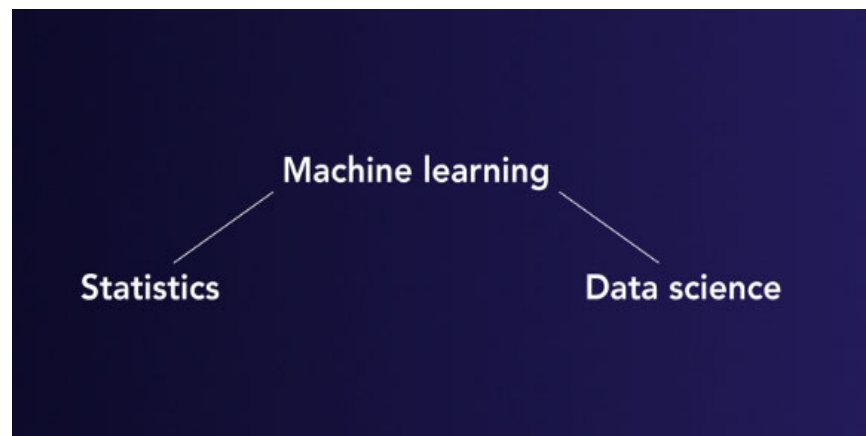
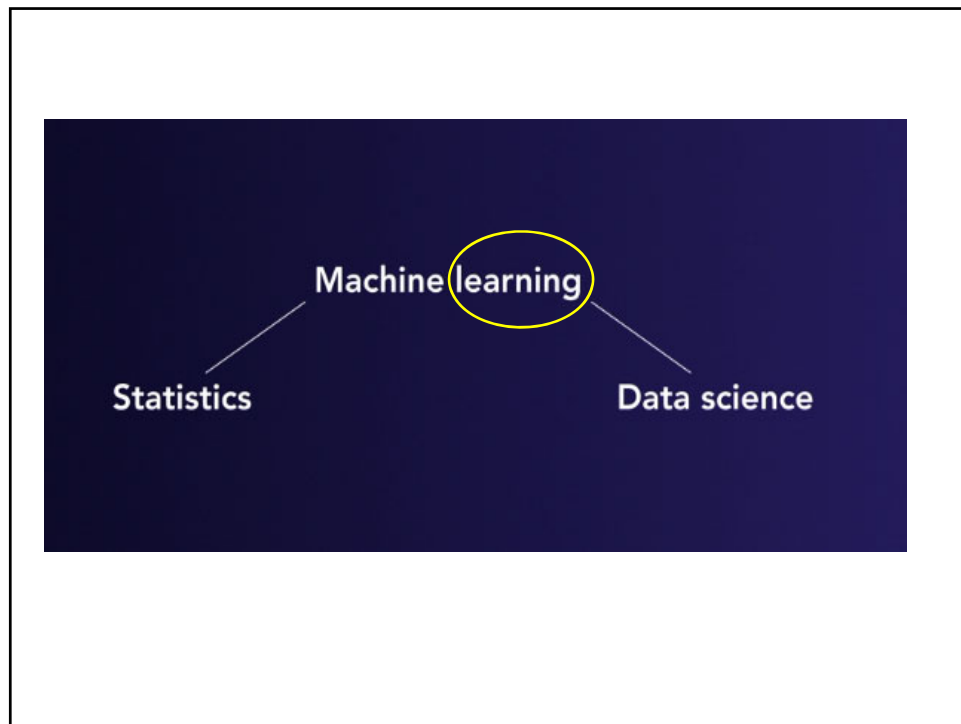


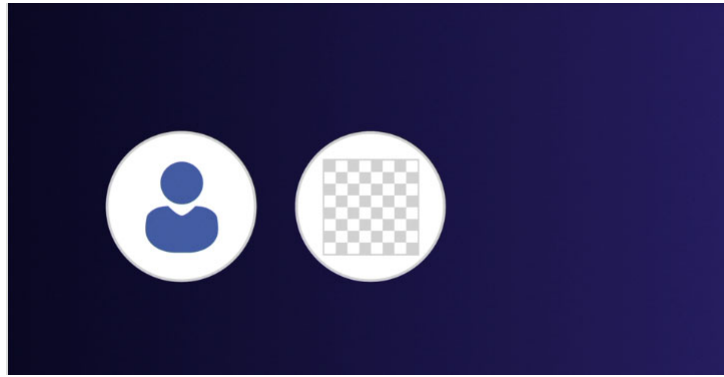
# Machine Learning Overview





How do humans learn?

