

Computer Vision: Machine learning

Siheng Chen 陈思衡

Machine learning

What is machine learning?

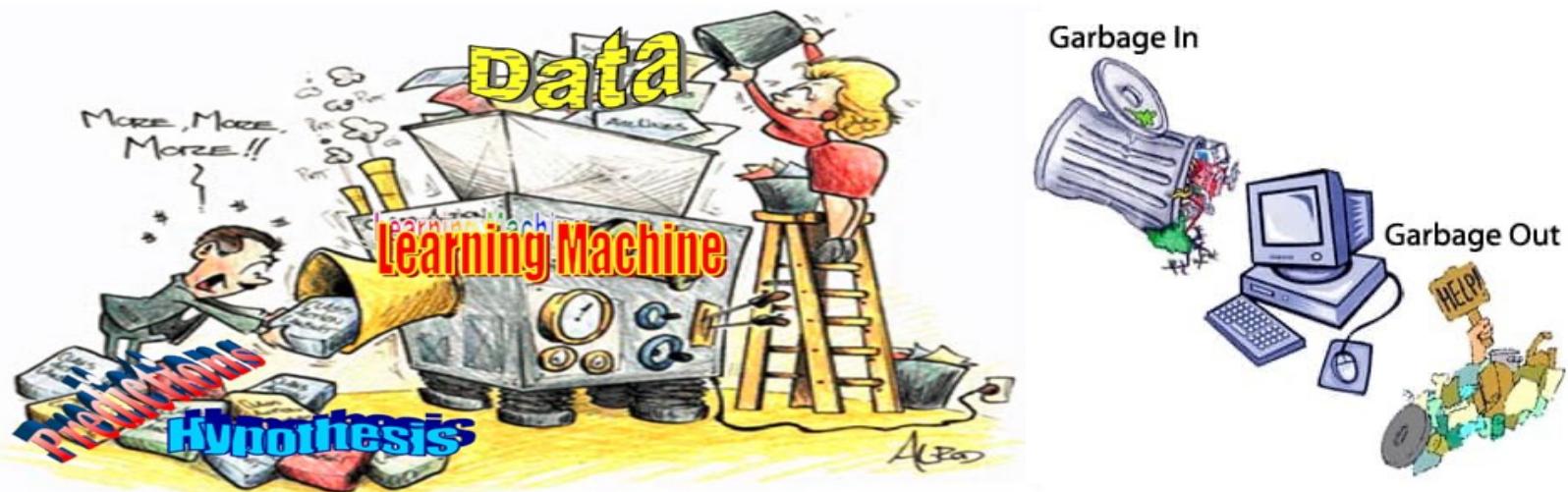
Connections to computer vision

A tour of K-NN classifier

What is machine learning?



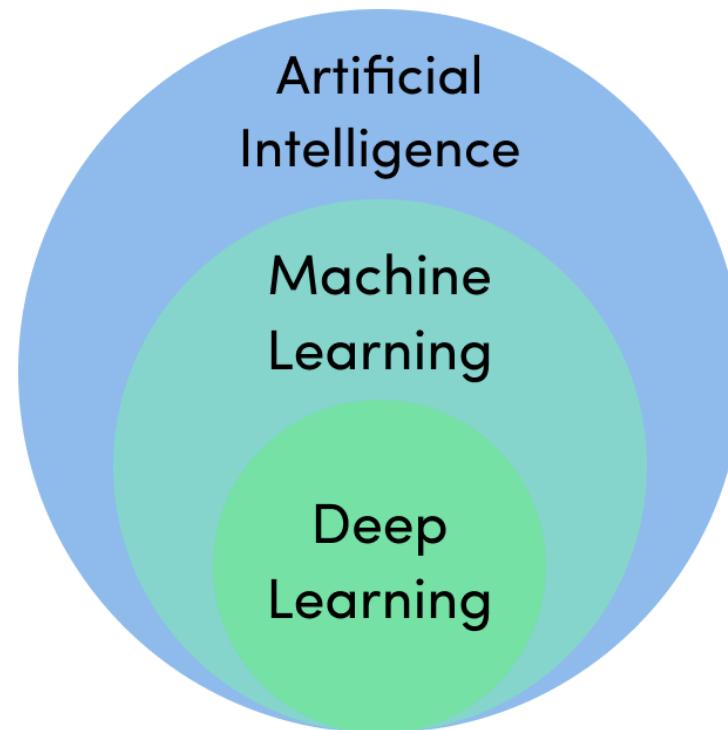
Machine learning is the study of computer algorithms that can improve automatically through experience and by the use of data. It is seen as a part of artificial intelligence.



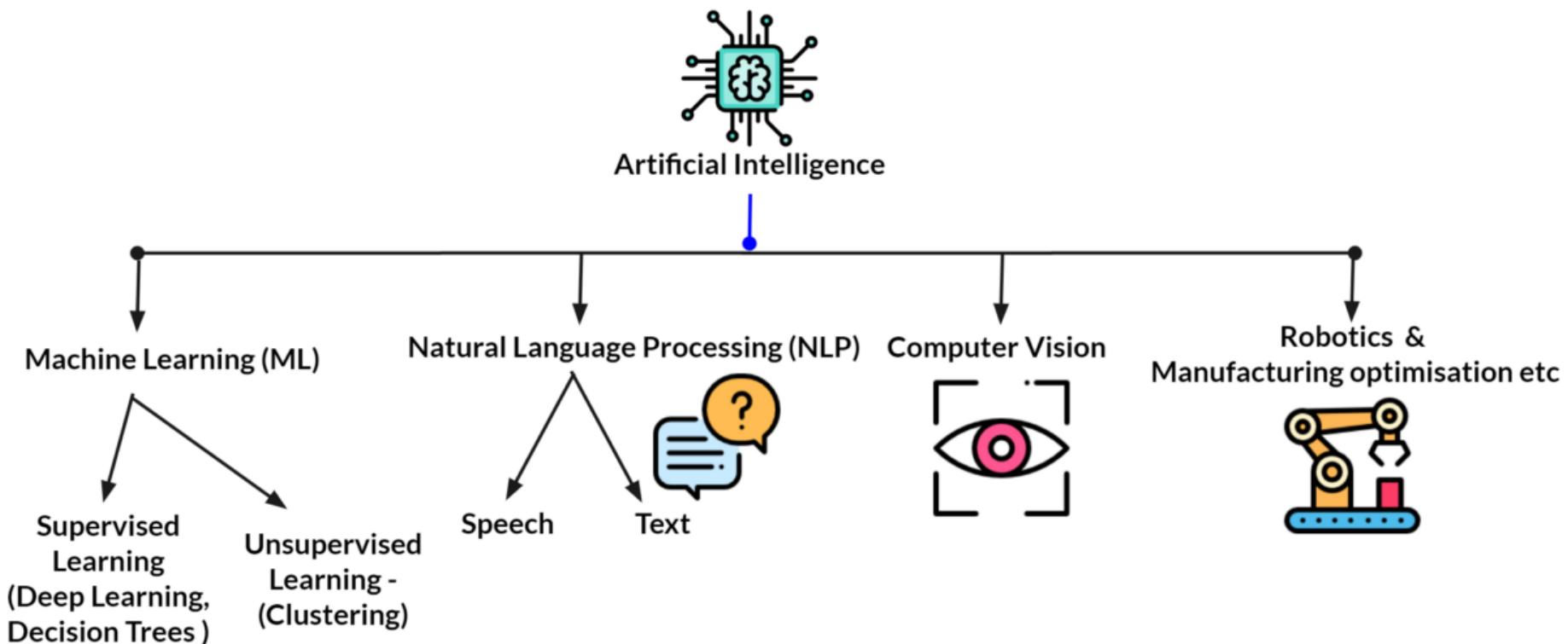
What is machine learning?

Time	Major events
<1960	Statistics
1960s	Bayesian methods
1970s	“AI winter”
1980s	Backpropagation
1990s	Data-driven, support vector machines
2000s	Kernel methods
2010s	Deep learning

