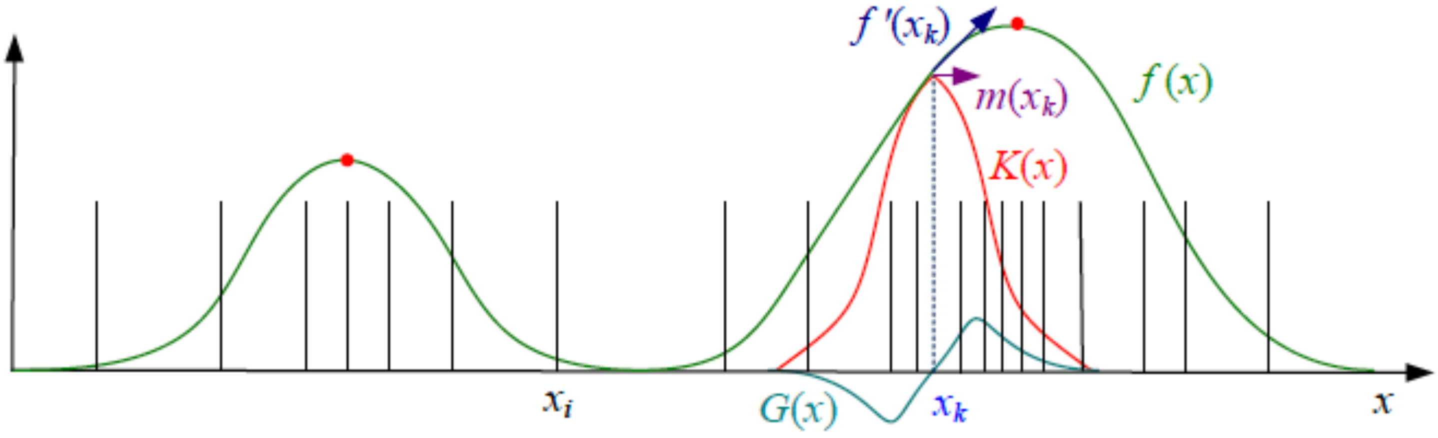
Mean-Shift Algorithm



- **Iterative Mode Search**
  1. Initialise random seed, and window W
  2. Calculate centre of gravity (the "mean") of W: $\sum_{x \in W} xH(x)$
  3. Shift the search window to the "mean"
  4. Repeat Step 2 until convergence

Mean-Shift and mode finding



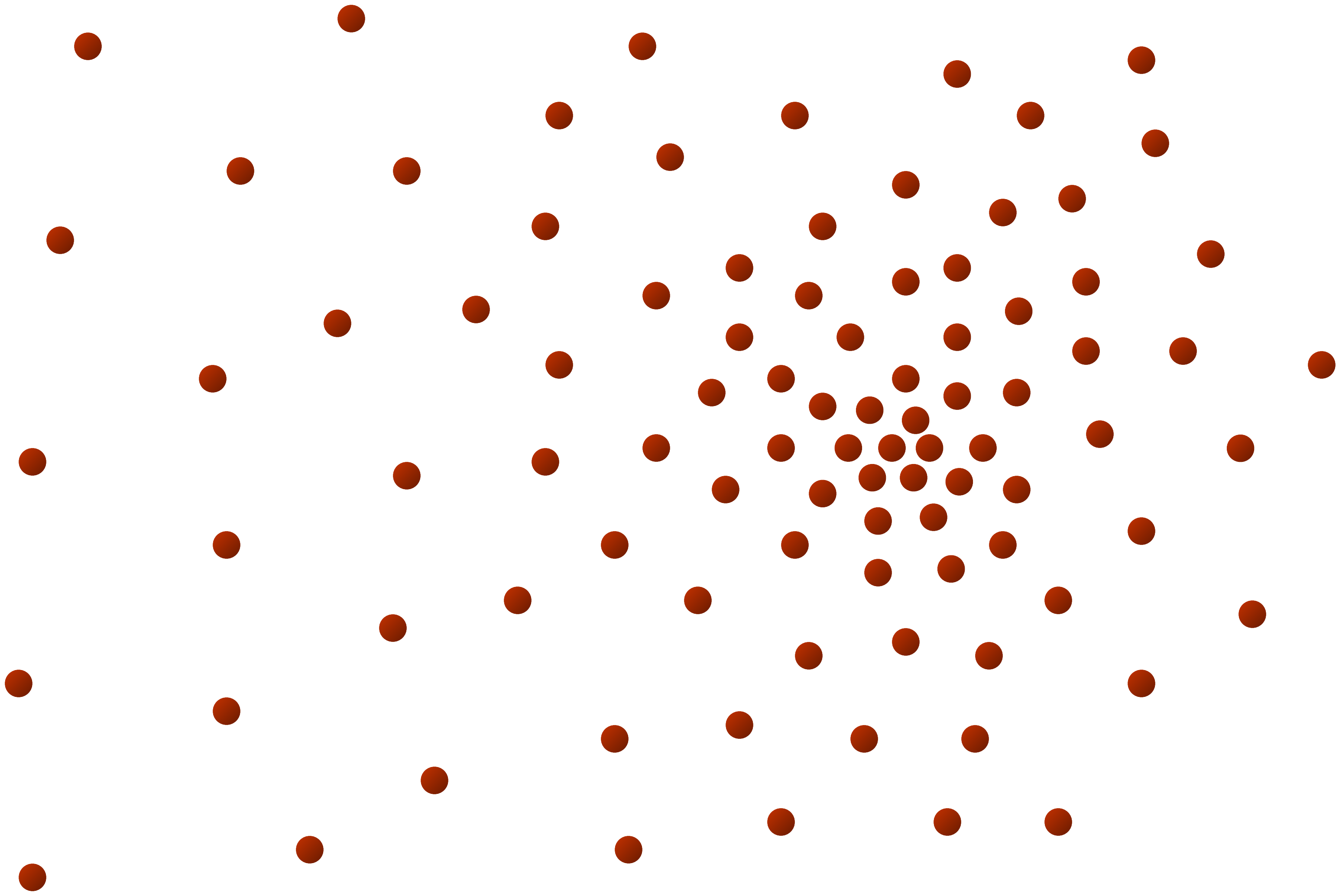
One-dimensional visualization of kernel density estimate, its derivative, and a mean shift.

<u>Further details:</u>

- **Parzen window or kernel approach to probability density estimation:**
  - **Duda, Hart, and stork 2001, section 4.3**
  - **Bishop 2006, section 2.5.1**
- **D. Comaniciu and P. Meer, <u>Mean Shift: A Robust Approach toward Feature Space Analysis</u>, PAMI 2002 (*copy on blackboard*)**

Figure credit: Szelinski, 2010

Mean-Shift



Slide credit Y. Ukrainitz & B. Sarel

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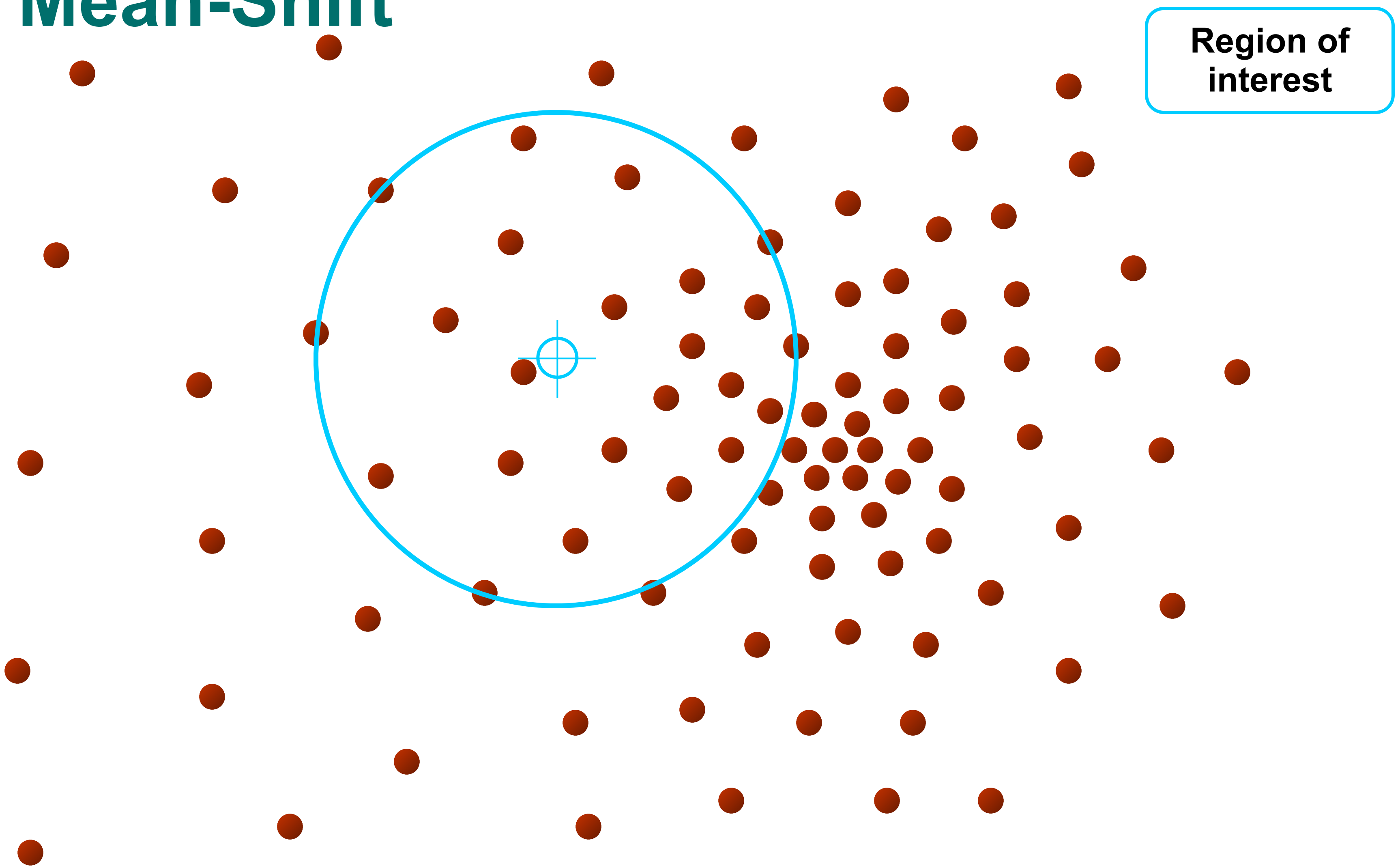