How can you learn to play chess?

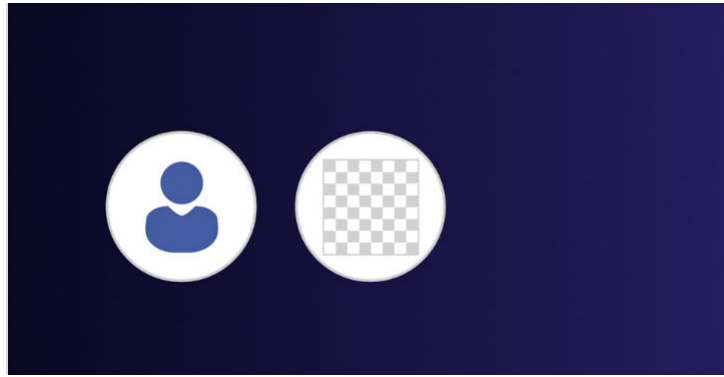


How can you learn to play chess?

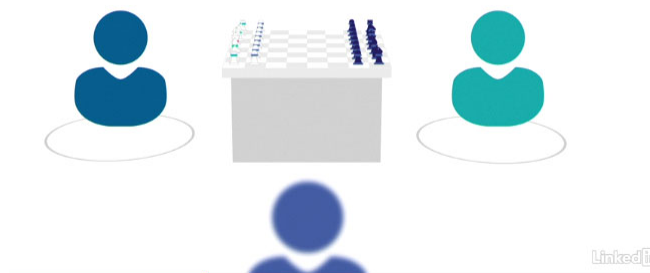


Hire a chess tutor – who will supervise your learning

Suppose you don't have a tutor or  
chess book?



Go to the park and observe games

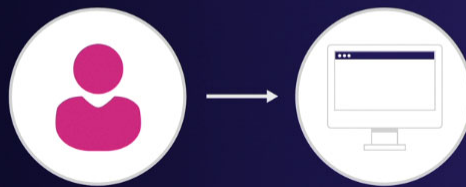


## Maybe try a combination

- Use a tutor for game basics
- Observe games and refine your skills

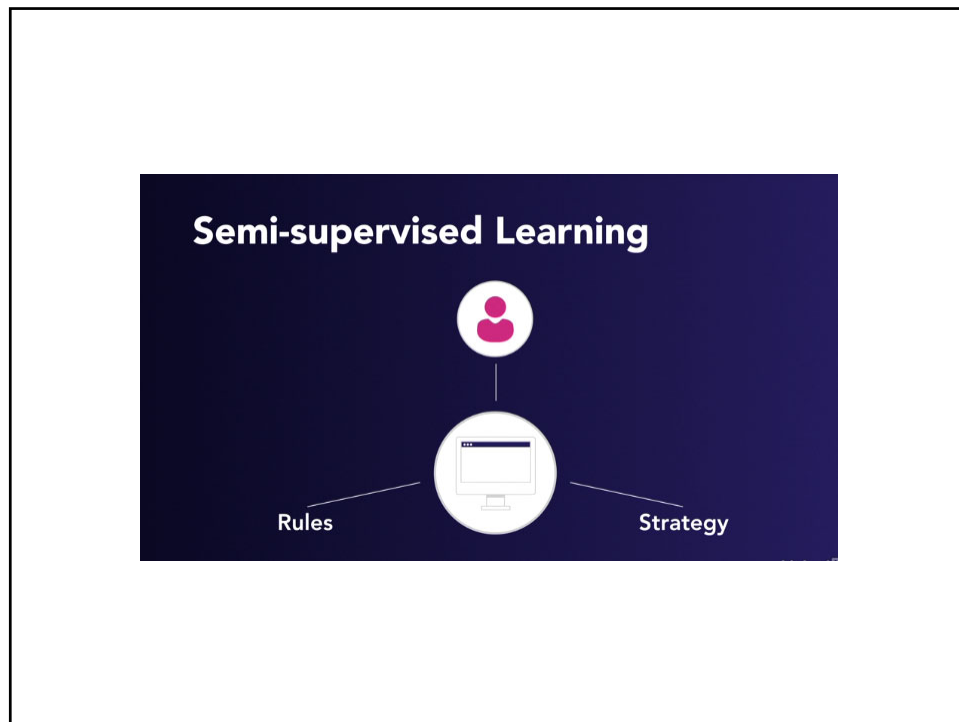
How does human learning relate to  
Machine Learning?

