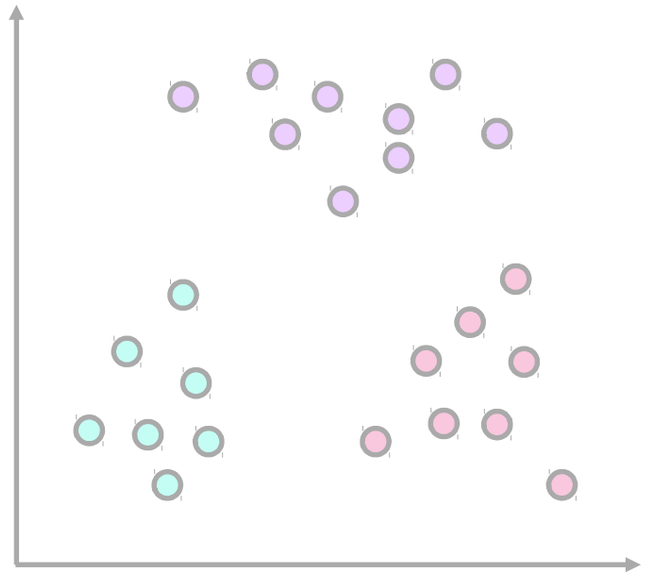
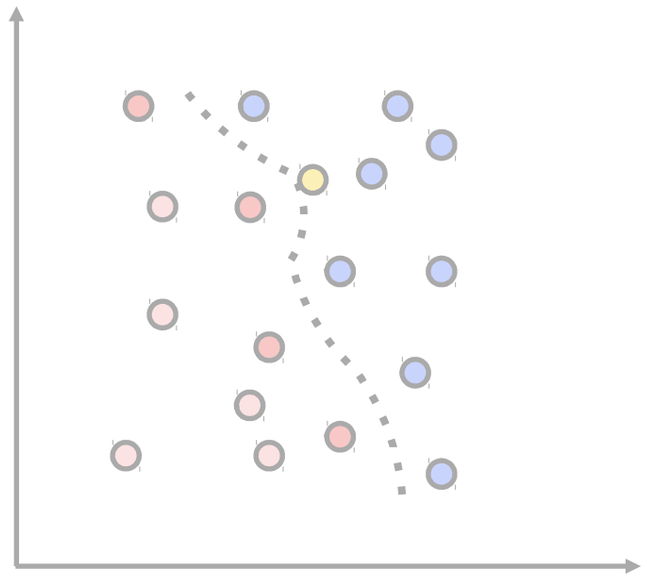
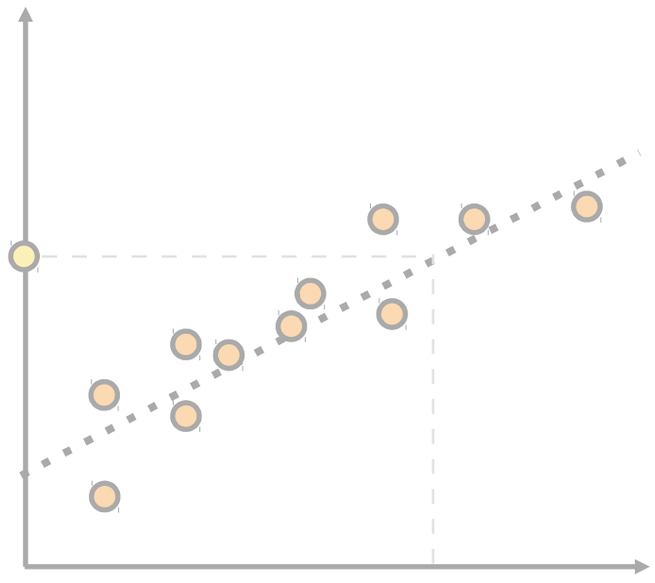
Machine Learning

1. Motivation + Theorie







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2019-09-30

Course Outline

Block I Foundations

Sep 30: Introduction
- Overview machine learning
- Theory: Linear Algebra
- Algorithms: Knn, K-means

Oct 01: Basics
- Theory: linear regression, logistic regression
- Algorithms: gradient descent

Block II Best practices

Neural Networks
- Data cleaning
- Algorithm: Neural Networks

Best practices
- Theory: Cross validation
- Theory: Regularization

Course Outline

Block III Dark Arts

Tricks of the Trade
- Ensembles
- Hyperparameter Search
- Deep Learning Black Magic

Outlook
- Theory: Dimensionality Reduction

Outline Today

1. Preliminaries
2. Dataset: MNIST
3. What is Machine Learning?
4. Notation
5. Classification: K nearest neighbours (Knn)
6. Clustering: K-means
7. Theory: Linear Algebra refresher
8. Application: Python Intro, Implementation
9. Dataset: CIFAR-10

Preliminaries

1. Programming Assignments
Teams of two (1 SAP 1 non-SAP), randomly assigned.

2. Schedule, Dates & Deadlines
3 blocks. 1 assignment per block.
Help desk: Monday after each block - doodle your slot.
Deadlines: Friday after the help desk.
Results: Friday after the deadline.

Preliminaries

1. Programming Assignments
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2. Schedule, Dates & Deadlines
3 blocks. 1 assignment per block.
Help desk: Monday after each block
Deadlines: Friday after the help desk.
Results: Friday after the deadline.

What's your schedule Monday?

3. Grades
Assignment I: 30 points
Assignment II: 30 points
Assignment III: 40 points
Late assignments will cost you points.

4. Resources
After the end of one block, you will get an email with slides, code demonstrations, assignments and a doodle link to the Help desk.

Dataset: MNIST

http://yann.lecun.com/exdb/mnist/

70,000 samples
images of handwritten digits
28x28 grayscale images
labels are digits from 0-9

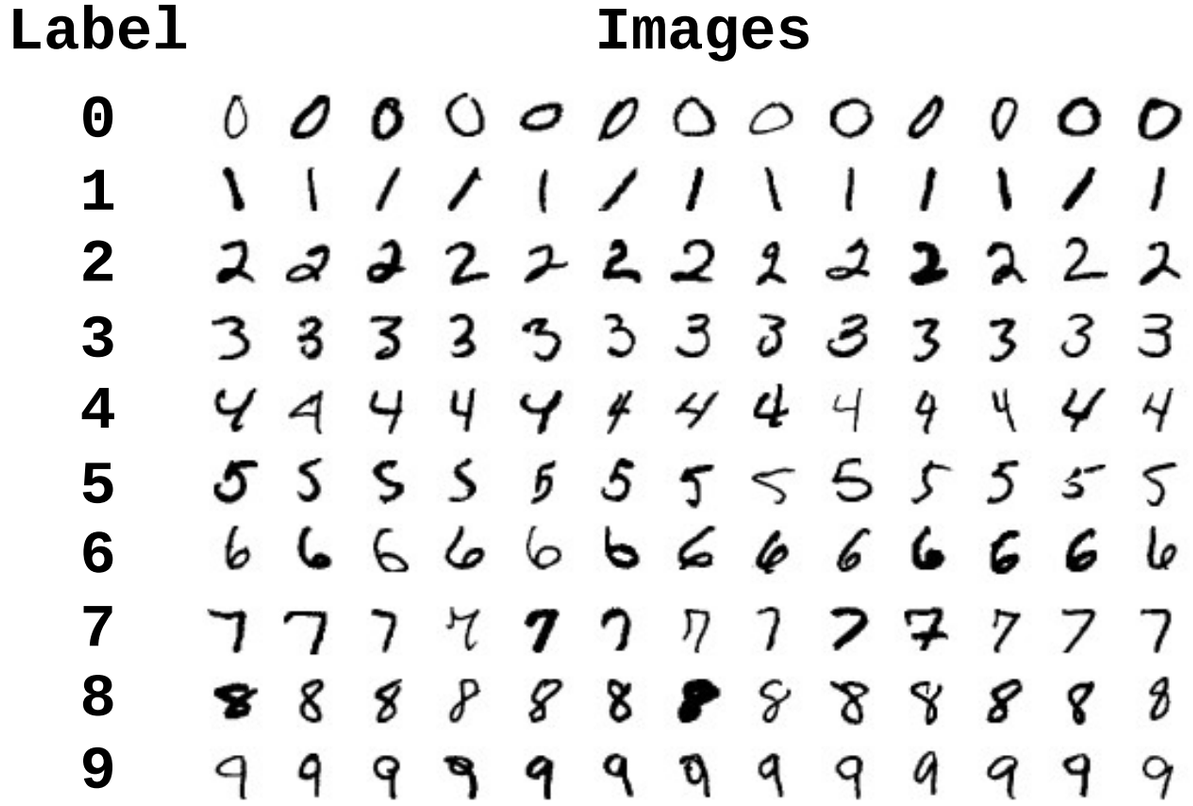


image: wikipedia.com

image: research.fb.com

Yann LeCun

NYU Professor
facebook Chief AI Scientist
Deep Learning (ConvNets)

