MANCHESTER 1824

The University of Manchester

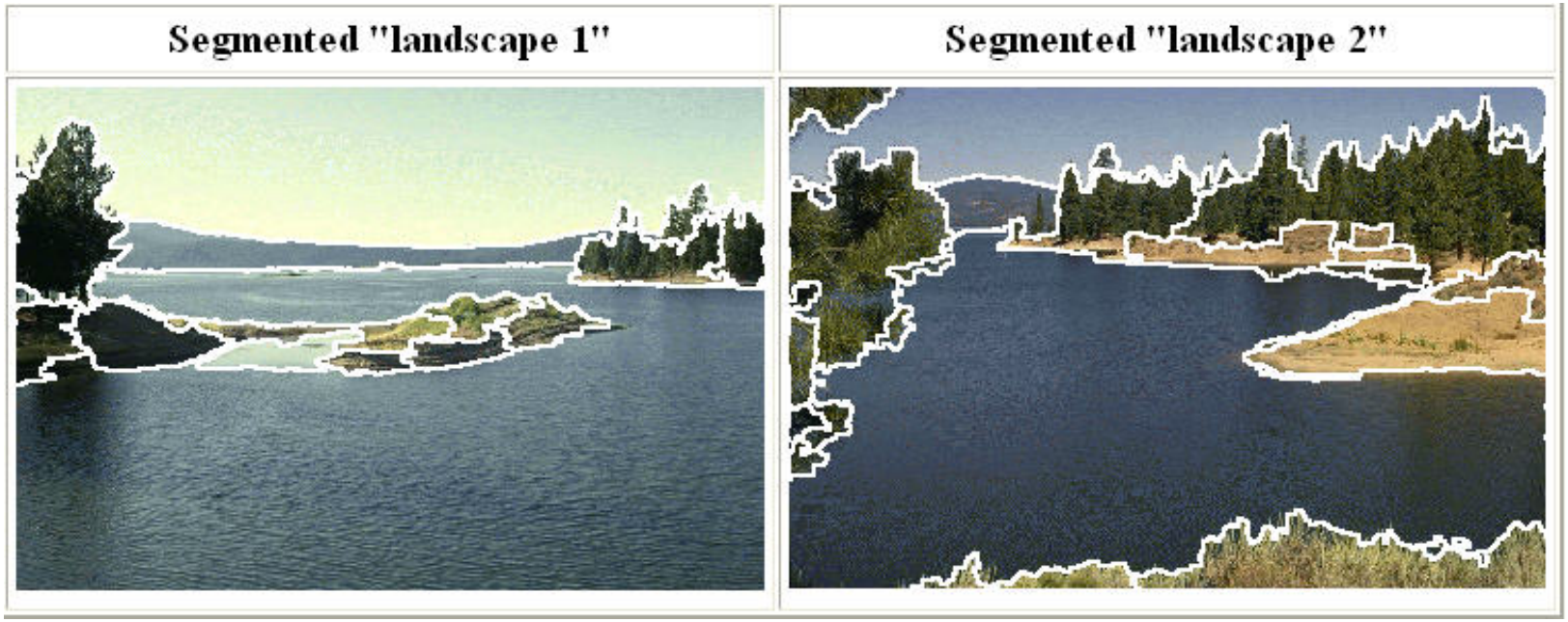
Segmentation and Clustering (Part 3)

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

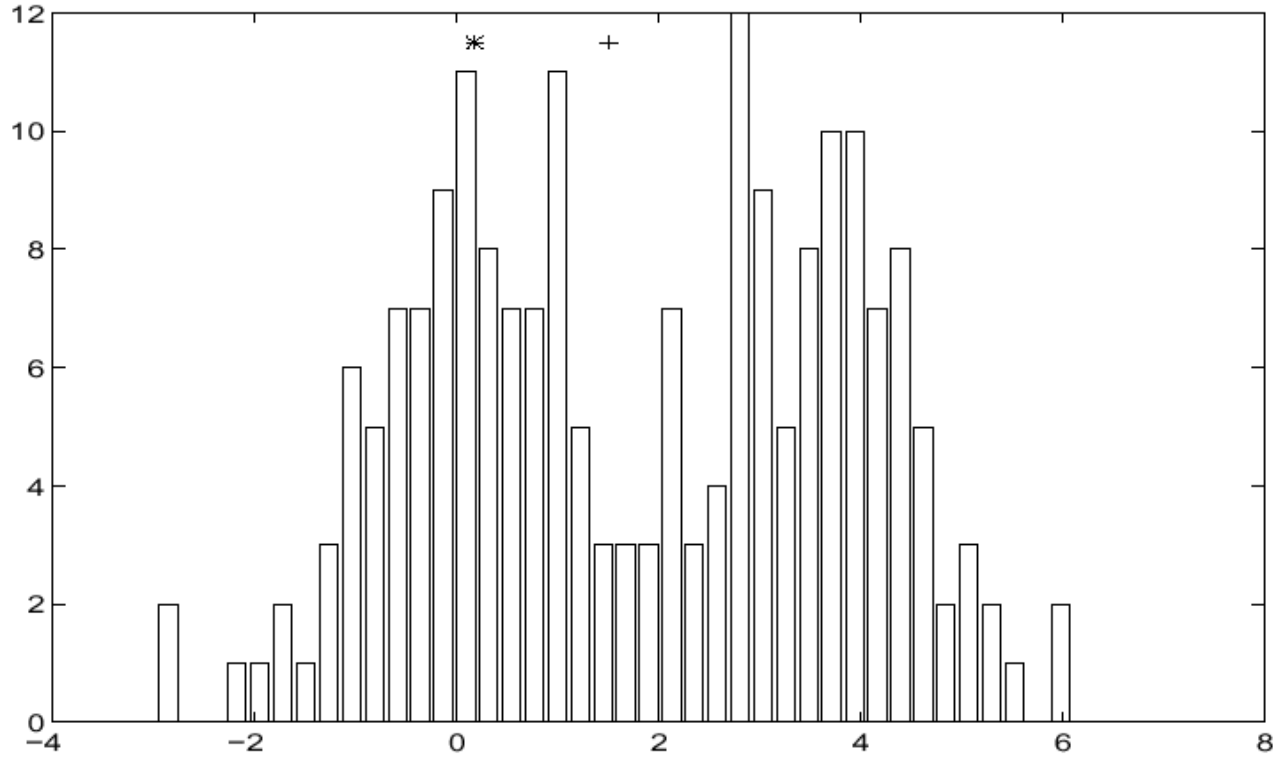
Mean-Shift Segmentation

- 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



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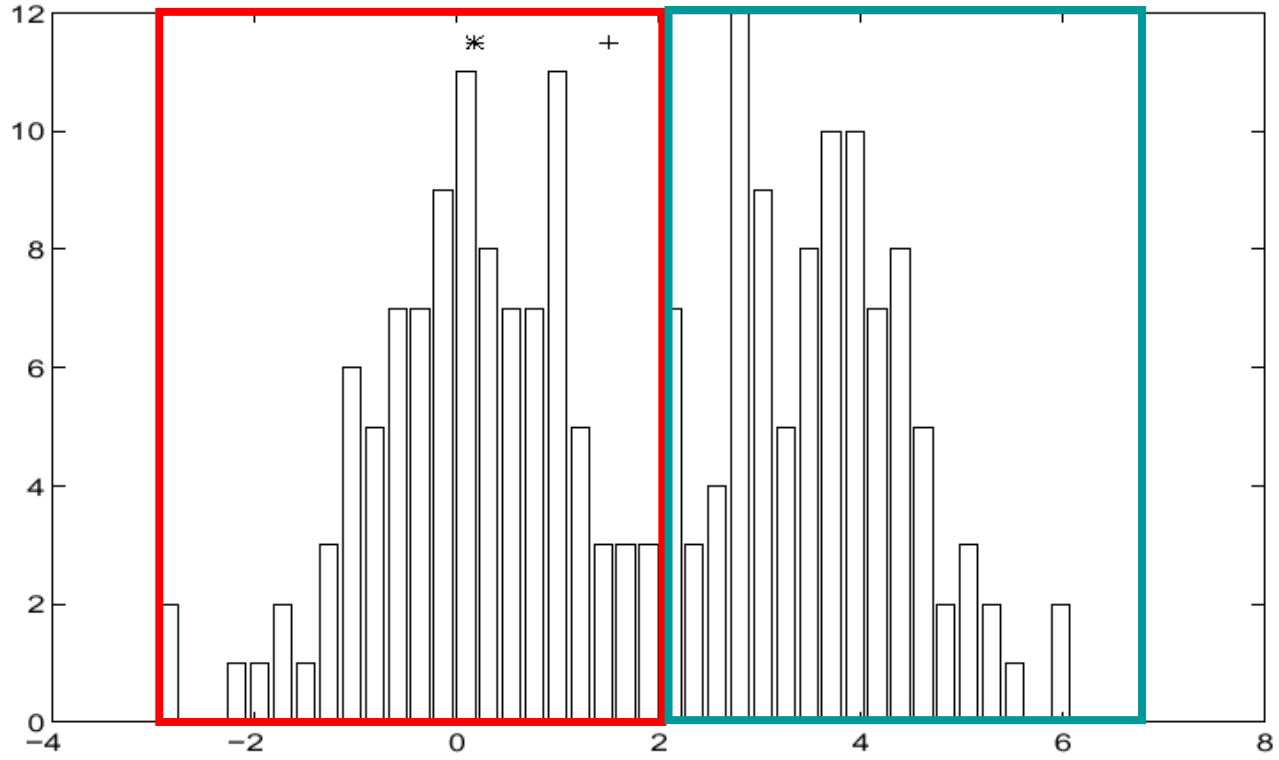
  - Easy to see, hard to compute

Finding Modes in a Histogram



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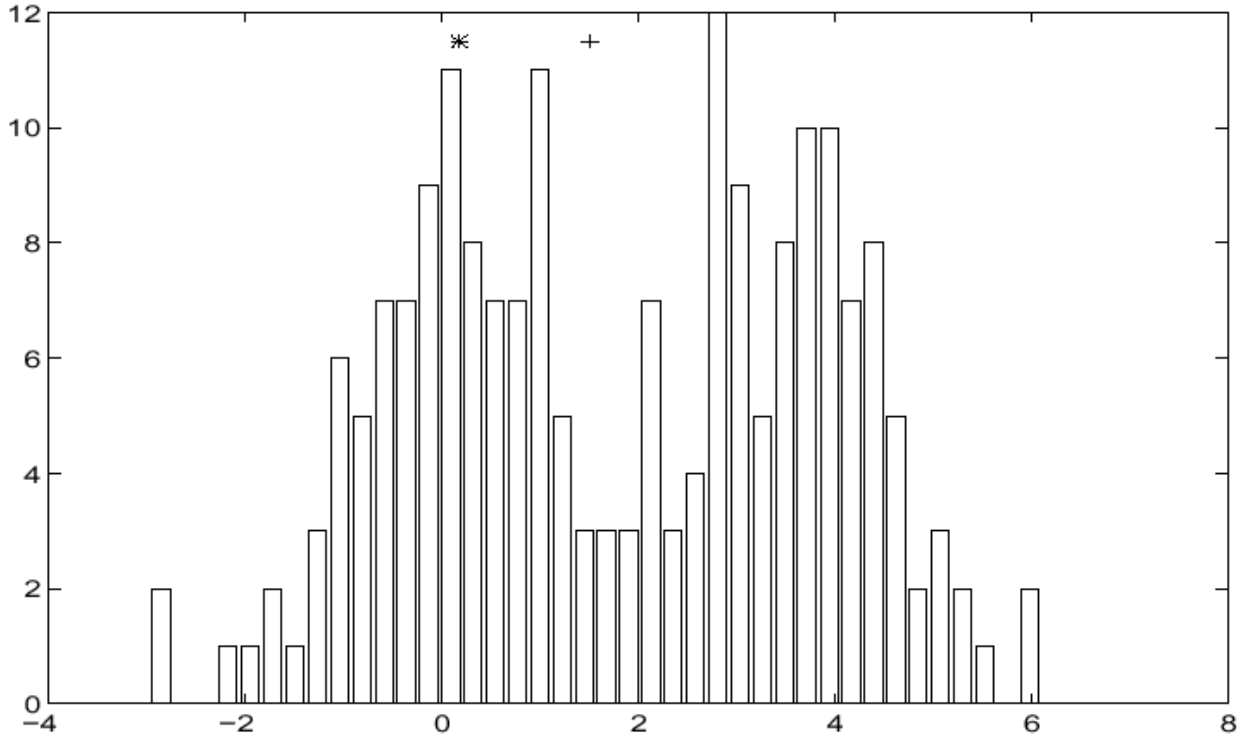
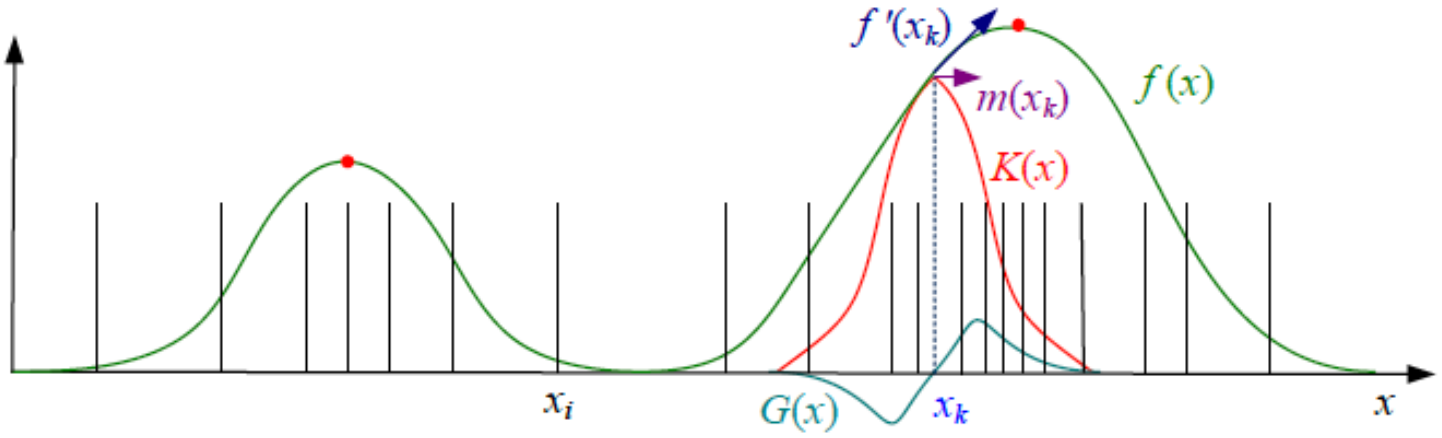
Mean-Shift Algorithm