## Supervised Learning



## Unsupervised Learning





Which approach is best?

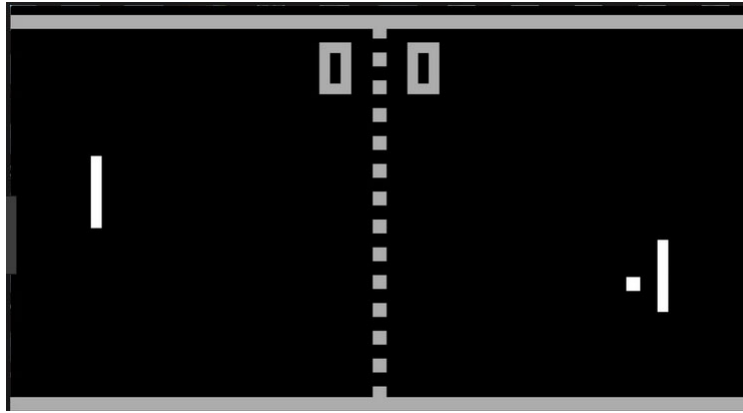
## ....It depends

- Do you have a good tutor?
  - supervised works
- Do you have lots of observations but no tutor?
  - unsupervised
- Do you have both?
  - semi-supervised
- Downsides?
  - bad tutor
  - poor observations

## Reinforcement Learning



## PONG



Give rewards – when paddle hits ball = +  
- when opponent misses = +

## Space Invaders

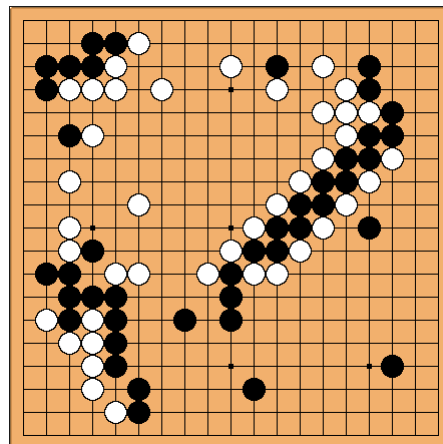


More complex game...

## Q-Learning

- States
- Actions
- Q = Quality of outcome
- What actions lead to better states – get a higher Q value
- **Unsupervised learning** based on playing numerous games

## GO

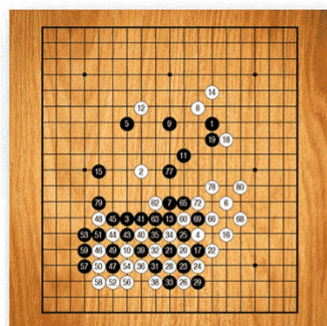


## Alpha Go

- AlphaGo's first formal match was against the reigning 3-times European Champion, Mr Fan Hui, in October 2015.
- Unsupervised Learning – studied thousands of Go Games

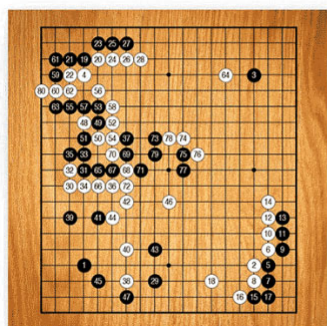
## Alpha Go Zero

- 5 months later
- Alpha Go Zero outplays Alpha GO
- Uses Q-Learning



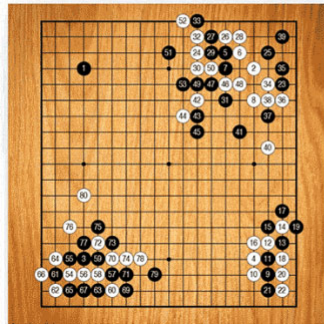
### 3 hours

AlphaGo Zero plays like a human beginner, forgoing long term strategy to focus on greedily capturing as many stones as possible.



### 19 hours

AlphaGo Zero has learnt the fundamentals of more advanced Go strategies such as life-and-death, influence and territory.



### 70 hours

AlphaGo Zero plays at super-human level.  
The game is disciplined and involves  
multiple challenges across the board.