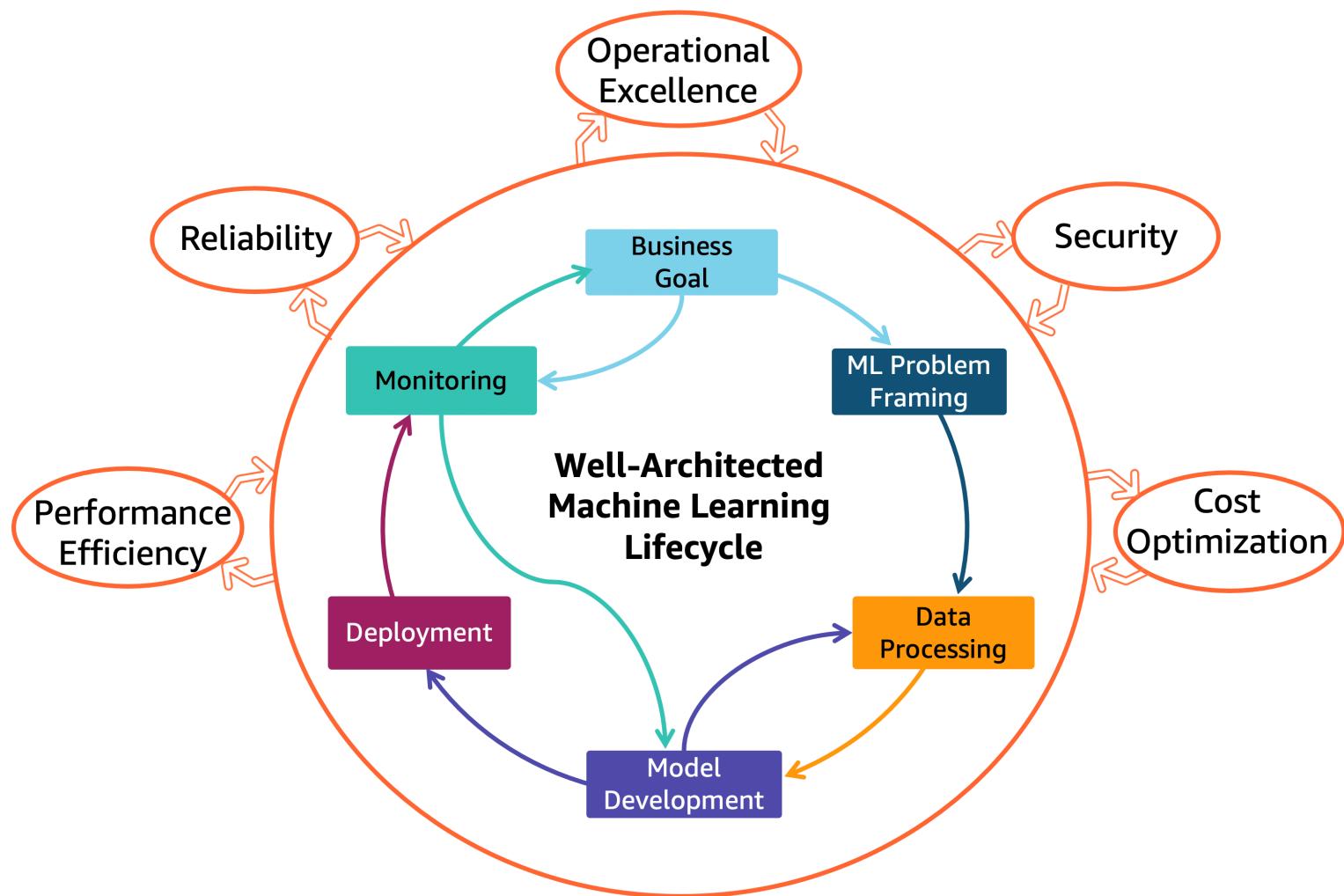
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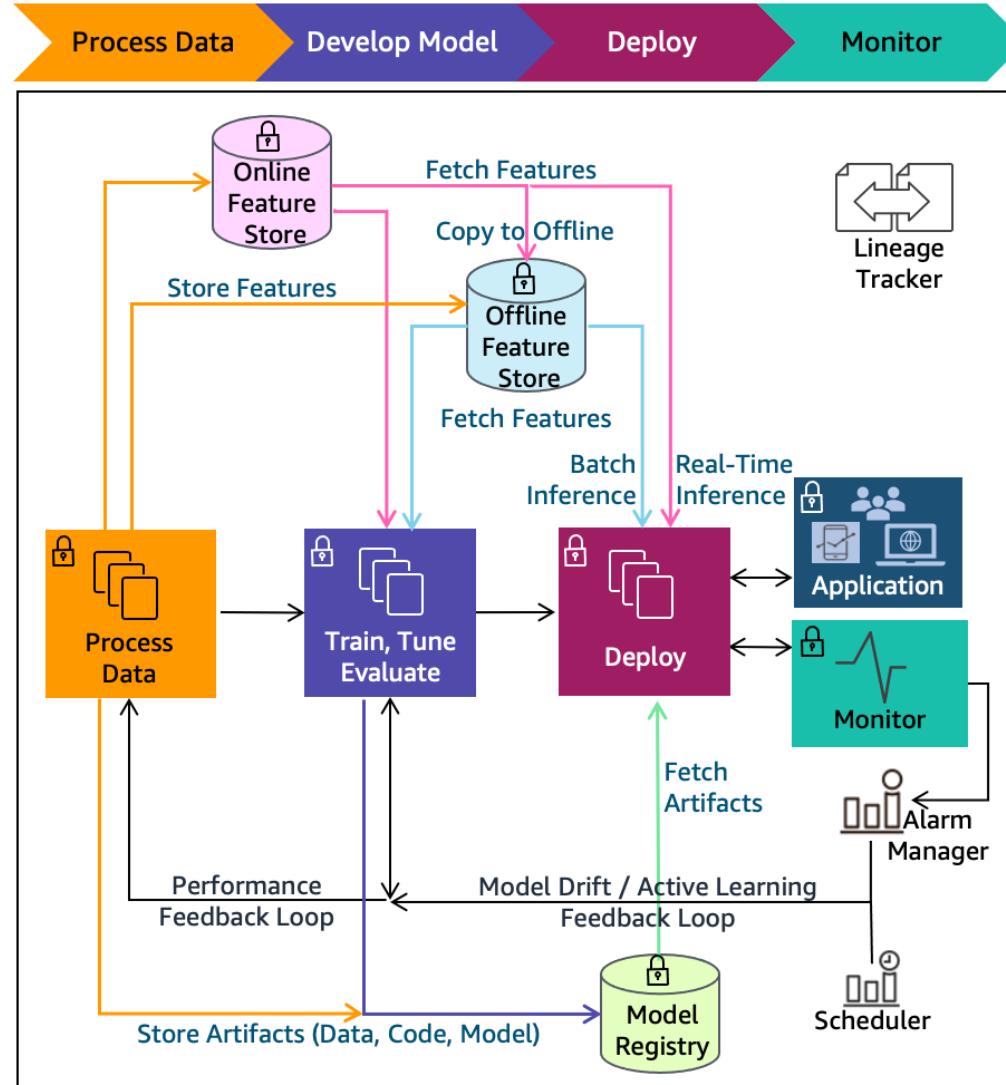
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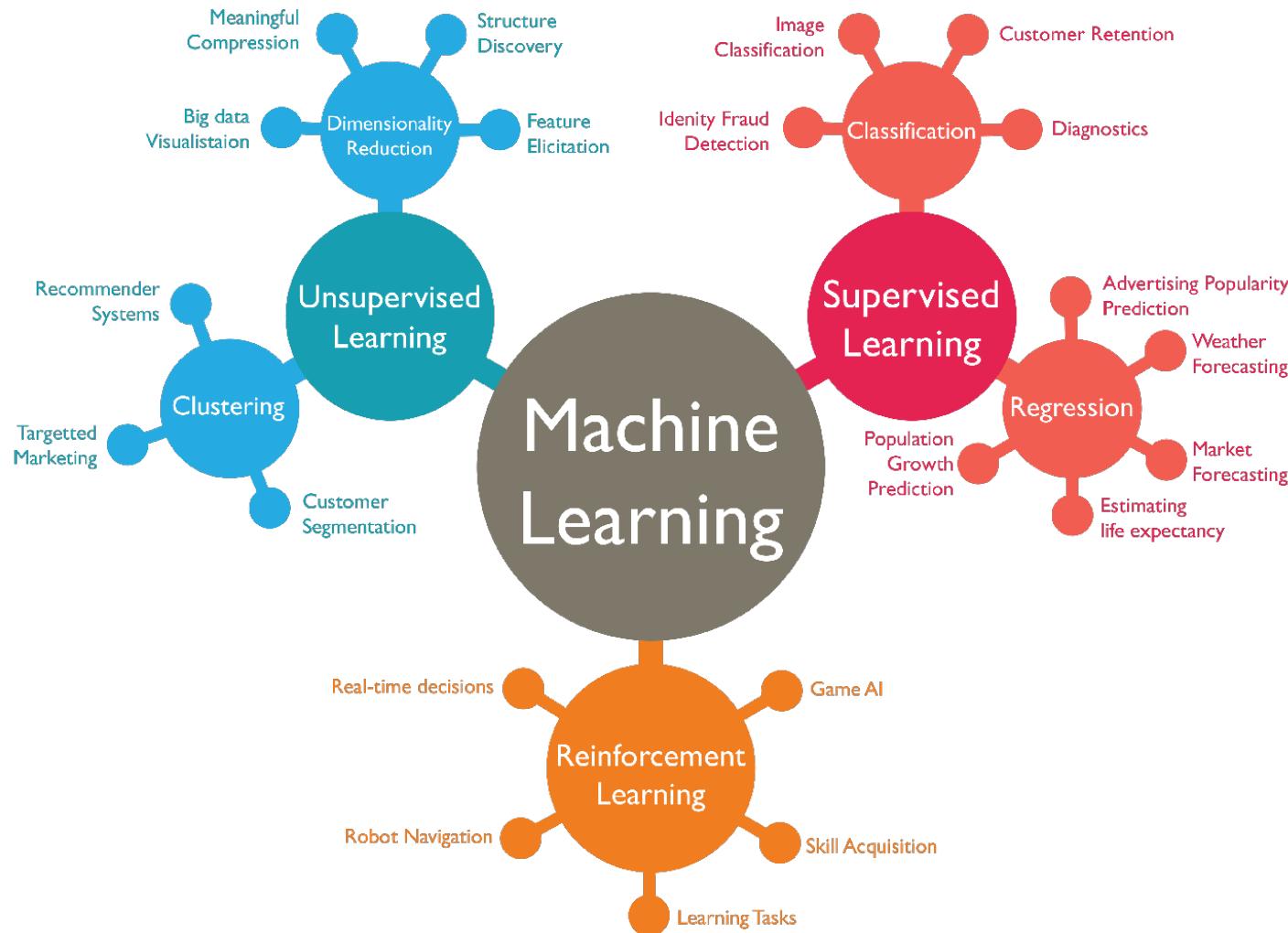
What is machine learning?



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What is machine learning?



Supervised learning (SL) is the machine learning task of learning a function that maps an input to an output based on example input-output pairs



What is machine learning?

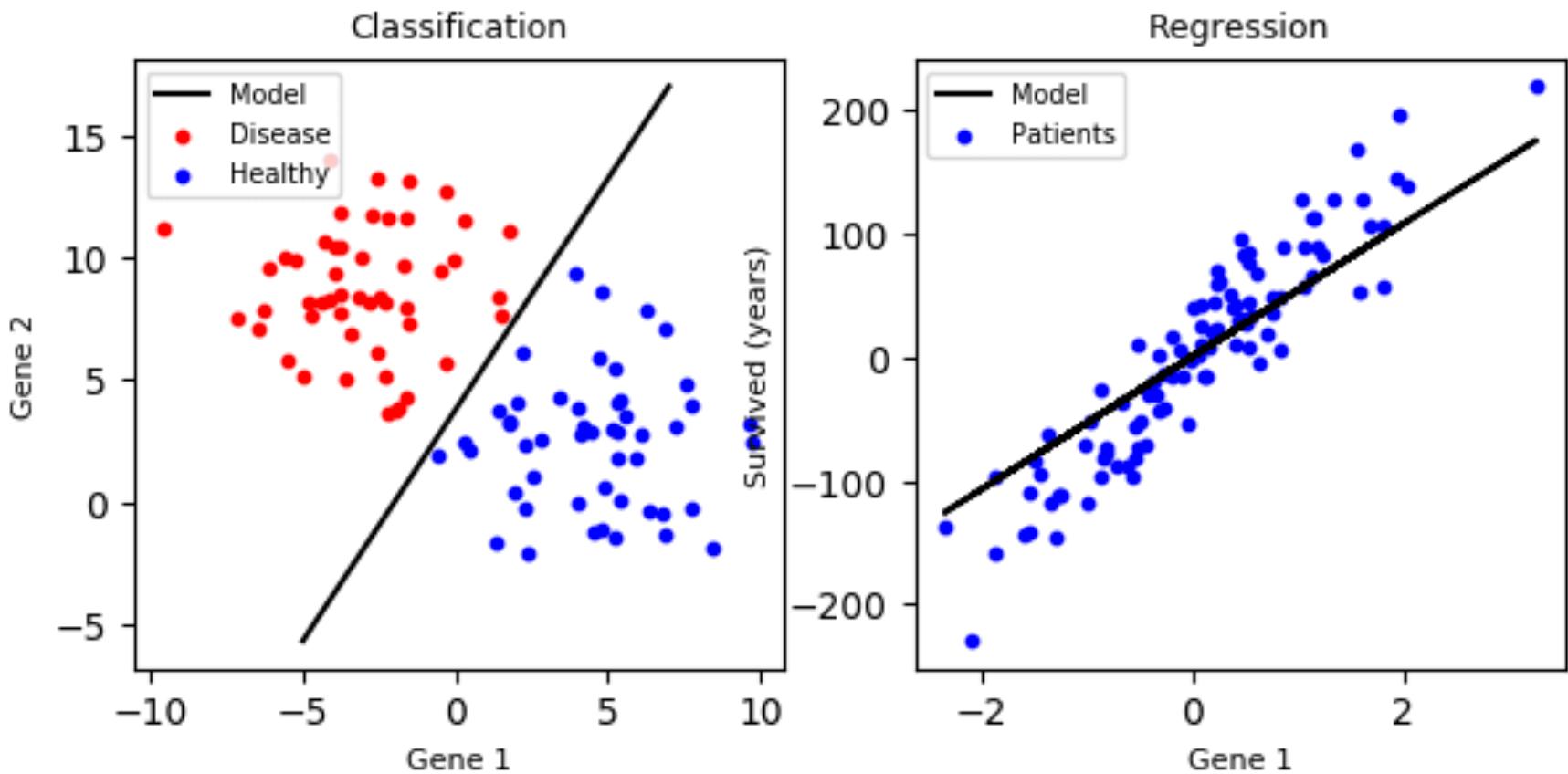


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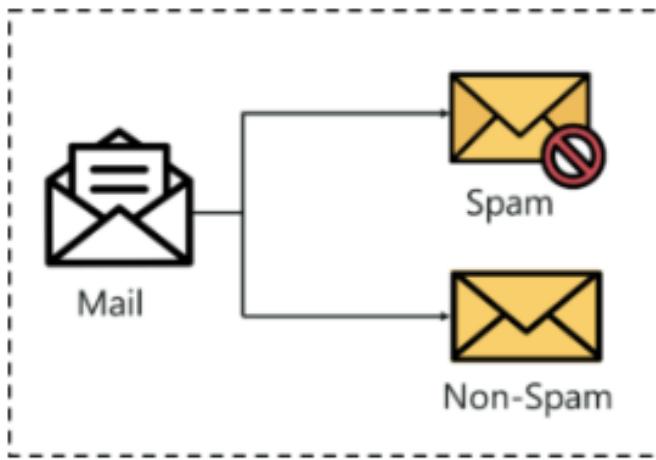
- Classification is the process of predicting the class of given data points
- Regression is the process of predicting the continuous outcome of given data points



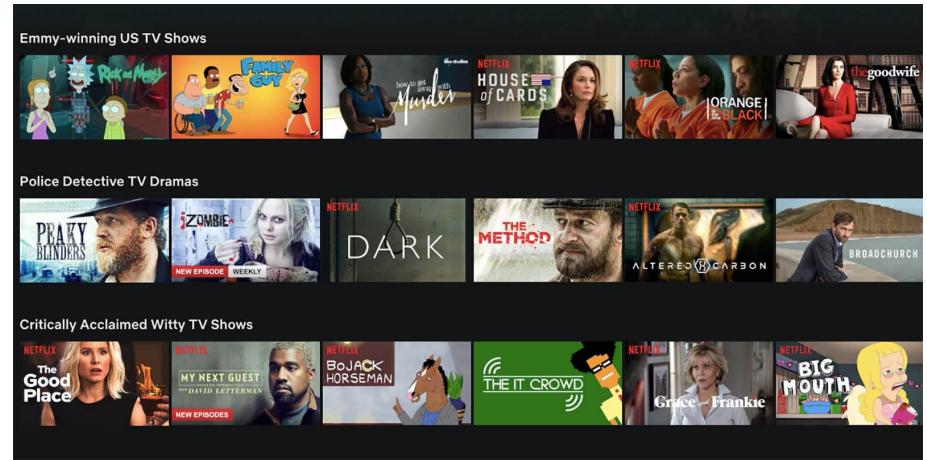
What is machine learning?



What is machine learning?