- **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



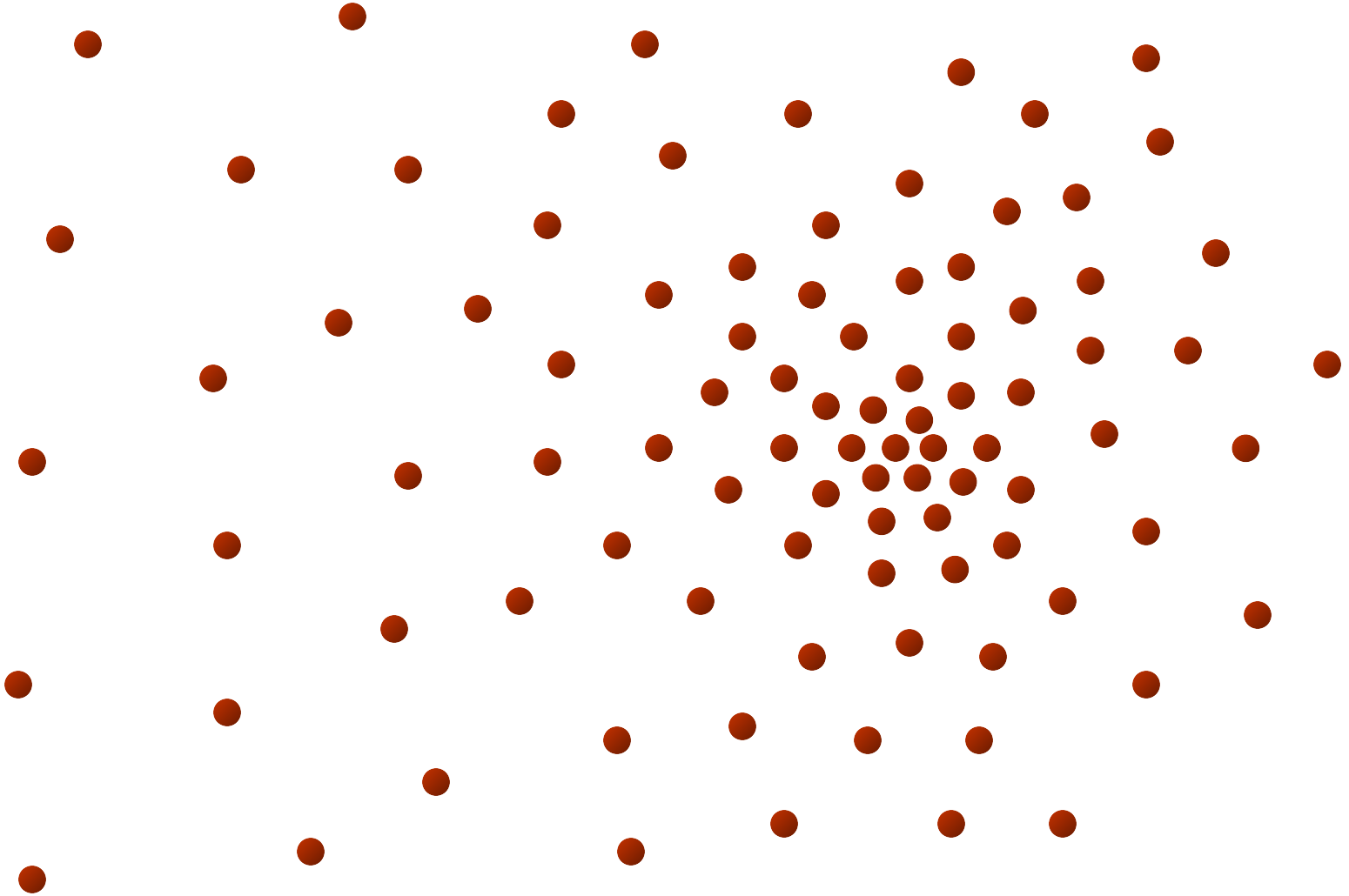
One-dimensional visualization of kernel density estimate, its derivative, and a mean shift.

Further details:

- **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, Mean Shift: A Robust Approach toward Feature Space Analysis, PAMI 2002 (*copy on blackboard*)**

Figure credit: Szelinski, 2010

Mean-Shift



Slide credit Y. Ukrainitz & B. Sarel

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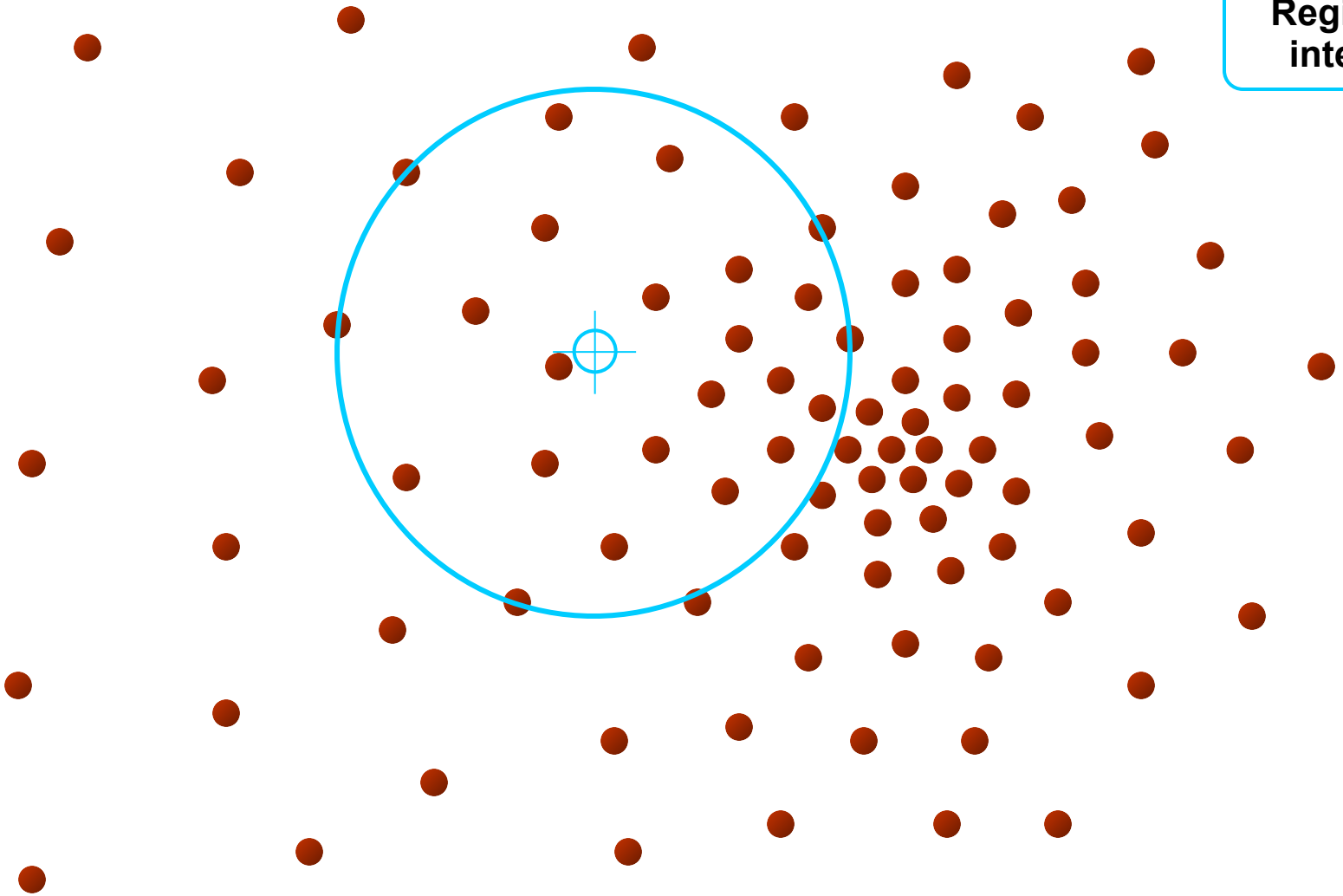

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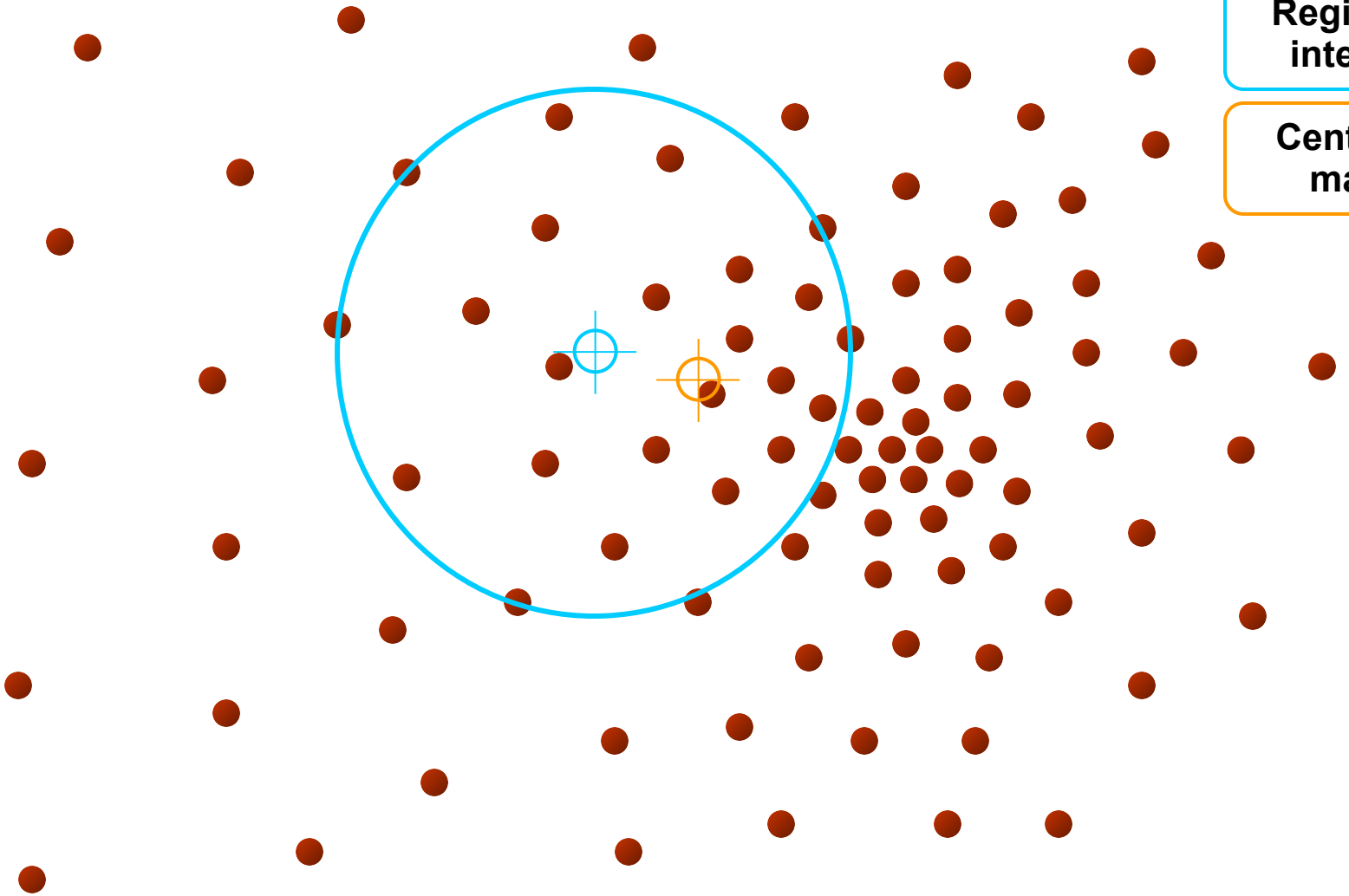