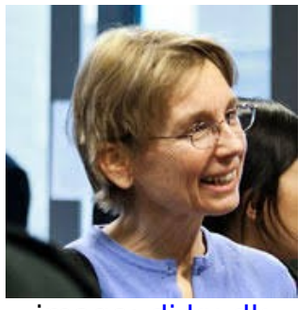


image: di.ku.dk

Corinna Cortes

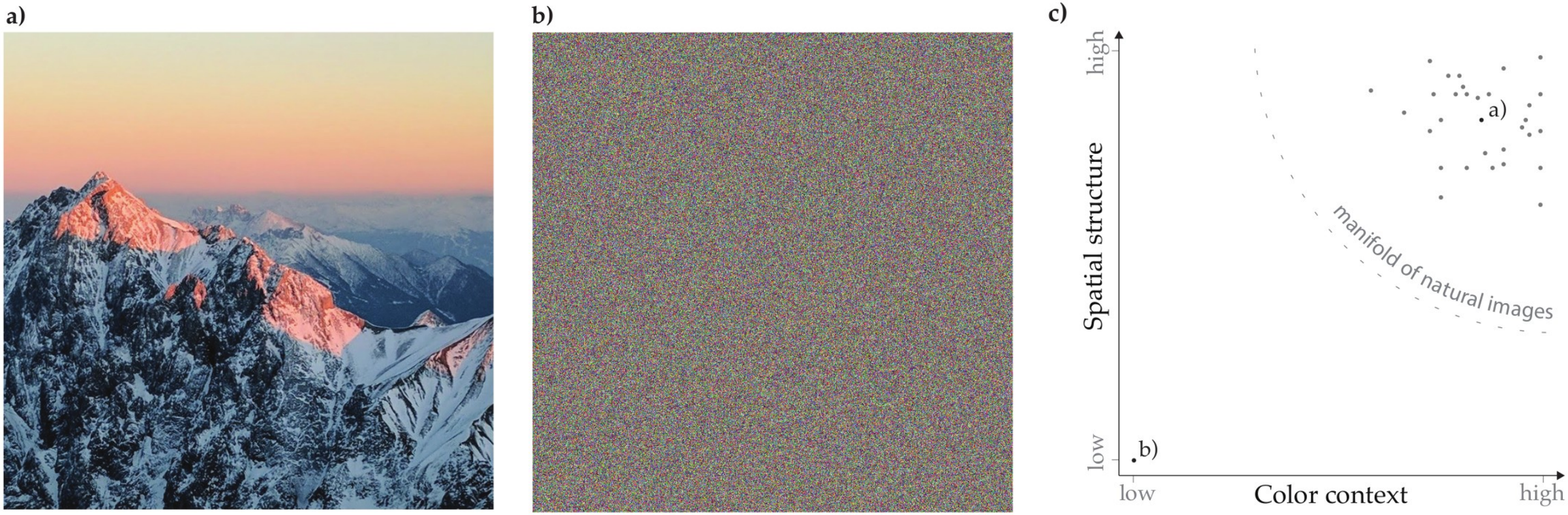
Head Google Research NY
Support Vector Machines

image: microsoft.com

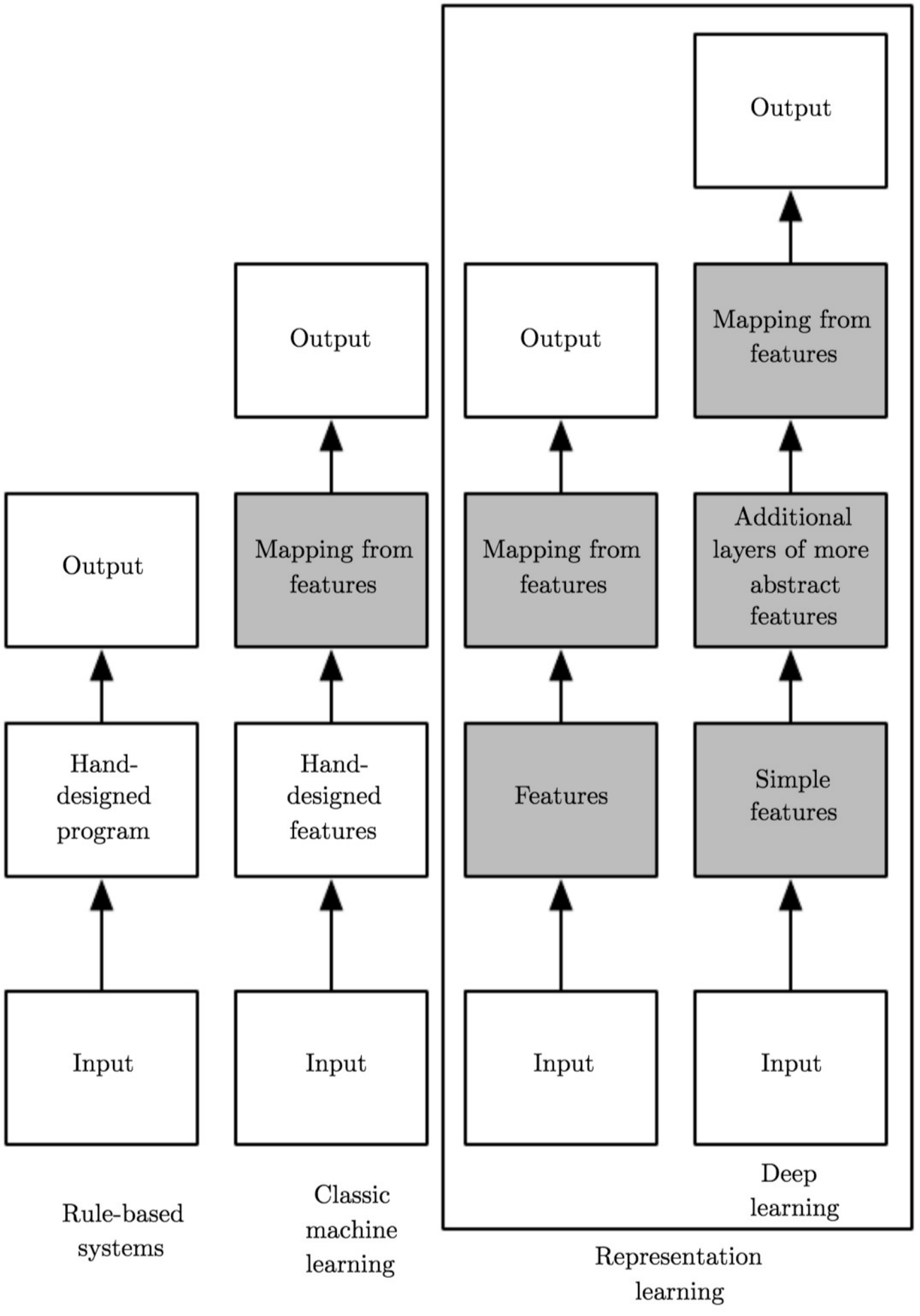
Christopher J.C. Burges

formerly Microsoft Research
Support Vector Machines

What is Machine Learning?