Email spam classification



Movie rating prediction

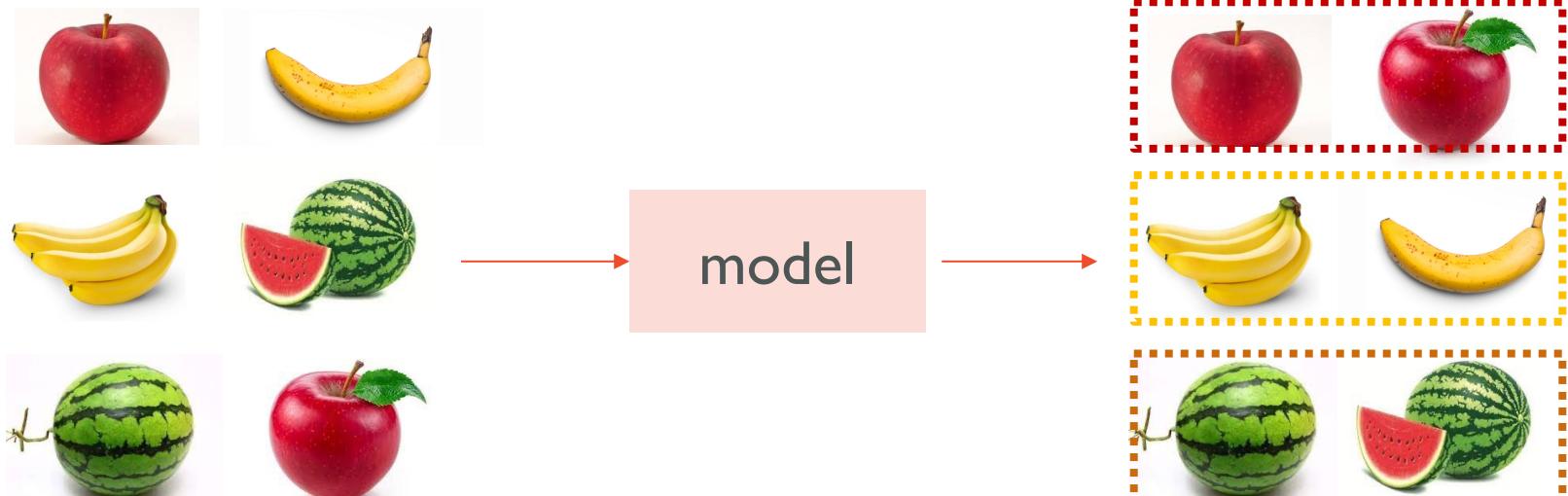
What is machine learning?



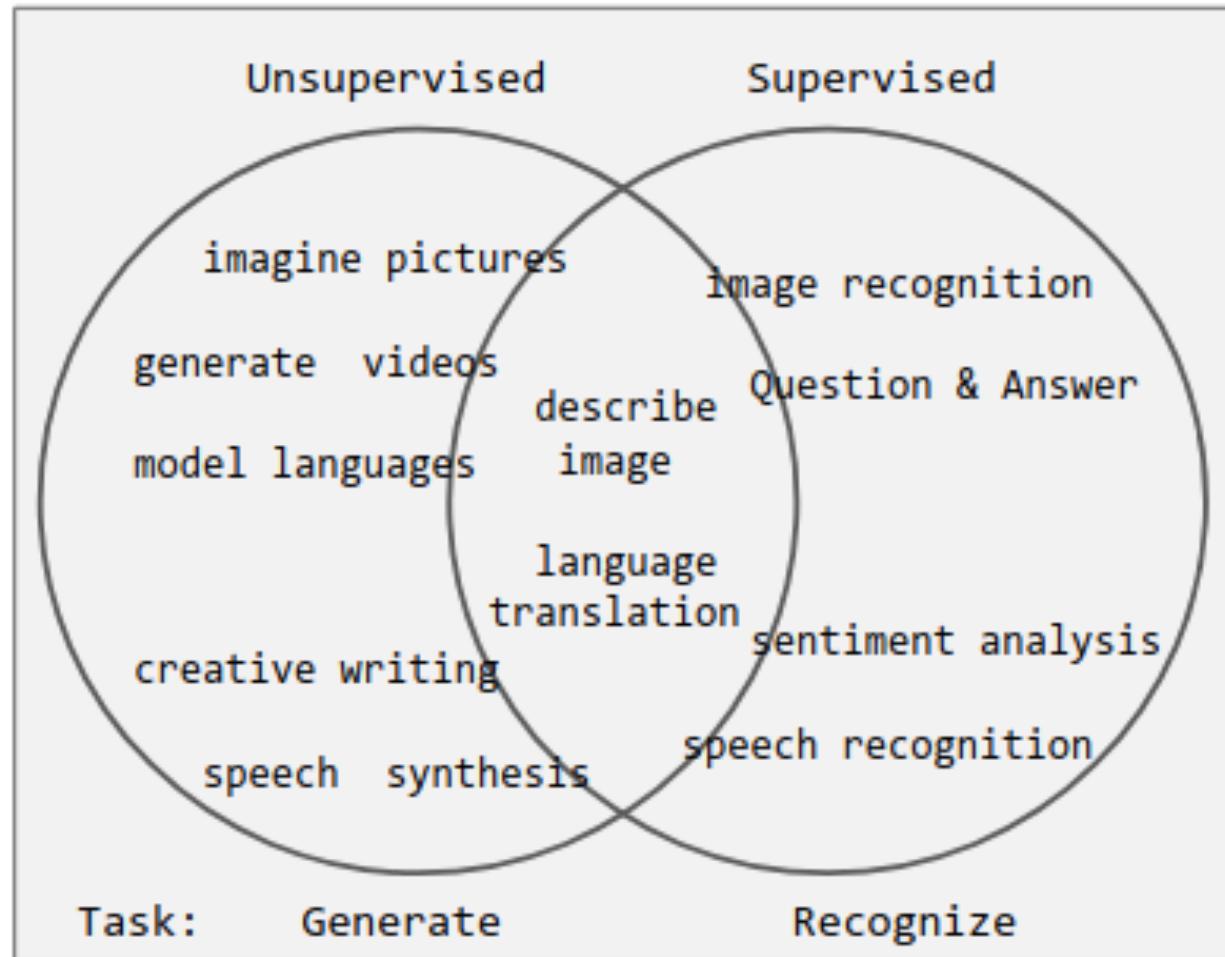
What is machine learning?



Unsupervised learning is a type of algorithm that learns patterns from **untagged data**.



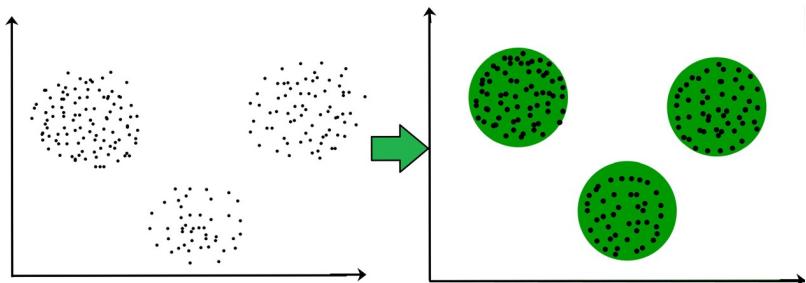
What is machine learning?



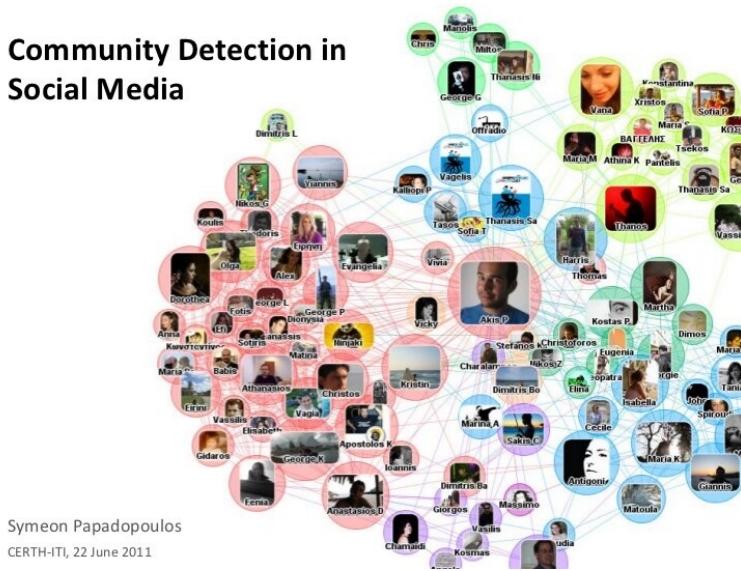
What is machine learning?



Clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense) to each other than to those in other groups (clusters)



Community Detection in Social Media

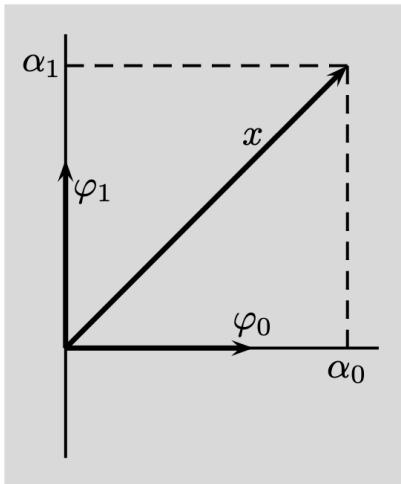


Symeon Papadopoulos
CERTH-ITI, 22 June 2011

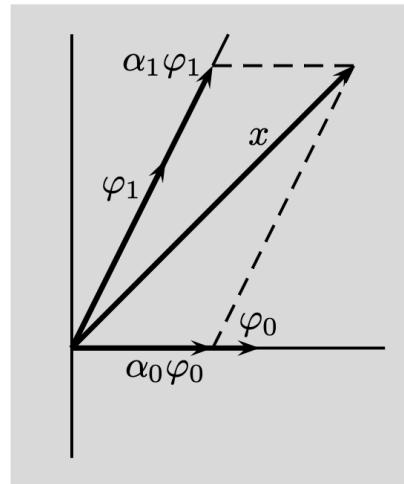
What is machine learning?



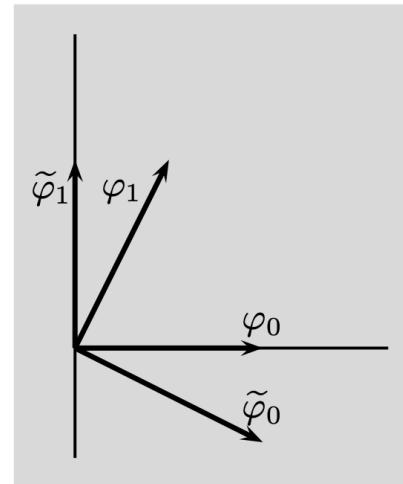
Dimension reduction is the transformation of data from a high-dimensional space into a low-dimensional space so that the low-dimensional representation retains some meaningful properties of the original data



(a) Expansion with an orthonormal basis.



(b) Expansion with a nonorthogonal basis.

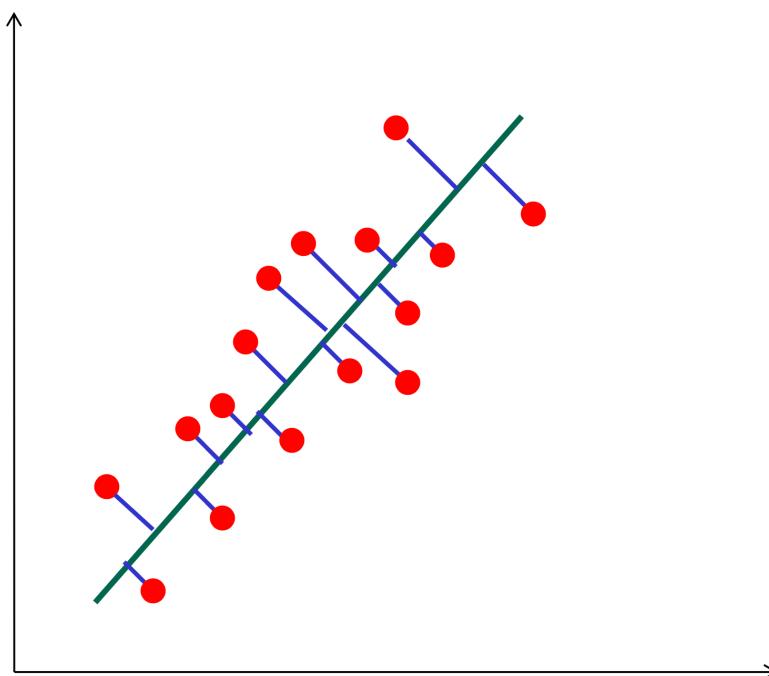


(c) Basis $\{\varphi_0, \varphi_1\}$ and its dual $\{\tilde{\varphi}_0, \tilde{\varphi}_1\}$.

What is machine learning?