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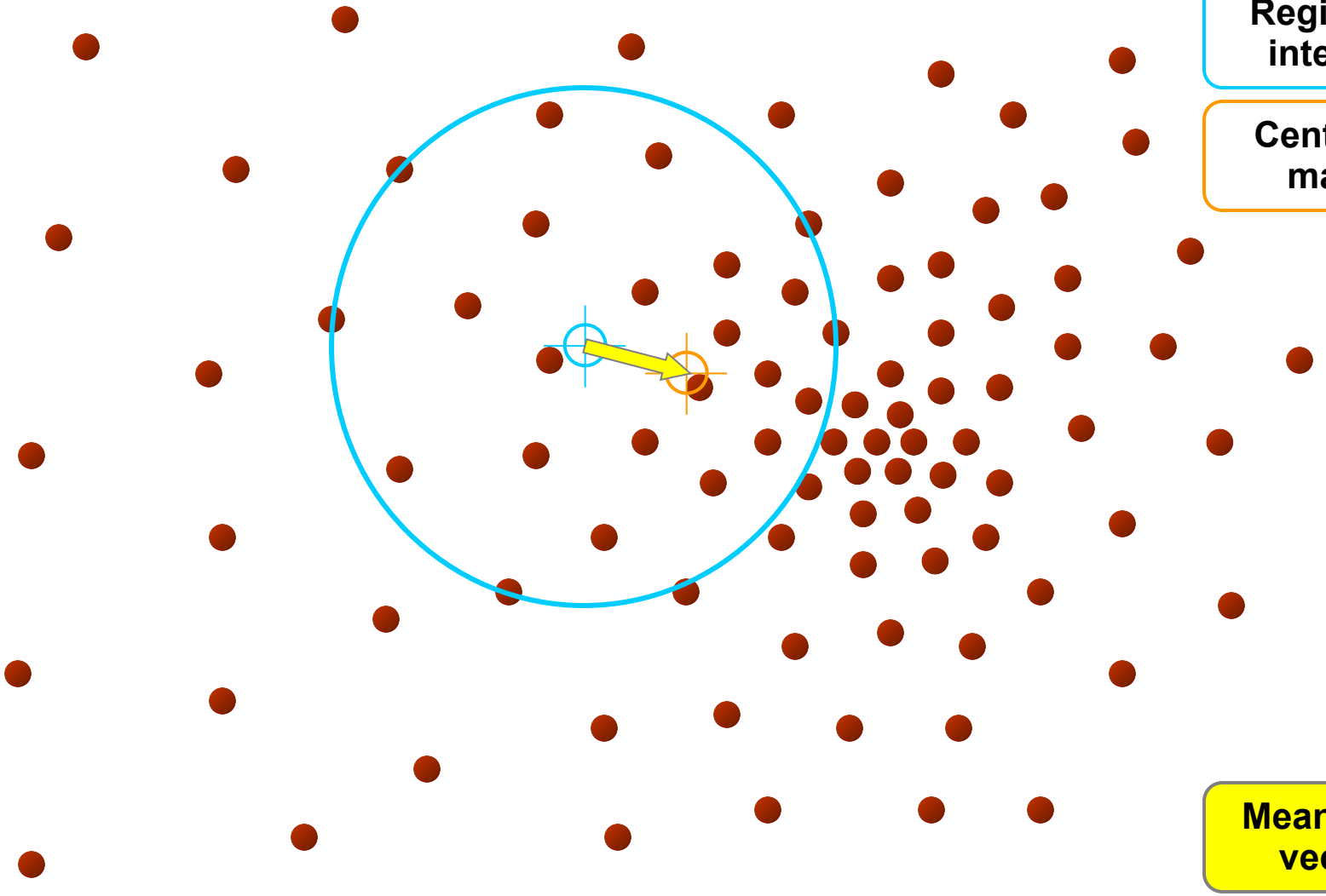

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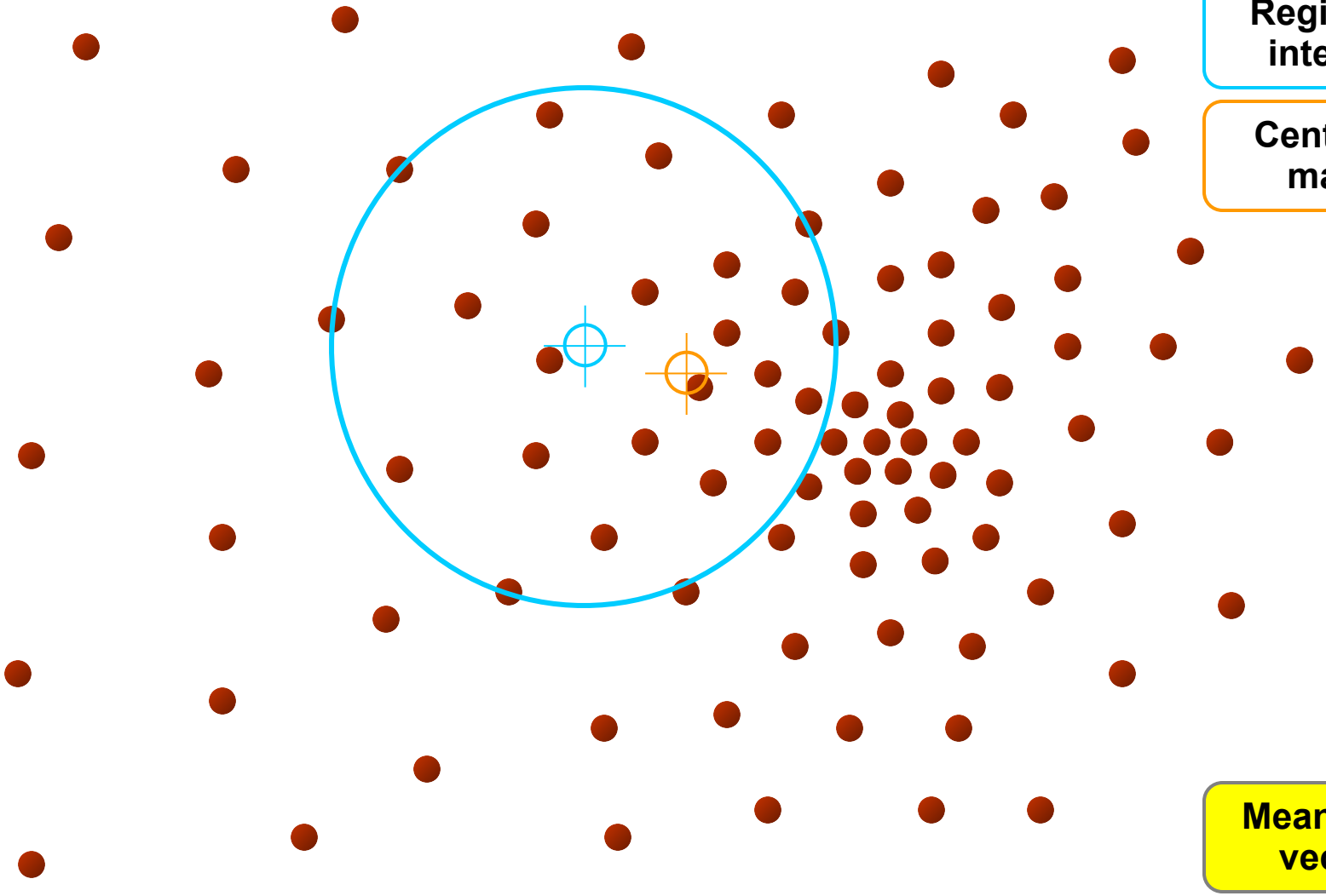

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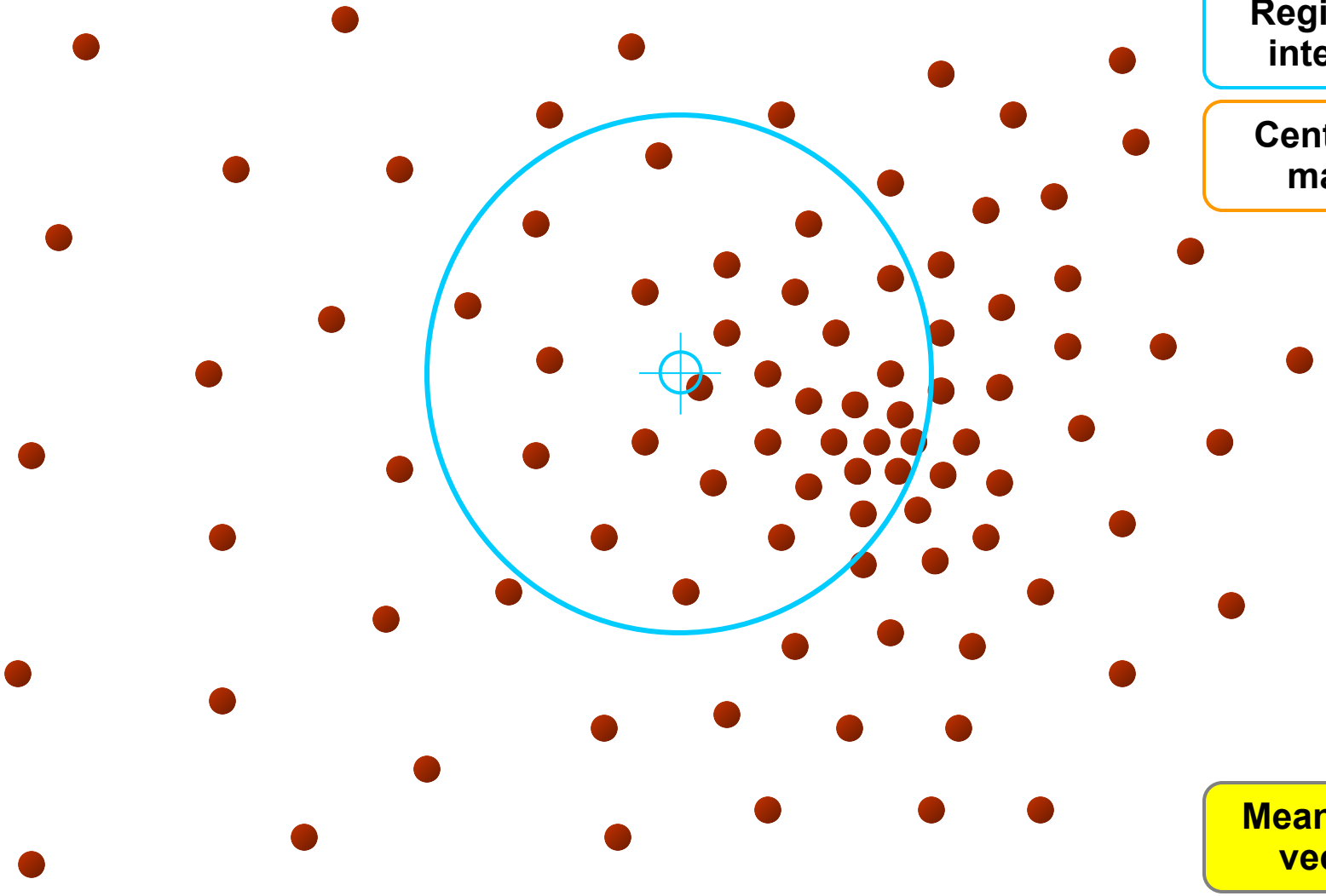

