



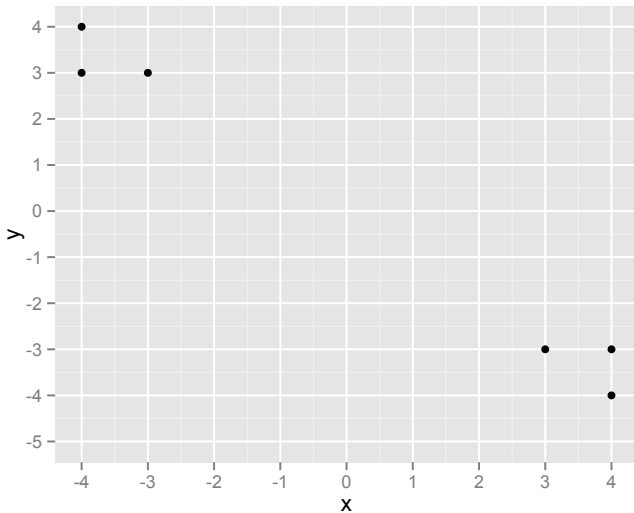
Clustering

Machine Learning: Jordan Boyd-Graber
University of Maryland

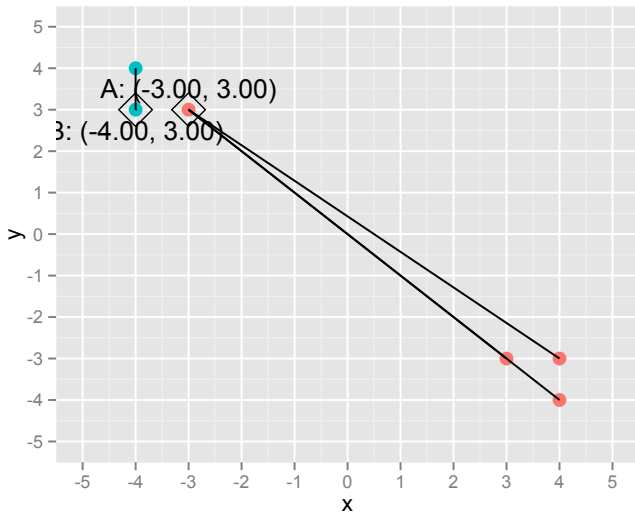
K-MEANS EXAMPLE

Content Questions

Two Points



Two Points



Two Points

$$\mu_A = \frac{1}{4}((-3, 3) + (3, -3) + (4, -3) + (4, -4))$$

=

$$\mu_B = \frac{(-4, 3) + (-4, 4)}{2}$$

=

Two Points

$$\mu_A = \frac{1}{4}((-3, 3) + (3, -3) + (4, -3) + (4, -4))$$

$$= (2, -1.75)$$

$$\mu_B = \frac{(-4, 3) + (-4, 4)}{2}$$

=

Two Points

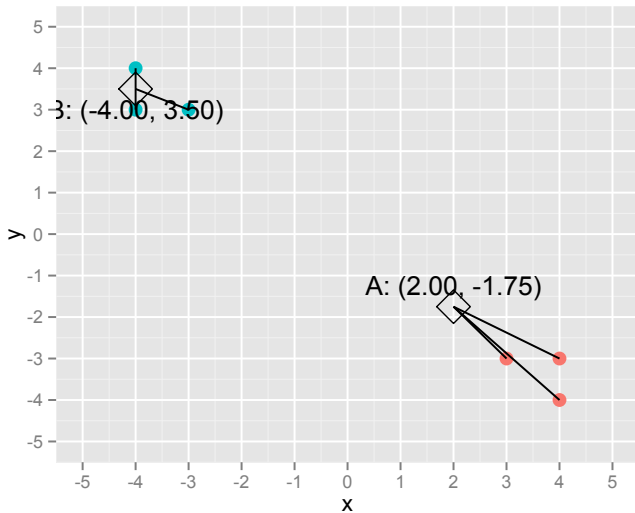
$$\mu_A = \frac{1}{4}((-3, 3) + (3, -3) + (4, -3) + (4, -4))$$