## Reinforcement Learning

- See: <https://skymind.ai/wiki/deep-reinforcement-learning>

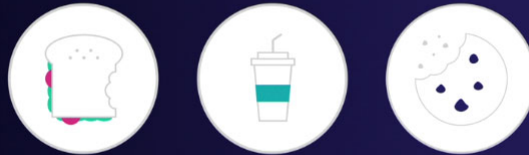
## Categories of Supervised Learning

- Binary
- Multiclass
- Regression

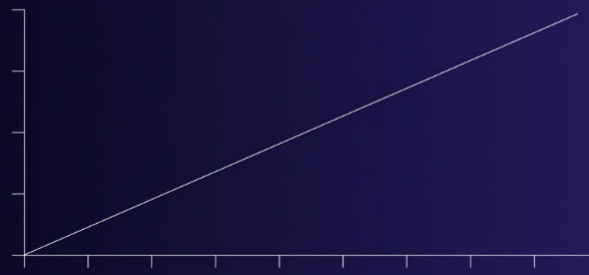
## Binary Classification



## Multiclass Classification



## Linear Regression



## Approaches to Machine Learning

- Decision Trees
- k-nearest neighbor
- K-mean clustering
- Regression
  - we have looked at single variable and multiple variable regression

## Decision Trees

- Use for binary classification with supervised machine learning. Should Yash go to the beach?

### Predictors

- Sky
- Weekend
- Wind speed

### Outcome

- Yash goes to the beach

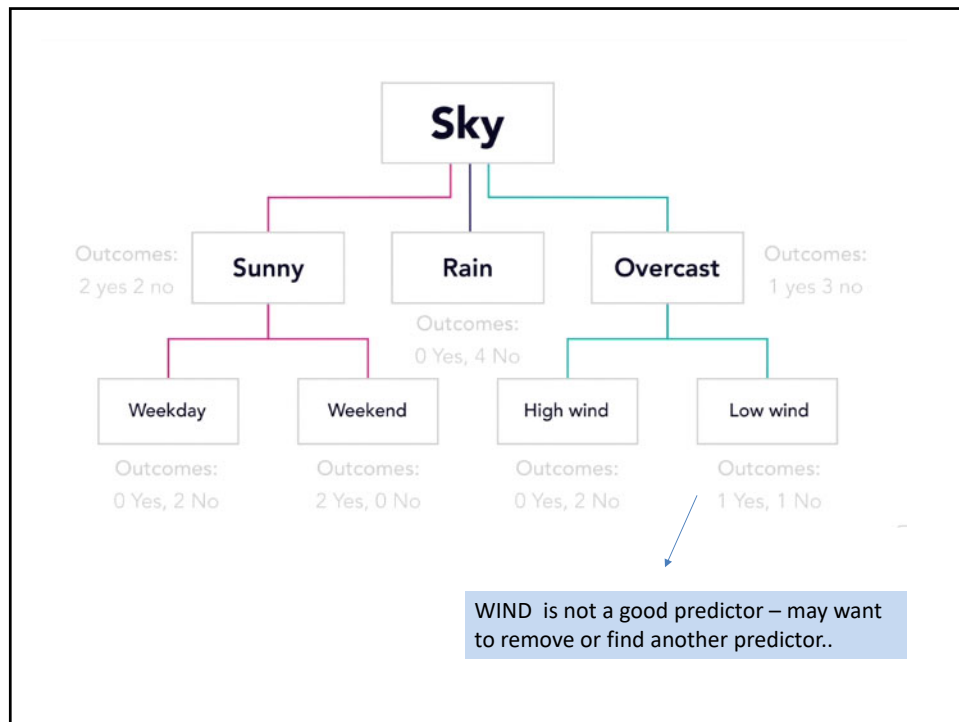


## Supervised Training Set

Predictors			Outcome
Sky	Weekend	Wind	Yash goes to the beach
Sunny	Weekday	Low	No
Sunny	Weekday	High	No
Overcast	Weekday	Low	Yes
Rain	Weekday	Low	Yes
Rain	Weekend	Low	Yes
Rain	Weekend	High	No
Overcast	Weekend	High	Yes
Sunny	Weekday	Low	No
Sunny	Weekend	Low	Yes
Rain	Weekend	Low	Yes
Sunny	Weekend	High	Yes
Overcast	Weekday	High	Yes
Overcast	Weekend	Low	Yes
Rain	Weekday	High	No