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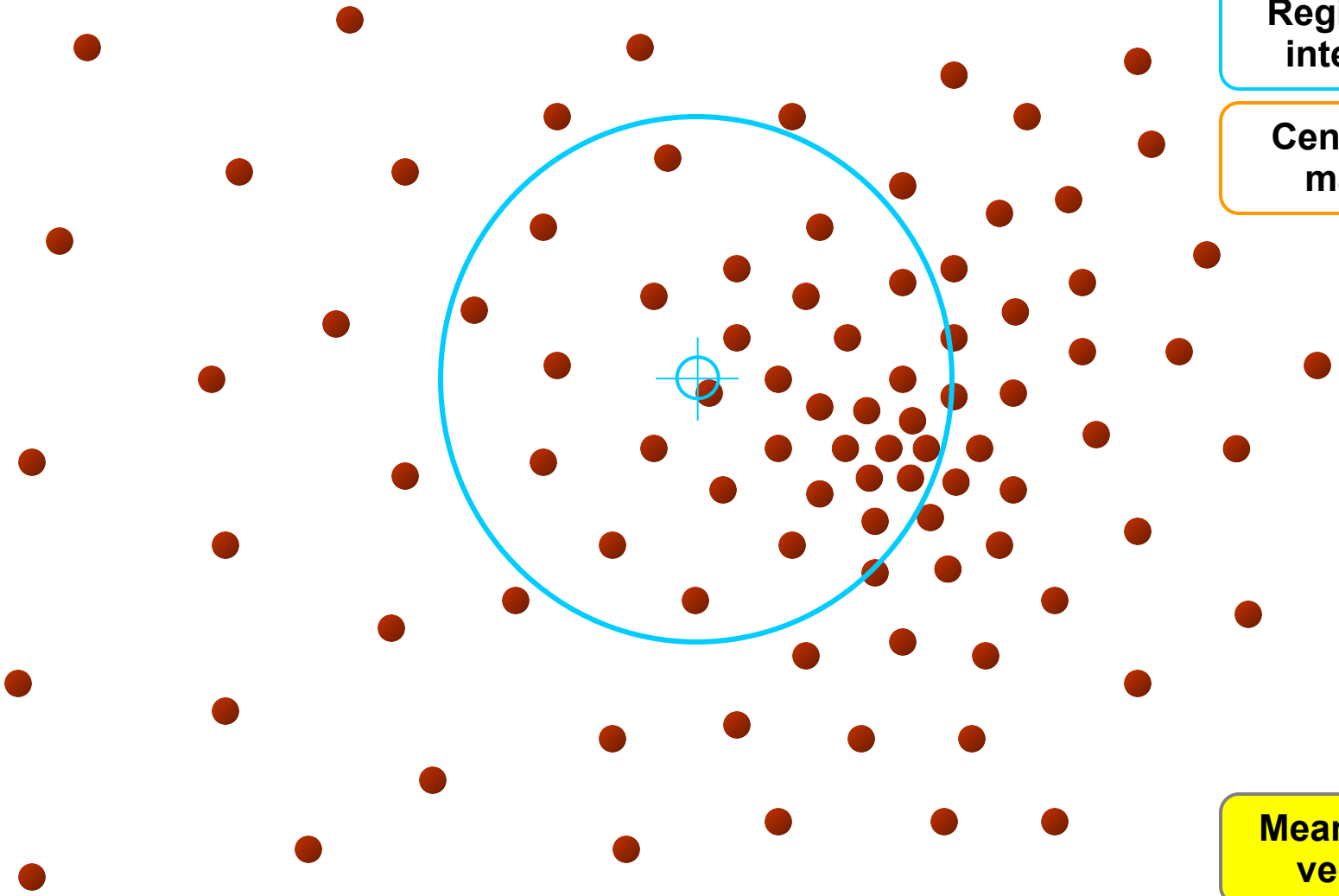

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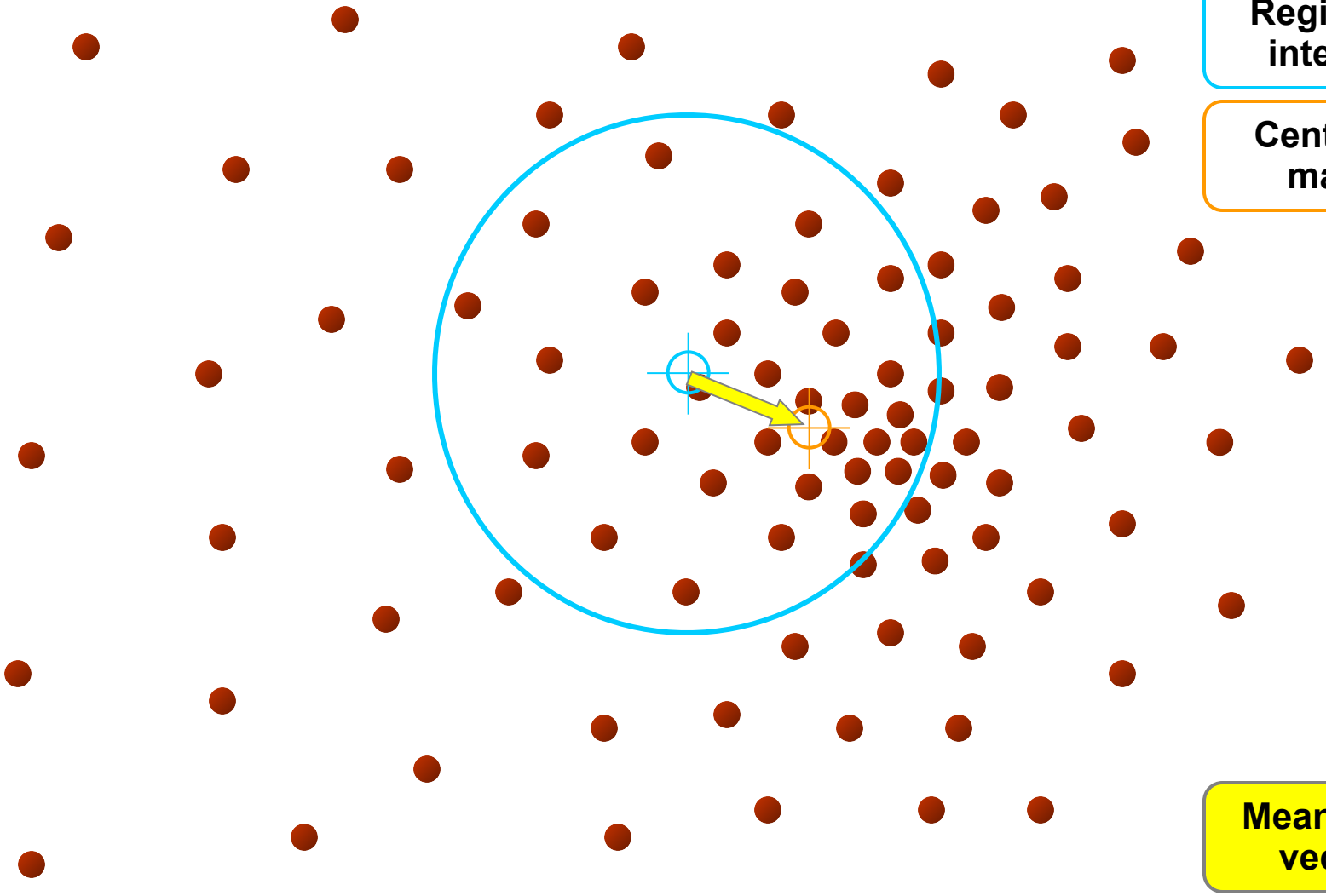

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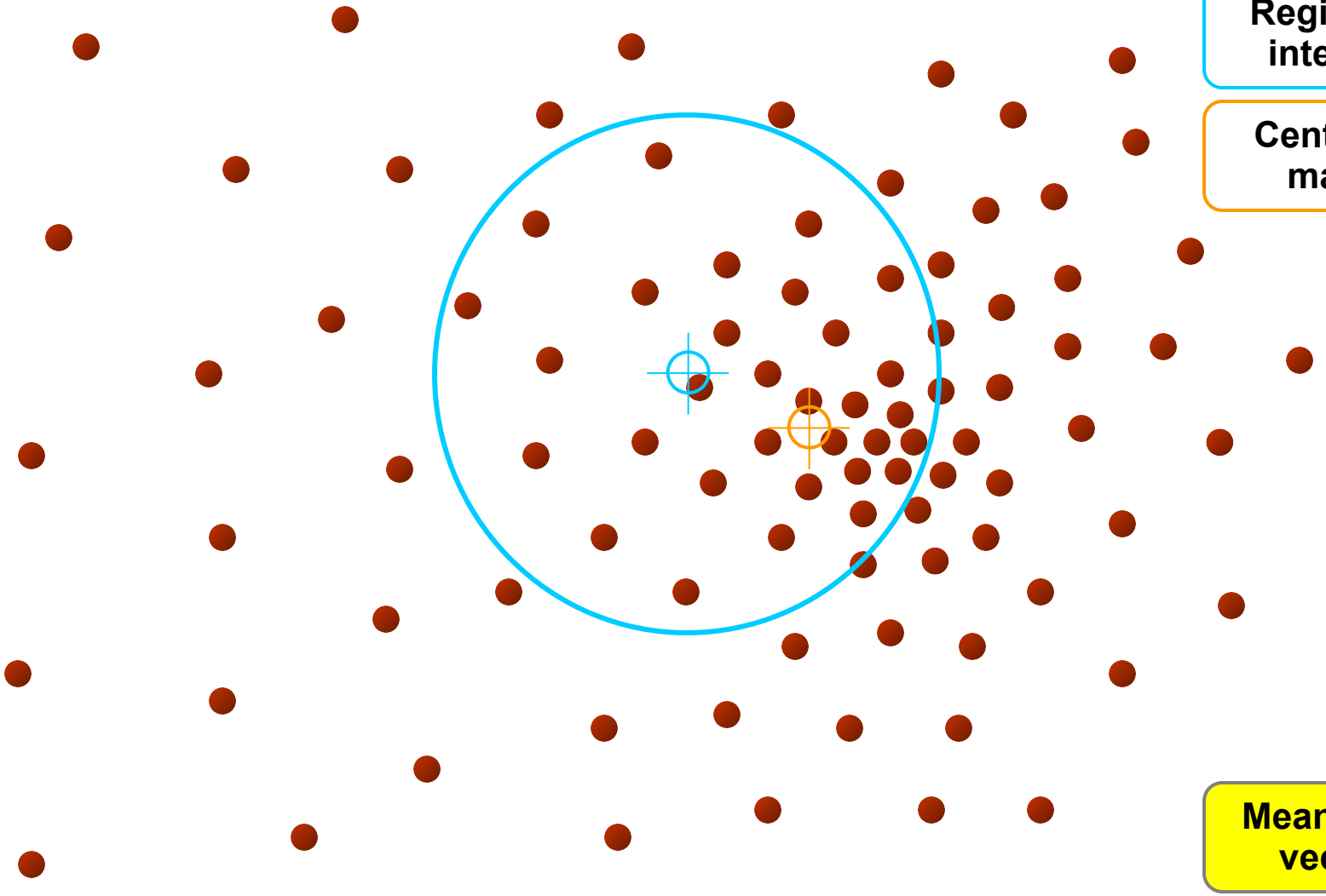