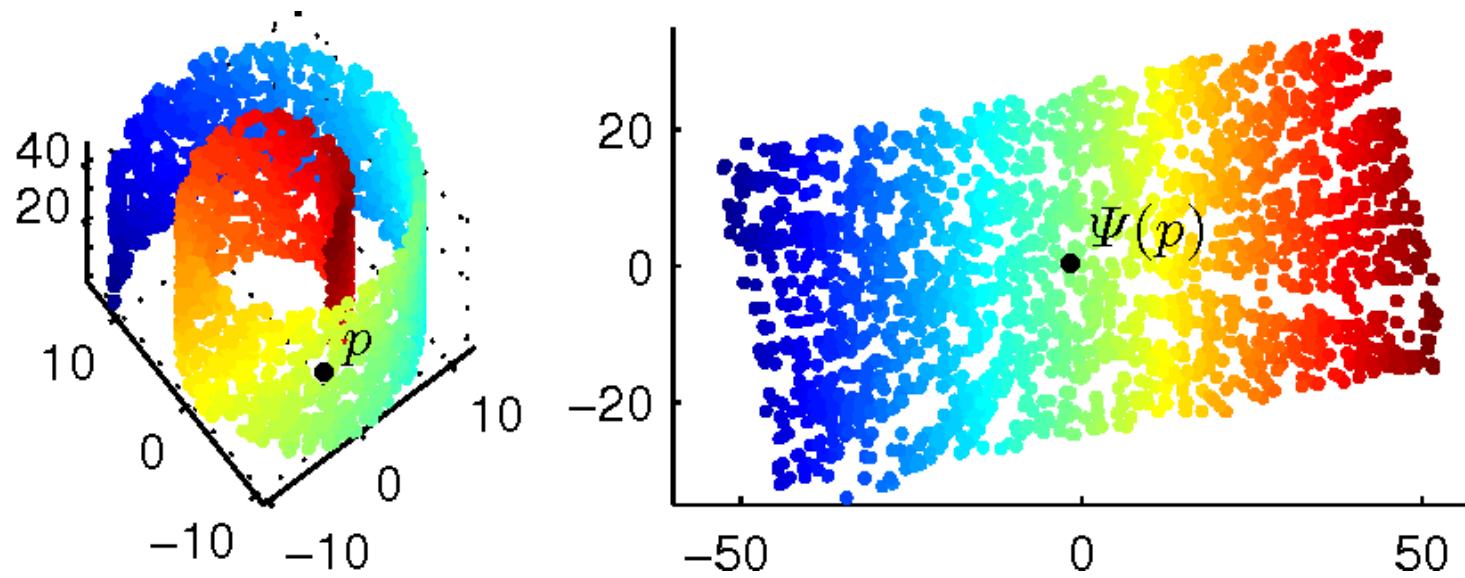
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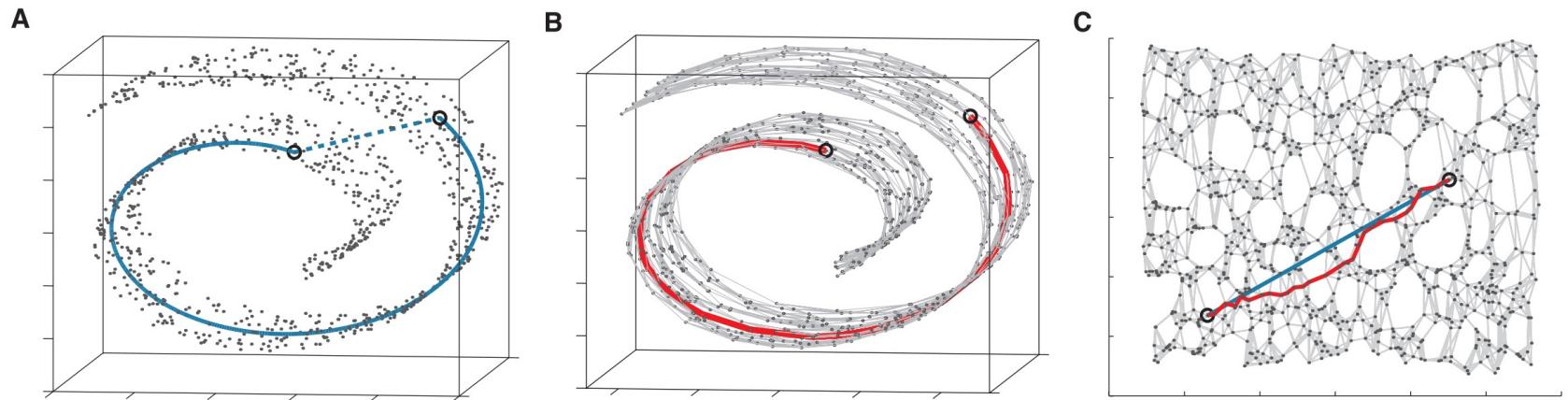
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What is machine learning?



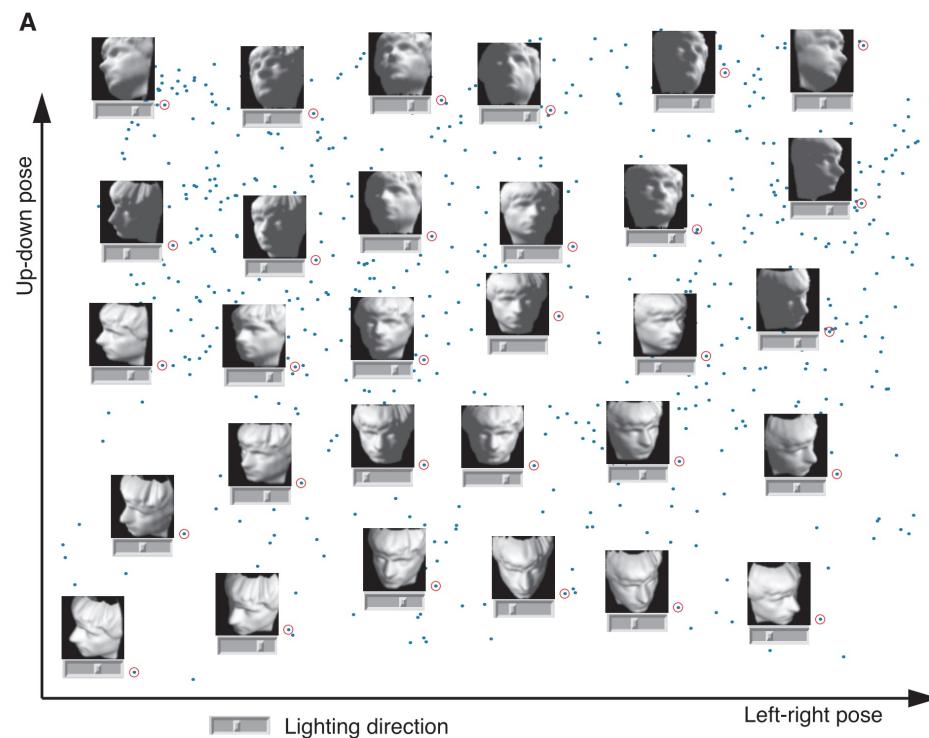
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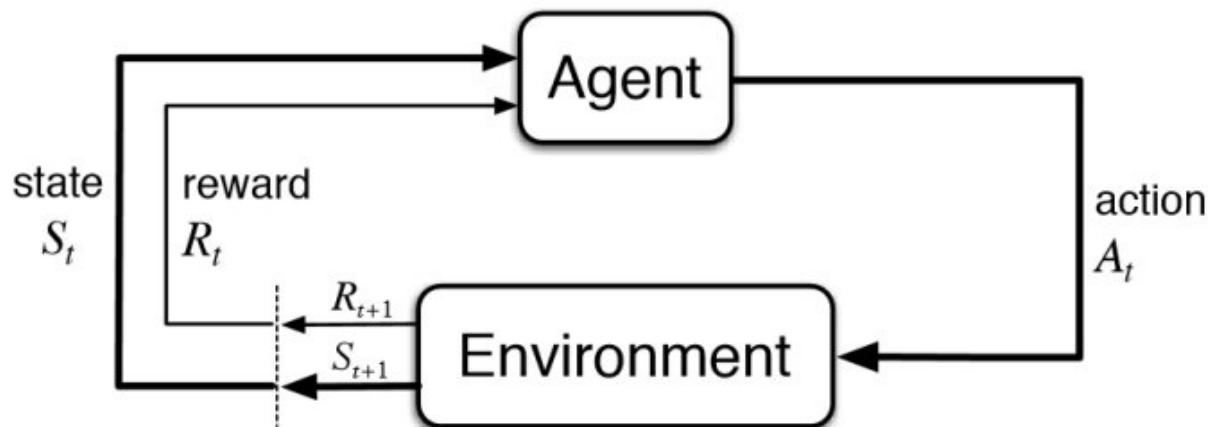
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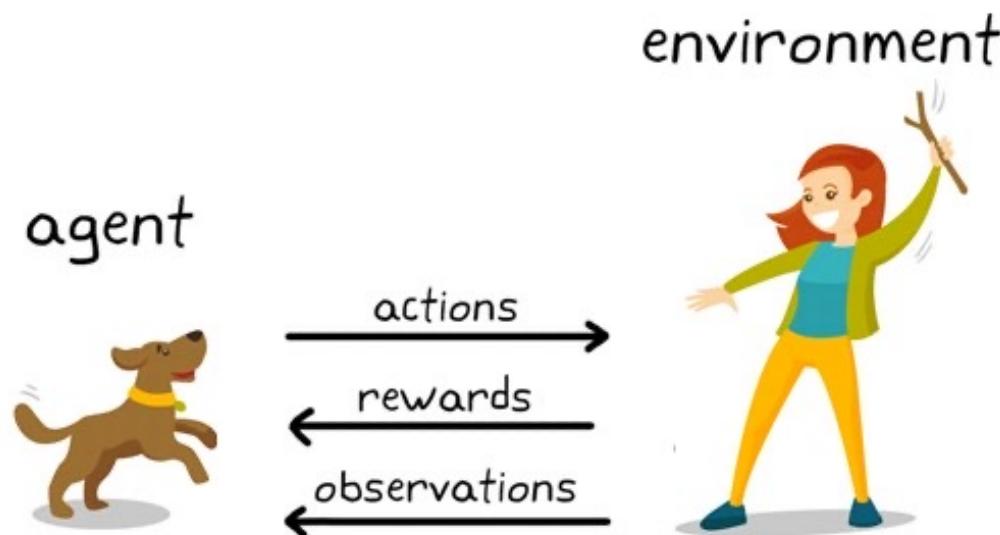
Reinforcement learning is an area of machine learning concerned with how intelligent agents ought to take actions in an environment in order to maximize the notion of **cumulative reward**.



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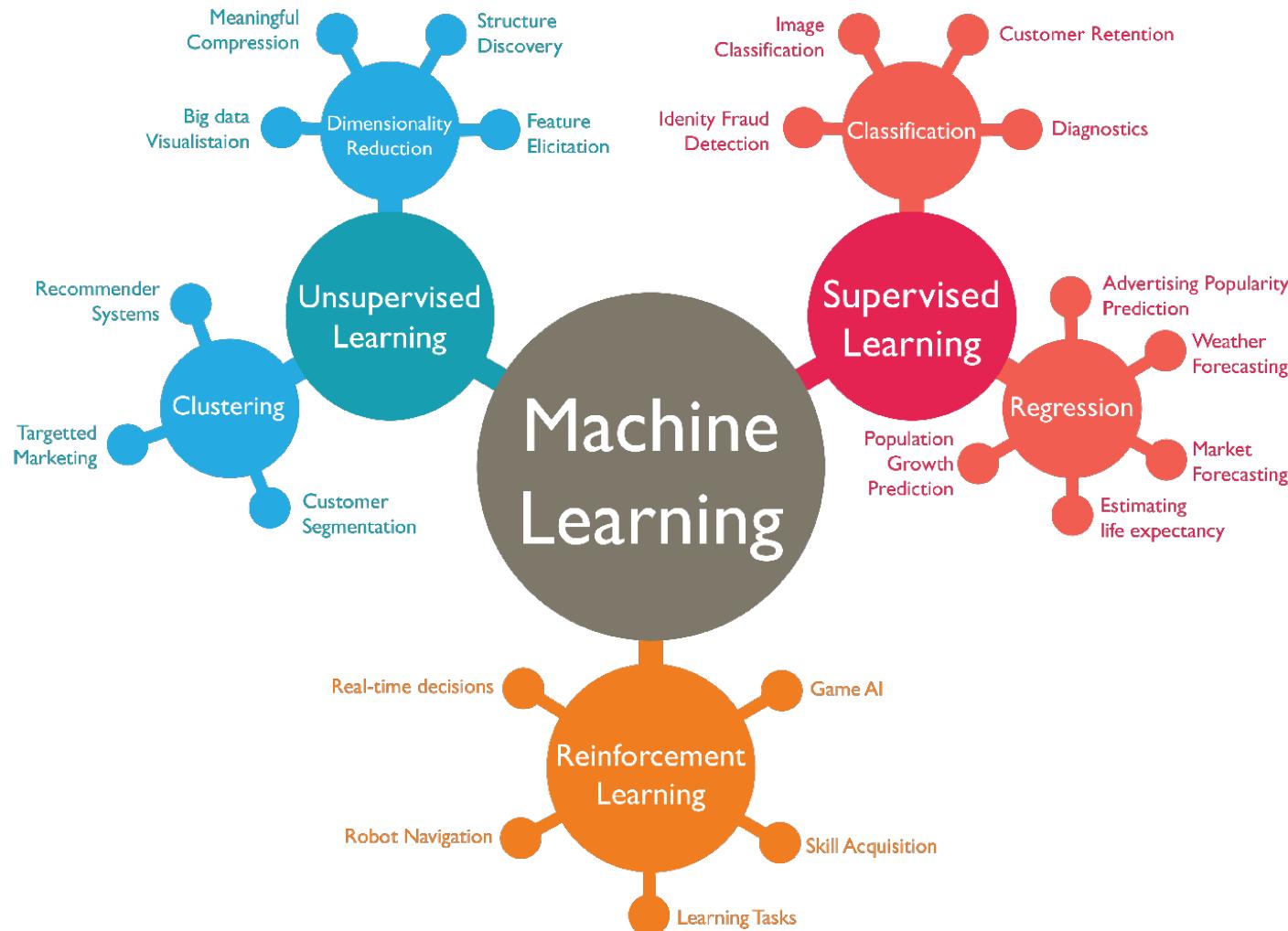


What is machine learning?



