Introduction to Machine Learning

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What is Machine Learning?

- It is a sub field of AI
- Machine can learn from data/observations and can enhance its performance over time
- Machine has become autonomous due to its ability to learn
- Before invention of ML, expert systems were written as a collection of rule bases by consulting experts
- ML has overcome the need of experts
- Main task of ML is classification/regression and prediction

What is Machine Learning?

- Easy job for humans is difficult for computers and vice versa
  - Sorting million of numbers is difficult for humans but easy for computers
  - Recognizing an animal in a picture is easy for human but difficult for computers
- Machine now is at par with human at tasks which were difficult before the invention of ML
- ML has applications in almost every areas which we can think of like education/agriculture/transportation/medical/genetics/business etc.
- ML applications will dominate the future world
- Unregulated and unethical use of ML may cause sufferings for the human race

Some Applications of ML

- Disease diagnosis
- Fraud detection
- Email filtering
- Computer vision
- Drug design
- Bio-Informatics
- Smart agriculture
- Natural Language Processing (NLP)
- Computer Aided Education
- Autonomous vehicle and many more

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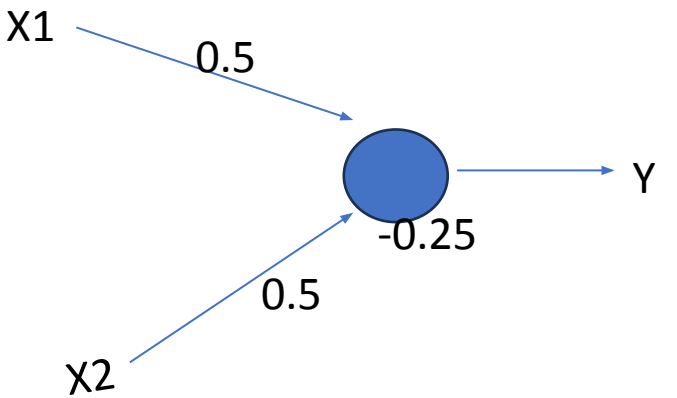
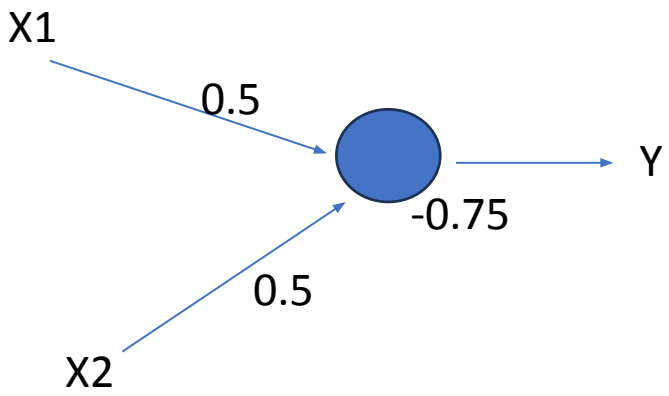
Small Examples



If X1*0.5 + X2*0.5 – 0.25 >= 0 then Y is 1

Other wise Y = 0

X1 = 0, X2=0 then Y =0
X1=0, X2=1 then Y = 1
X1 = 1, x2 = 0 then Y = 1
X1 = 1, X2 = 1 then Y = 1