$$= (2, -1.75)$$

$$\mu_B = \frac{(-4, 3) + (-4, 4)}{2}$$

$$= (-4, 3.5)$$

Two Points



Two Points

$$\mu_A = \frac{(3, -3) + (4, -3) + (4, -4)}{3}$$

=

$$\mu_B = \frac{(-4, 3) + (-4, 4) + (-3, 3)}{3}$$

=

Two Points

$$\mu_A = \frac{(3, -3) + (4, -3) + (4, -4)}{3}$$

$$= (3.67, -3.33)$$

$$\mu_B = \frac{(-4, 3) + (-4, 4) + (-3, 3)}{3}$$

=

Two Points

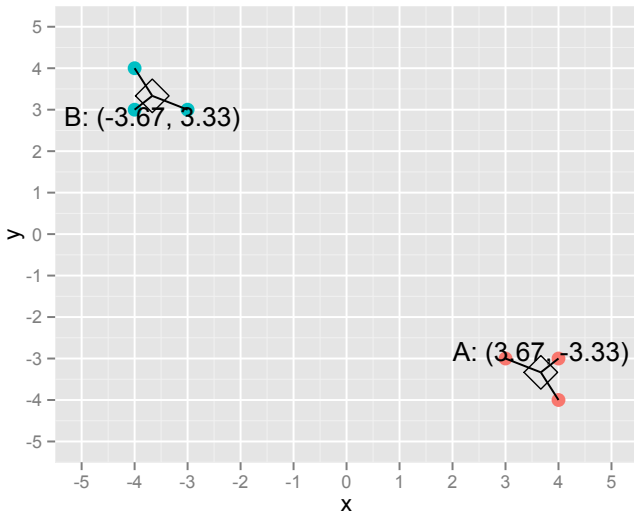
$$\mu_A = \frac{(3, -3) + (4, -3) + (4, -4)}{3}$$

$$= (3.67, -3.33)$$

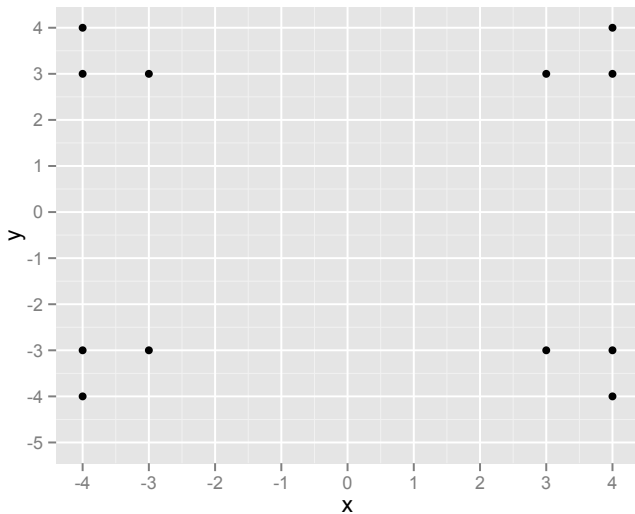
$$\mu_B = \frac{(-4, 3) + (-4, 4) + (-3, 3)}{3}$$

$$= (-3.67, 3.33)$$

Two Points



Four Points



Four Points

The observation at $(3, 3)$ is the same distance from μ_A and μ_C . If you look at Line 10 in the algorithm, the **first** mean with the smallest distance gets the assignment. So $(3, 3)$ gets assigned to cluster A .

$$\mu_A =$$

$$\mu_B =$$

$$\mu_C =$$

$$\mu_D =$$

Four Points

The observation at $(3, 3)$ is the same distance from μ_A and μ_C . If you look at Line 10 in the algorithm, the **first** mean with the smallest distance gets the assignment. So $(3, 3)$ gets assigned to cluster A.

$$\mu_A = (-1, 1)$$

$$\mu_B =$$

$$\mu_C =$$

$$\mu_D =$$

Four Points

The observation at $(3, 3)$ is the same distance from μ_A and μ_C . If you look at Line 10 in the algorithm, the **first** mean with the smallest distance gets the assignment. So $(3, 3)$ gets assigned to cluster A.

$$\mu_A = (-1, 1)$$

$$\mu_B = (-4, 0)$$

$$\mu_C =$$

$$\mu_D =$$

Four Points

The observation at $(3, 3)$ is the same distance from μ_A and μ_C . If you look at Line 10 in the algorithm, the **first** mean with the smallest distance gets the assignment. So $(3, 3)$ gets assigned to cluster A.

$$\mu_A = (-1, 1)$$

$$\mu_B = (-4, 0)$$

$$\mu_C = (3, -3)$$

$$\mu_D =$$

Four Points

The observation at $(3, 3)$ is the same distance from μ_A and μ_C . If you look at Line 10 in the algorithm, the **first** mean with the smallest distance gets the assignment. So $(3, 3)$ gets assigned to cluster A.