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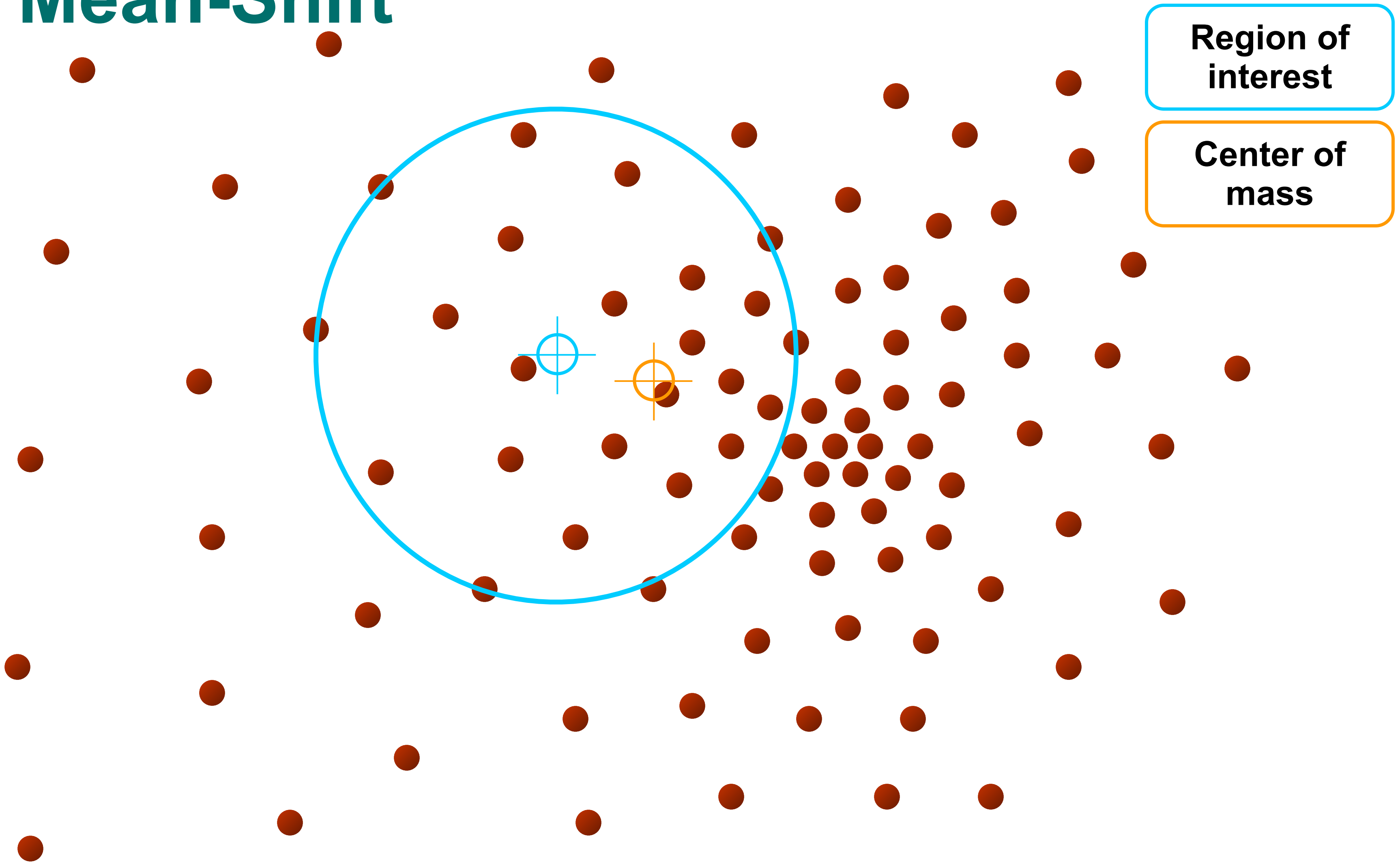

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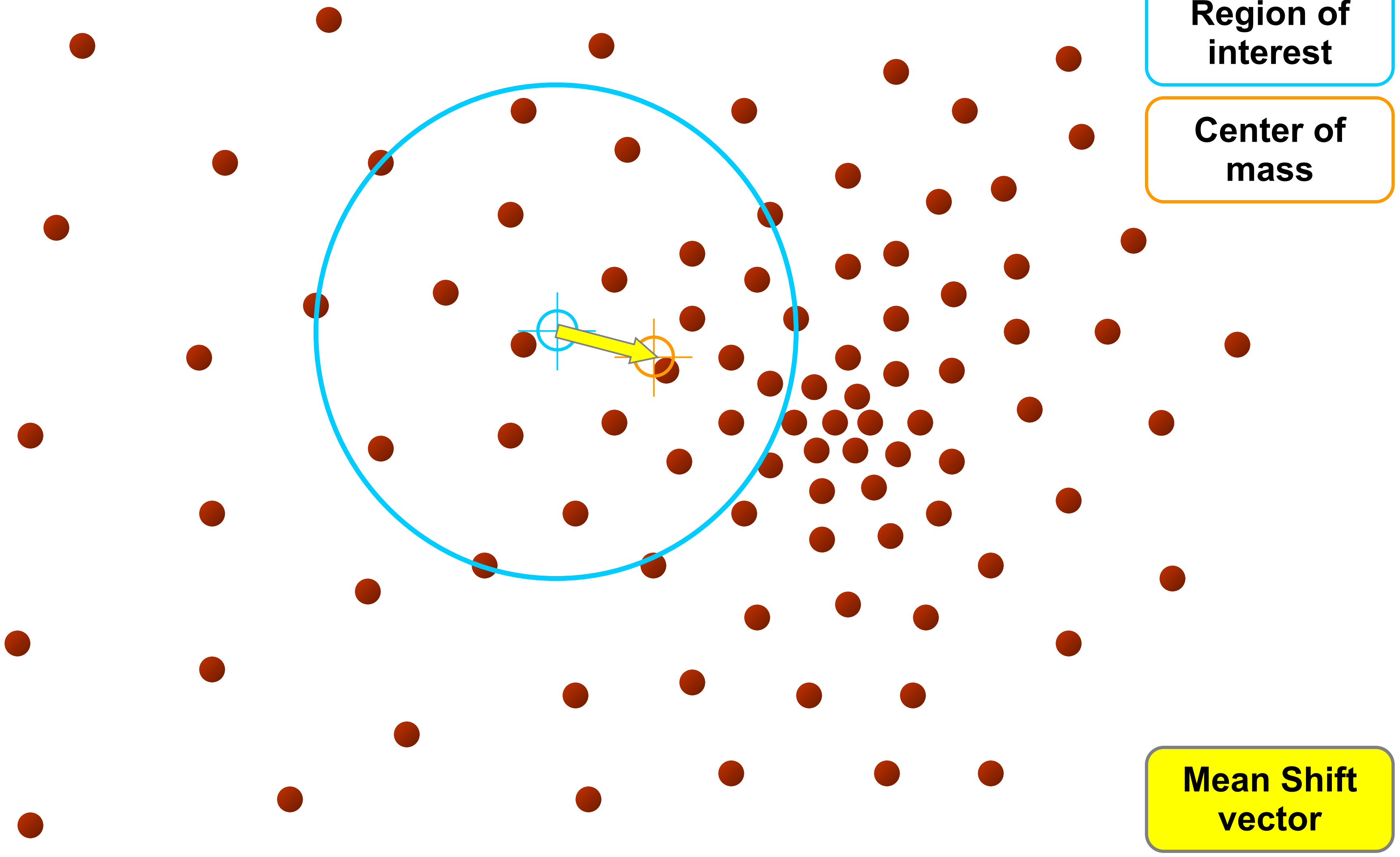

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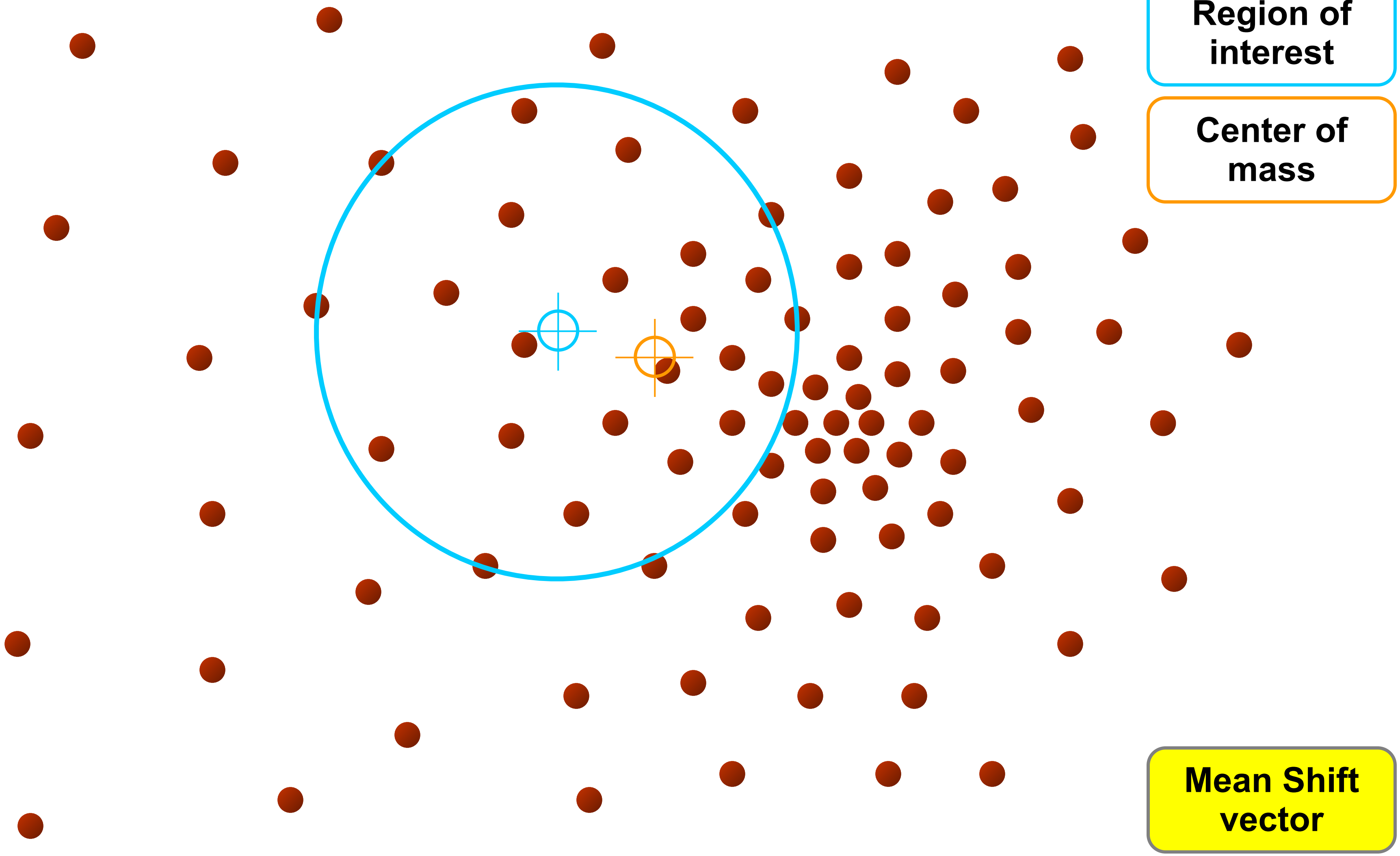