What is Machine Learning?



graphic: "Deep Learning" Goodfellow, Bengio, Courville

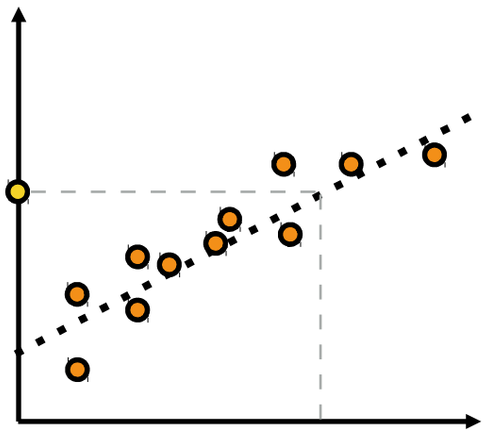
Machine Learning Overview

Do you have labeled data?

✓ → **supervised**

what kind of label?

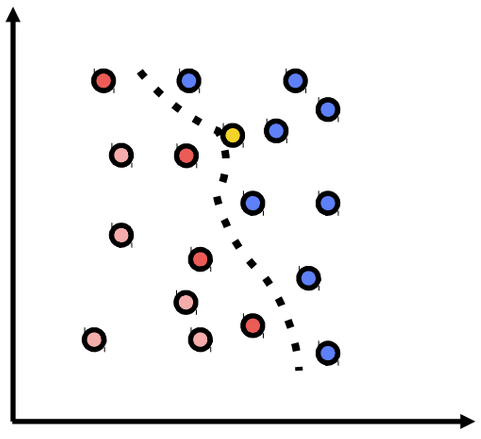
- continuous → **regression**



Boston Housing

predict real estate price by attributes of the property

- discrete → **classification**



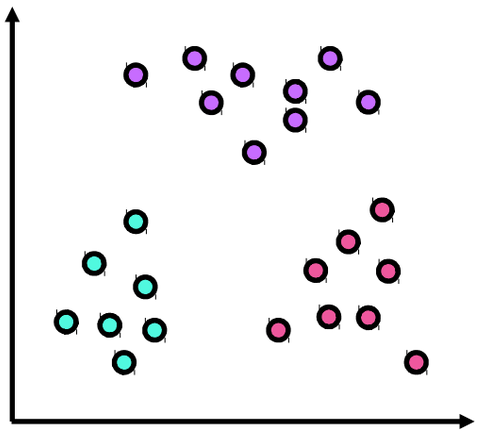
MNIST

classify handwritten digit as 0-9

✗ → **unsupervised**

what to generate?

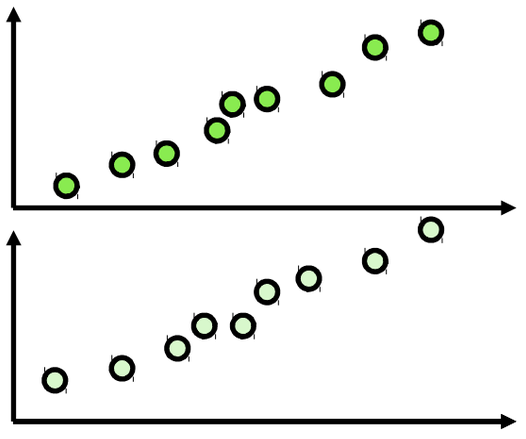
- sample → <u>label</u> → **clustering**



MNIST

cluster handwritten digits in 10 clusters

- sample → <u>sample</u> → **generative**



MNIST

generate images of handwritten digits

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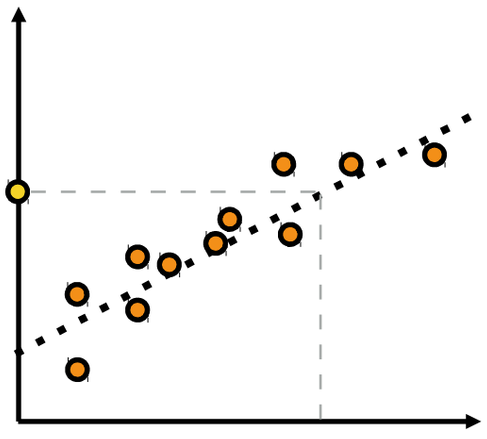
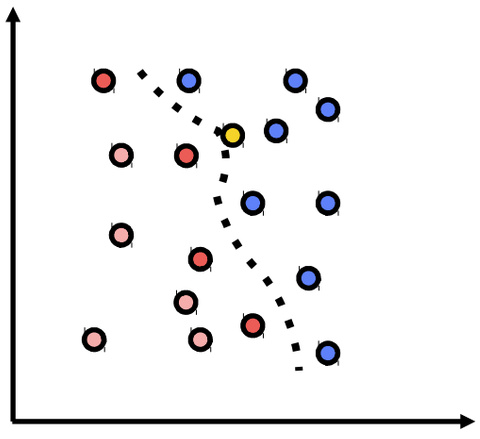


- K-nearest-neighbours
- Linear Regression
- Regression Trees
- Support Vector Regression
- Neural Networks

- discrete → **classification**



- Logistic Regression
- Support Vector Machines
- Decision Trees / Forests
- Neural Networks
- (Gaussian) Mixture Model

✗ → **unsupervised**

what to generate?

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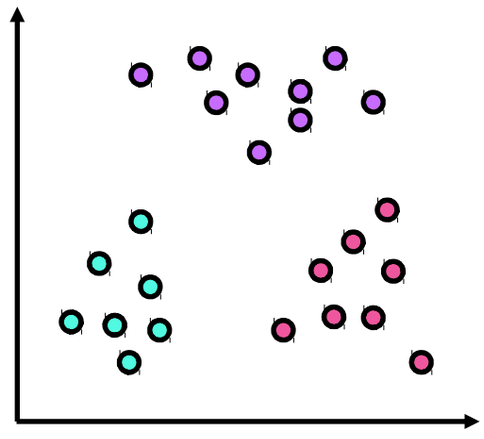
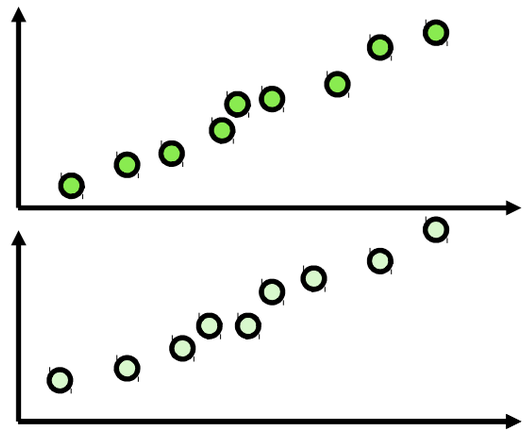


- K-means
- (Gaussian) Mixture Models
- Self-organising maps*

- sample → <u>sample</u> → **generative**



- Markov Chains
- Autoencoder*
- Generative Adversarial Networks*

* neural network

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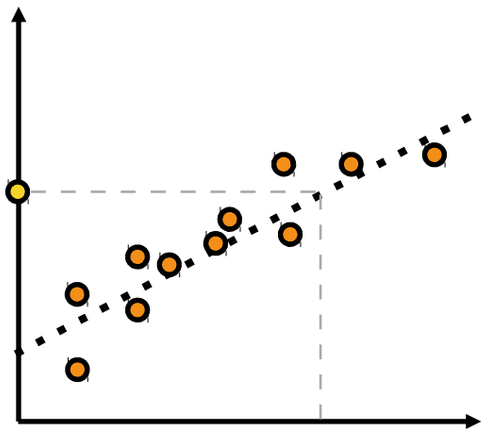

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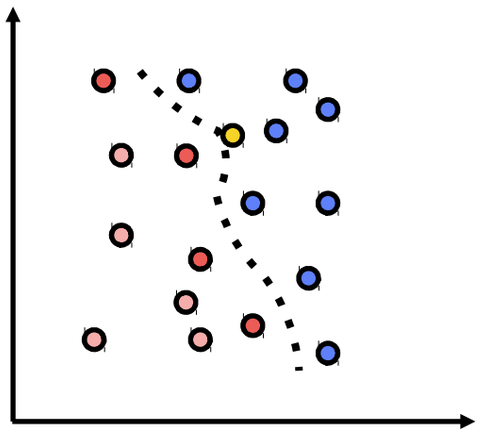