Use data to  
build decision  
tree



k-nearest neighbor

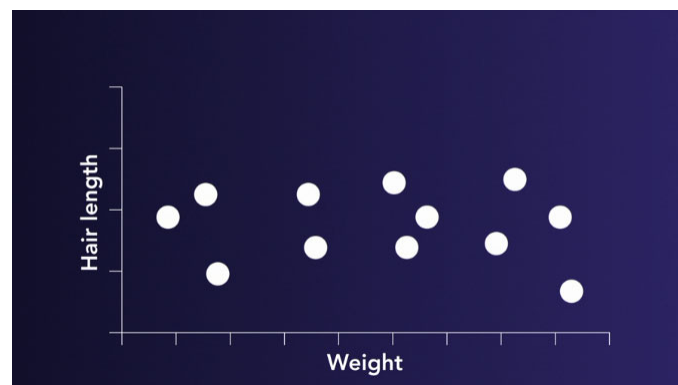
## k-nearest neighbor

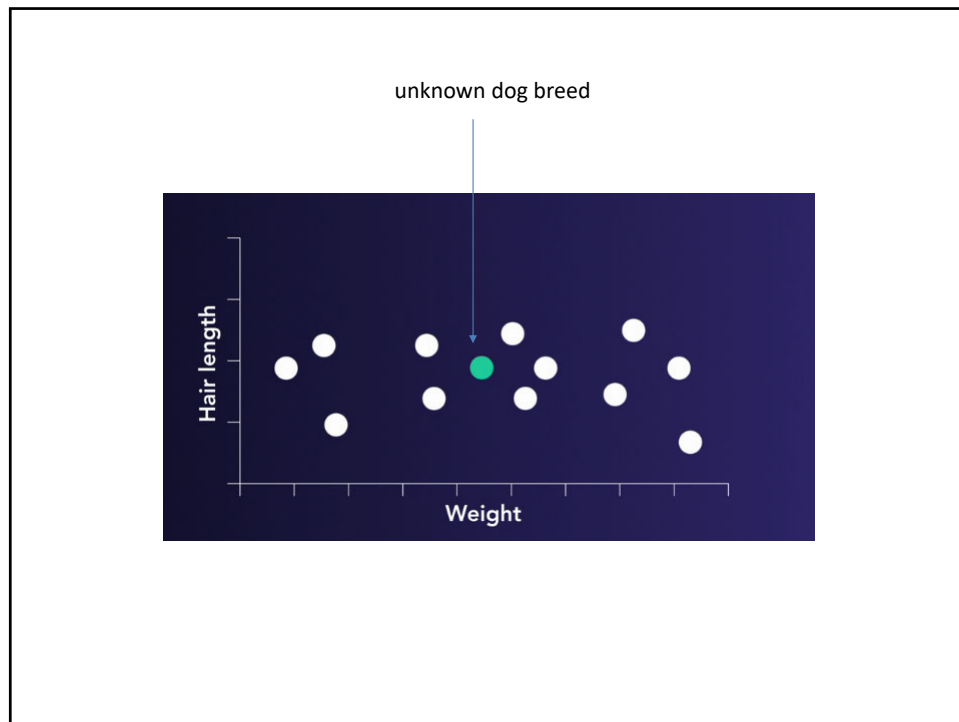
- KNN – one of simplest and most commonly used classifiers
- Does not actually train a model to predict
- An observation is predicted based on the class with the largest proportion of nearest neighbors
- If observation is surrounded by class Z, then we conclude our observation is class Z

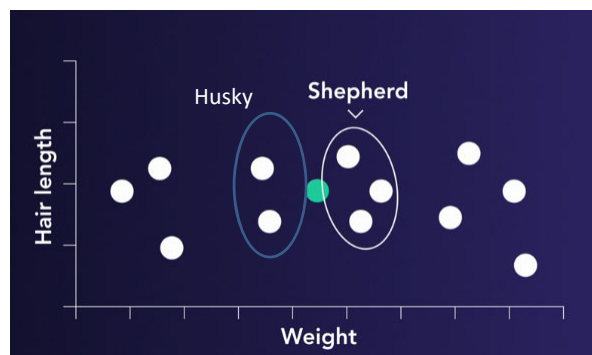
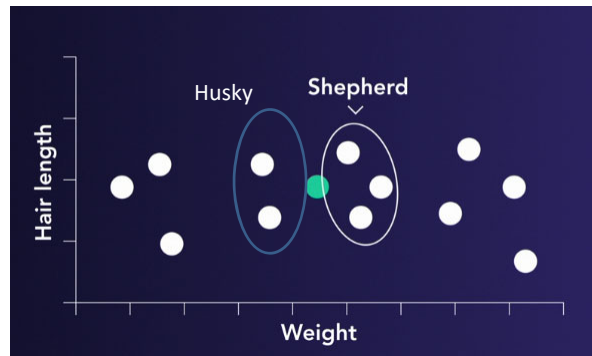
make predictions by classifying your data with what you already know