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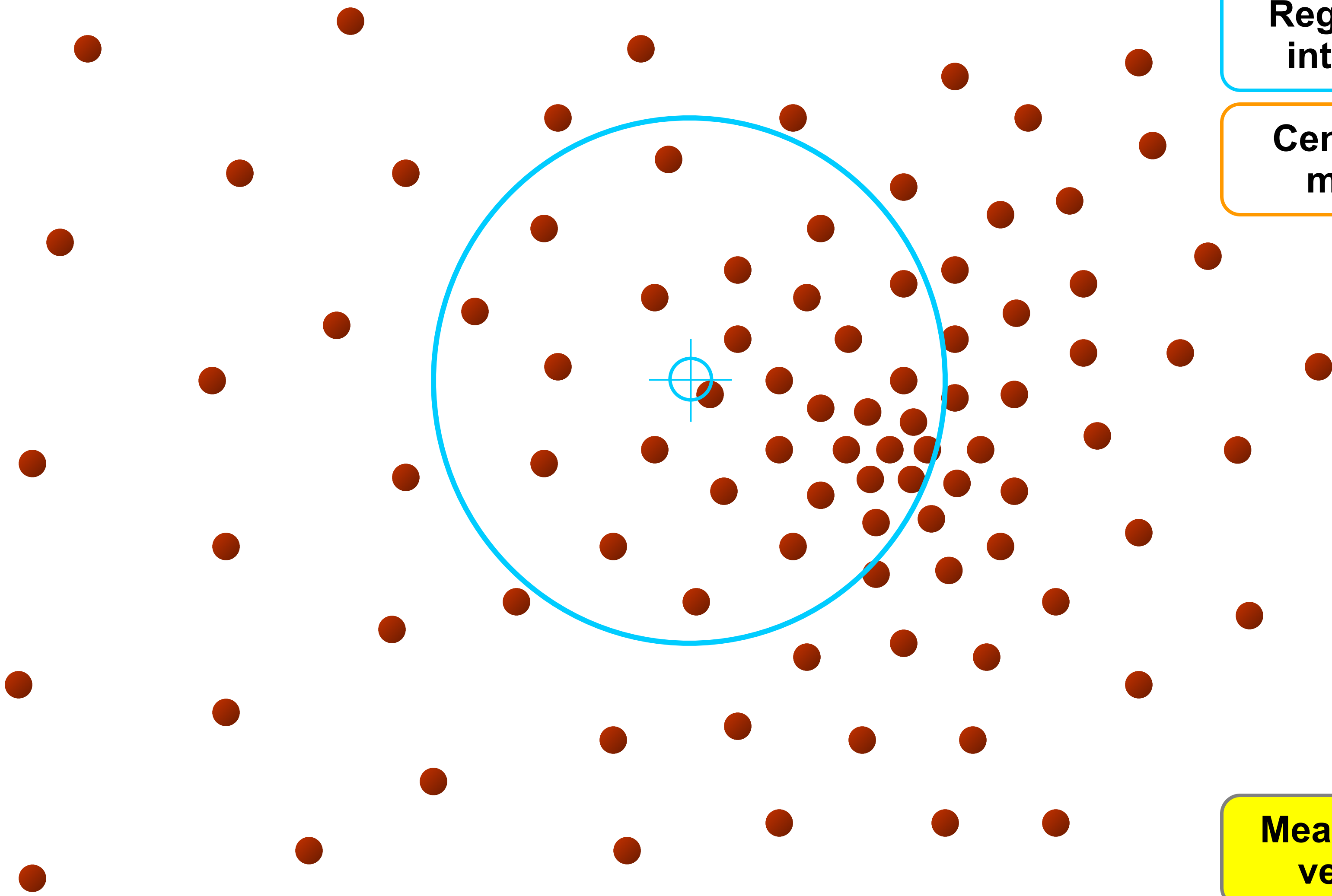


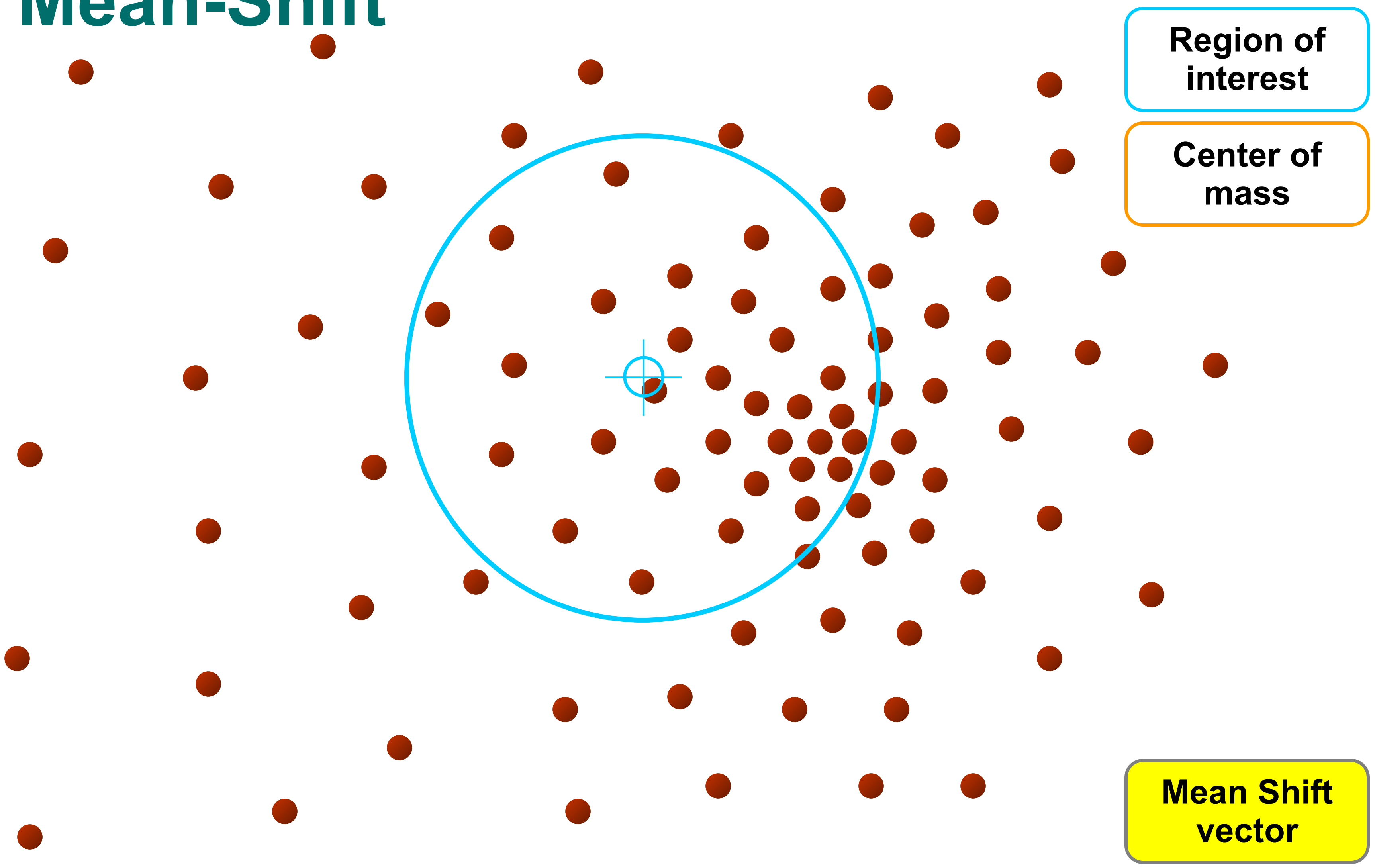
Region of interest

Center of mass

Mean Shift vector

Slide credit Y. Ukrainitz & B. Sarel

Mean-Shift



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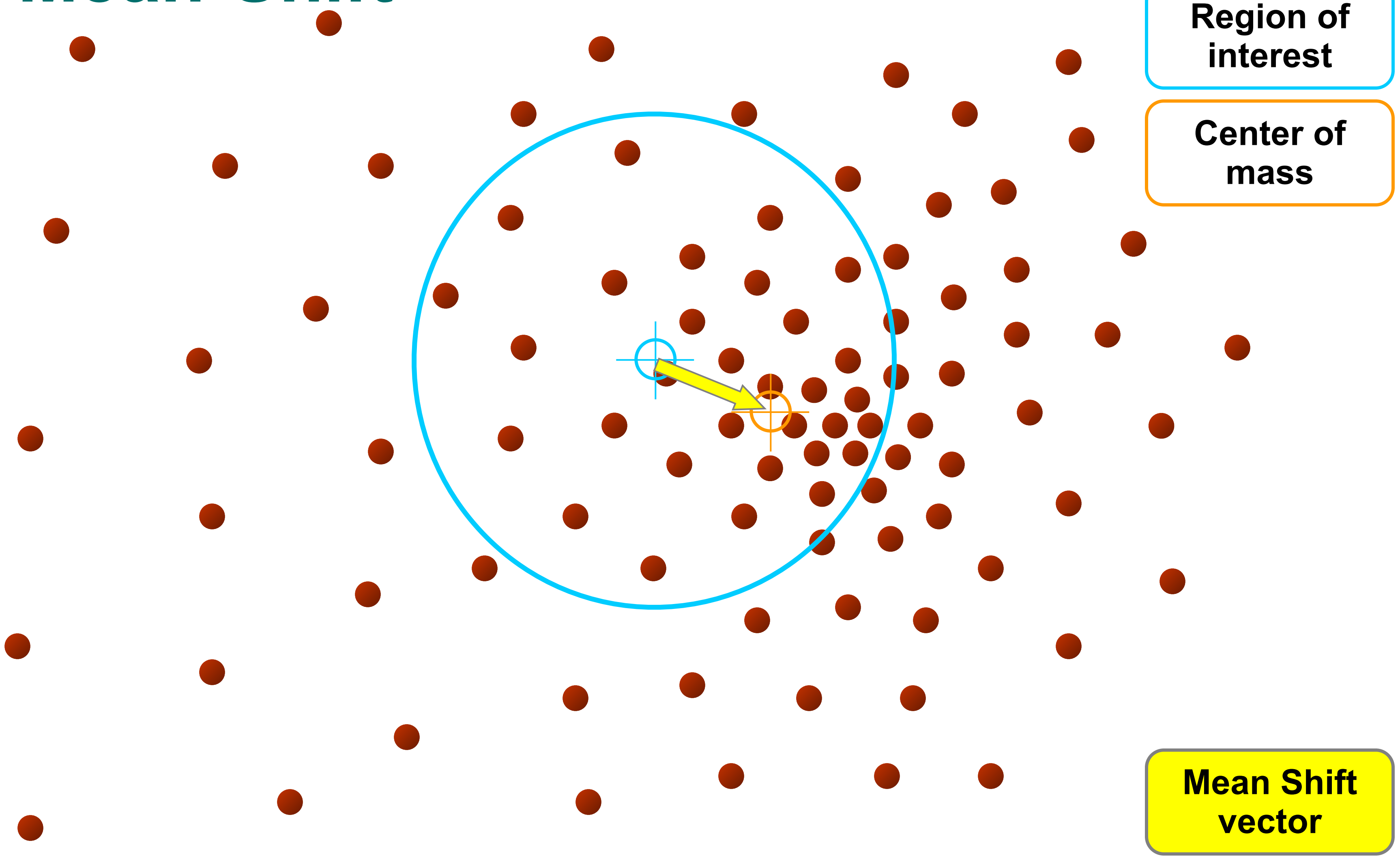