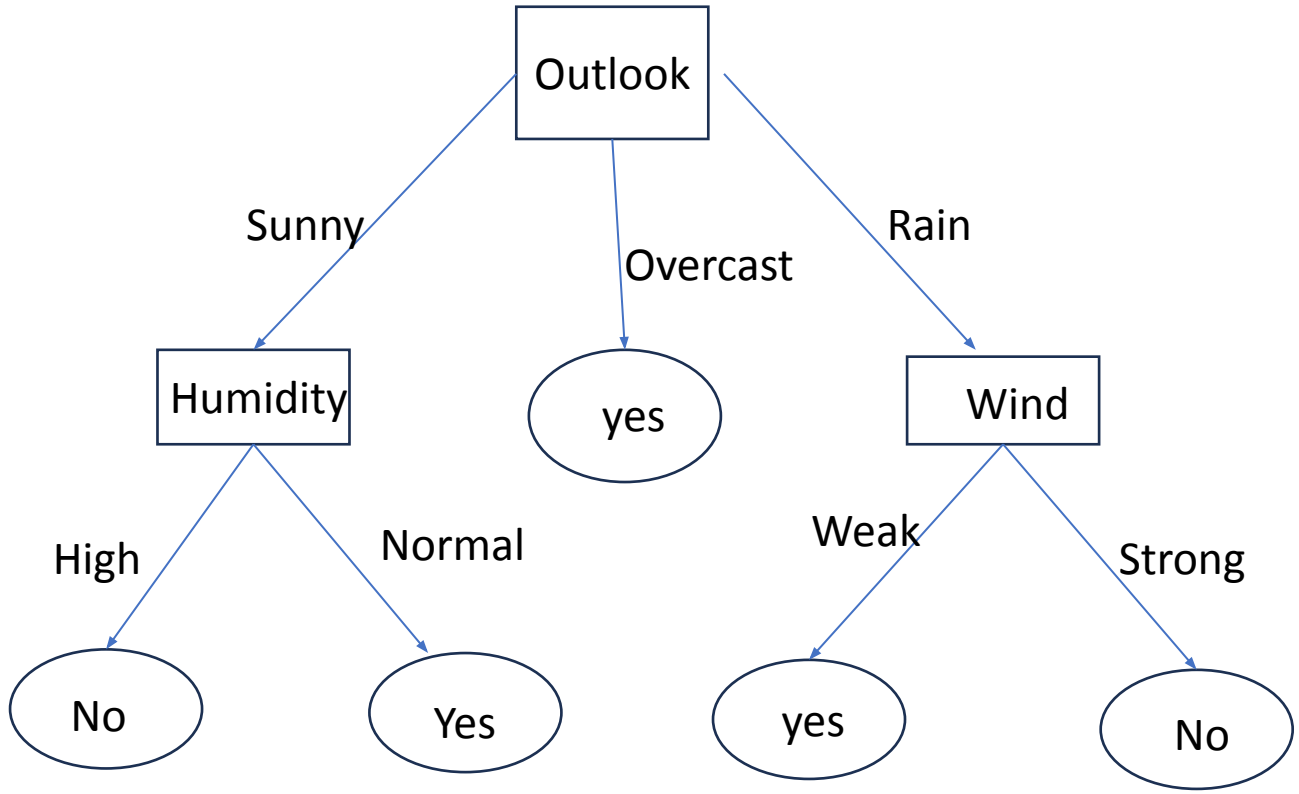


X1 = 0, X2=0 then Y =0
X1=0, X2=1 then Y = 0
X1 = 1, x2 = 0 then Y = 0
X1 = 1, X2 = 1 then Y = 1

Small Examples

Outlook	Temperature	Humidity	Wind	PlayTennis
Sunny	Hot	High	Strong	No
Sunny	Hot	High	Strong	No
Overcast	Hot	High	Weak	Yes
Rain	Mild	High	Weak	Yes
Rain	Cool	Normal	Strong	No
Rain	Cool	Normal	Strong	Yes
Overcast	Cool	Normal	Strong	Yes
Sunny	Mild	High	Strong	No
Sunny	Cool	Normal	Weak	Yes
Rain	Mild	Normal	Weak	Yes
Sunny	Mild	Normal	Strong	Yes
Overcast	Mild	High	Strong	Yes
Overcast	Hot	Normal	Weak	Yes
Rain	Mild	High	Strong	No

Decision Tree



Broad Categories

- Supervised learning – Classification, Regression
- Unsupervised learning – Clustering, Density estimation
- Semi supervised learning
- On line learning
- Reinforcement learning

Supervised Learning

Feature Space $\mathcal{X}$

Label Space $\mathcal{Y}$

"Sports"
"News"
"Science"
...