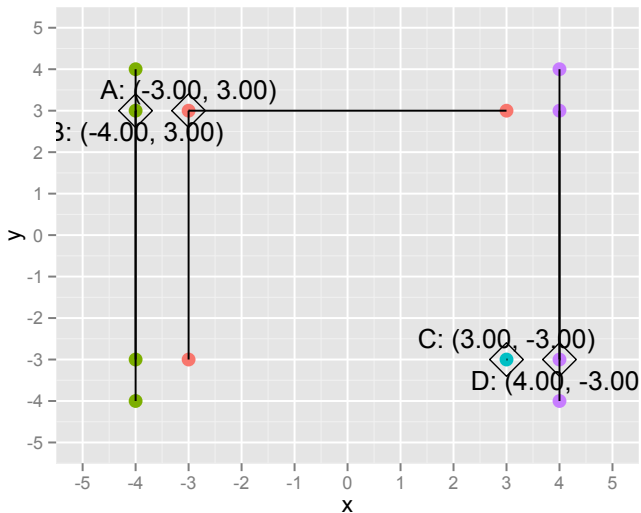
$$\mu_A = (-1, 1)$$

$$\mu_B = (-4, 0)$$

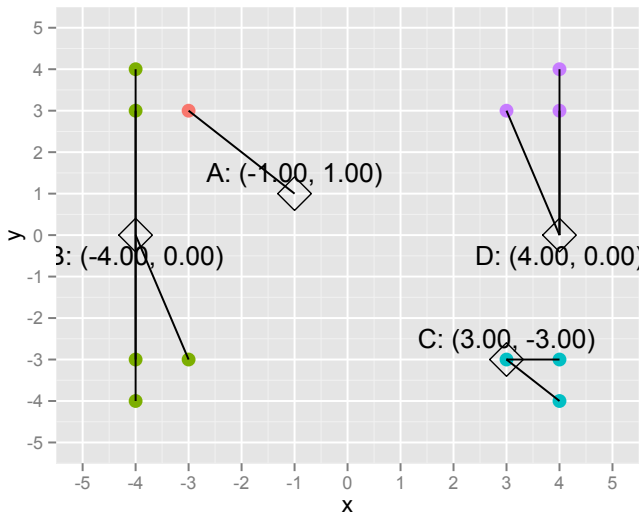
$$\mu_C = (3, -3)$$

$$\mu_D = (4, 0)$$

Four Points



Four Points



Four Points

$$\mu_A =$$

$$\mu_B =$$

$$\mu_C =$$

$$\mu_D =$$

Four Points

$$\mu_A = (-3, 3)$$

$$\mu_B =$$

$$\mu_C =$$

$$\mu_D =$$

Four Points

$$\mu_A = (-3, 3)$$

$$\mu_B = (-3.8, -0.6)$$

$$\mu_C =$$

$$\mu_D =$$

Four Points

$$\mu_A = (-3, 3)$$

$$\mu_B = (-3.8, -0.6)$$

$$\mu_C = (3.67, -3.33)$$

$$\mu_D =$$

Four Points

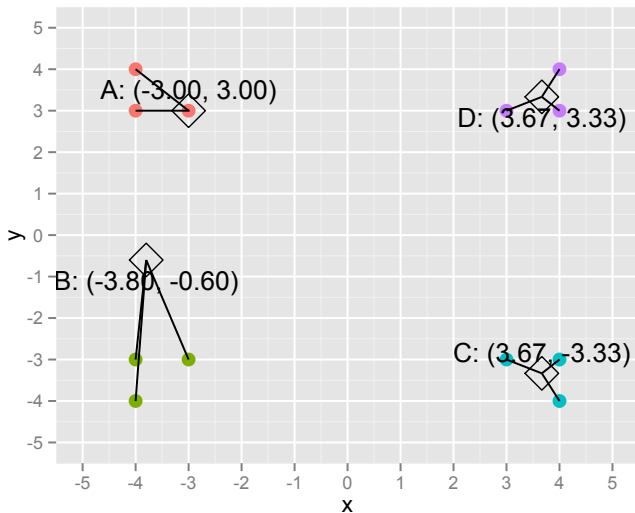
$$\mu_A = (-3, 3)$$

$$\mu_B = (-3.8, -0.6)$$

$$\mu_C = (3.67, -3.33)$$

$$\mu_D = (3.67, 3.33)$$

Four Points