a form of supervised learning

We have dog data – we know breeds and measure hair length and weight







Conclude Shepherd

<https://medium.com/@adi.bronshtein/a-quick-introduction-to-k-nearest-neighbors-algorithm-62214cea29c7>

## Code – k-nearest neighbor

### Iris - dataset

The data set consists of 50 samples from each of three species of *Iris* ([\*Iris setosa\*](#), [\*Iris virginica\*](#) and [\*Iris versicolor\*](#)). Four [features](#) were measured from each sample: the length and the width of the [sepals](#) and [petals](#), in centimeters. Based on the combination of these four features, Fisher developed a linear discriminant model to distinguish the species from each other.



Ronald Fisher

## K-Nearest Neighbor

```
1 # Load libraries
2 from sklearn.neighbors import KNeighborsClassifier
3 from sklearn.preprocessing import StandardScaler
4 from sklearn import datasets
```

```
1 # Load data
2 iris = datasets.load_iris()
3 X = iris.data
4 y = iris.target
```

```
1 # create standardizer
2 standardizer = StandardScaler()
3
4 # standarize features
5 X_std = standardizer.fit_transform(X)
```

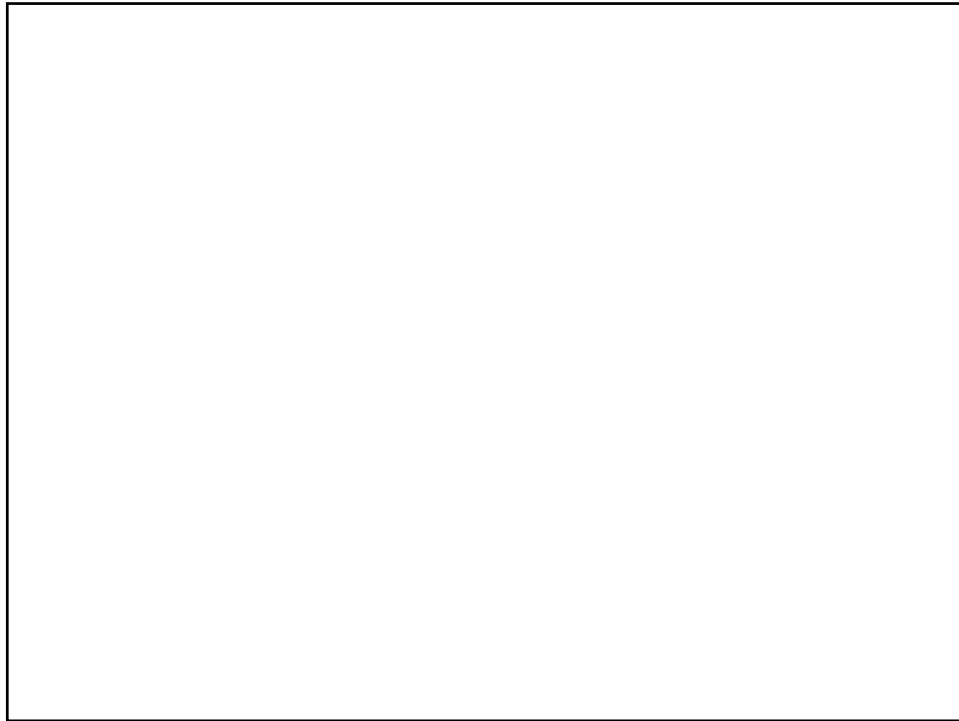
```
1 # train KNN classifier with 5 neighbors
2 knn = KNeighborsClassifier(n_neighbors=5, n_jobs=-1).fit(X_std,y)
```

```
1 # create two observations
2 new_observations = [[0.75, 0.75, 0.75, 0.75],
3                    [1, 1, 1, 1]]
4
5 # predict the class
6 knn.predict(new_observations)
7
```

array([1, 2])

```
1 # view probability of our observations is in one of three classes
2 knn.predict_proba(new_observations)
```