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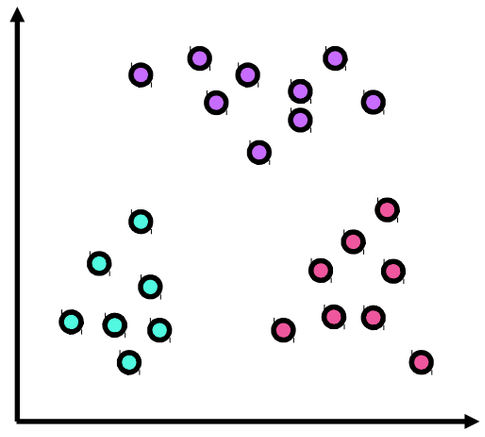

- K-means
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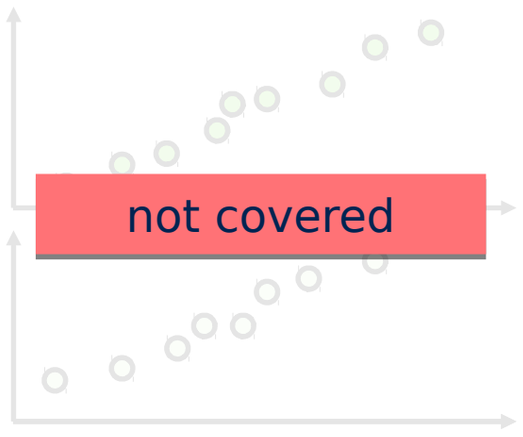
- sample → <u>sample</u> → **generative**



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Machine Learning Overview

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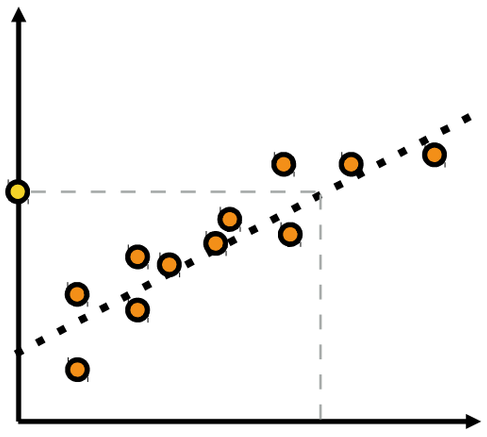


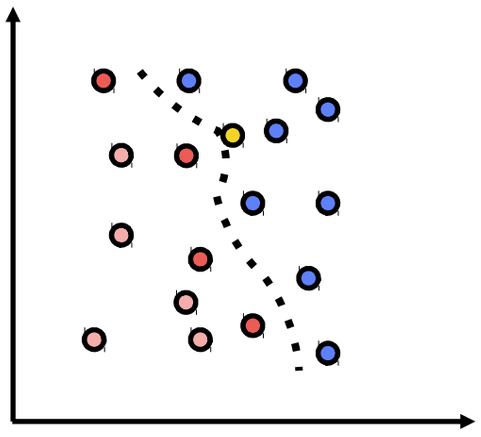
- K-nearest-neighbours

Sep 30

- Linear Regression

Oct 01

- discrete → **classification**



- Logistic Regression
- Support Vector Machines

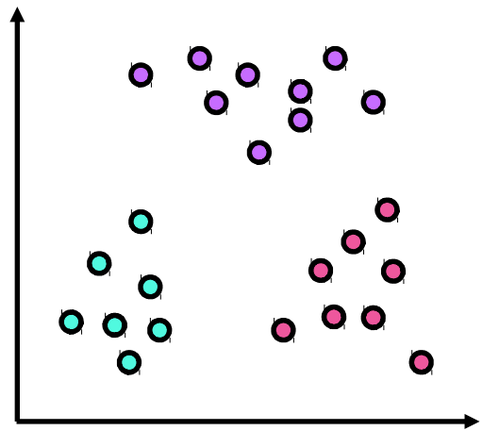
Oct 02

- (Gaussian) Mixture Model

✗ → **unsupervised**

what to generate?

- sample → label



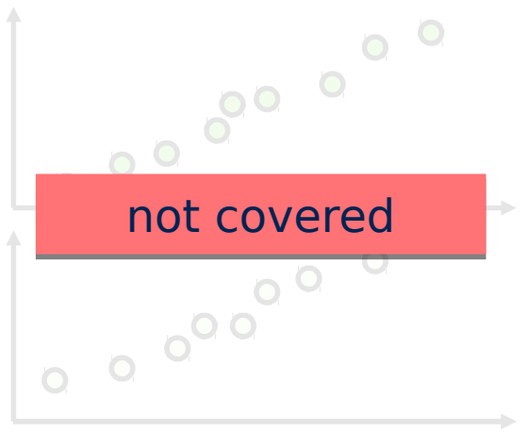
- K-means

Sep 30

- Self-organising maps*

- sample → sample

- generative

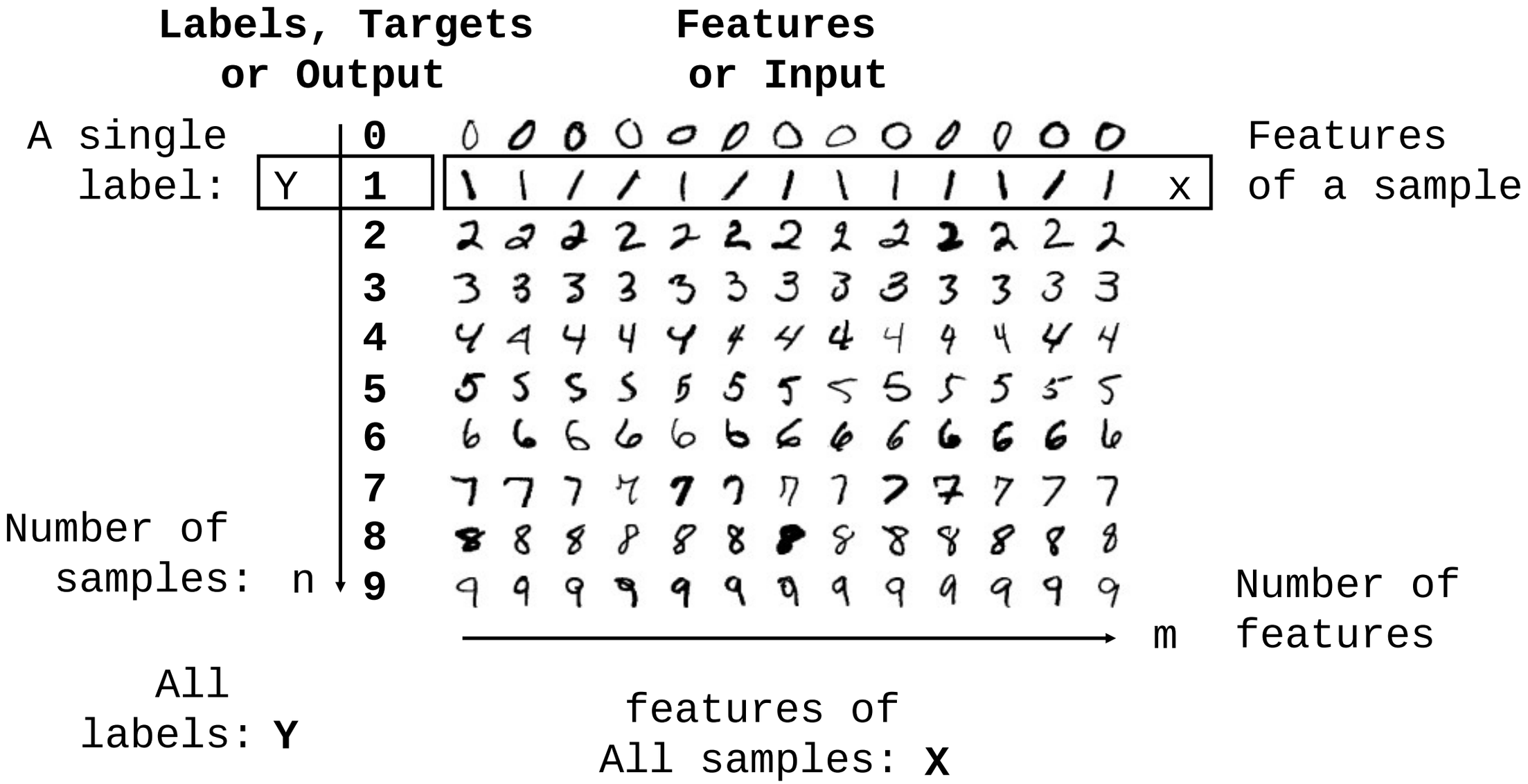


not covered

- Markov Chains
- Autoencoder*
- Generative Adversarial Networks*

* neural network

Notation



A machine learning model is a function mapping X to Y.
Θ is what the model “learned”.