Four Points

$$\mu_A =$$

$$\mu_B =$$

$$\mu_C =$$

$$\mu_D =$$

Four Points

$$\mu_A = (-3.67, 3.33)$$

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Four Points

$$\mu_A = (-3.67, 3.33)$$

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Four Points

$$\mu_A = (-3.67, 3.33)$$

$$\mu_B = (-3.67, -3.33)$$

$$\mu_C = (3.67, -3.33)$$

$$\mu_D =$$

Four Points

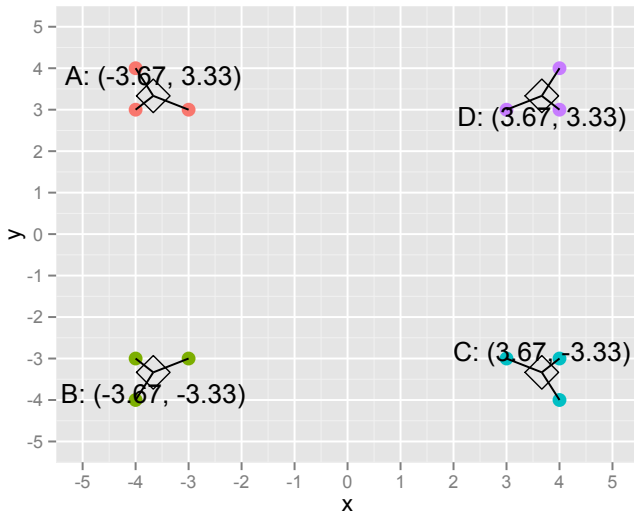
$$\mu_A = (-3.67, 3.33)$$

$$\mu_B = (-3.67, -3.33)$$

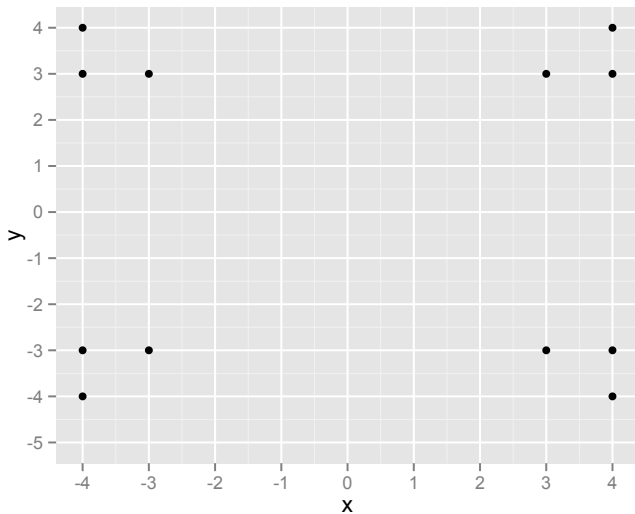
$$\mu_C = (3.67, -3.33)$$

$$\mu_D = (3.67, 3.33)$$

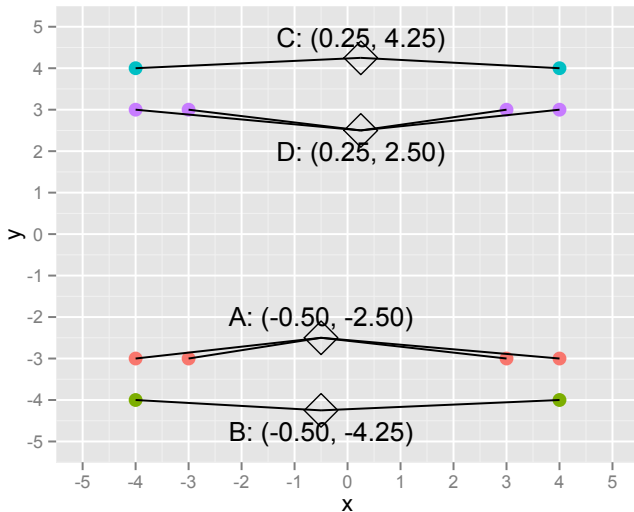
Four Points



Bad Initialization



Bad Initialization



Bad Initialization