array([[0. , 0.6, 0.4],
 [0. , 0. , 1. ]])



k-Means Clustering



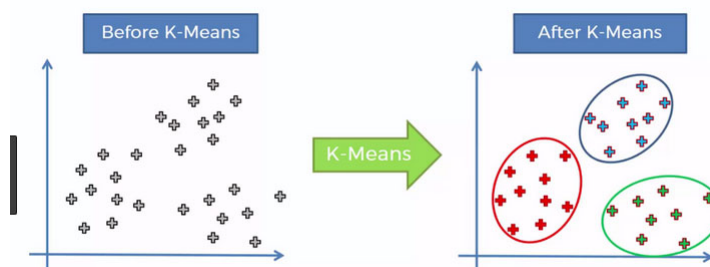
# k-Means Clustering

k-Means Clustering  $\neq$  k-NN

k-means clustering is an unsupervised machine learning algorithm – developed in 1967

Use it to create clusters based on what the machine sees in the data

Assumes there are groups that are not labeled that have different characteristics



## K-means clustering algorithm

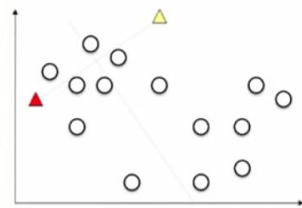
- Input:  $K$ , set of points  $x_1 \dots x_n$
- Place centroids  $c_1 \dots c_K$  at random locations
- Repeat until convergence:
  - for each point  $x_i$ :
    - find nearest centroid  $c_j$   $\arg \min_j D(x_i, c_j)$
    - assign the point  $x_i$  to cluster  $j$
  - for each cluster  $j = 1 \dots K$ :
    - new centroid  $c_j$  = mean of all points  $x_i$  assigned to cluster  $j$  in previous step

distance (e.g. Euclidian) between instance  $x_i$  and cluster center  $c_j$

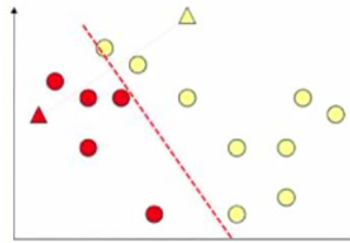
$$c_j(a) = \frac{1}{n_{j \rightarrow c_j}} \sum x_i(a) \quad \text{for } a = 1 \dots d$$