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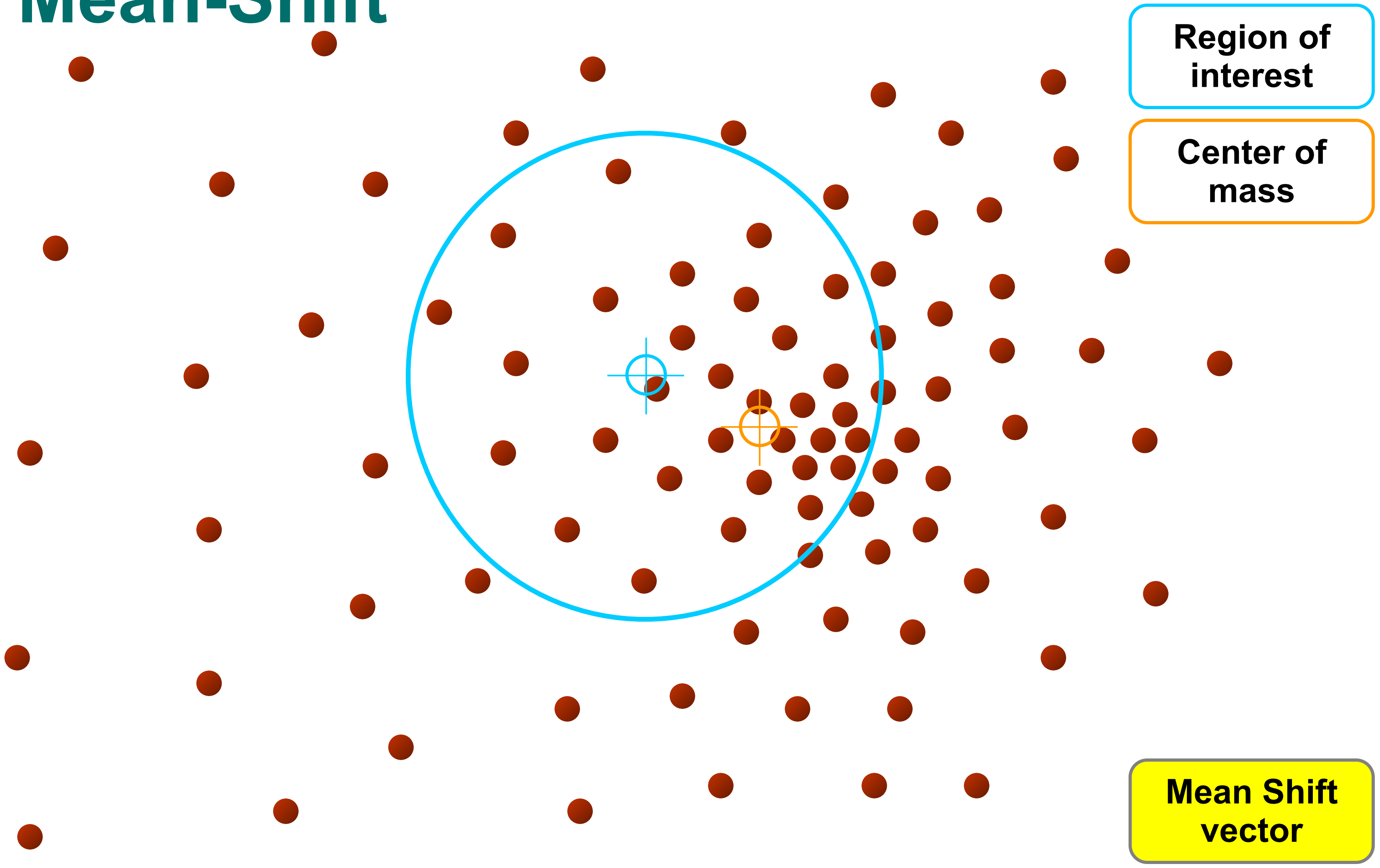

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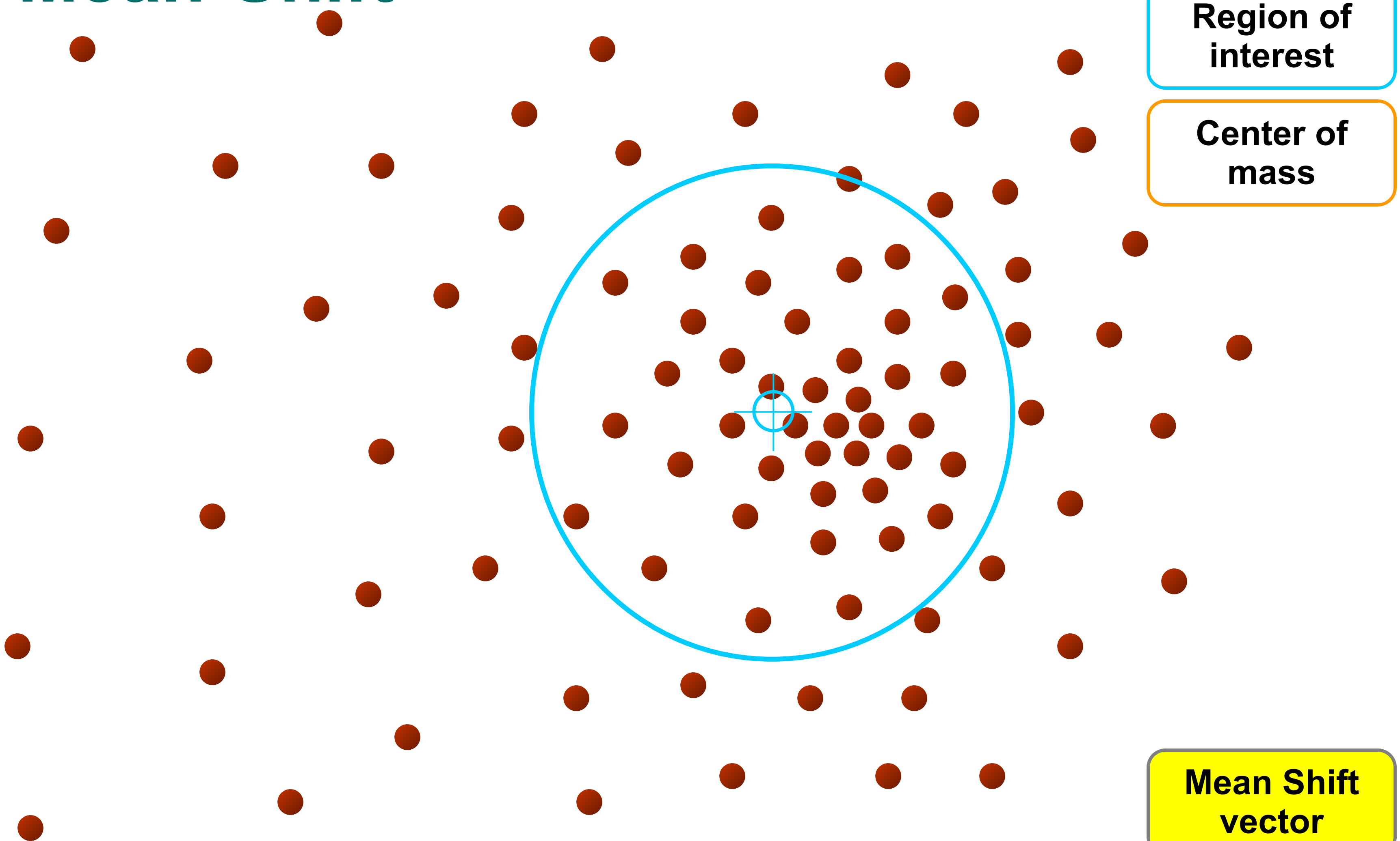

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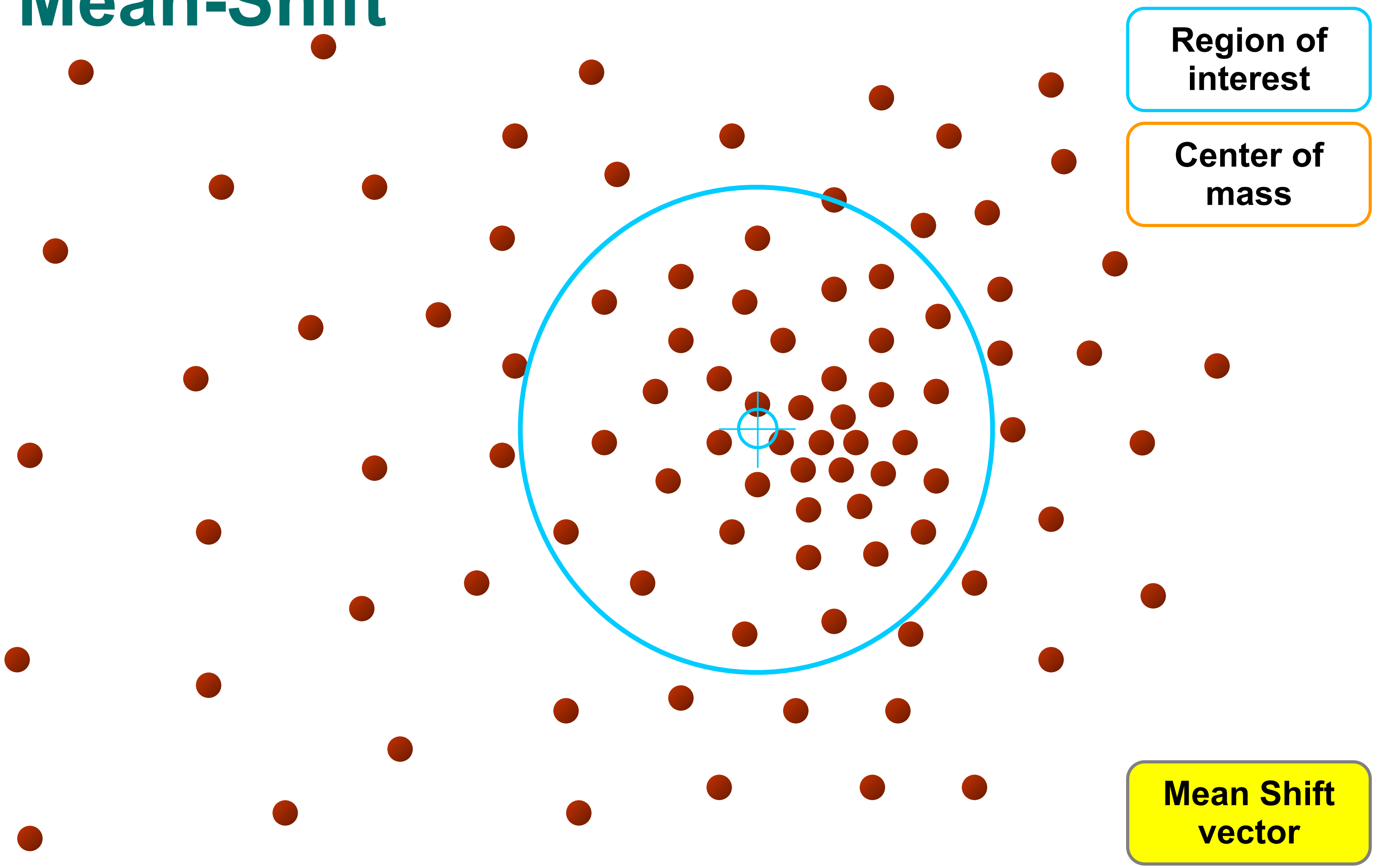