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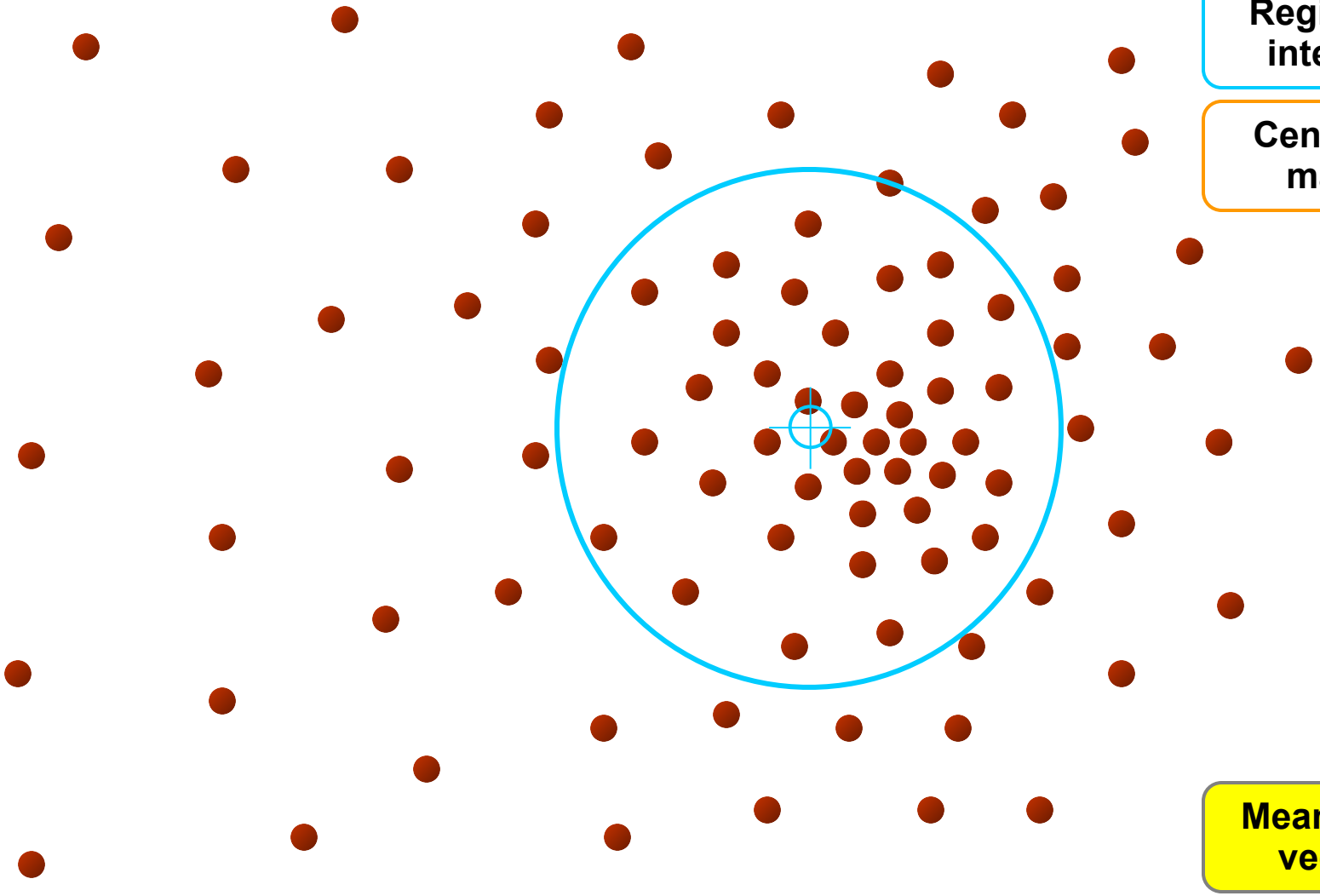

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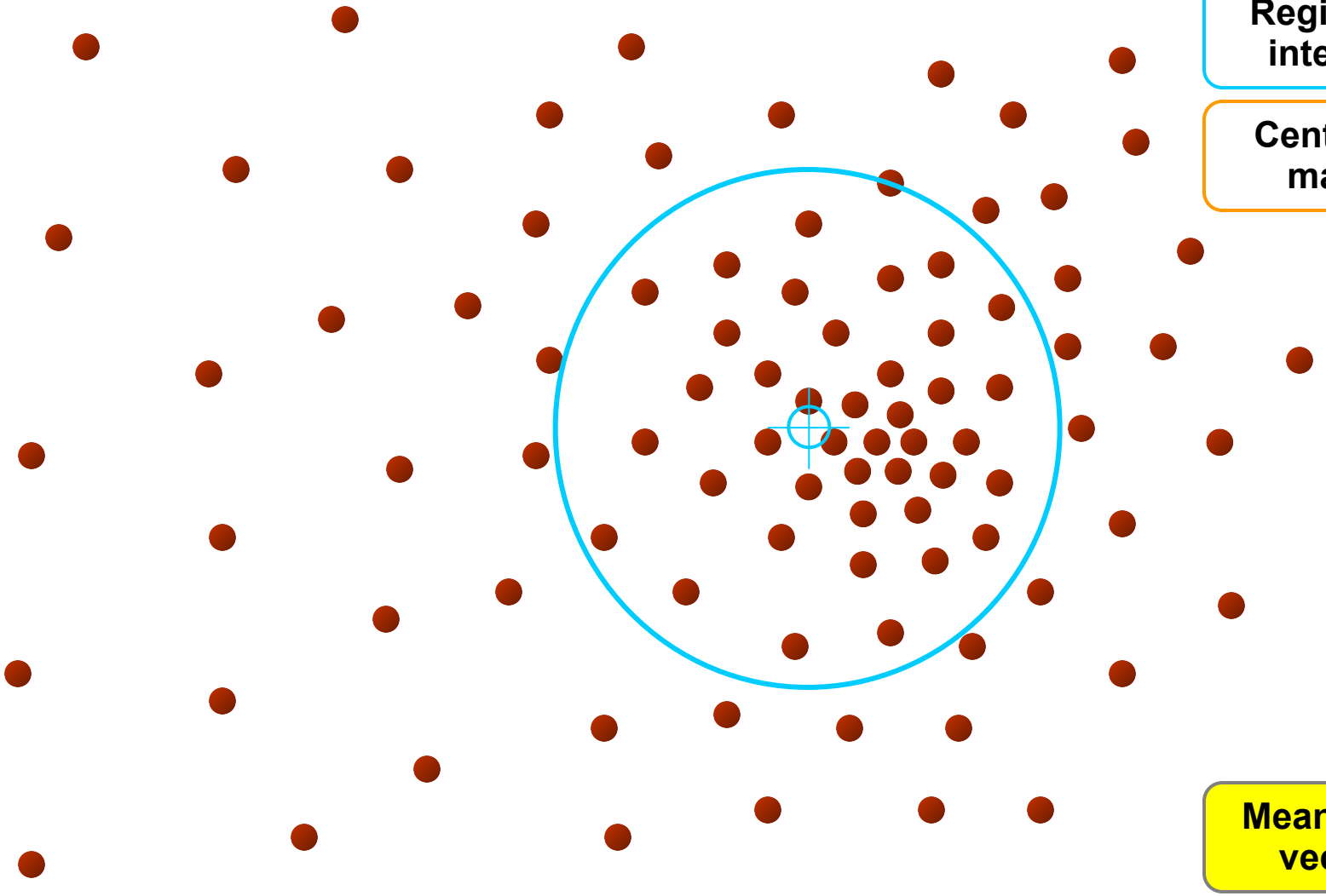

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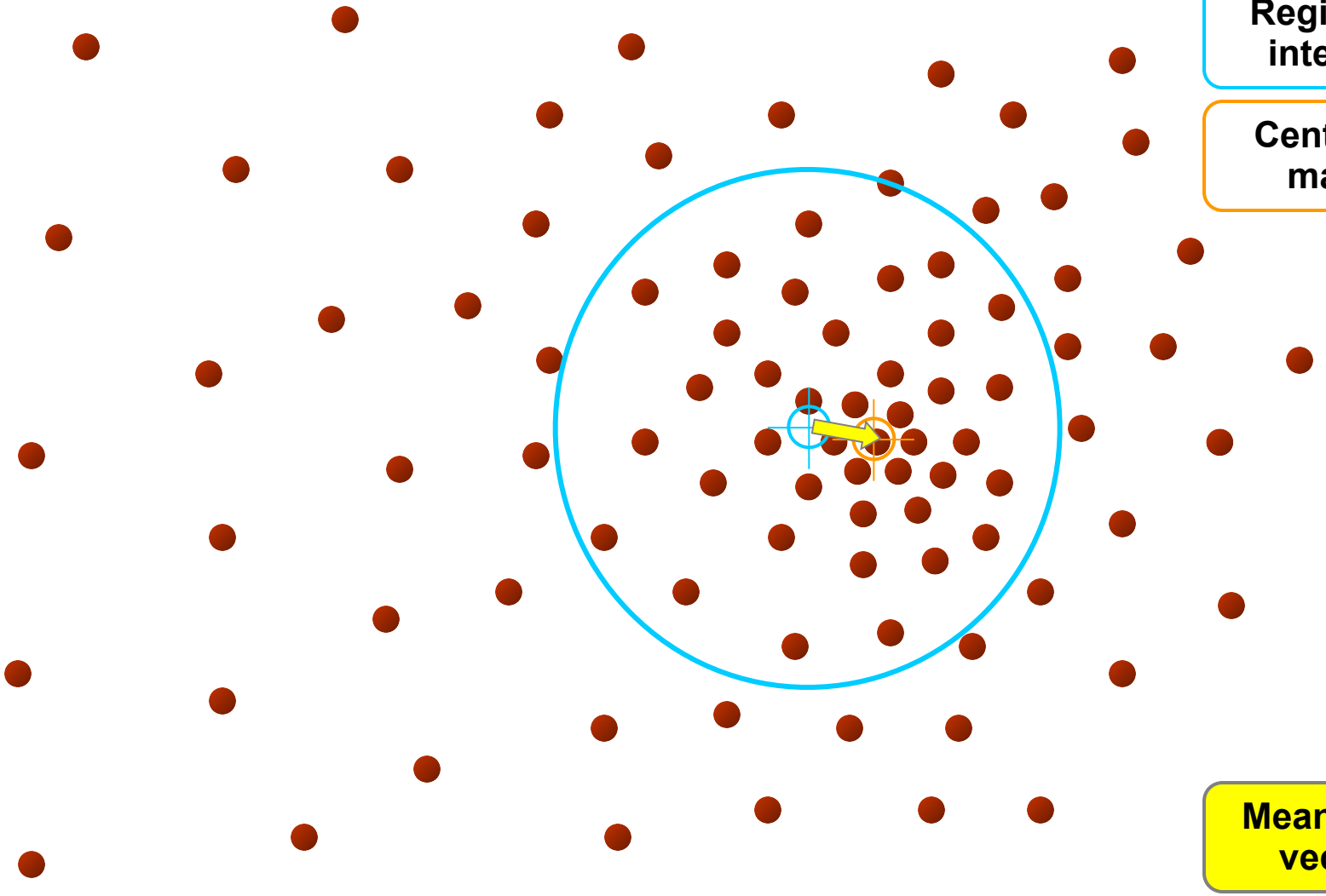

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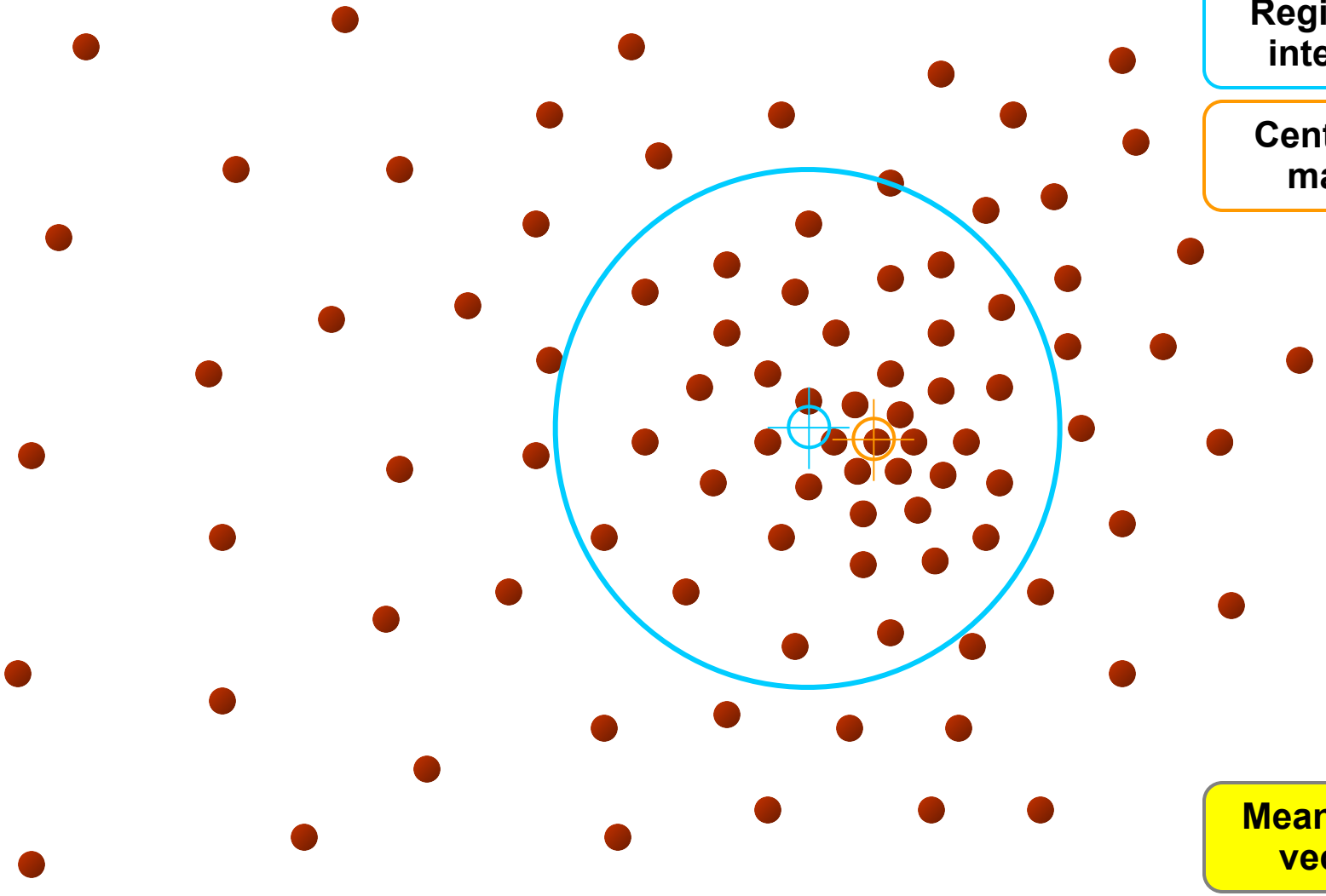