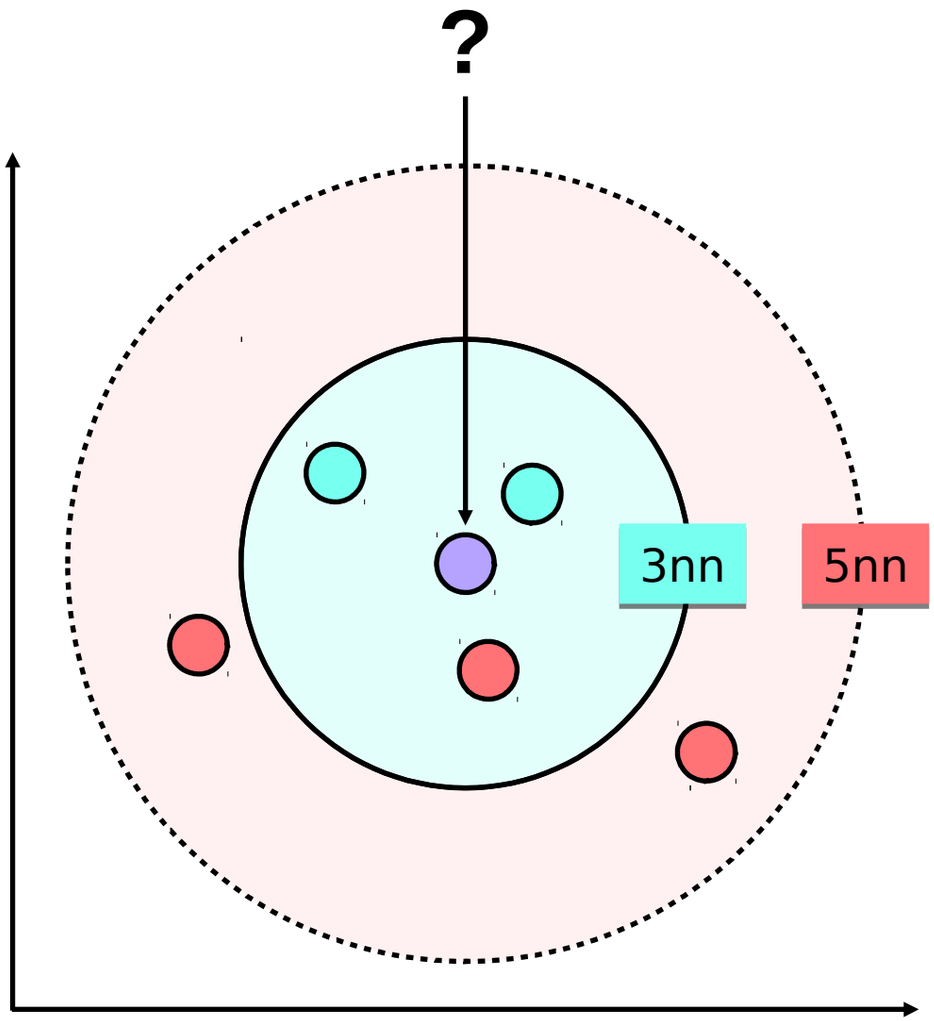
$$f_\theta : X \rightarrow Y$$

Classification: k-nearest neighbors (knn)

Intuition

1. Of all neighbors, which are the k nearest to my sample?

2. What label does the majority of the k neighbors have?



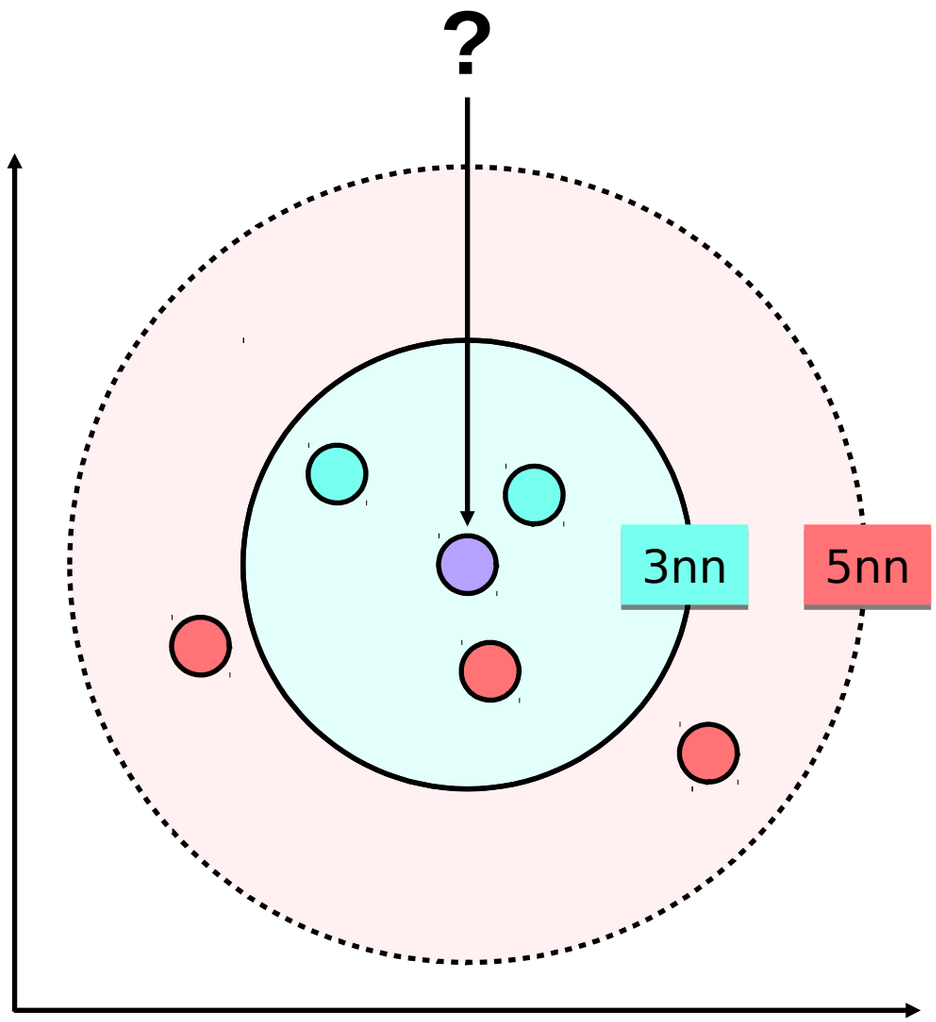
Classification: k-nearest neighbors (knn)

Algorithm

Input
- dataset **M** - matrix of samples (vector, class)
- sample **v** to classify
- number of neighbors **n**