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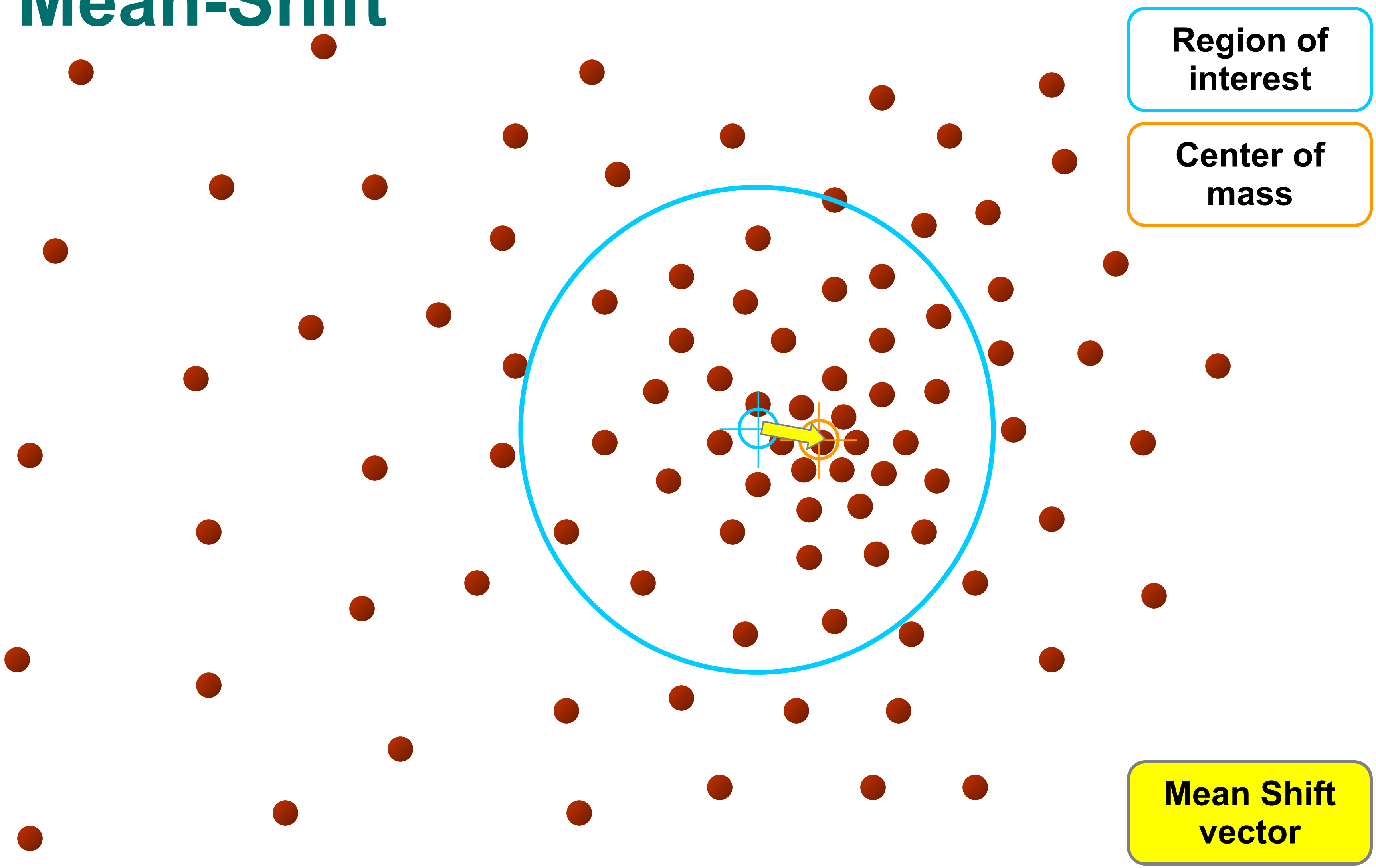

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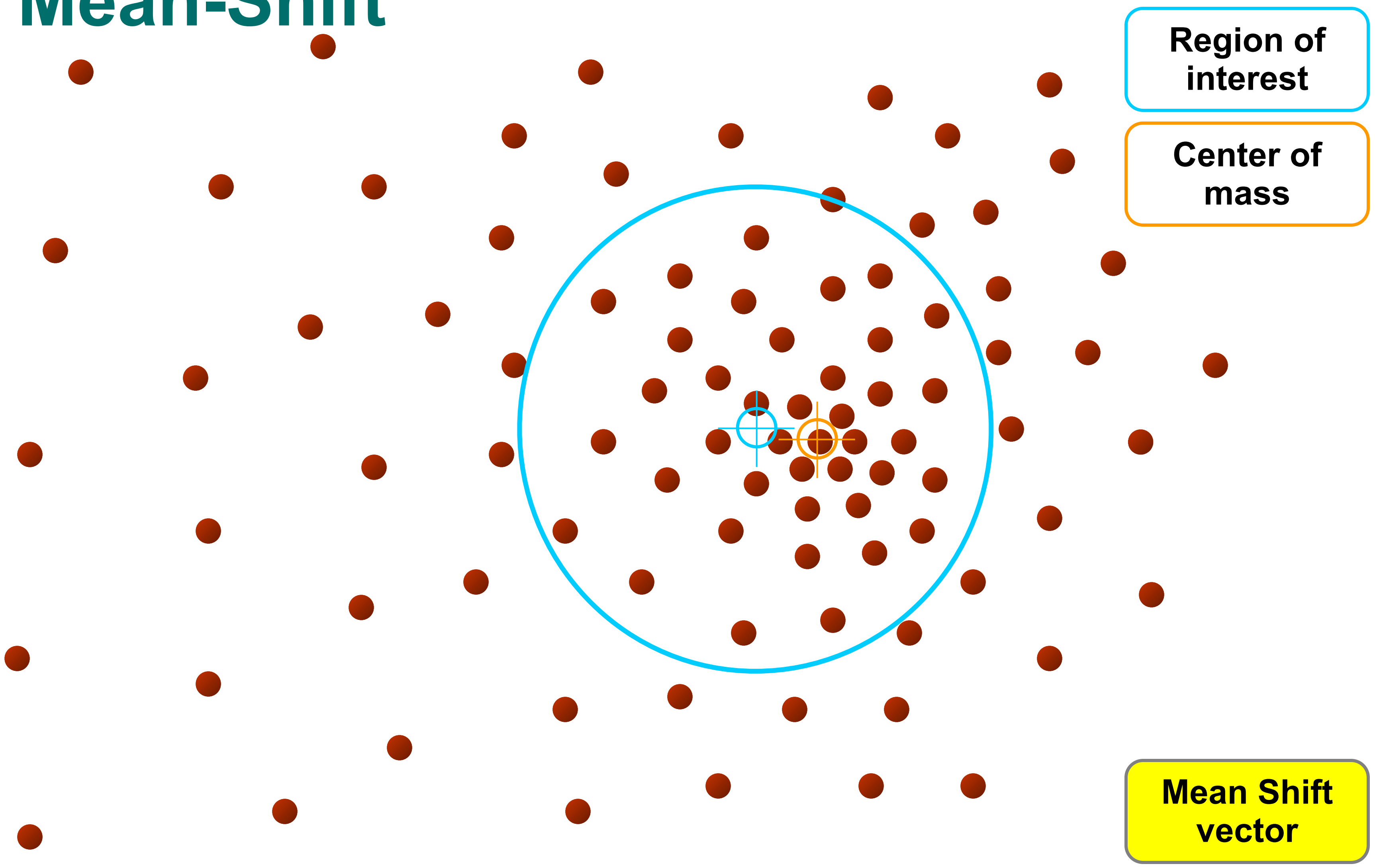

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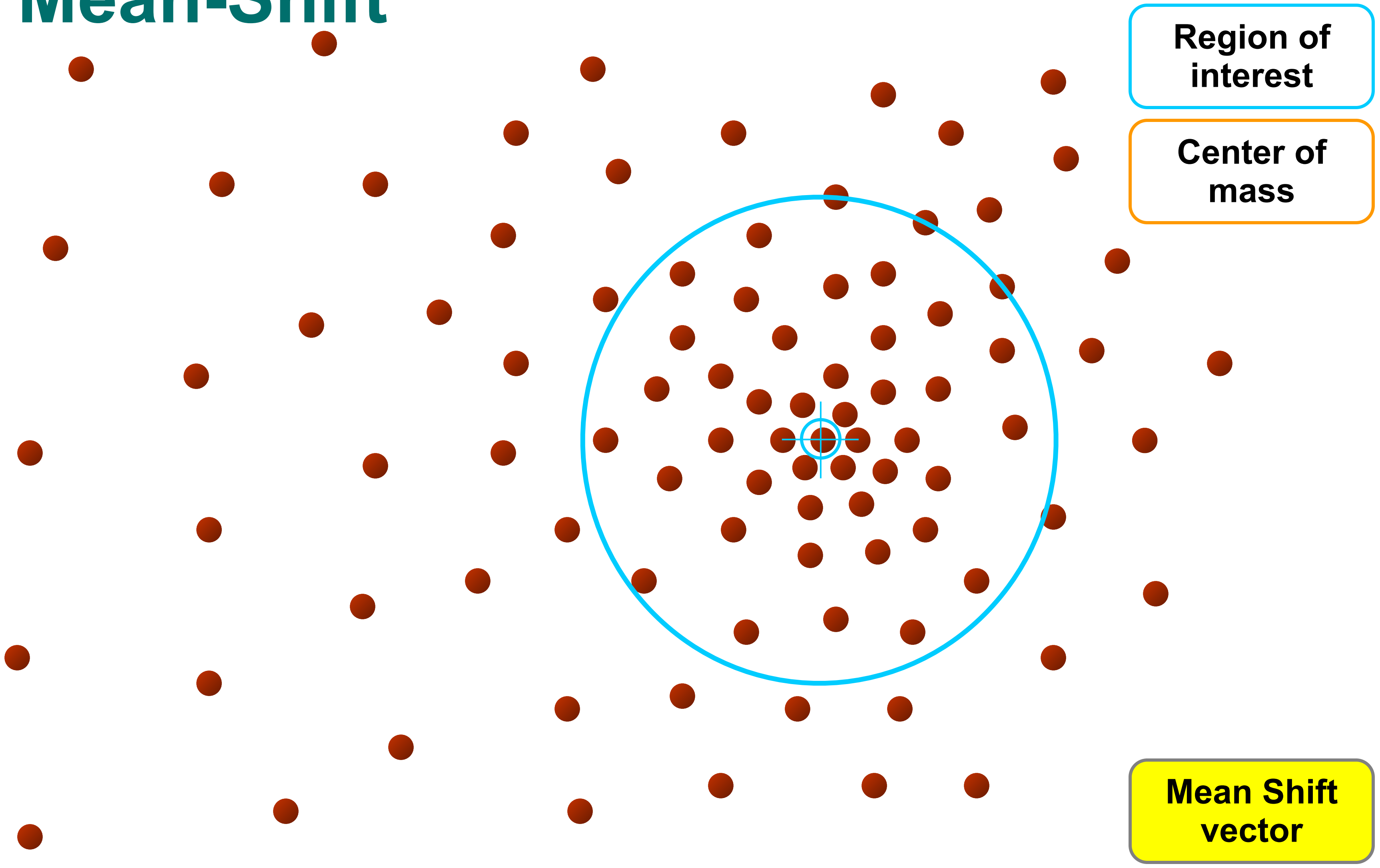