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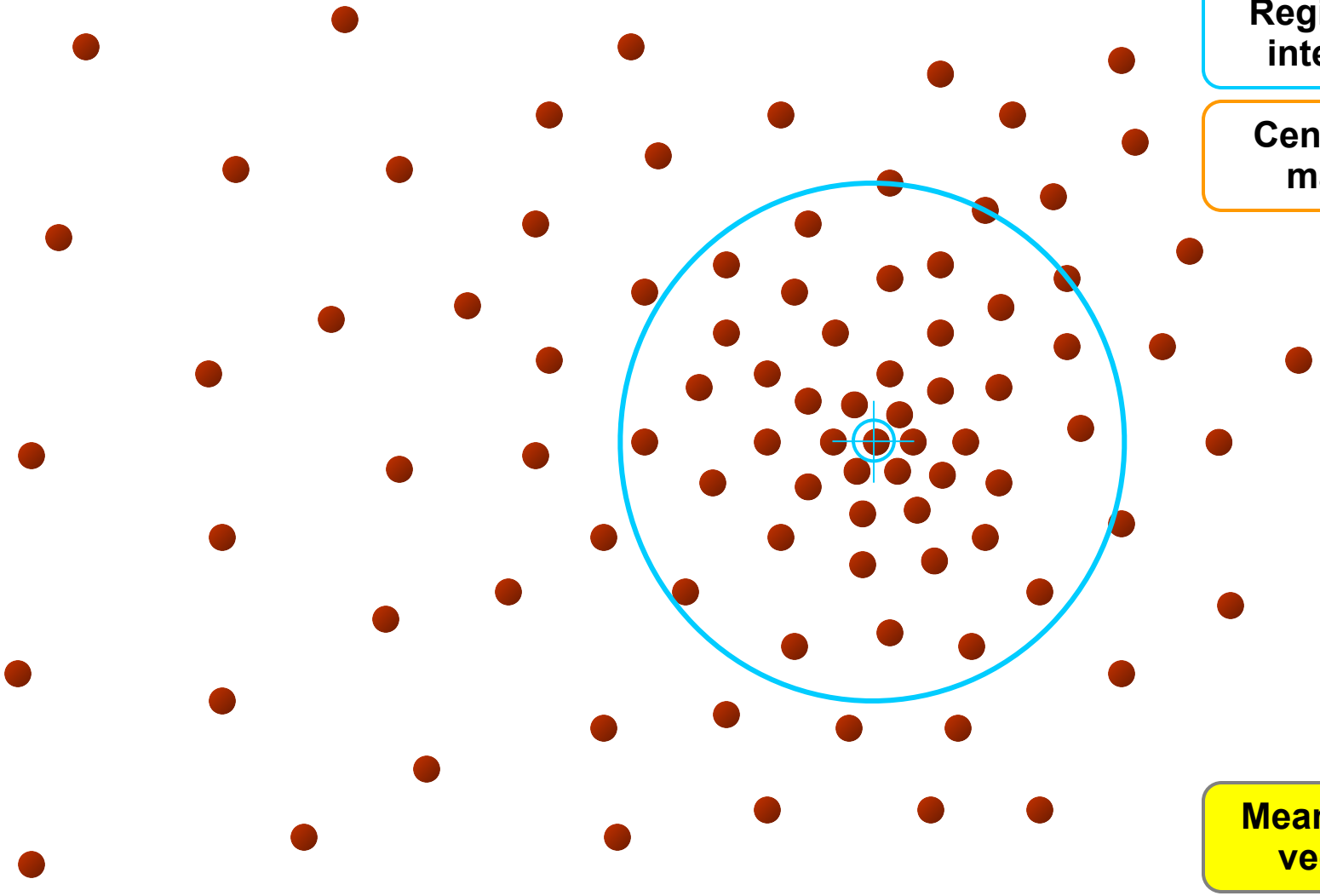

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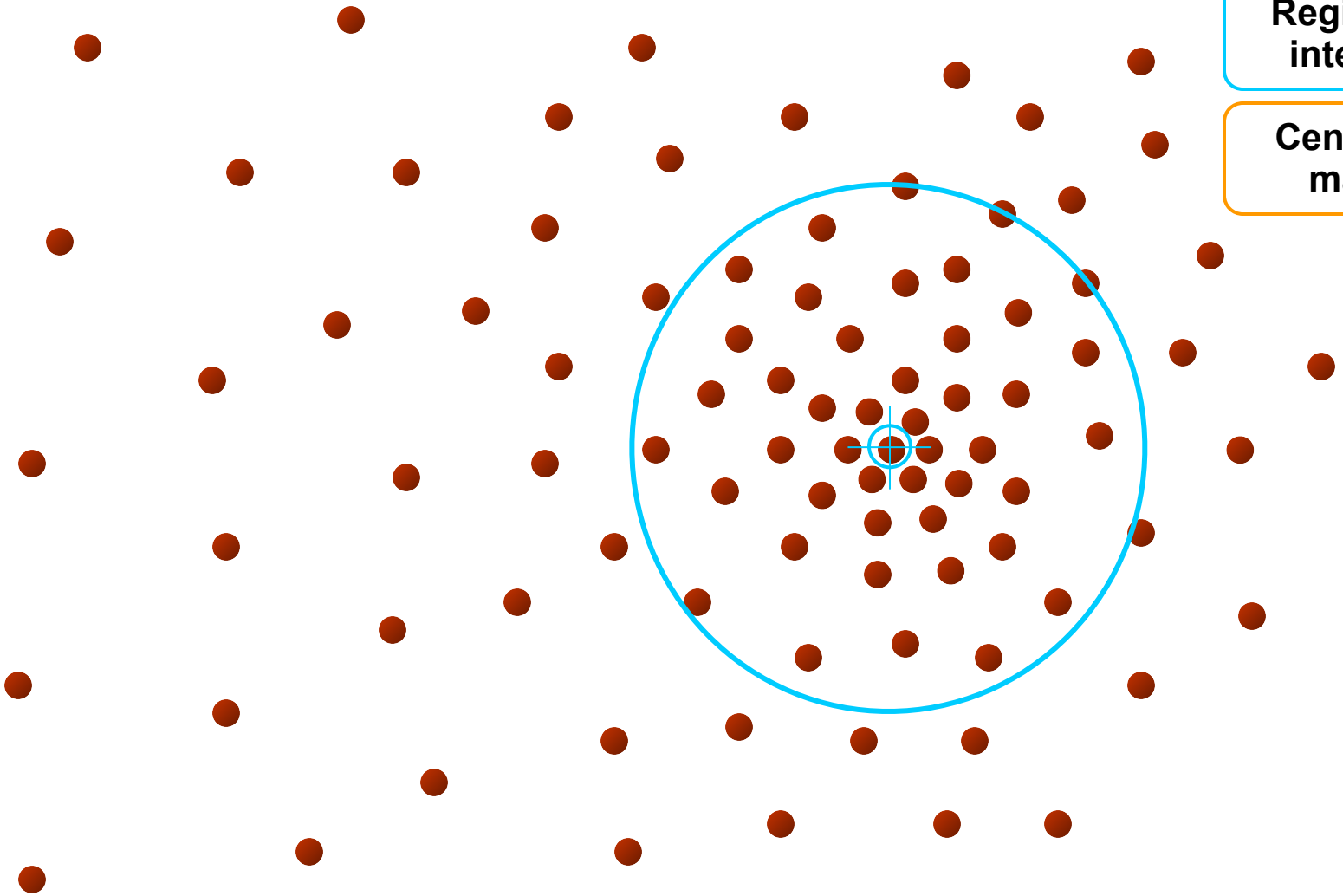

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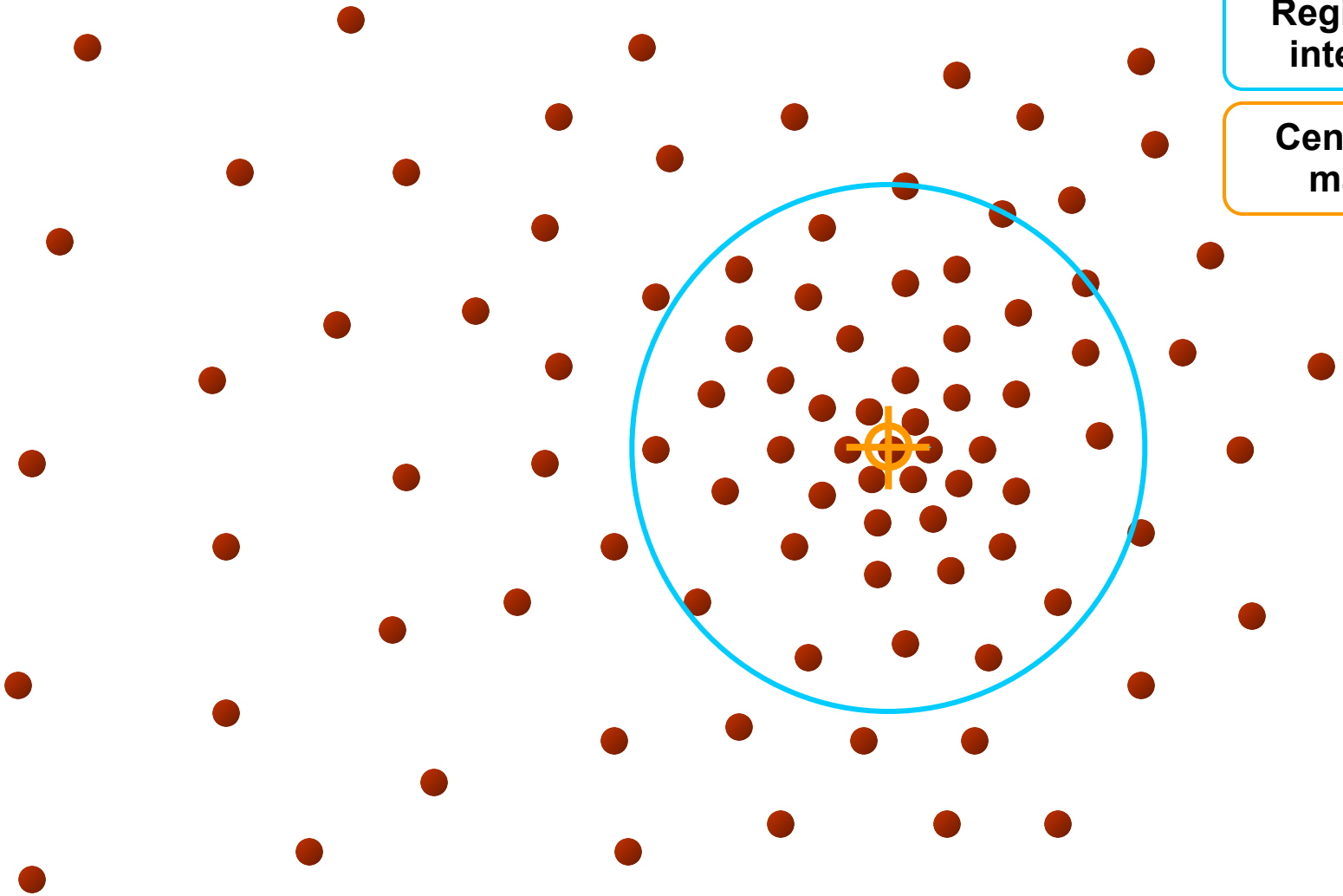