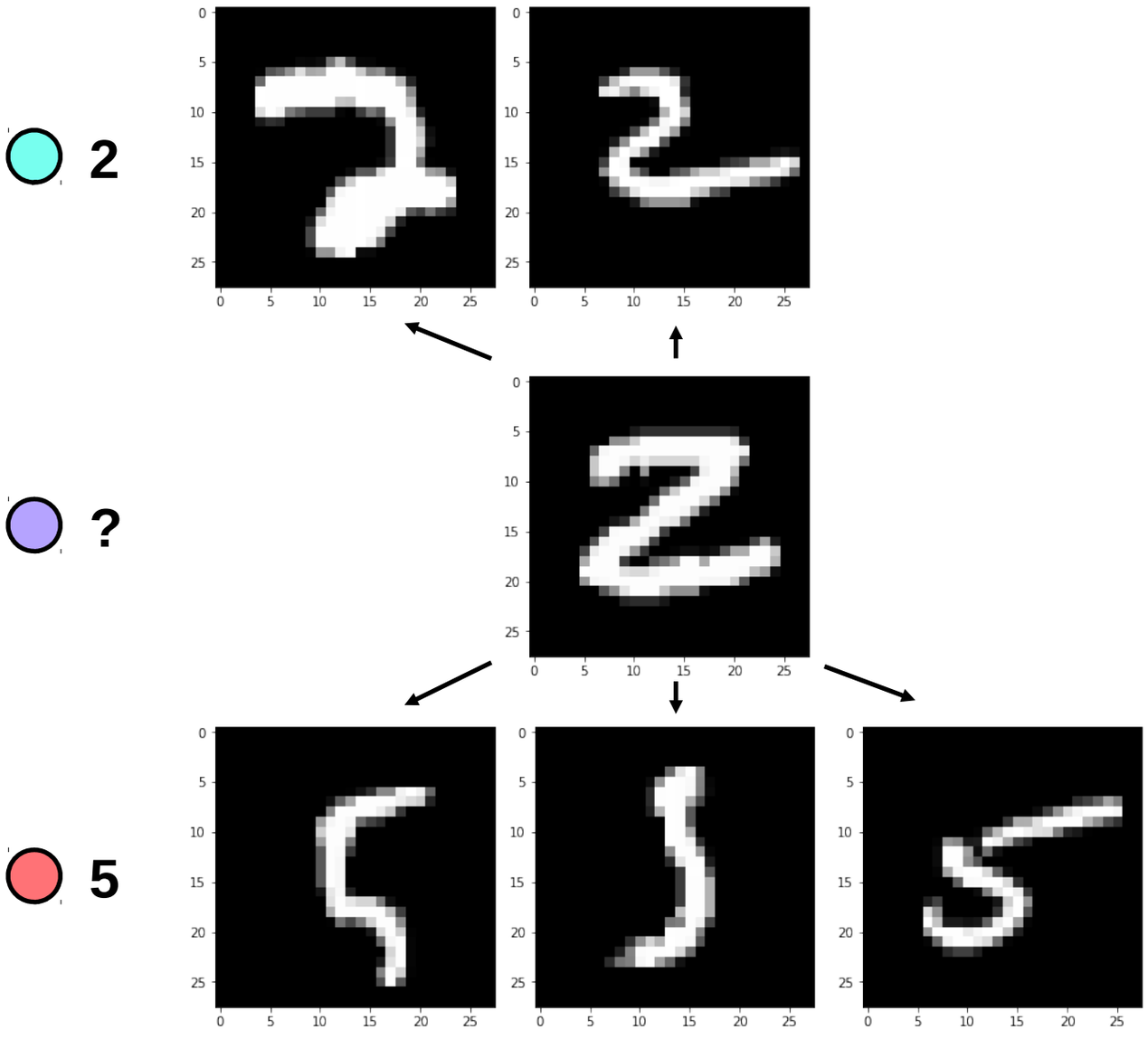
Output
- class **k**

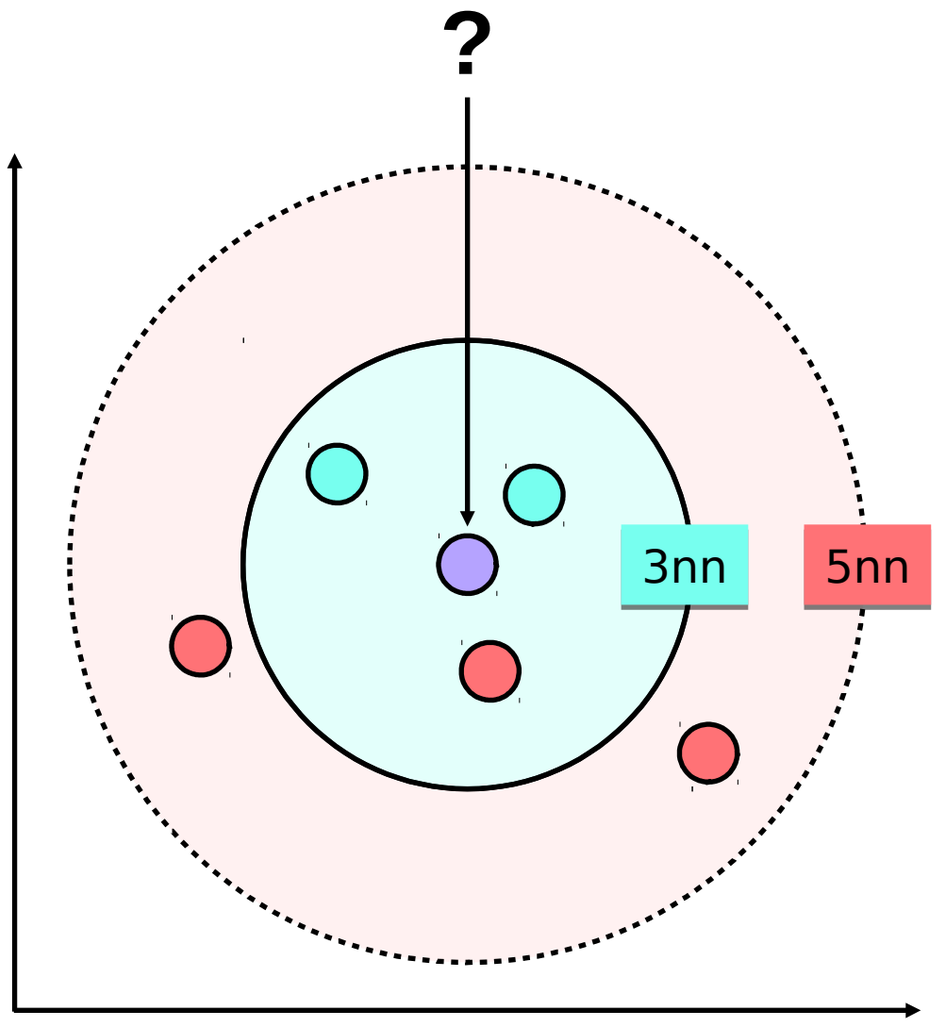
0. Calculate distance of **v** to all samples in **M**
1. Select the **n** samples closest to **v**
2. choose **k** to be the majority of classes in selection



Classification: k-nearest neighbors (knn)