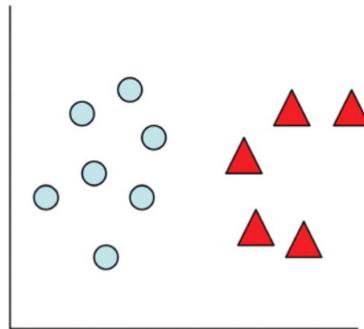
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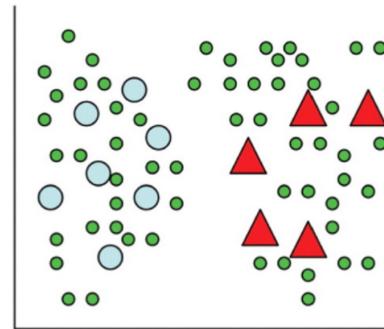


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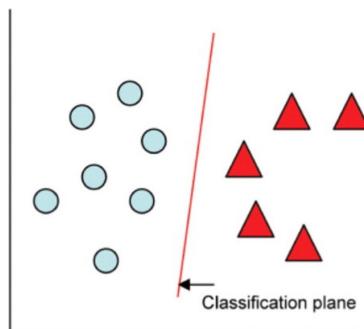
Semi-supervised learning.



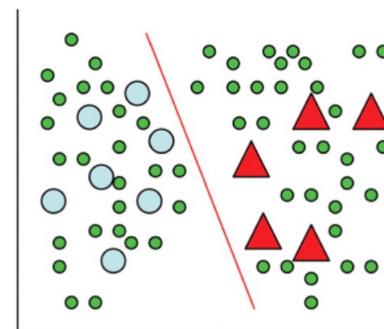
Labeled Data
(a)



Labeled and Unlabeled Data
(b)



Supervised Learning
(c)



Semi-Supervised Learning
(d)

What is machine learning?

Weakly-supervised learning.

Image-level class labels: ~27 sec [11]



Instance spotting: + 14 sec [11]



Instance Segmentation: + 80 sec [11]



Dense pixel-level annotations: 1.5h [4]



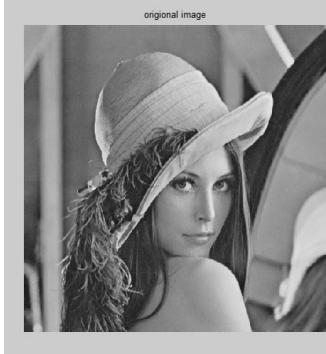
Machine learning

What is machine learning?

Connections to computer vision

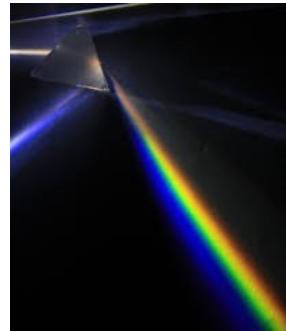
A tour of K-NN classifier

Connections to computer vision



Low-level vision

Edit an image



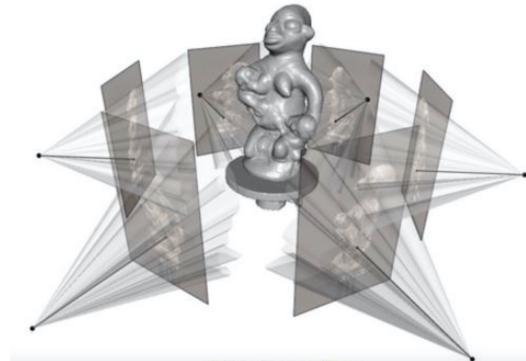
Physics-based vision

Understand physics that governs how an image was formed



Learning-based vision

Understand an image



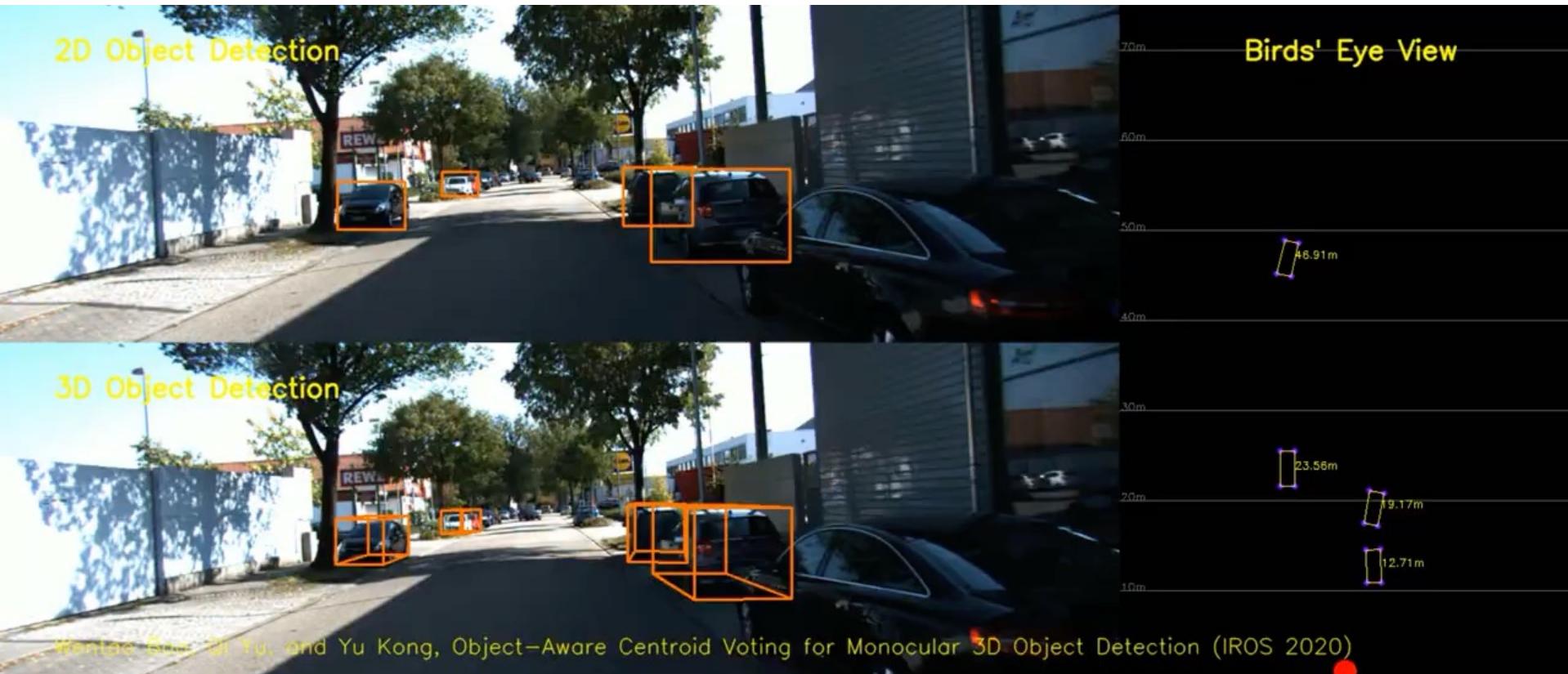
Geometry-based vision

3D reconstruction and calibration

Connections to computer vision

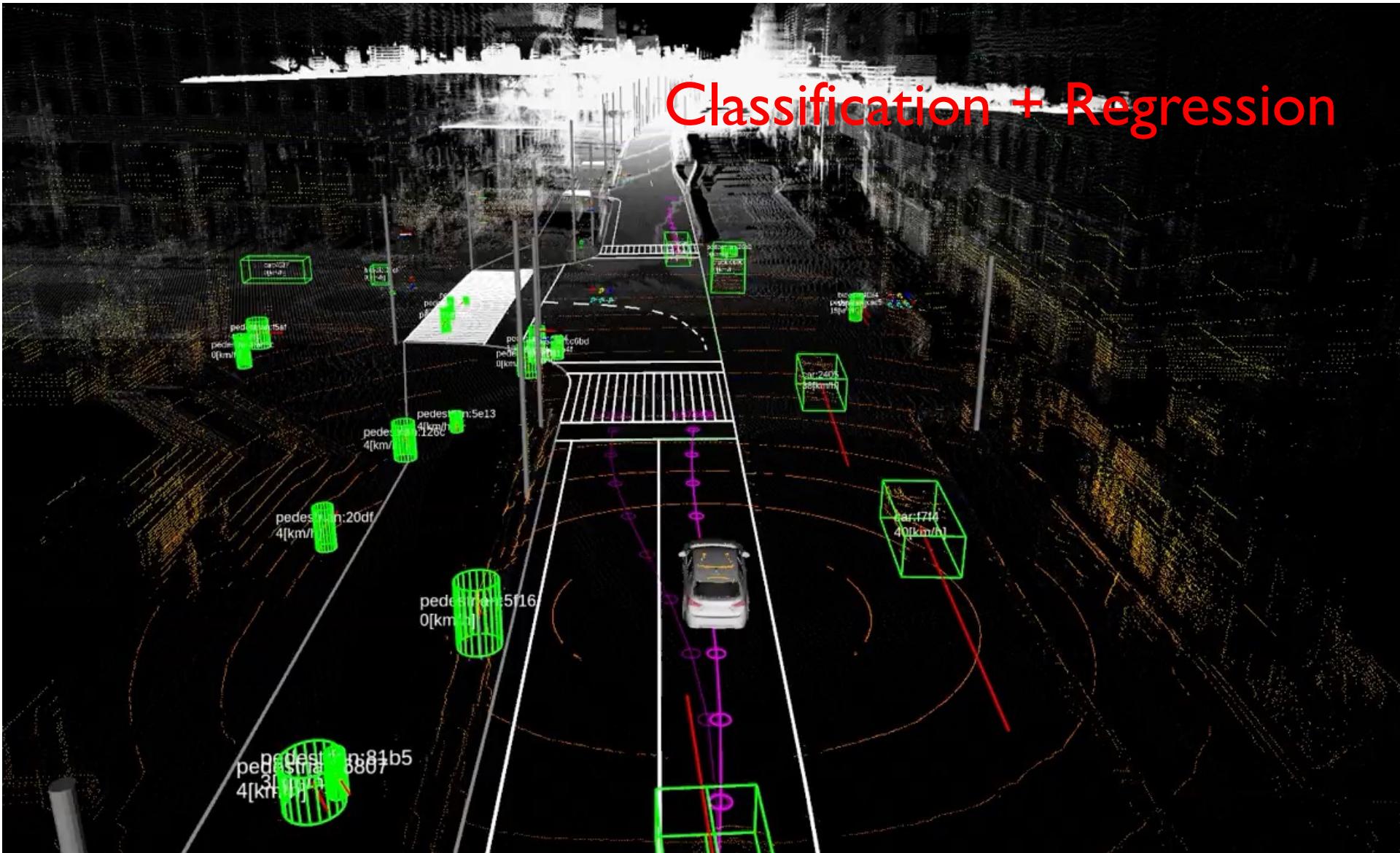
Object detection

Classification + Regression



Connections to computer vision

Classification + Regression



Connections to computer vision

Object tracking



Connections to computer vision

Image segmentation

Classification

ICNet for Real-Time Semantic Segmentation on High-Resolution Images

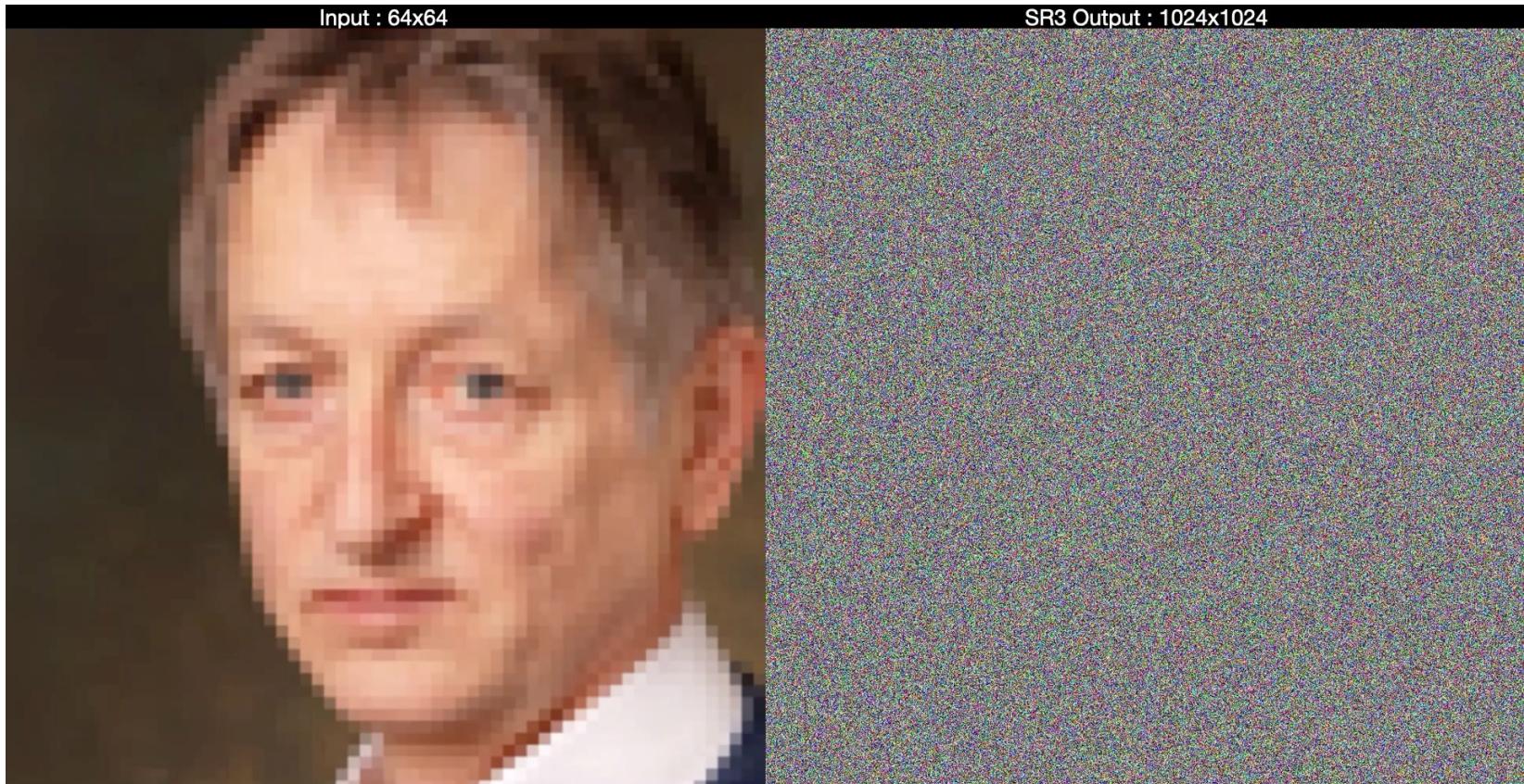
Hengshuang Zhao¹ Xiaojuan Qi¹ Xiaoyong Shen¹ Jianping Shi² Jiaya Jia¹