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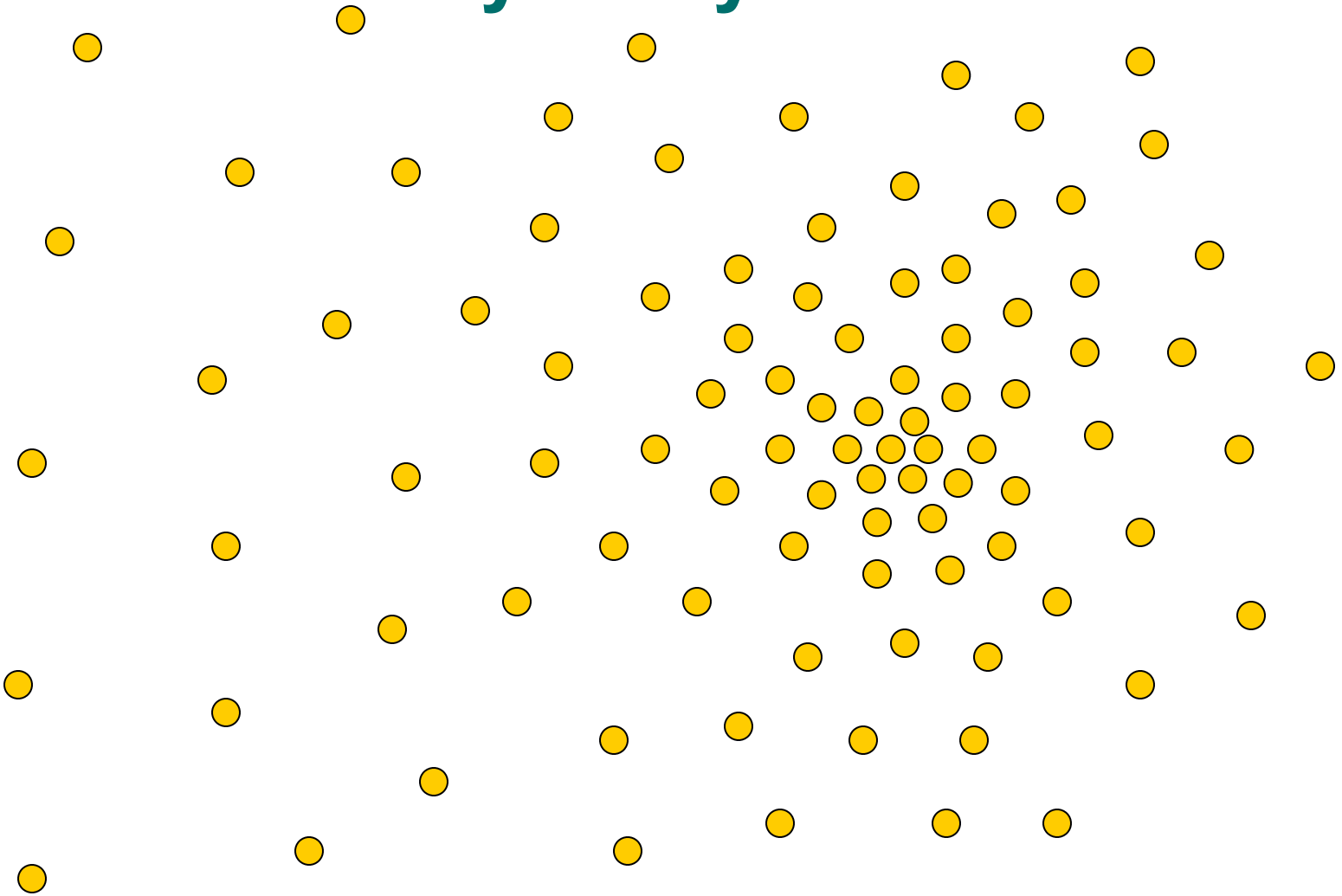
Real Modality Analysis



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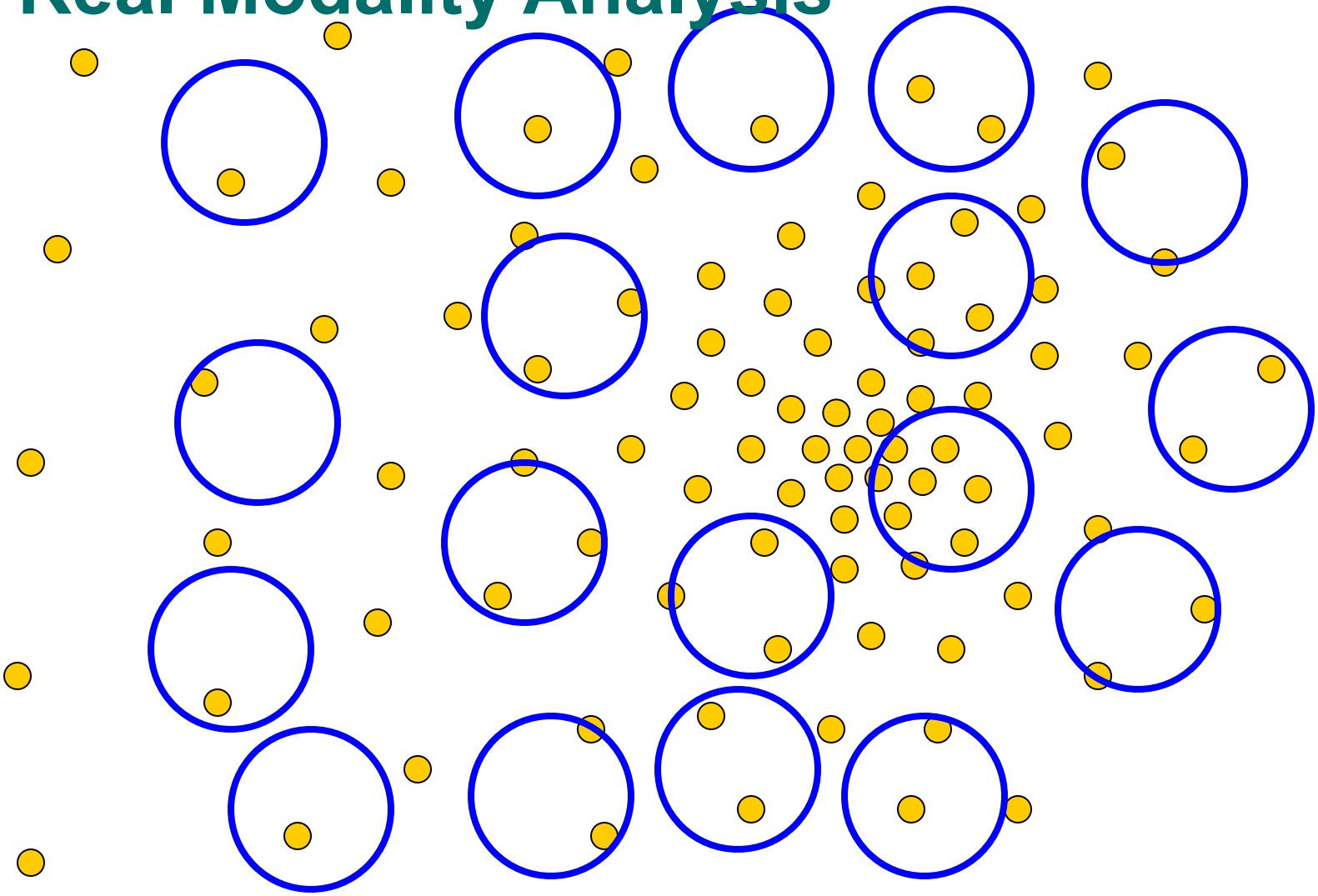

Run the procedure in parallel

Slide by Y. Ukrainitz & B. Sarel

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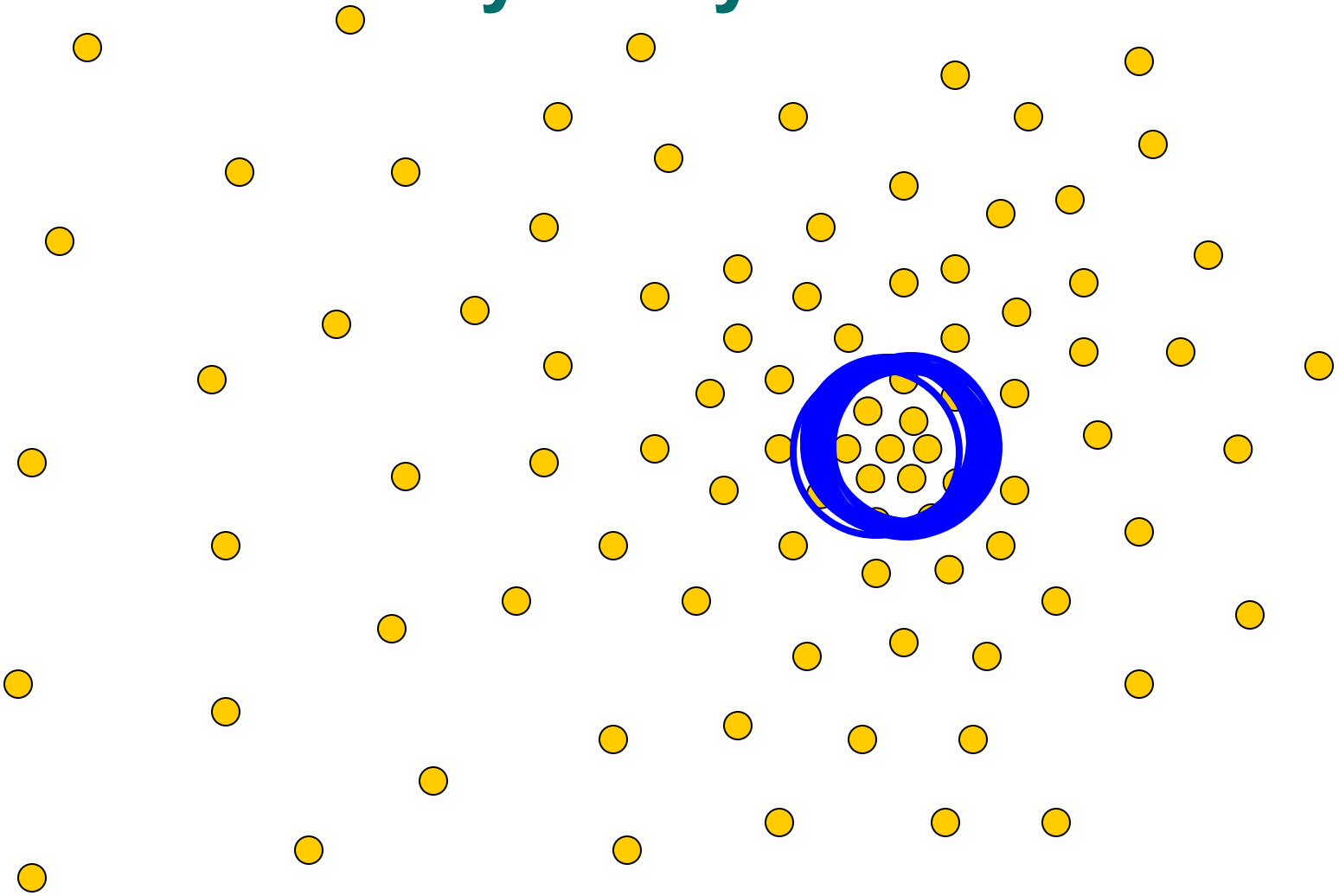