Share Price
"$ 24.50"

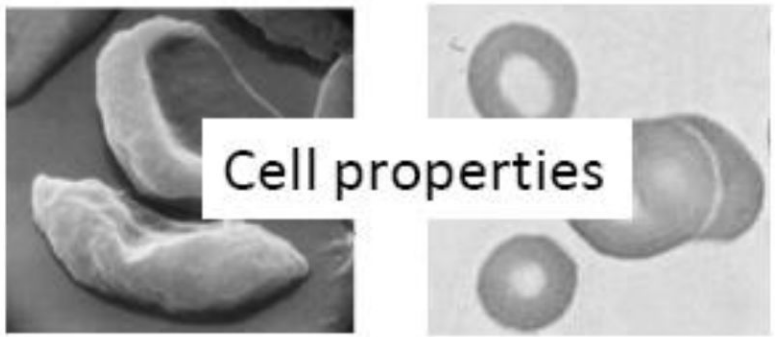
Task: Given $X \in \mathcal{X}$, predict $Y \in \mathcal{Y}$.

Supervised Learning - Classification

Feature Space $\mathcal{X}$

Label Space $\mathcal{Y}$

"Sports"
"News"
"Science"
...

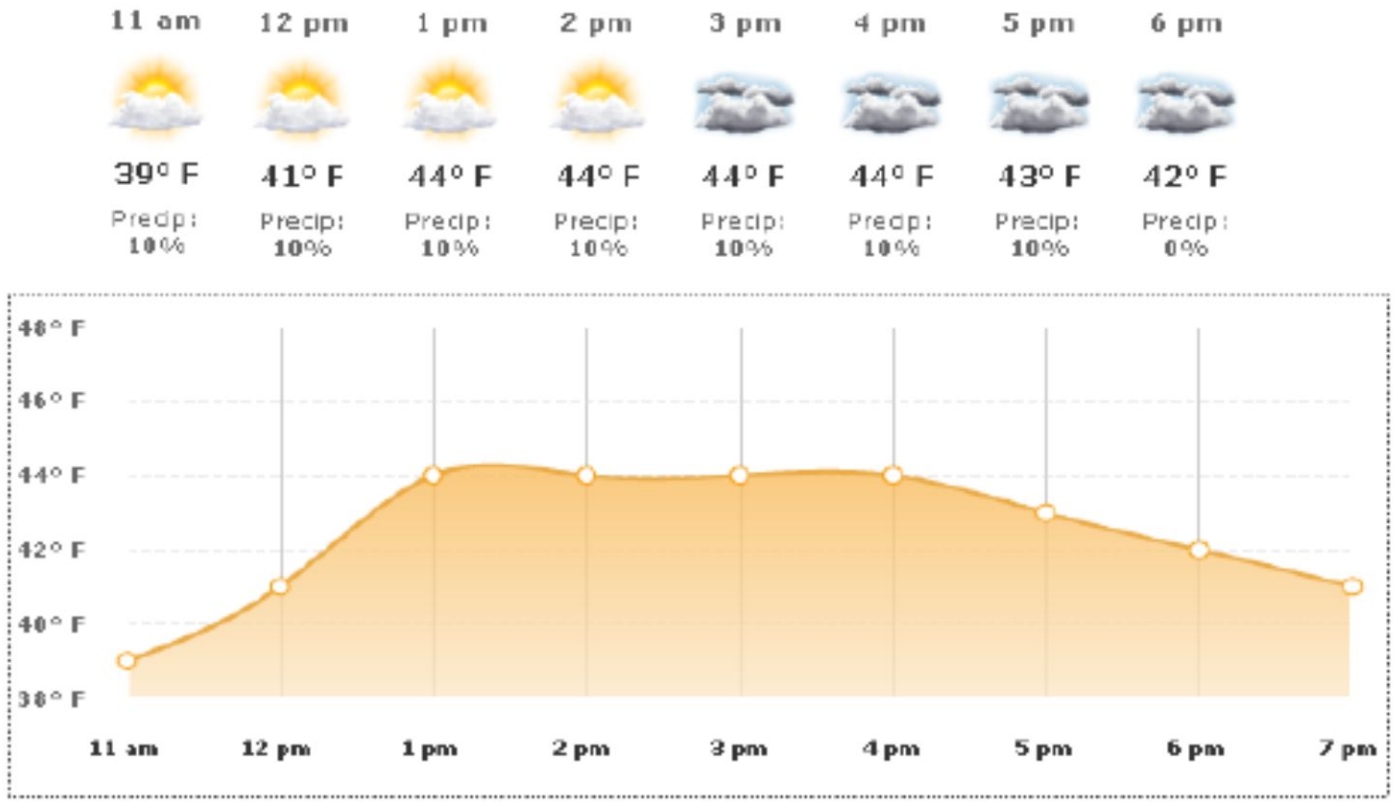


"Anemic cell"
"Healthy cell"