¹The Chinese University of Hong Kong ²SenseTime Group Limited

*Each frame in the video is processed independently at the rate of 30 fps on a 1024*2048 resolution image.*

Connections to computer vision

Image super-resolution

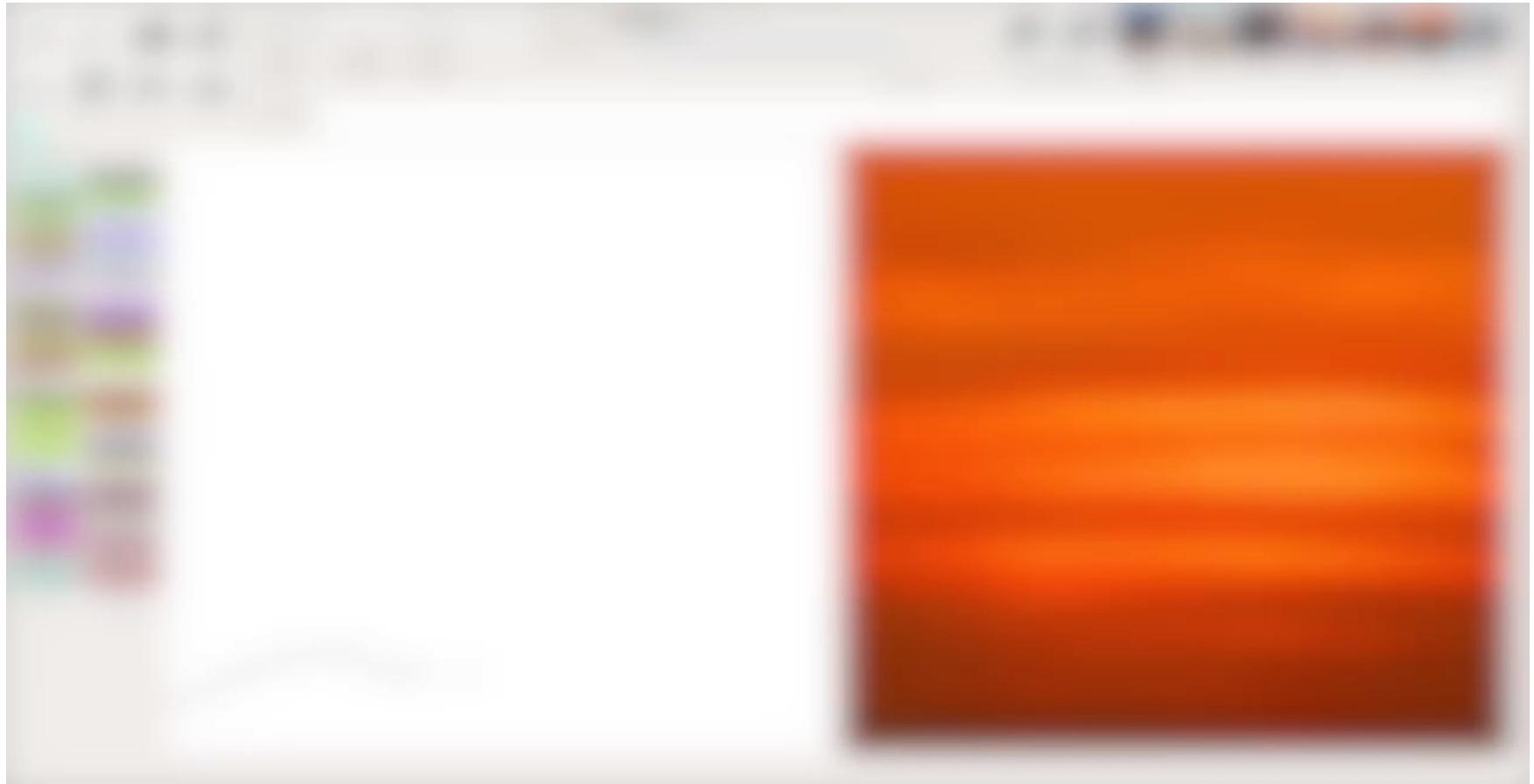


regression

Connections to computer vision

Image generation

regression



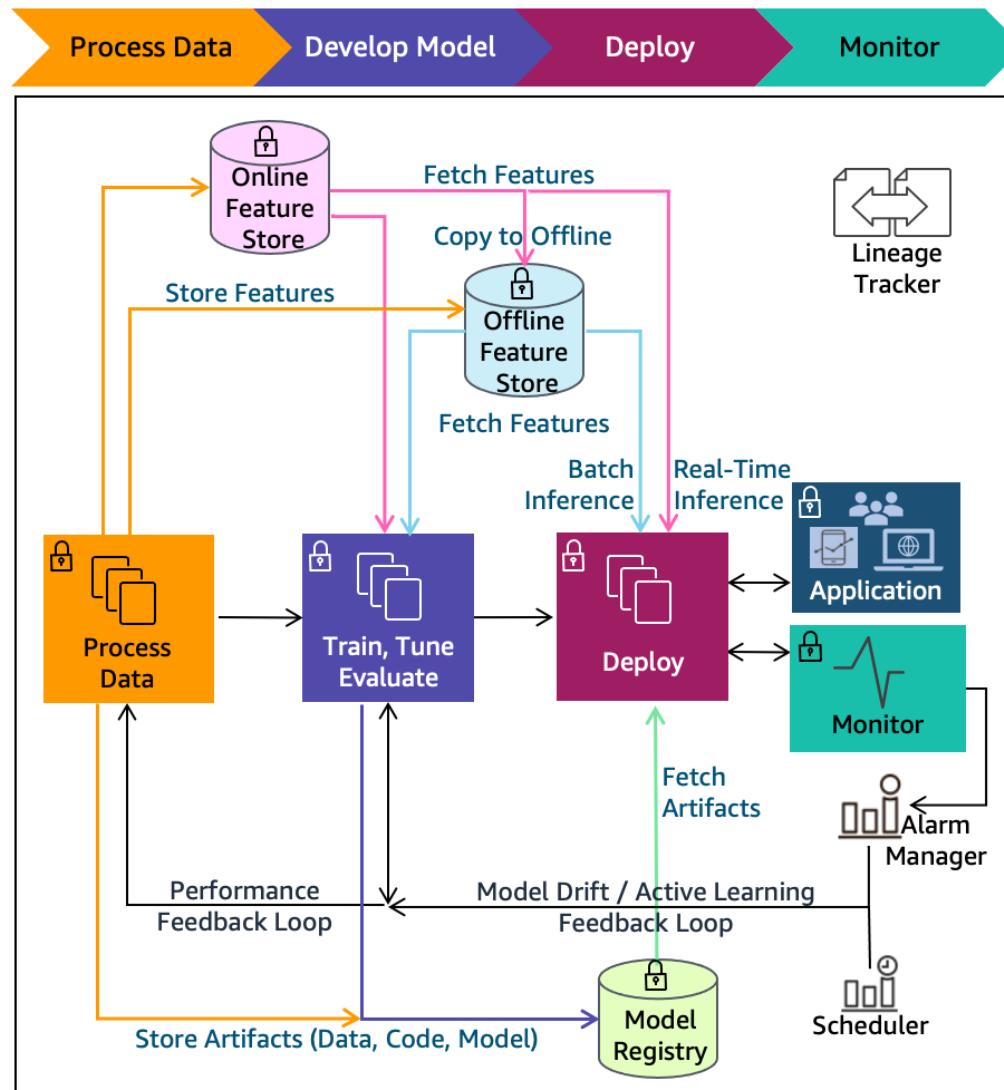
Machine learning

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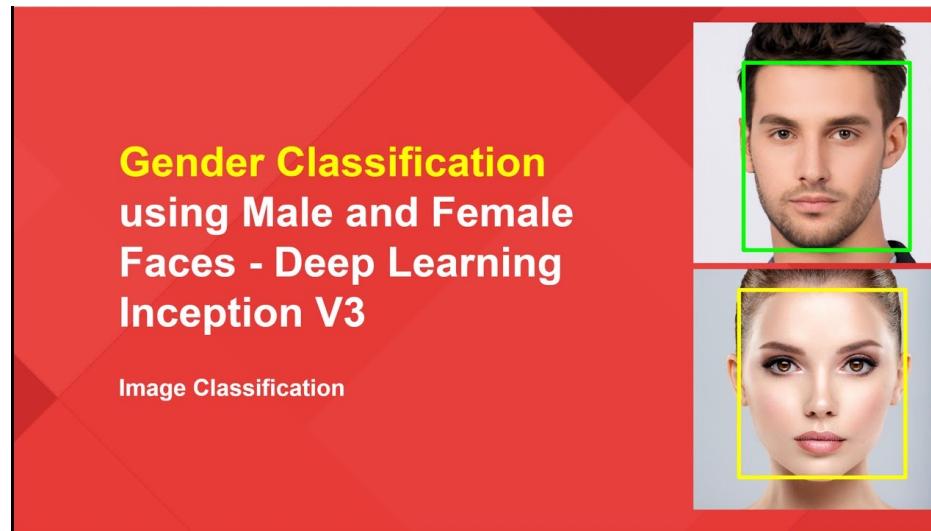
Connections to computer vision

A tour of K-NN classifier

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A tour of K-NN classifier



Feature
extraction



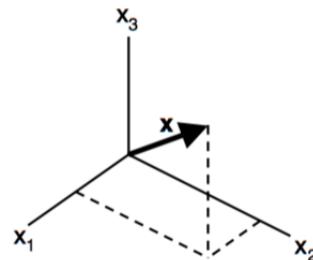
Handcrafted feature

- Facial landmarks
- Color
- ...

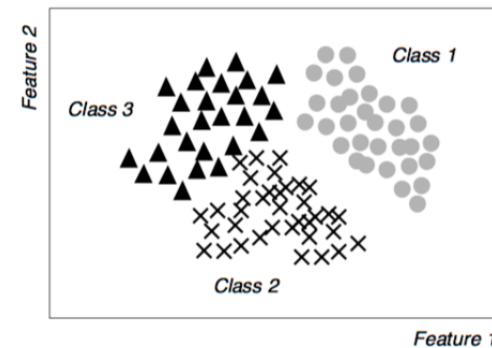
High-level feature

- PCA
- Dictionary learning
- ...