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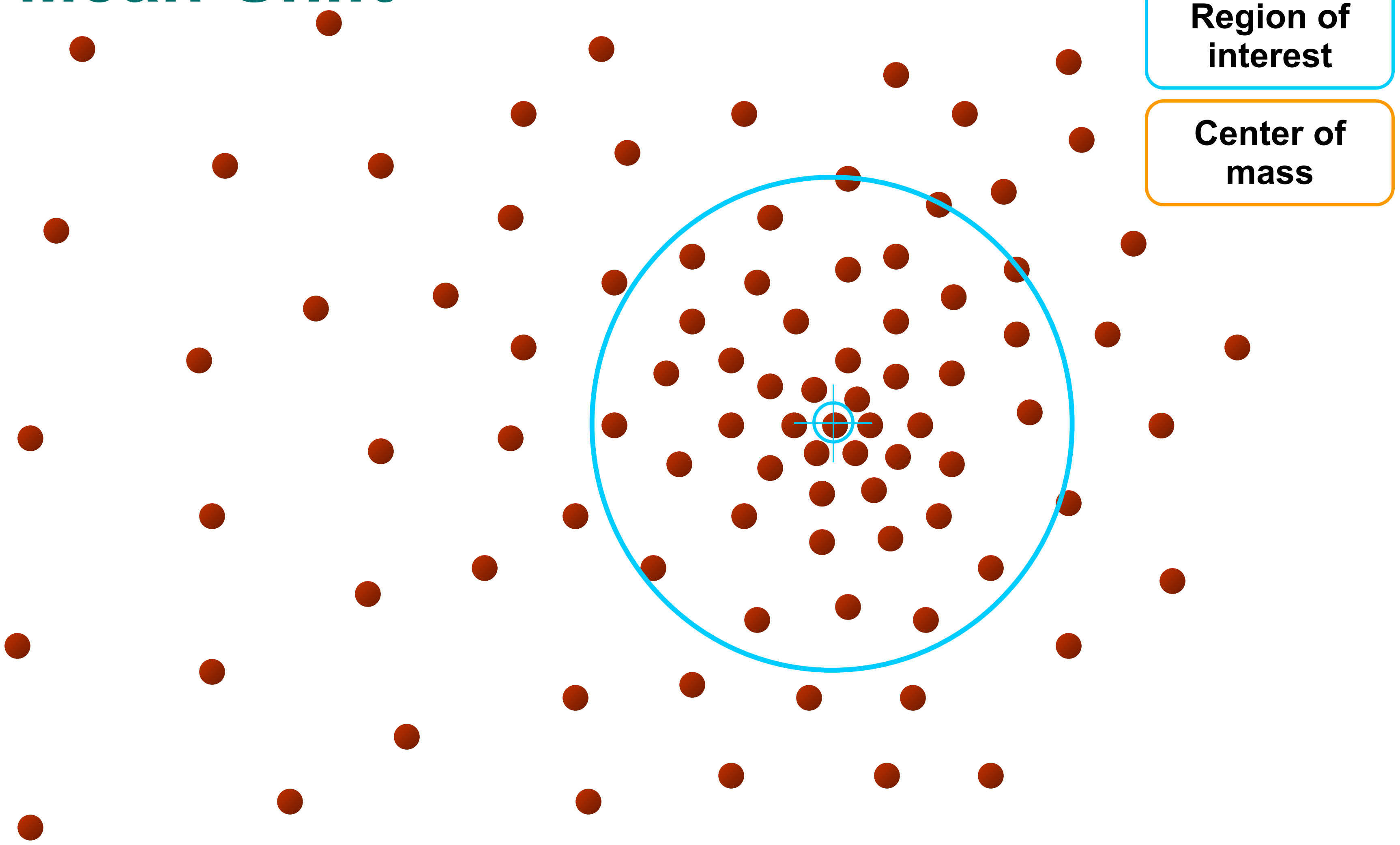

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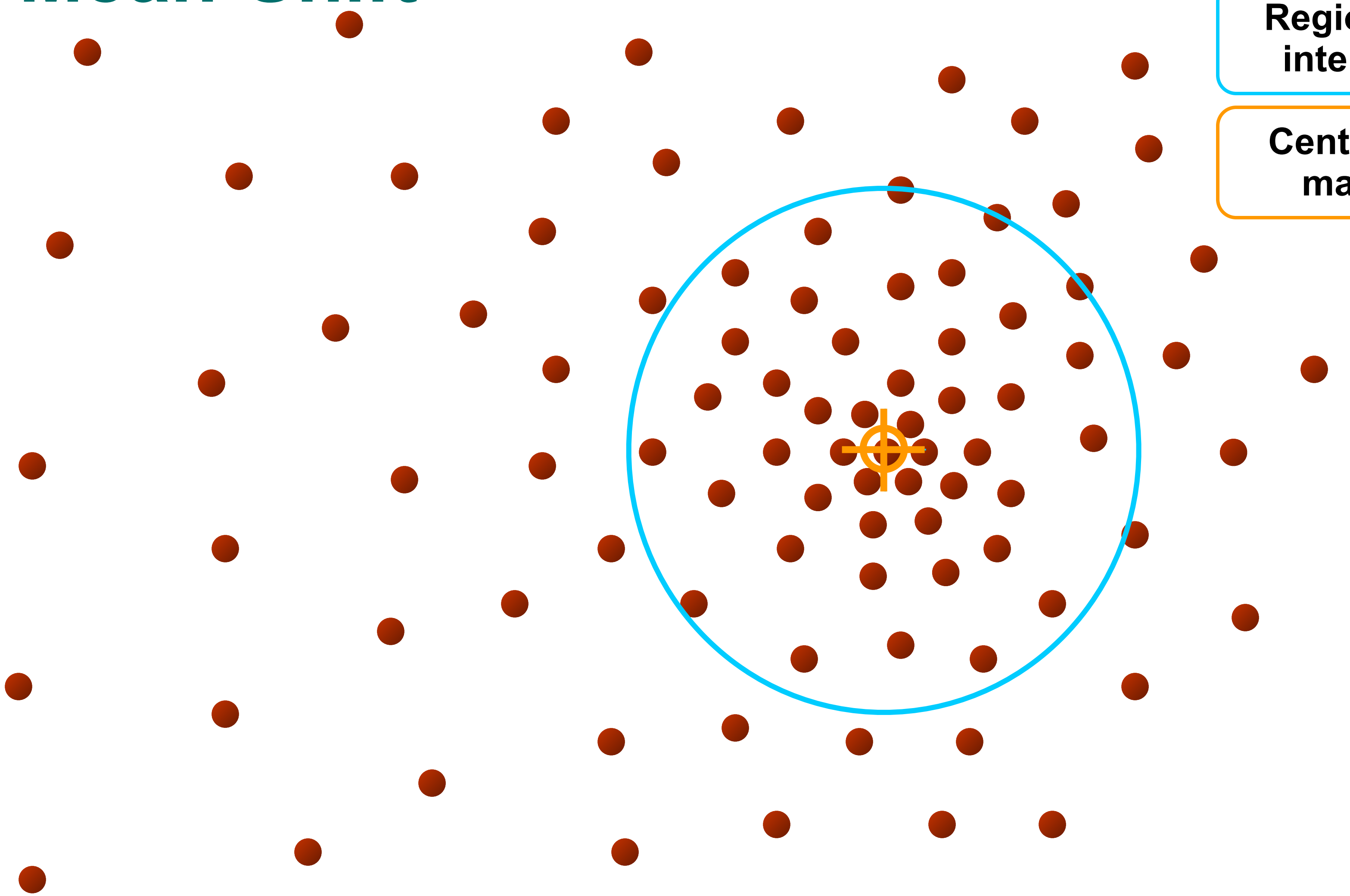

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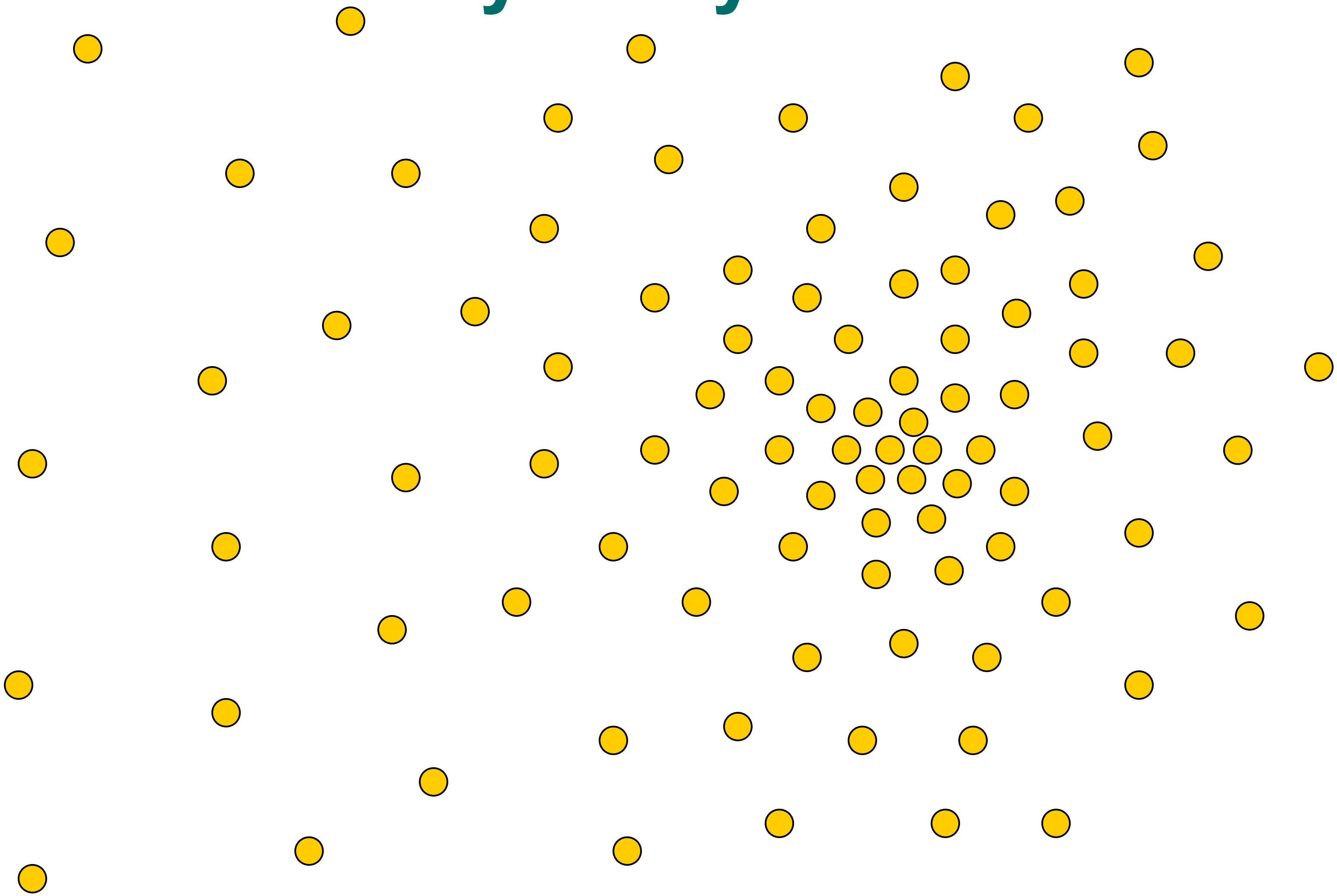
Real Modality Analysis