Discrete Labels

Supervised Learning Problems

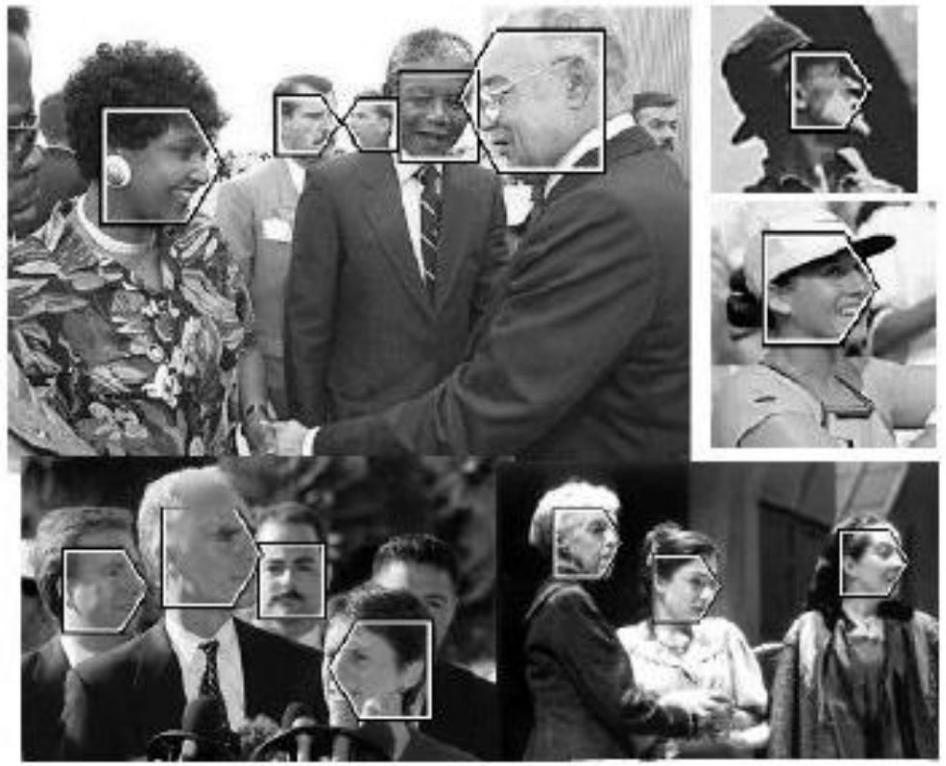
Features? **Labels?** **Classification/Regression?**



Temperature/Weather prediction

Supervised Learning Problems

Features? **Labels?** **Classification/Regression?**



Face Detection

Supervised Learning

- Data: A set of data records (also called examples, instances or cases) described by
  - k attributes: $A_1, A_2, \ldots A_k$.
  - a class: Each example is labelled with a pre-defined class.
- Goal: To learn a classification/regression model from the data that can be used to predict the classes/values of new (future, or test) cases/instances.