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_d \end{bmatrix}$$



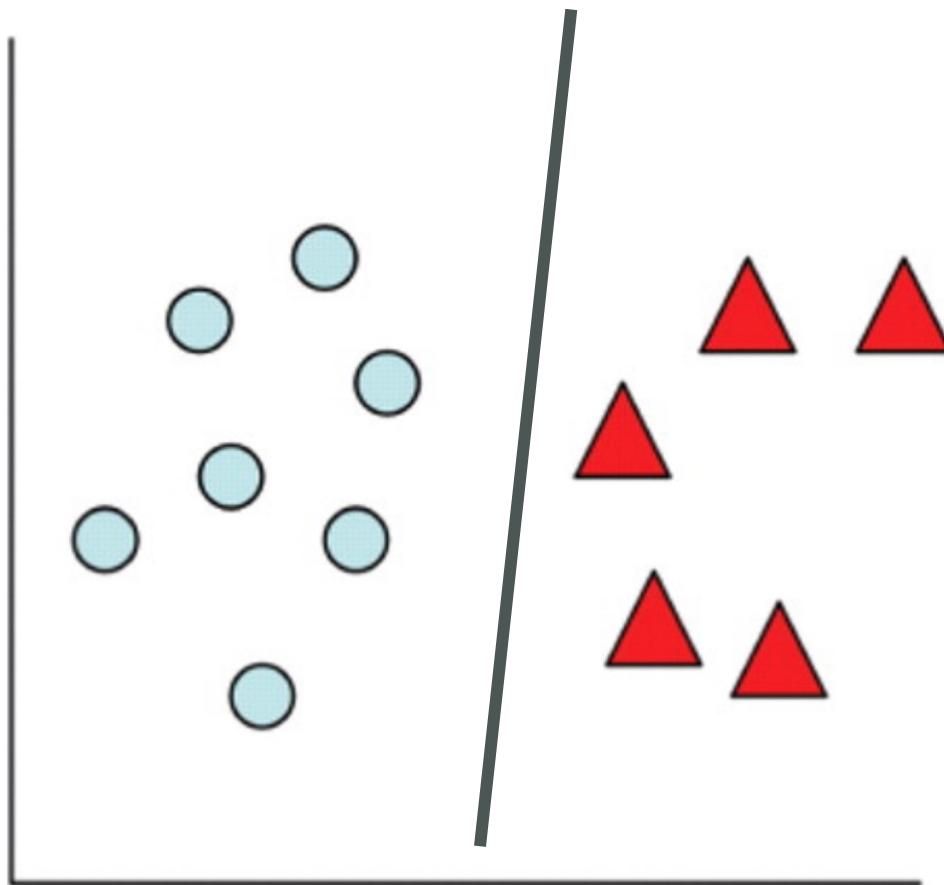
Feature vector



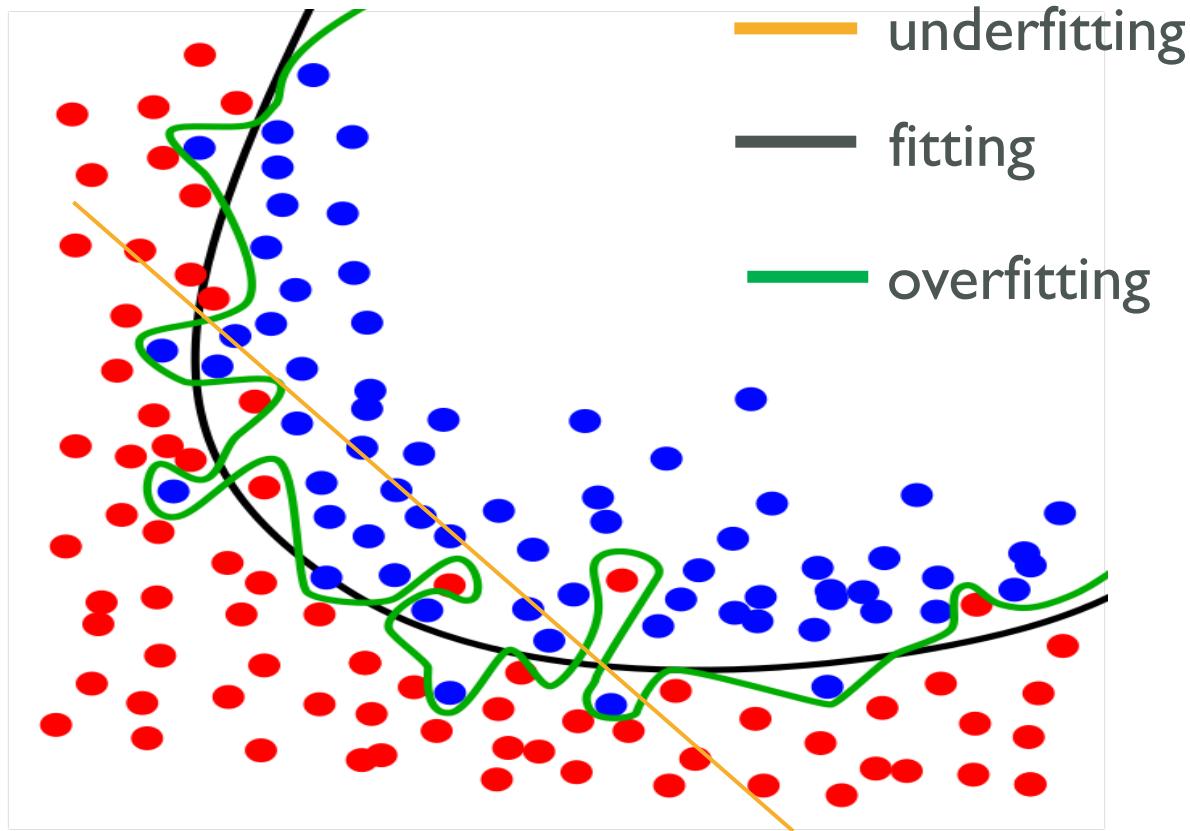
Feature space (3D)

Scatter plot (2D)

A tour of K-NN classifier

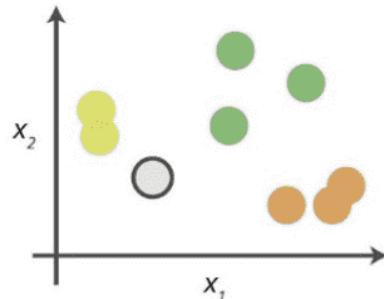


A tour of K-NN classifier



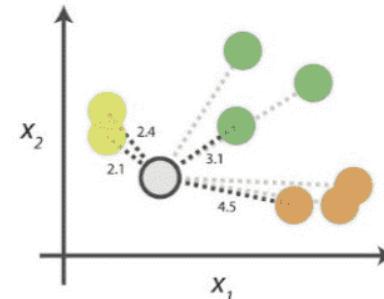
A tour of K-NN classifier

0. Look at the data



Say you want to classify the grey point into a class. Here, there are three potential classes - lime green, green and orange.

1. Calculate distances



Start by calculating the distances between the grey point and all other points.

2. Find neighbours

Point Distance		
...	lime green	2.1
...	lime green	2.4
...	green	3.1
...	orange	4.5

→ 1st NN
→ 2nd NN
→ 3rd NN
→ 4th NN

Next, find the nearest neighbours by ranking points by increasing distance. The nearest neighbours (NNs) of the grey point are the ones closest in dataspace.

3. Vote on labels

Class	# of votes
lime green	2
green	1
orange	1

→ Class lime green wins the vote!
→ Point grey is therefore predicted to be of class lime green.

Vote on the predicted class labels based on the classes of the k nearest neighbours. Here, the labels were predicted based on the k=3 nearest neighbours.

A tour of K-NN classifier

Step-1: Select the number K of the neighbors

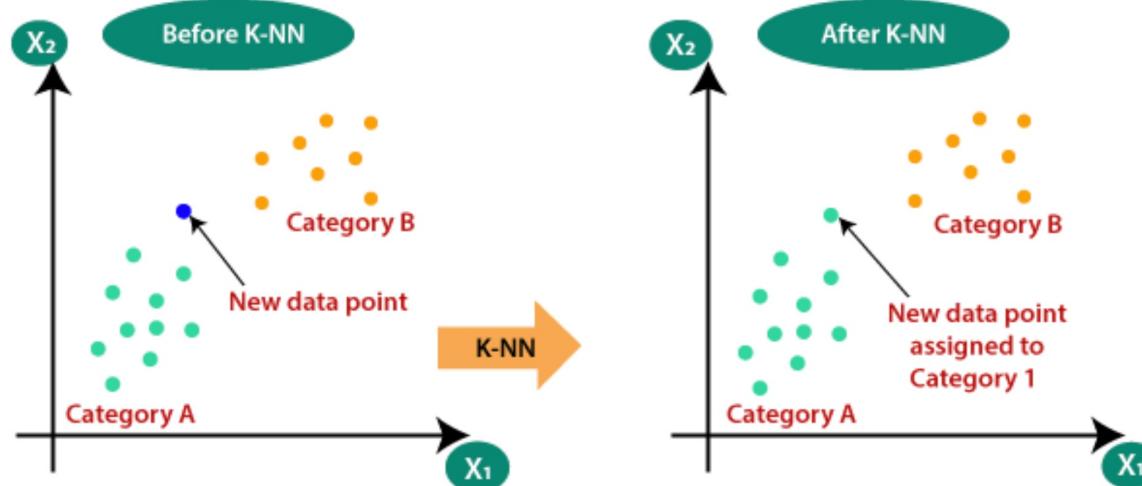
Step-2: Calculate the Euclidean distance of K number of neighbors

Step-3: Take the K nearest neighbors as per the calculated Euclidean distance.

Step-4: Among these k neighbors, count the number of the data points in each category.

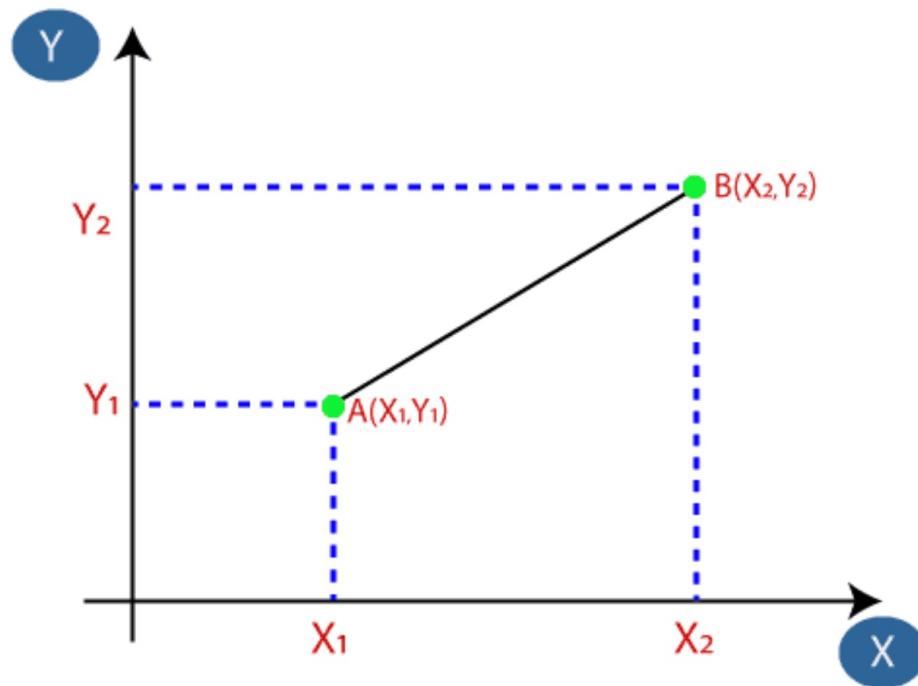
Step-5: Assign the new data points to that category for which the number of the neighbor is maximum.

Step-6: Our model is ready.