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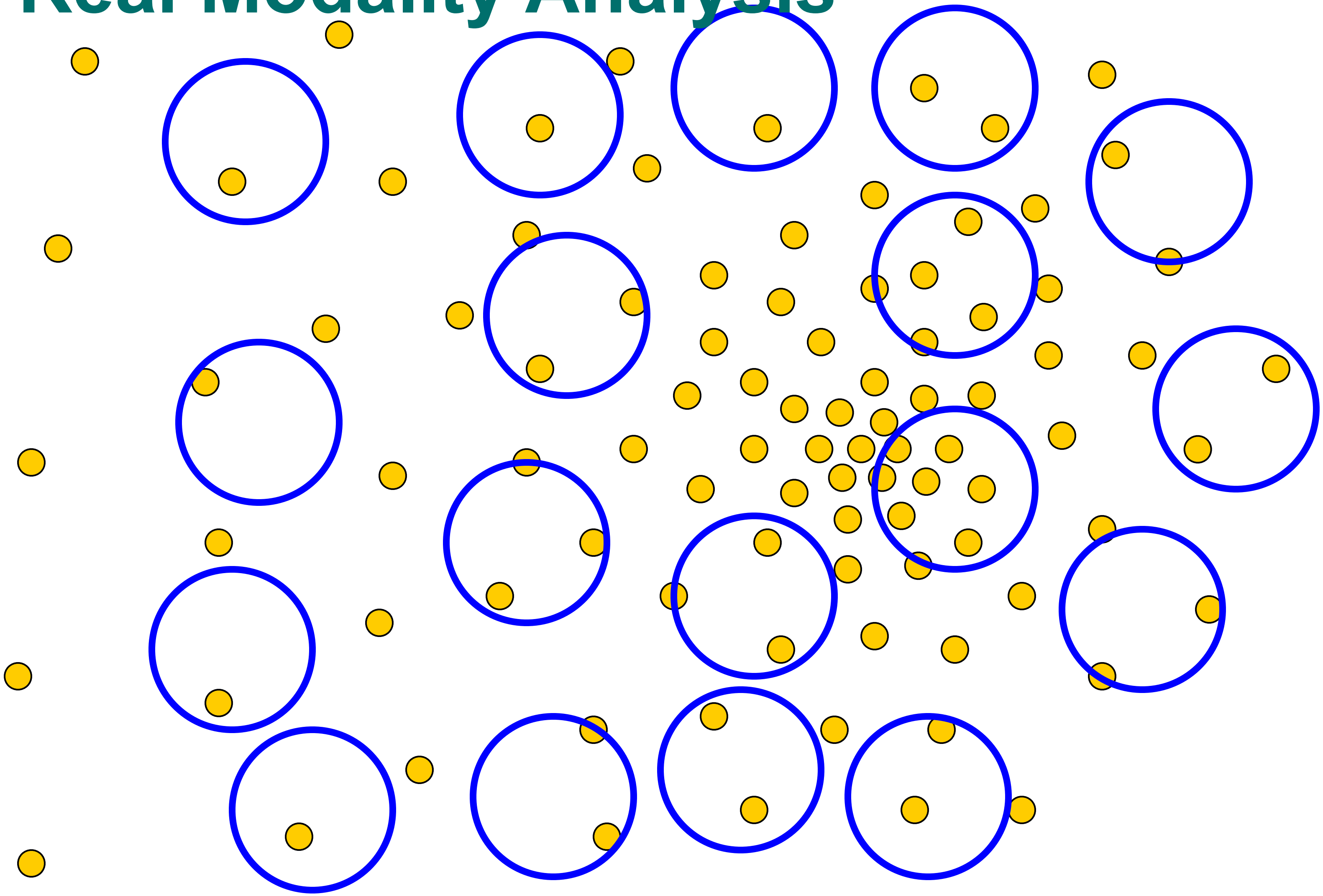

Run the procedure in parallel

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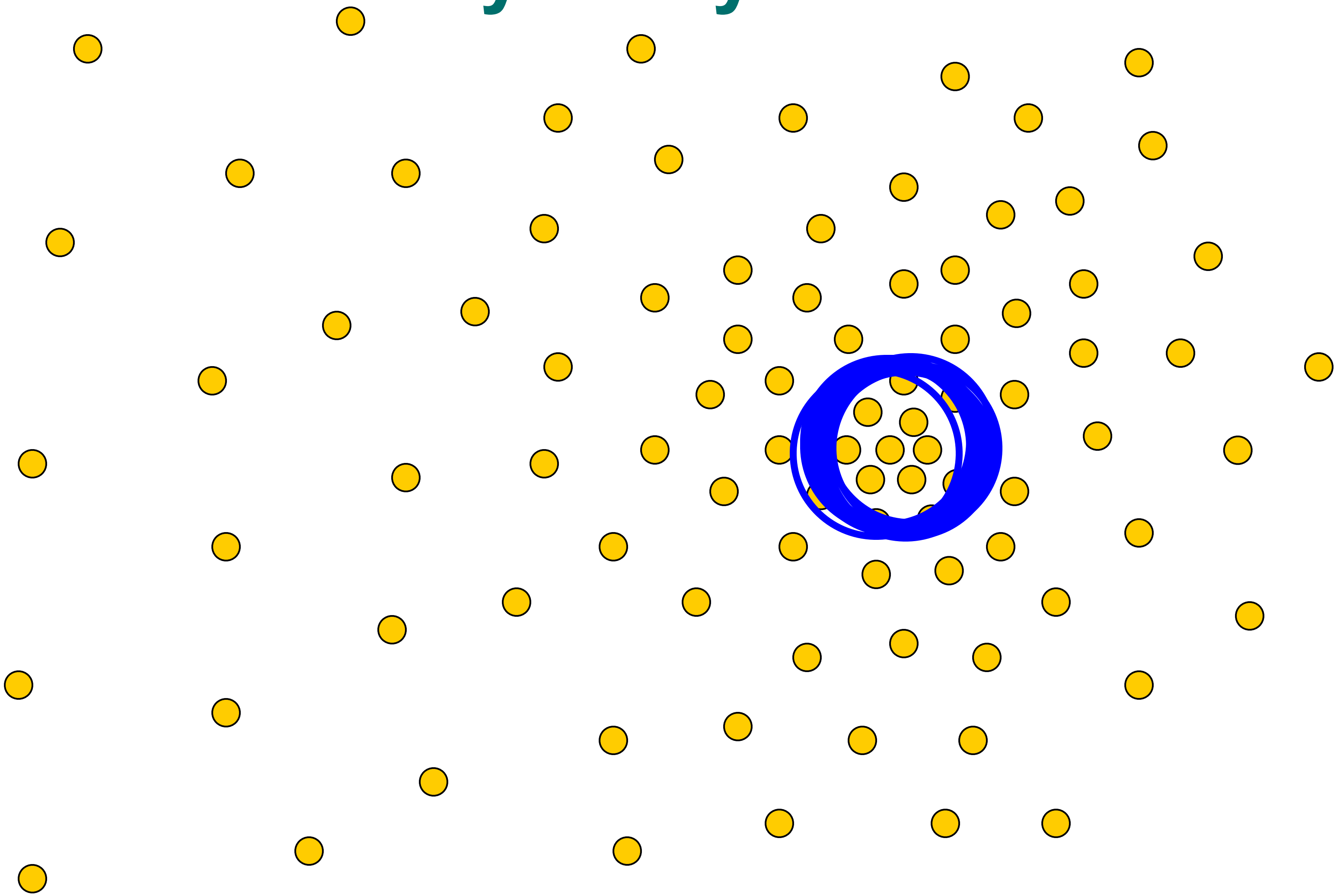

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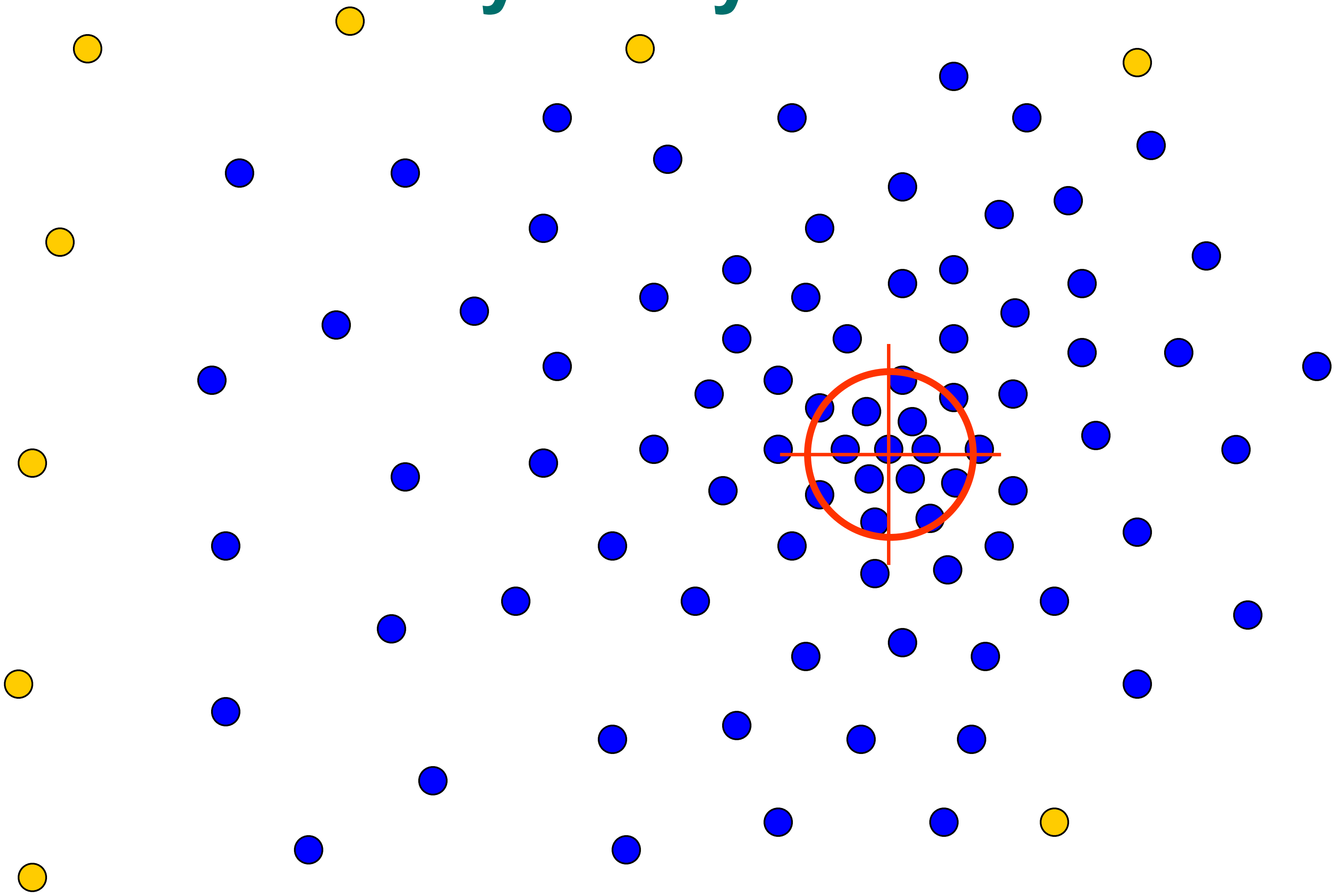

The blue data points were traversed by the windows towards the mode.