STOP when none of the cluster assignments change

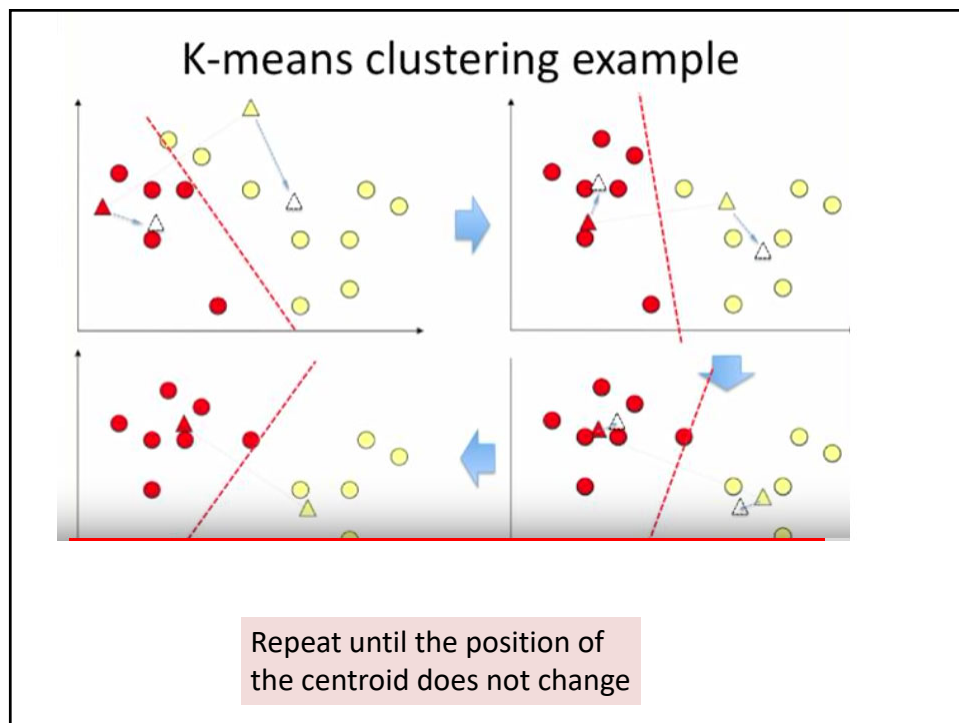
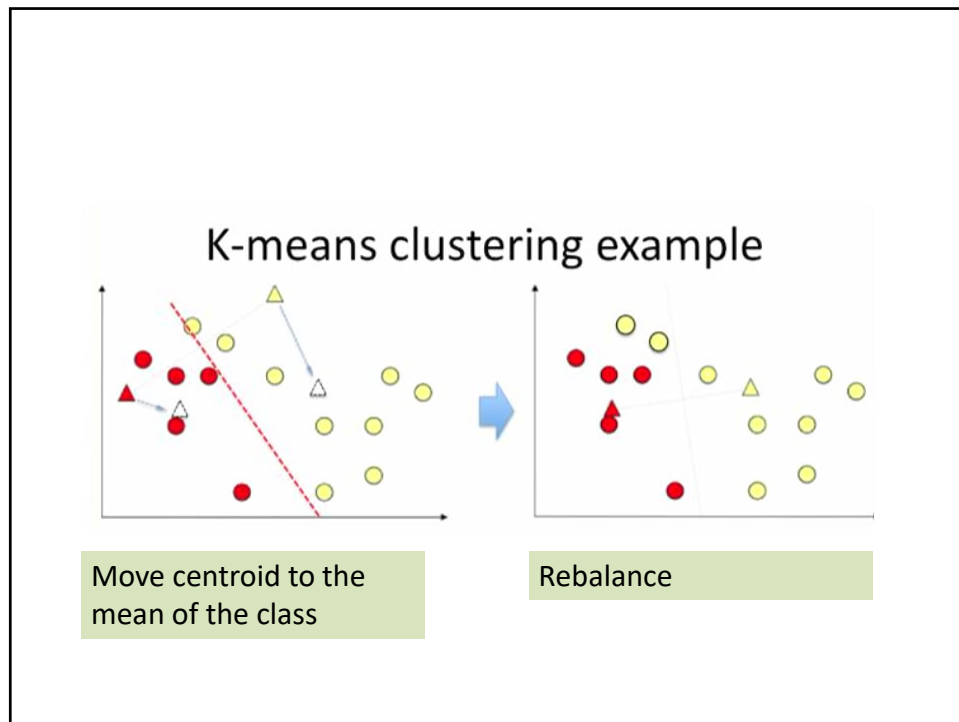
## K-means clustering example



Pick  $k$  centroids at random



Categorize data based on how close to the centroid



## k-means assumptions

- Assumes clusters are convex shapes (circles, ellipses)
- All features equally scaled
- Groups are balanced – have roughly the same number of observations

See: <https://www.datascience.com/blog/k-means-clustering>

## Code

```
1 from sklearn import datasets
2 from sklearn.preprocessing import StandardScaler
3 from sklearn.cluster import KMeans

1 #load data
2 iris = datasets.load_iris()
3 features = iris.data

1 # standardize features
2 scaler = StandardScaler()
3 features_std = scaler.fit_transform(features)
4

1 # create K-means object
2 cluster = KMeans(n_clusters=3, random_state=0, n_jobs=-1)
3
```

```
1 # Train model
2 model = cluster.fit(features_std)
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```

Very close to actual data – note that different category numbers

```
1 # create new observation
2 new_observation = [[0.8, 0.8, 0.8, 0.8]]
3
4 # predict
5 model.predict(new_observation)
6
7
```

array([0])

closest match is category 0

```
1 # view cluster centers
2 model.cluster_centers_
```

array([[ 1.13597027, 0.09659843, 0.996271 , 1.01717187],  
 [-1.01457897, 0.84230679, -1.30487835, -1.25512862],  
 [-0.05021989, -0.88029181, 0.34753171, 0.28206327]])

## Readings

- Reinforcement Learning:
  - See: <https://skymind.ai/wiki/deep-reinforcement-learning>
- K-Means Clustering
  - See: <https://www.datascience.com/blog/k-means-clustering>
- KNN – K-Nearest Neighbor
  - <https://medium.com/@adi.bronshtein/a-quick-introduction-to-k-nearest-neighbors-algorithm-62214cea29c7>
- Decision Trees
  - <https://towardsdatascience.com/decision-trees-in-machine-learning-641b9c4e8052>