A tour of K-NN classifier

Distance metric



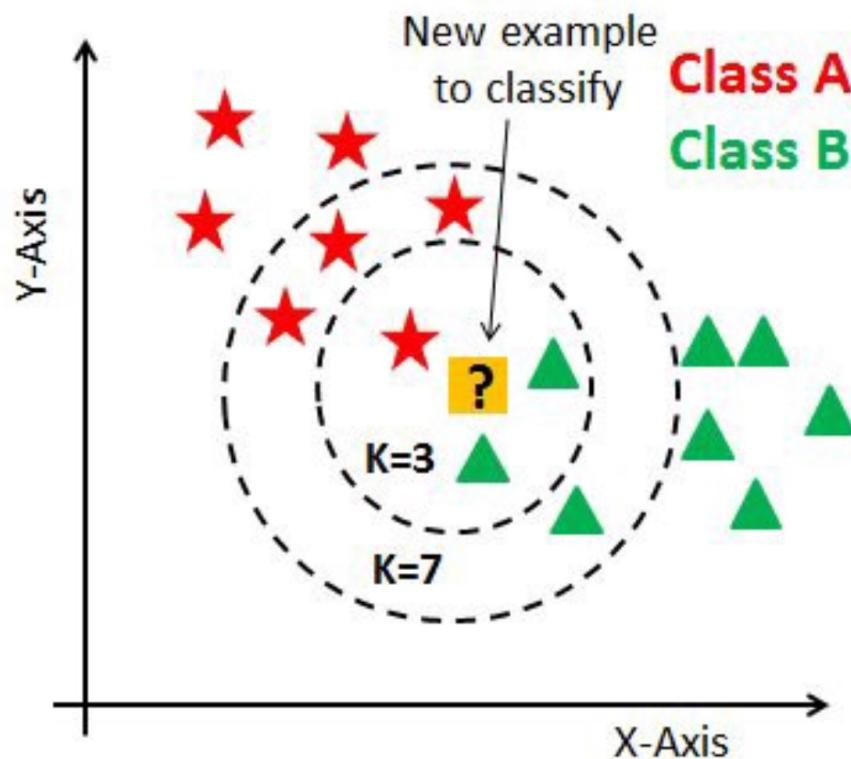
Euclidean

$$\sqrt{\sum_{i=1}^k (x_i - y_i)^2}$$

Manhattan

$$\sum_{i=1}^k |x_i - y_i|$$

A tour of K-NN classifier



A tour of K-NN classifier

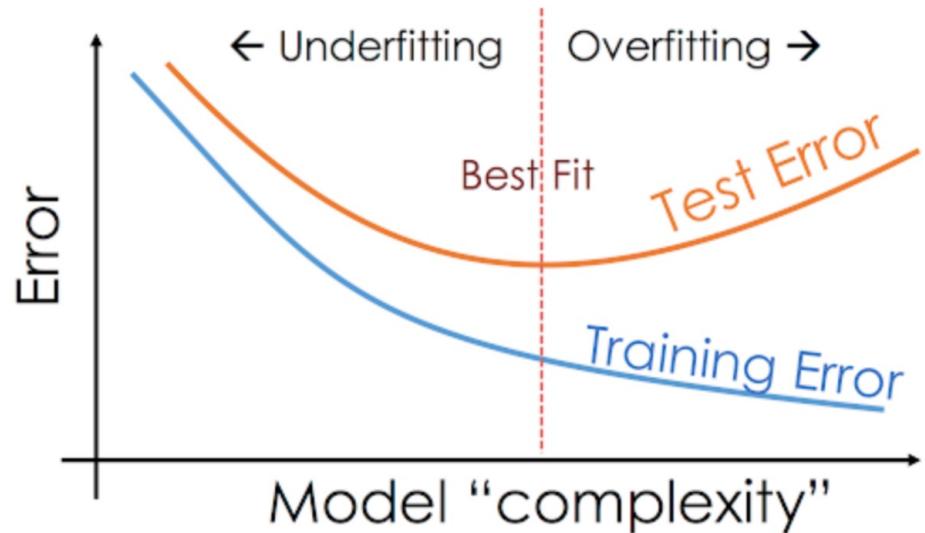
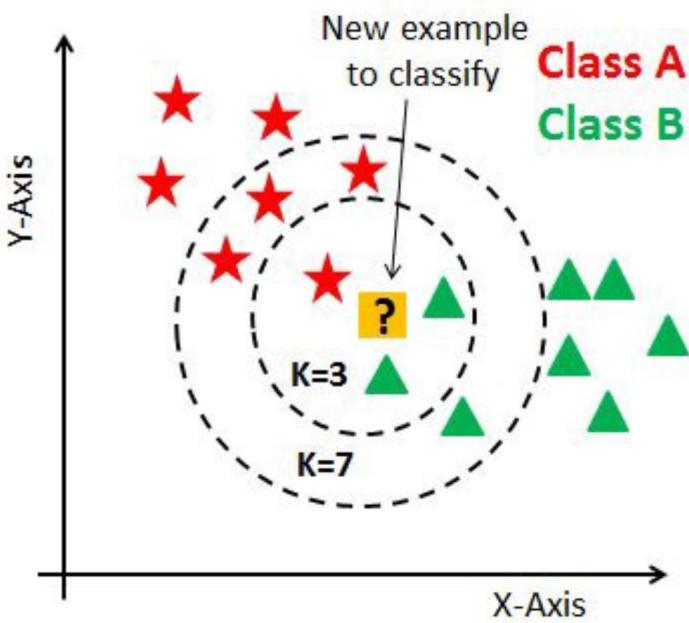
Evaluation metric

Error rate $E(f; D) = \frac{1}{m} \sum_{i=1}^m \mathbf{I}(f(x_i) \neq y_i)$

Accuracy $E(f; D) = \frac{1}{m} \sum_{i=1}^m \mathbf{I}(f(x_i) = y_i) = 1 - E(f; D)$

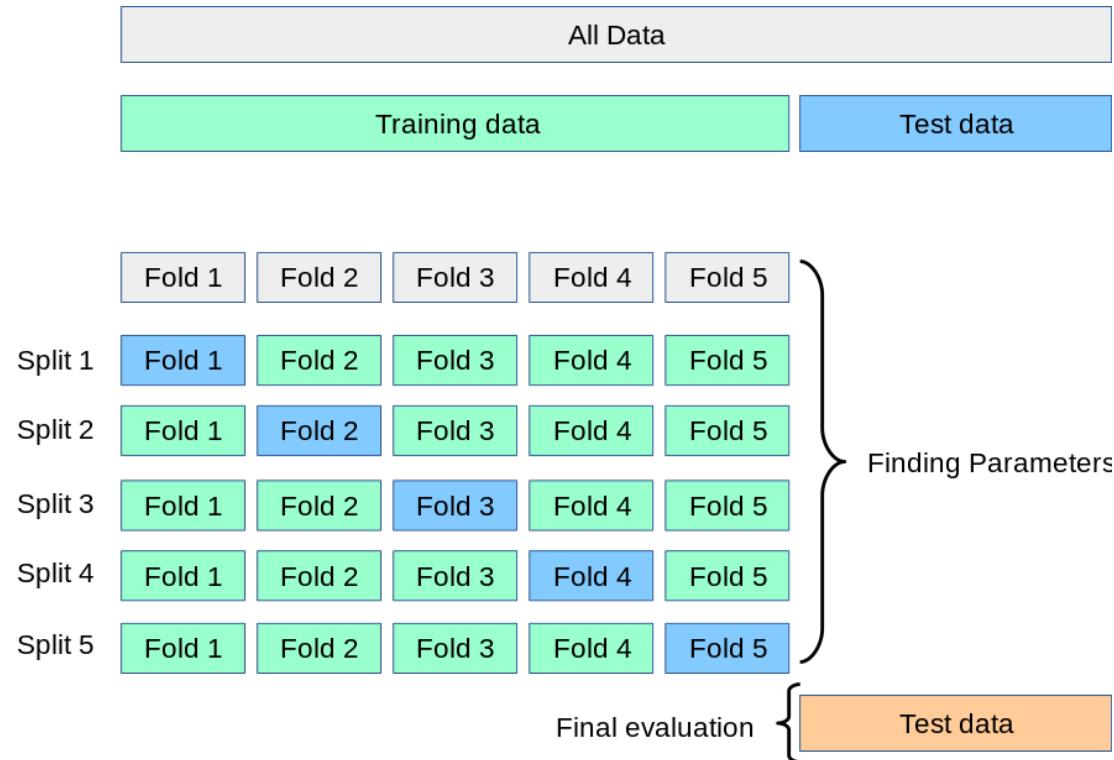
A tour of K-NN classifier

How to choose hyperparameter K?



A tour of K-NN classifier

Model selection: Cross-validation



A tour of K-NN classifier

Implementation

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split( X, y,
test_size=0.2, random_state=4)

from sklearn.neighbors import KNeighborsClassifier
from sklearn import metrics
#Train Model and Predict
k = 4
neigh = KNeighborsClassifier(n_neighbors = k).fit(X_train,y_train)
Pred_y = neigh.predict(X_test)
print("Accuracy of model at K=4 is",metrics.accuracy_score(y_test,
Pred_y))
```

A tour of K-NN classifier

Implementation

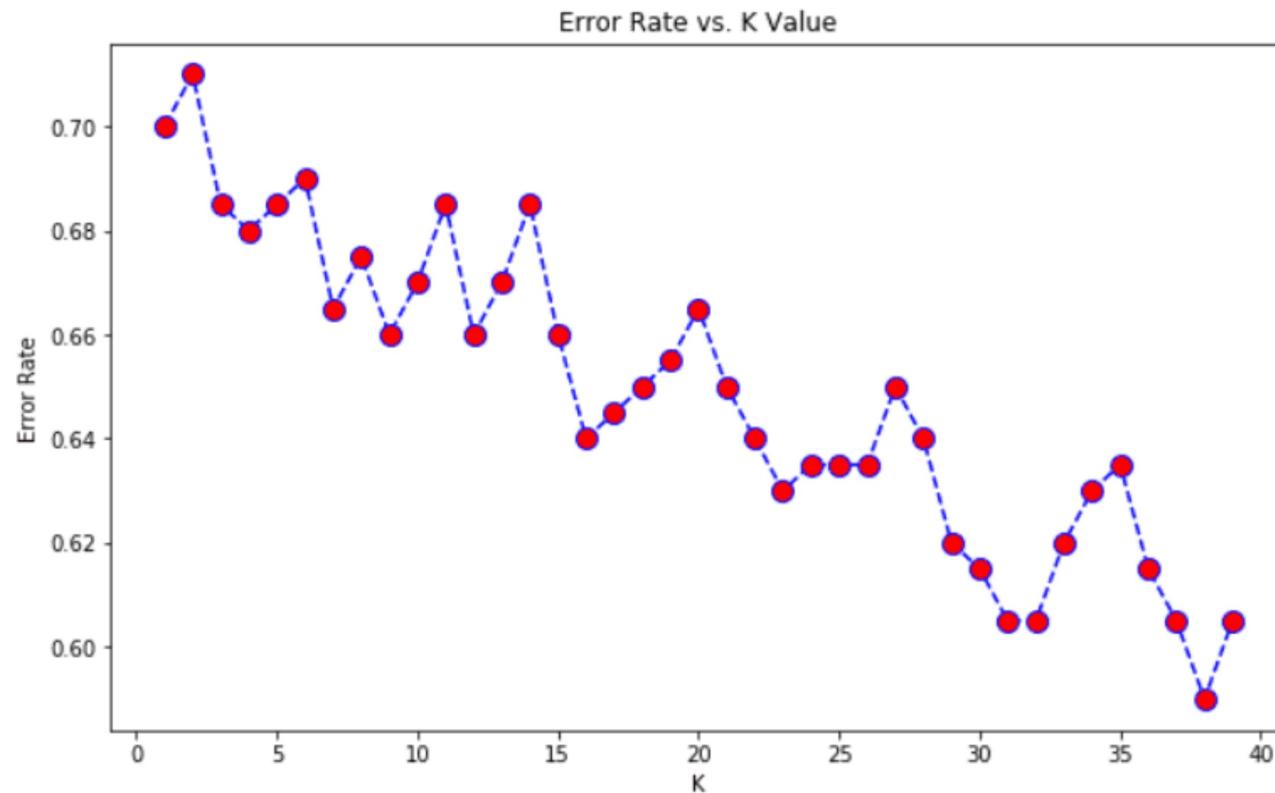
```
error_rate = []
for i in range(1,40):
    knn = KNeighborsClassifier(n_neighbors=i)
    knn.fit(X_train,y_train)
    pred_i = knn.predict(X_test)
    error_rate.append(np.mean(pred_i != y_test))

plt.figure(figsize=(10,6))
plt.plot(range(1,40),error_rate,color='blue', linestyle='dashed',
          marker='o',markerfacecolor='red', markersize=10)
plt.title('Error Rate vs. K Value')
plt.xlabel('K')
plt.ylabel('Error Rate')
print("Minimum error:-",min(error_rate),"at K
      =",error_rate.index(min(error_rate)))
```

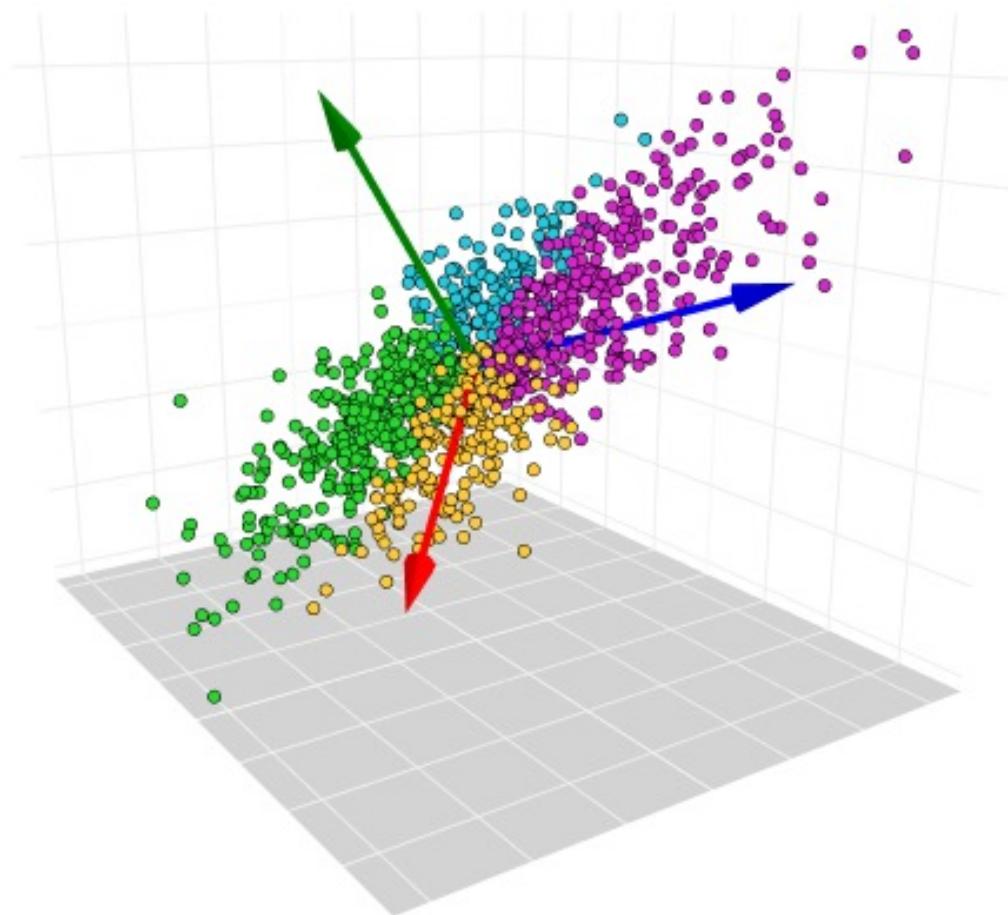
A tour of K-NN classifier

Implementation

Minimum error:- 0.59 at K = 37



Next lecture: PCA



Thank you very much!

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