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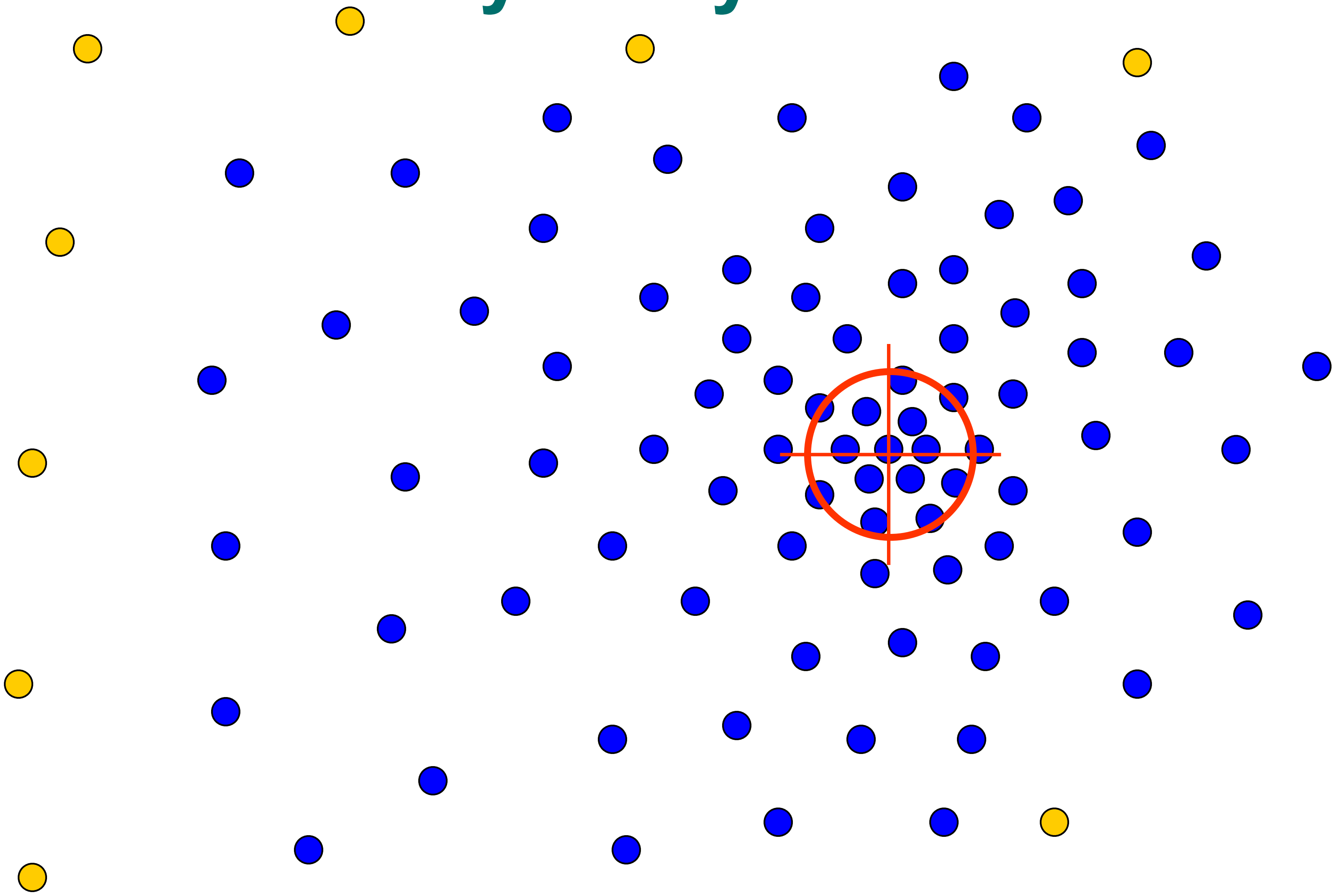

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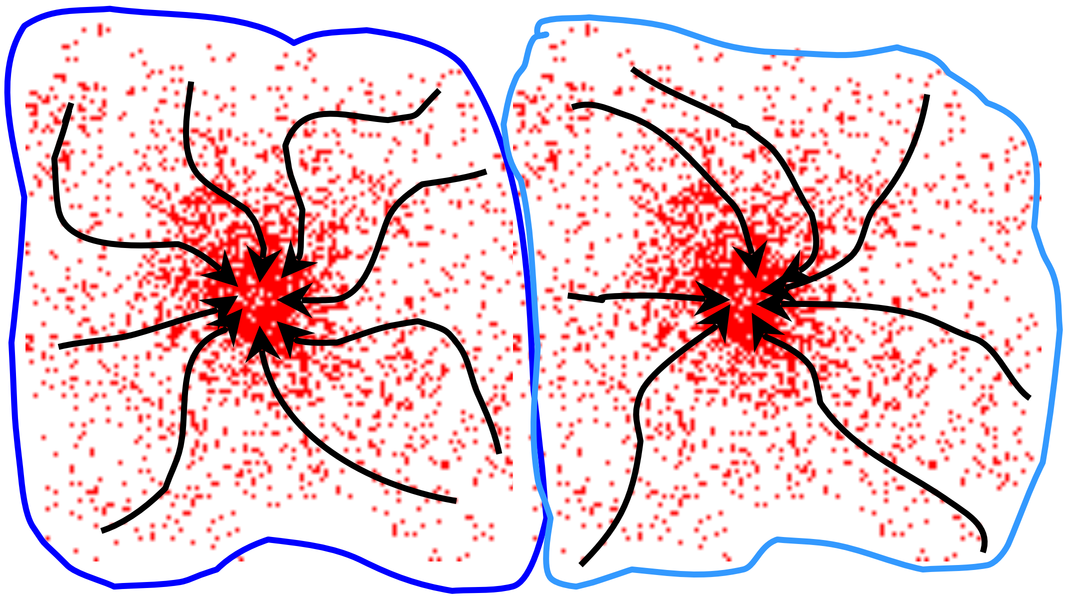
Mean-Shift Clustering

- **Cluster: all data points in the attraction basin of a mode**
- **Attraction basin: the region for which all trajectories lead to the same mode**



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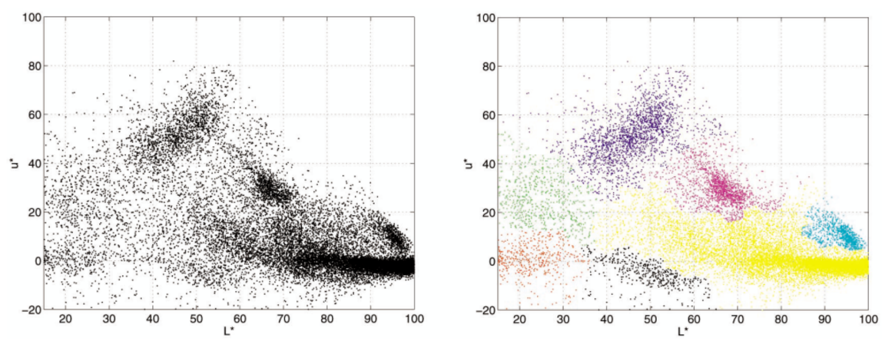
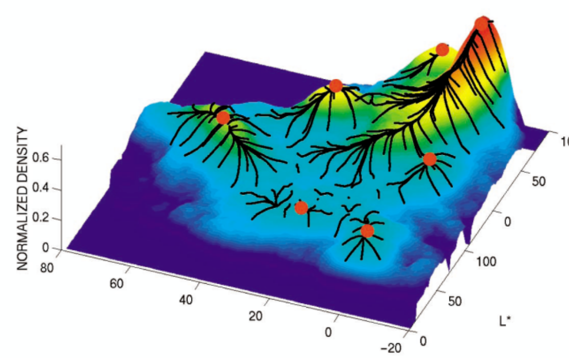
Mean-Shift Clustering/Segmentation

- Find features (<u>colour</u>, gradients, texture, etc)
- Initialize windows at individual pixel locations
- Perform mean shift for each window until convergence
- Merge windows that end up near the same “peak” or mode

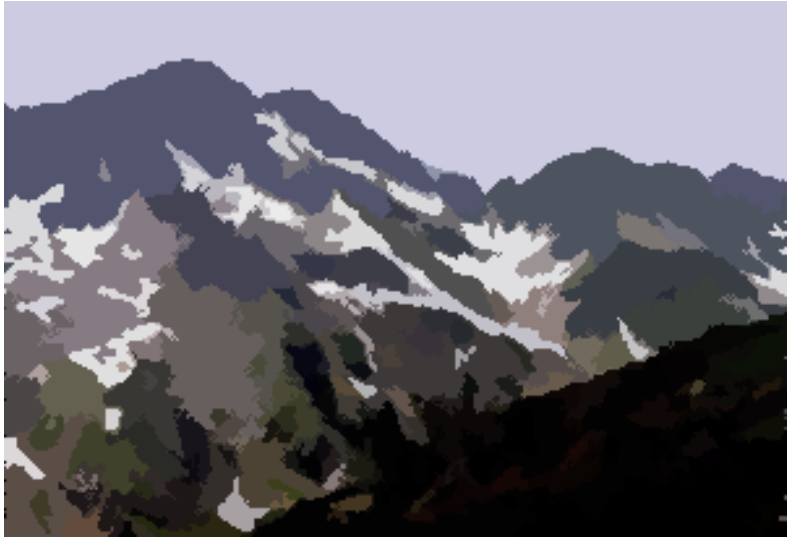


(a) (b)



D. Comaniciu and P. Meer, 2002

Mean-Shift Segmentation Results



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- **Pros**
  - General, application-independent tool
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  - Does not scale well with dimension of feature space

Today's Lecture

- **Segmentation and grouping**
  - Gestalt principles
  - Image segmentation
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- **Probabilistic clustering**
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- **Model-free clustering**
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Reading

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- **Forsyth, Ponce: Chapter 14**

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