Data



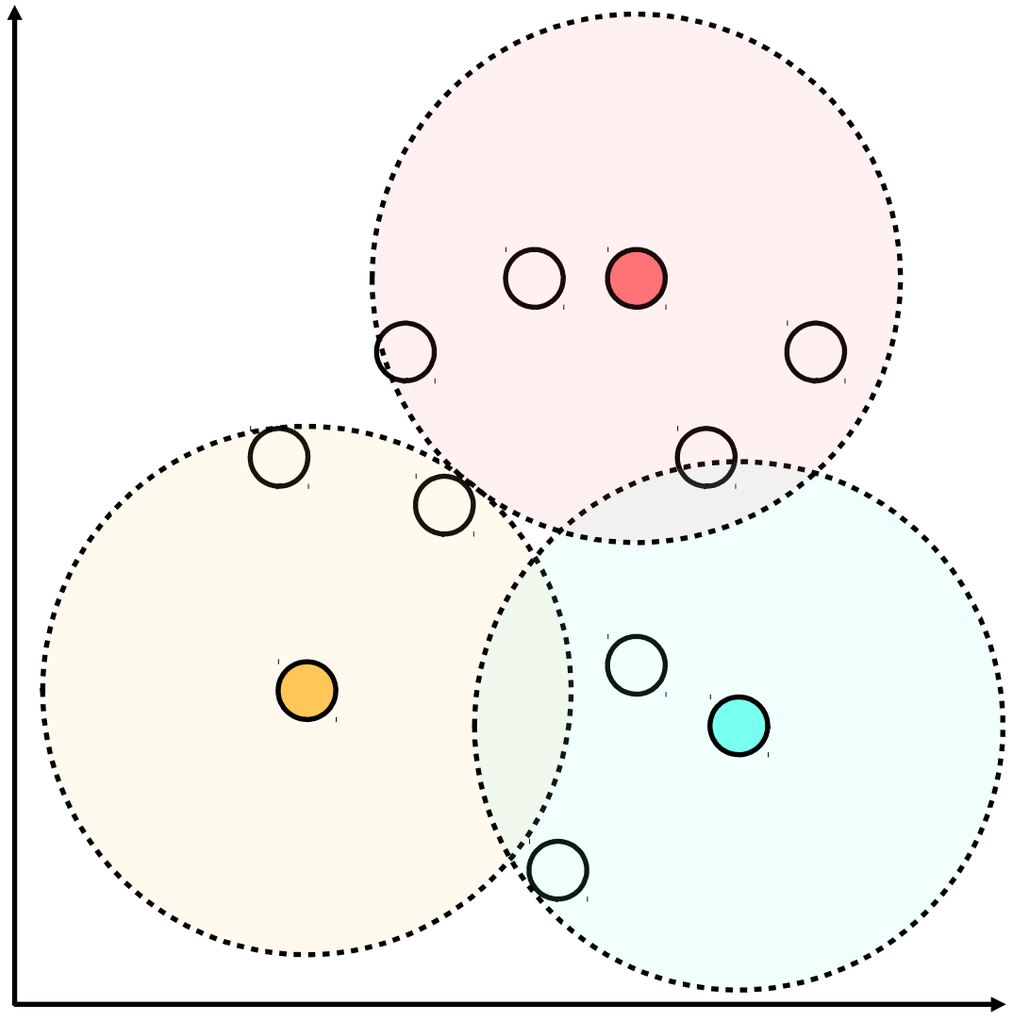


Clustering: k-means

Intuition

Initially, select k random samples,
those are your class centroids.

1. assign each sample the class of the closest centroid.
2. determine centroid for each class with smallest distance to each all samples in class
3. if one of the centroids changed, repeat.



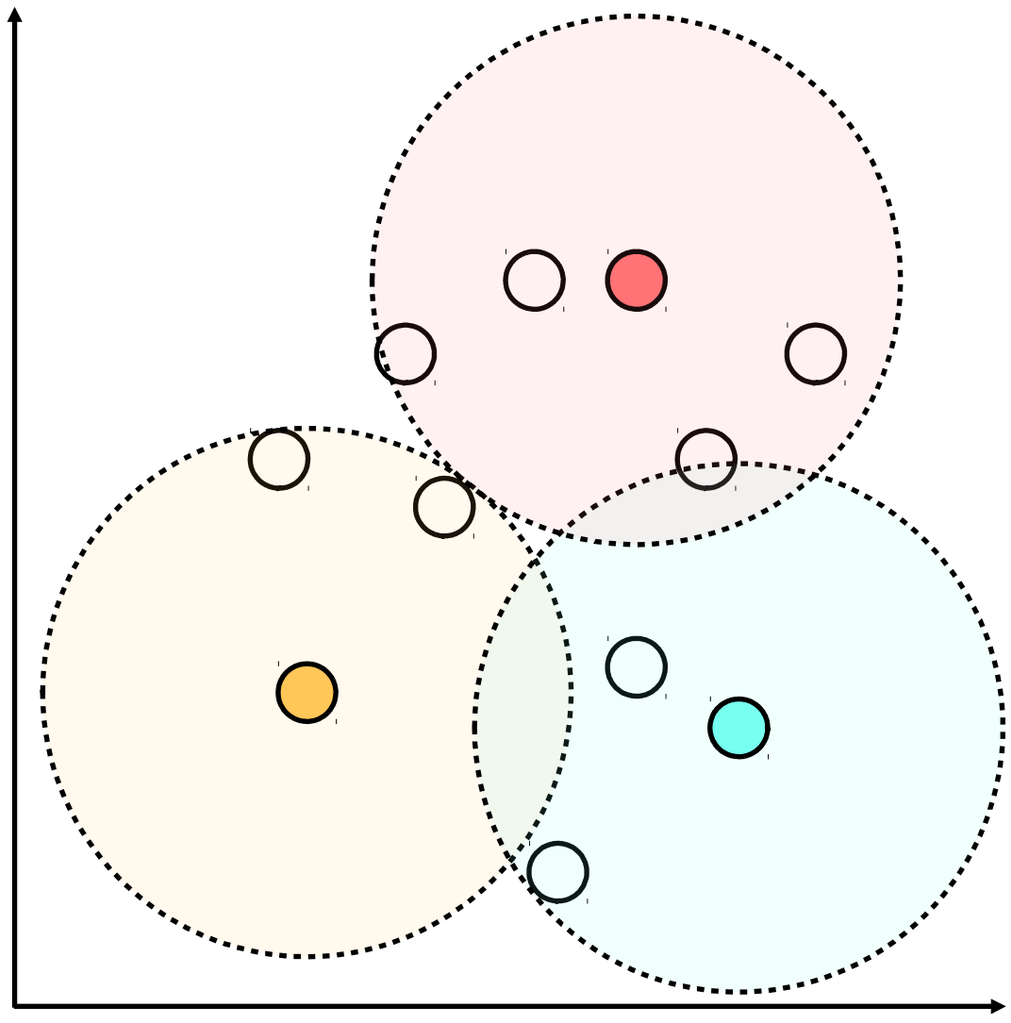
Clustering: k-means

Algorithm

Input
- dataset **M** - matrix of samples (vector)
- number of clusters **k**

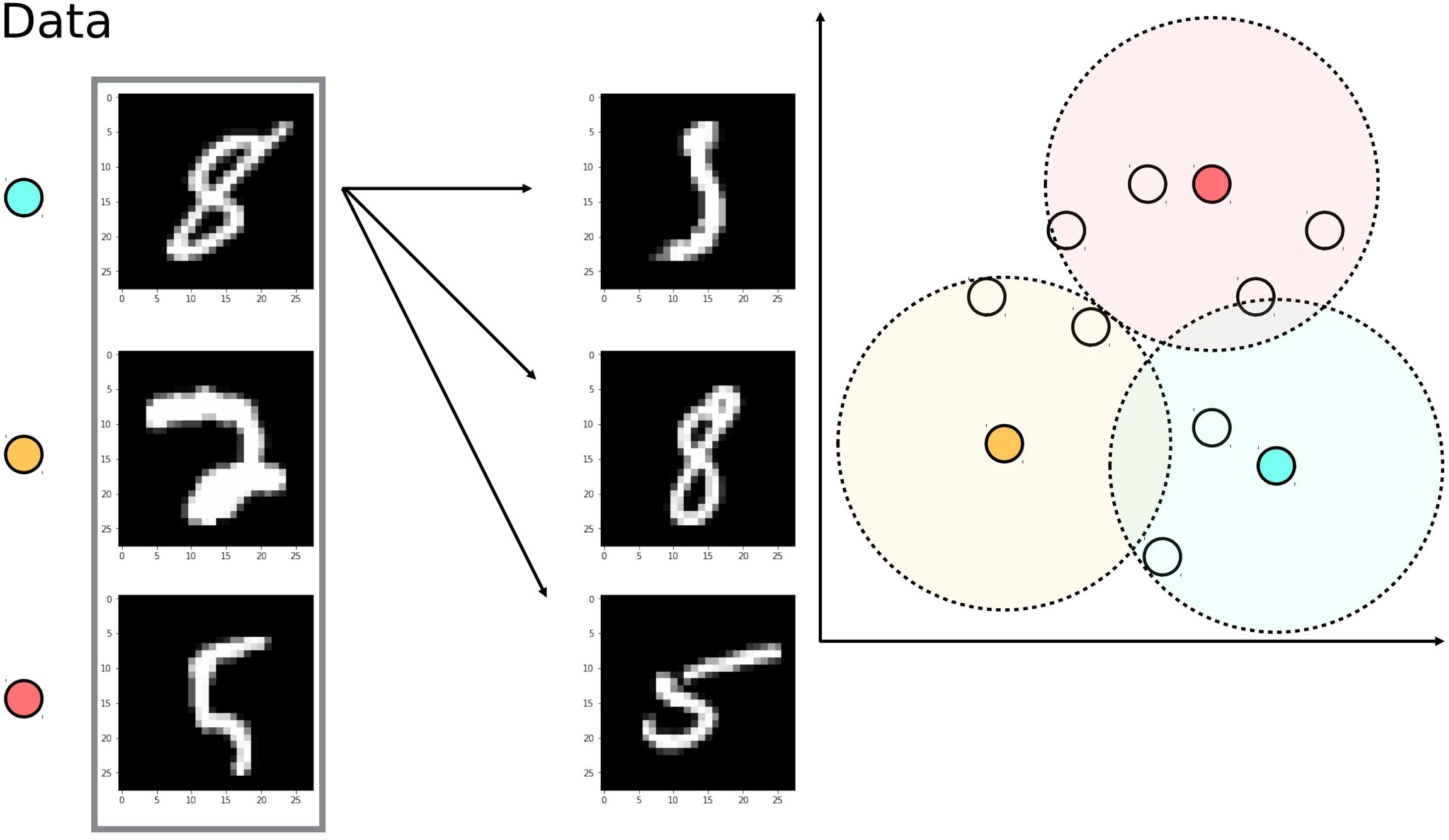
Output
- dataset **R** - matrix of samples (vector, class)