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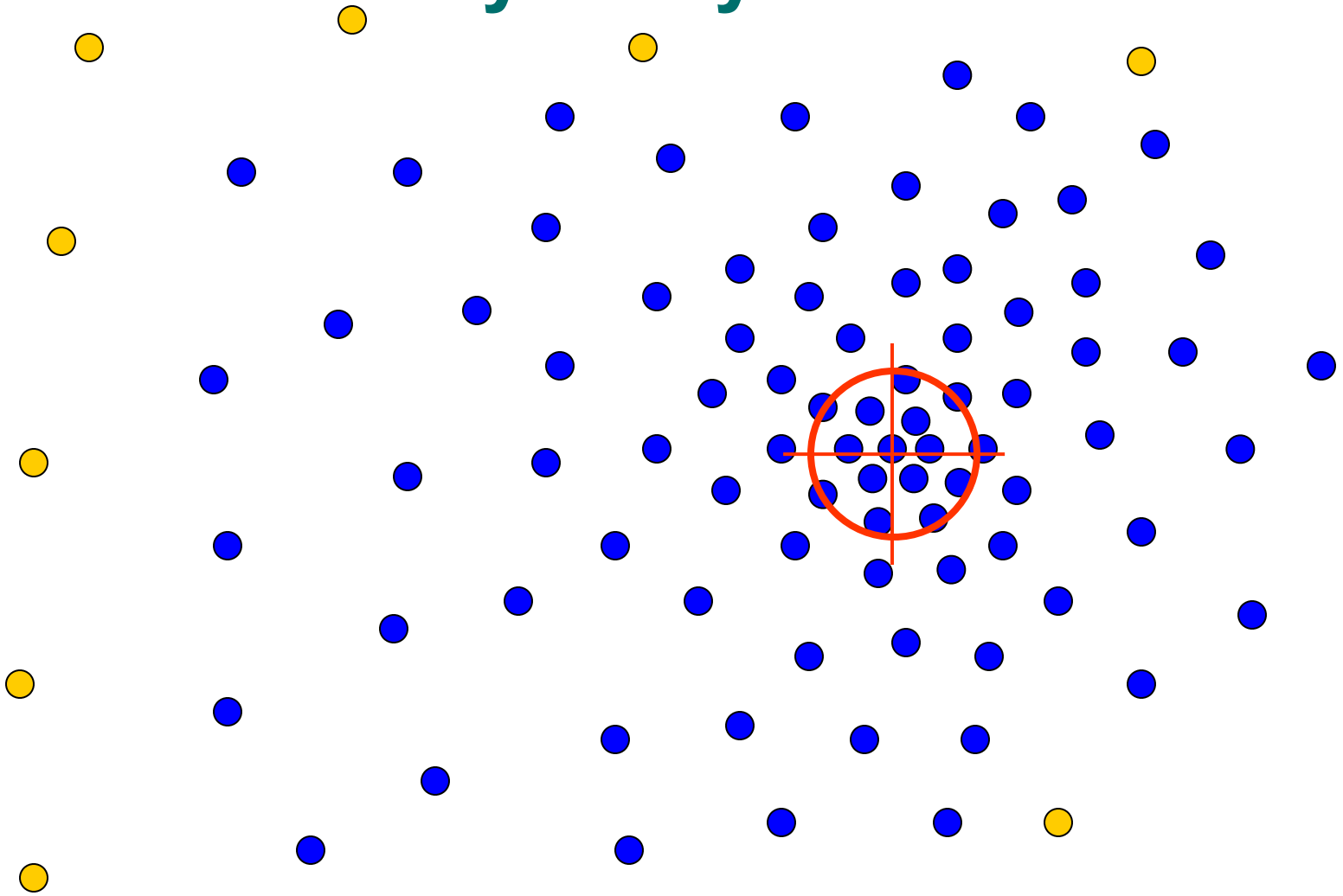

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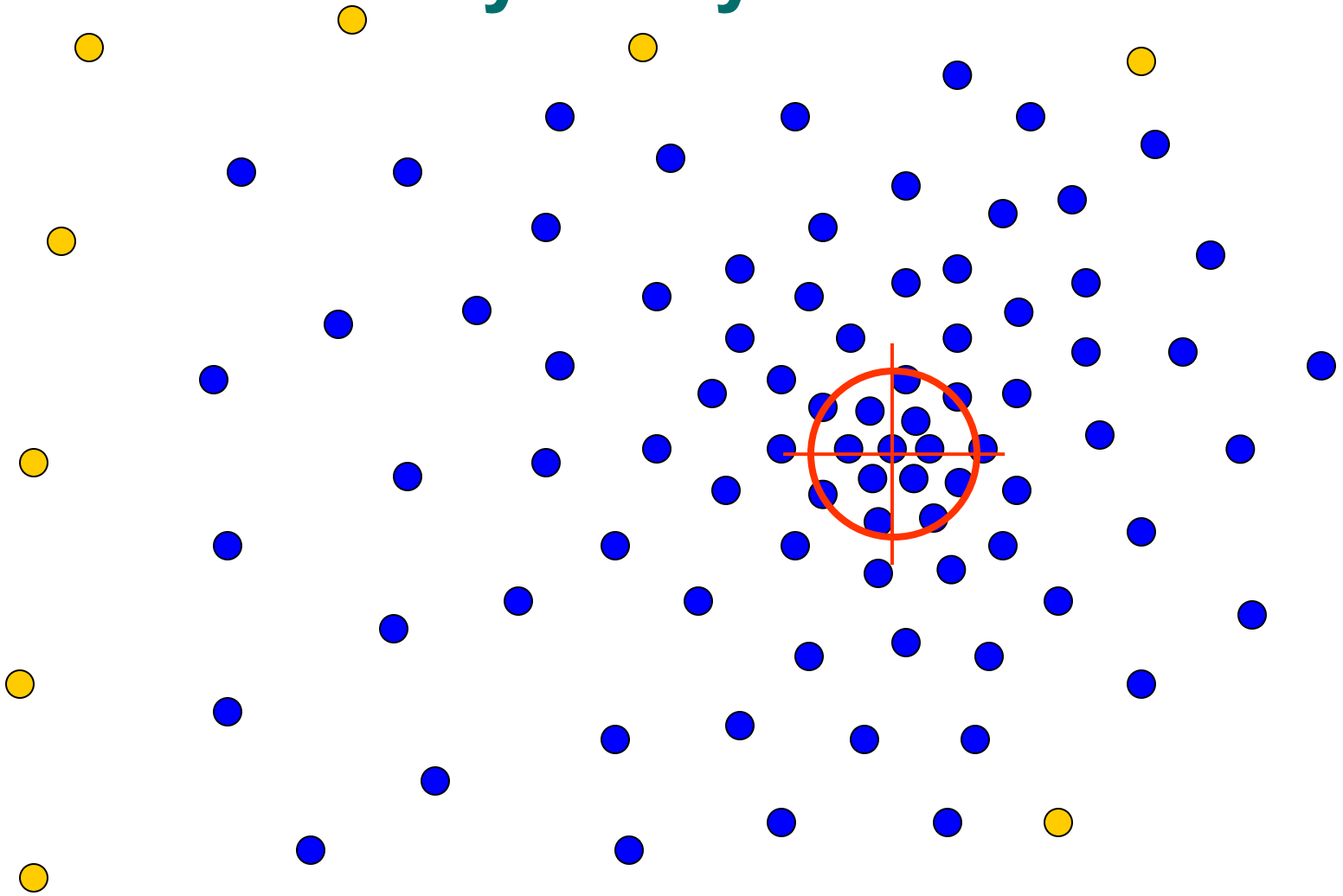

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Mean-Shift Clustering

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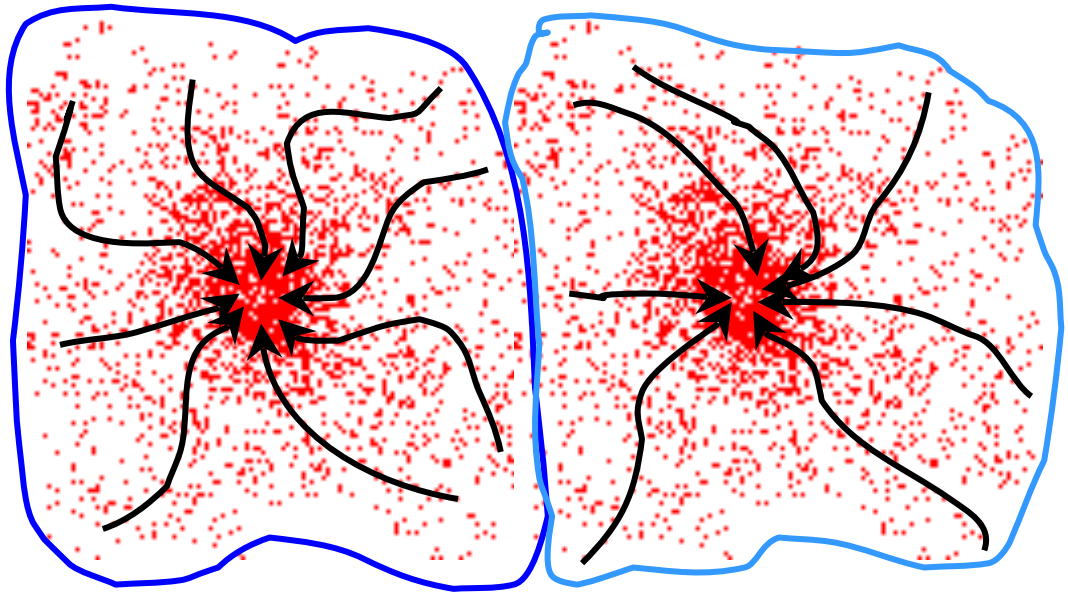
- **Attraction basin:** the region for which all trajectories 轨迹 lead to the same mode



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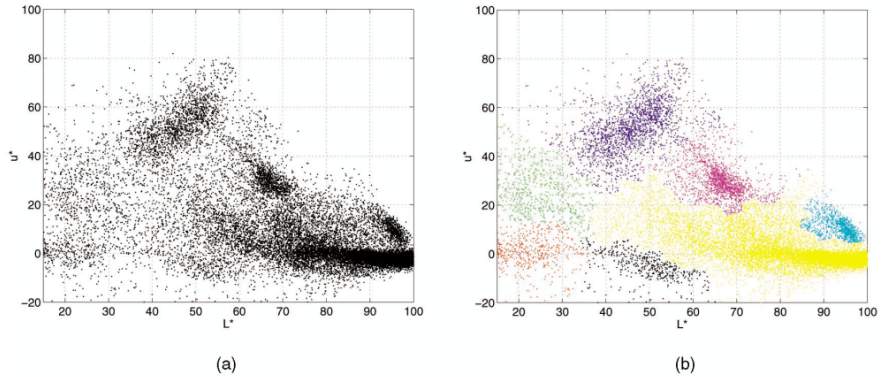
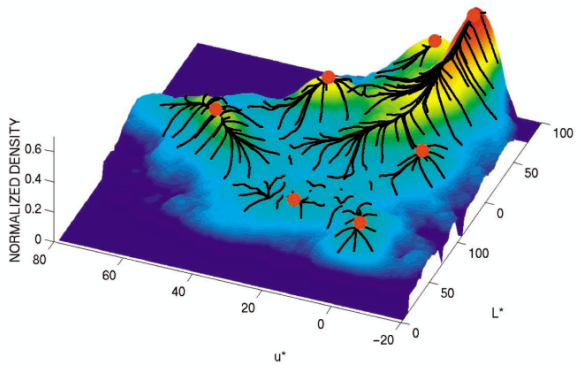
Mean-Shift Clustering/Segmentation

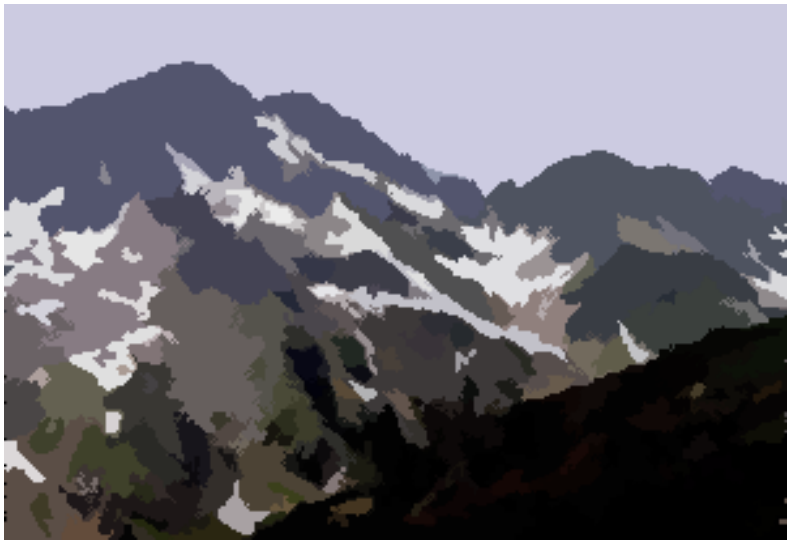
- Find features (colour, gradients, texture, etc)
- Initialize windows at individual pixel locations
- Perform mean shift for each window until convergence
- Merge windows that end up near the same "peak" or mode





D. Comaniciu and P. Meer, 2002

Mean-Shift Segmentation Results



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  - Does not scale well with dimension of feature space

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