Unsupervised Learning

- Learning without a teacher

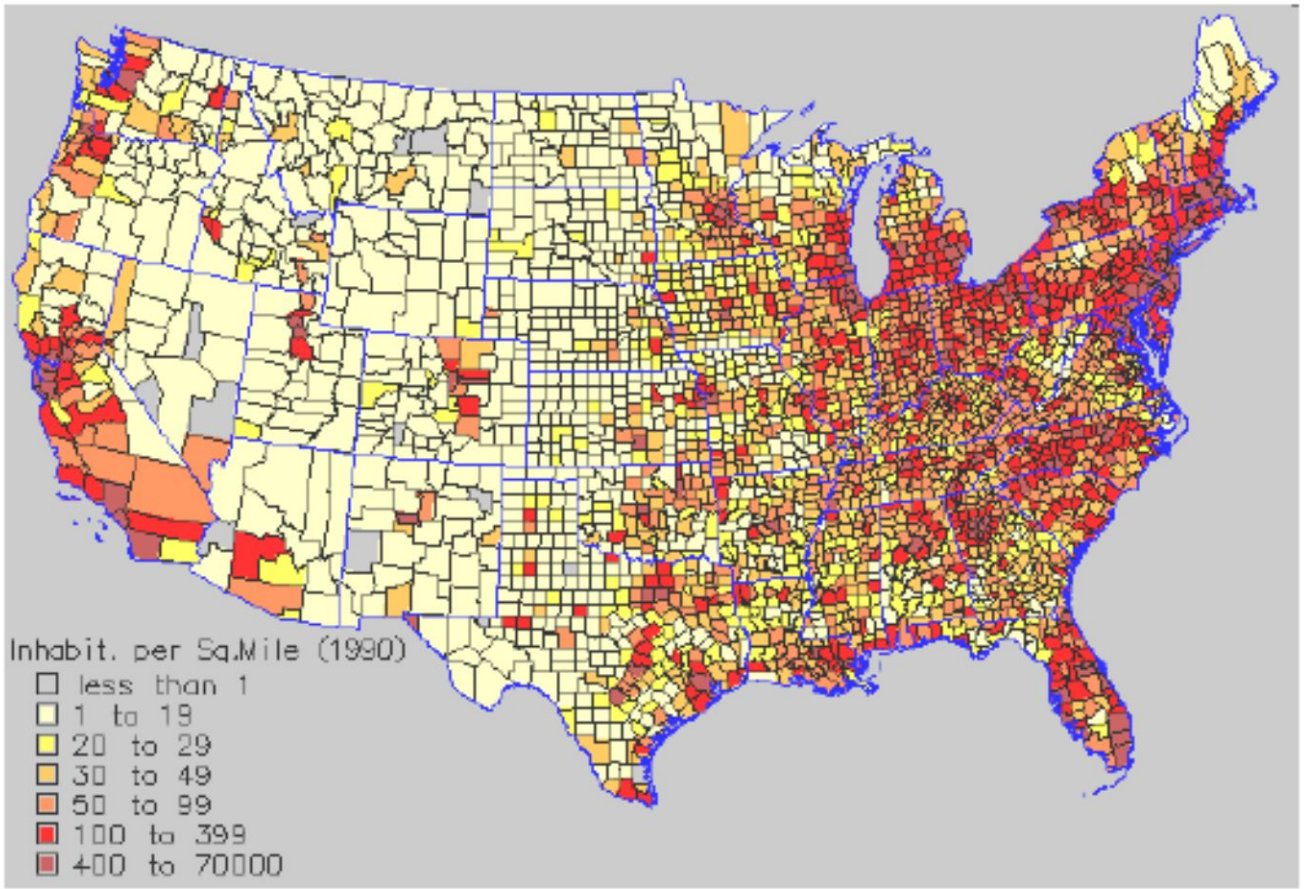
Feature Space $\mathcal{X}$

Word distribution
(Probability of a word)

Task: Given $X \in \mathcal{X}$, learn $f(X)$.

Unsupervised Learning - Density Estimation

Population density



Unsupervised Learning - Clustering

- Group similar things e.g. images

Unsupervised Learning - Clustering

- The data set has three natural groups of data points, i.e., 3 natural clusters.

Reinforcement Learning

Reinforcement learning (RL) is a type of machine learning where an agent learns to make decisions by taking actions in an environment to maximize some notion of cumulative reward.

The agent receives feedback from its actions in the form of rewards or penalties and learns to adapt its strategy to improve future performance.

Reinforcement Learning Examples

- **Game Playing**: In games like chess or Go, the RL agent improves its play by trying different strategies and learning which actions lead to winning more games through trial and error.
- **Robotics**: A robot can learn to walk, pick up objects, or navigate a room through reinforcement learning. It performs actions, observes the outcome, and gradually develops a refined movement strategy by receiving feedback in the form of successful or unsuccessful task completion.
- **Self-driving Cars**: RL can be used to help autonomous vehicles make decisions such as when to change lanes or adjust speed by continuously receiving feedback from the driving environment and honing its decision-making process to ensure safety and efficiency.