1. select **k** samples from **M** at random (**K** cluster centroids)
2. assign all samples in **M** to the nearest sample in **K**
3. Calculate the cluster centroid **k'** for each cluster **k** in **K** as **K'.**
4. if **K != K'** then set **K** := **K'**; Repeat from 3.



Clustering: k-means

Data



Theory: Linear Algebra

Euclidean distance

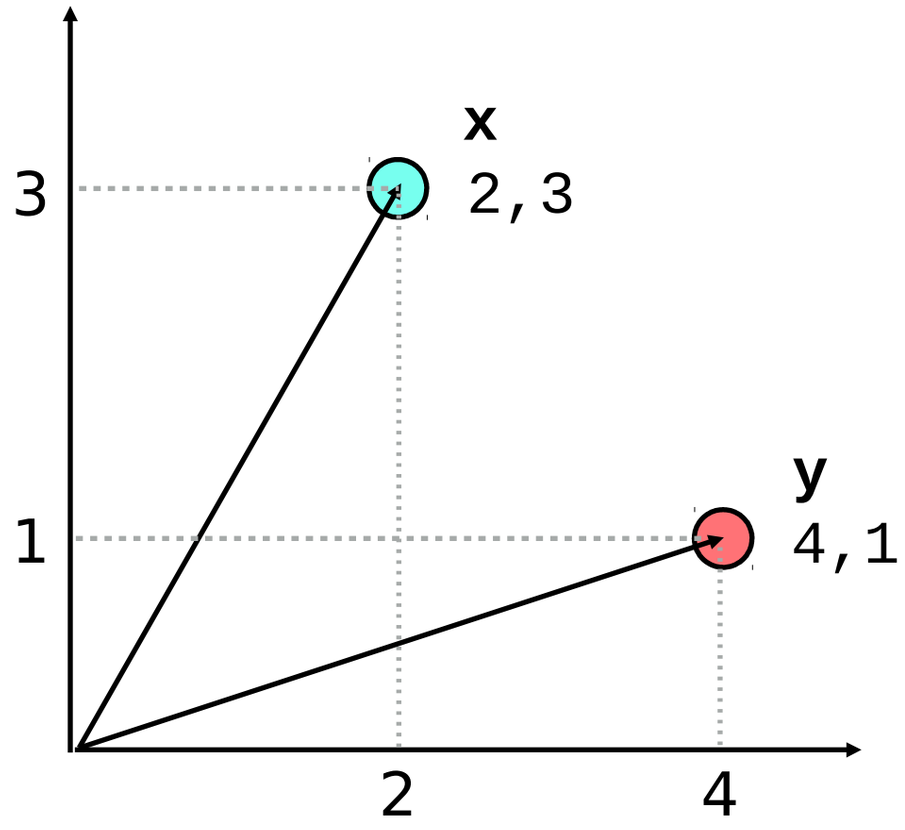
$$dist(x, y) = \|x - y\|_2 = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

Example

$$\sqrt{\sum_{i=1}^{2}\left(\begin{bmatrix}2\\3\end{bmatrix} - \begin{bmatrix}4\\1\end{bmatrix}\right)^2} = \sqrt{\sum_{i=1}^{2}\left(\begin{bmatrix}-2\\2\end{bmatrix}\right)^2}$$

$$= \sqrt{\sum_{i=1}^{2}\begin{bmatrix}4\\4\end{bmatrix}}$$

$$= \sqrt{8}$$



Code

```
dist = np.linalg.norm(x - y)
```

Dataset: CIFAR-10

cs.toronto.edu/~kriz/cifar.html

60,000 samples
images of objects
32x32 color images with labels
labels are 10 categories

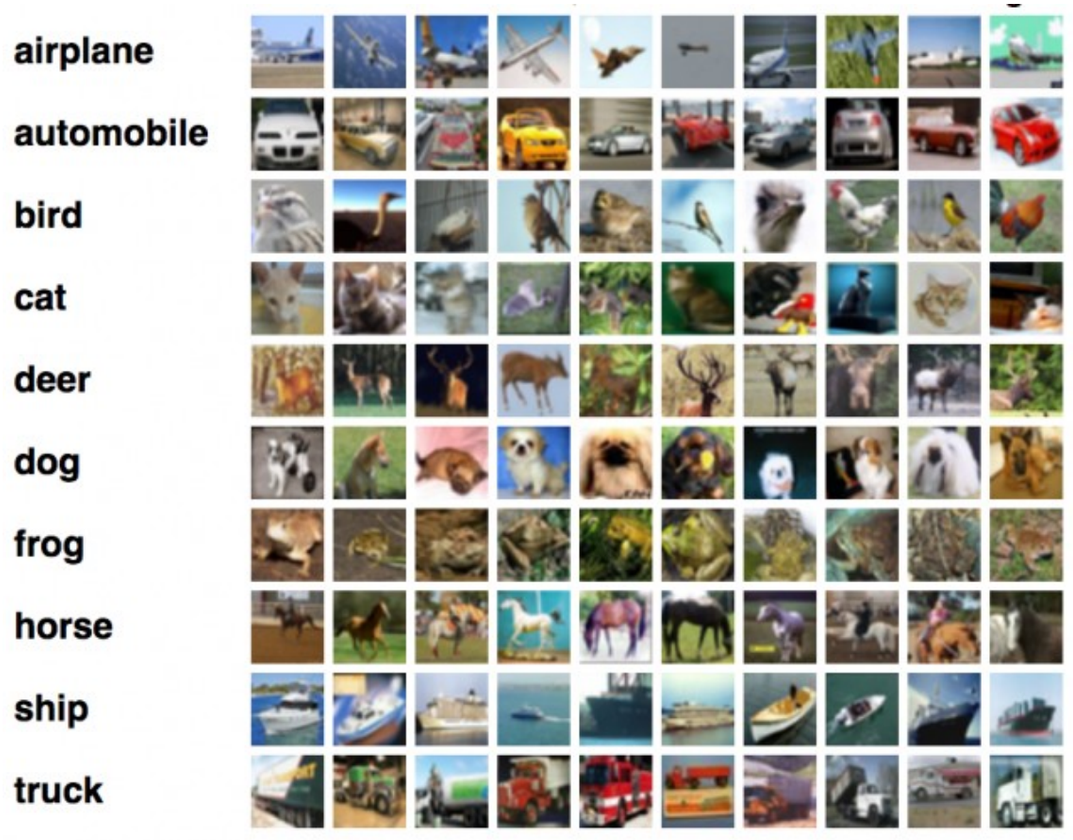


image: kaggle.com

image: qz.com

Alex Krizhevsky

Dessa, formerly Google
Deep Learning (AlexNet)

image: cs.toronto.edu

Vinod Nair

Yahoo Labs
Deep Learning

image: thestar.com

Geoffrey Hinton

U Toronto Professor
Google Brain
Deep Learning