

Introduction to Machine Learning

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What is ML?

- ▶ A branch of artificial intelligence, concerned with the design and development of algorithms that allow computers to evolve behaviors based on empirical data.
- ▶ The goal is to program computers to use example data or past experience to solve a problem.
- ▶ Learning is used when:
 - ▶ Human expertise does not exist (navigating on Mars),
 - ▶ Humans are unable to explain their expertise (speech recognition)
 - ▶ Solution changes in time (routing on a computer network)
 - ▶ Solution needs to be adapted to particular cases (user biometrics)

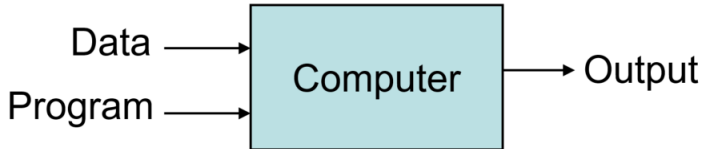
The essence of ML

- ▶ A pattern exists
- ▶ We cannot pin it down mathematically
- ▶ We have data on it

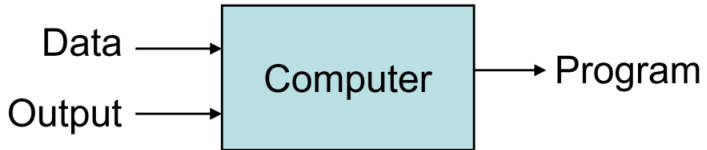
- ▶ Automating automation
- ▶ Getting computers to program themselves
- ▶ Writing software is the bottleneck
- ▶ Let the data do the work instead!

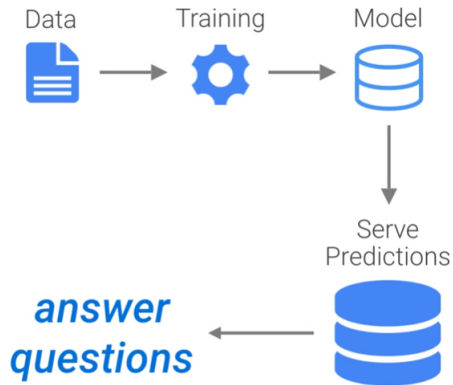
Using data to answer questions

Traditional Programming



Machine Learning

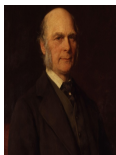




- ▶ Applications:
 - ▶ analyze past sales data to predict customer behavior,
 - ▶ optimize robot behavior so that a task can be completed using minimum resources,
 - ▶ extract knowledge from bioinformatics data.

History of ML

- ▶ Early 19th Century - Gauss and Legendre independently discovering the method of least squares.
- ▶ Sir Francis Galton - Regression to the mean (Tall Parents -> Less tall children), correlation. Cousin of Charles Darwin. Coined term Eugenist. Discouraged low intelligence people from reproducing
- ▶ Karl Pearson - student of Galton. Father of mathematical statistics. Eugenist and racist
- ▶ Ronald Fisher - father of modern stats and experimental design. ANOVA. Also Eugenist and racist



Machine Learning Timeline

- ▶ 1940's: Linear discriminant analysis - First classification method developed by Fisher
- ▶ 1950's: Perceptron and Neural Networks - Frank Rosenblatt
- ▶ 1960's: Nearest Neighbor, K-means clustering
- ▶ 1970's: Logistic regression
- ▶ 1980's: Decision Trees and other non-linear methods
- ▶ 1990's: Support Vector Machines(Vapnik)
- ▶ 2000's: Random Forest (Brieman), Deep Learning (Hinton)

Types of Learning

- ▶ **Supervised Learning**

Training data includes desired outputs.

Fit a model.

- ▶ **Unsupervised Learning**

Training data does not include desired outputs.

Clustering.

- ▶ **Semi-supervised Learning**

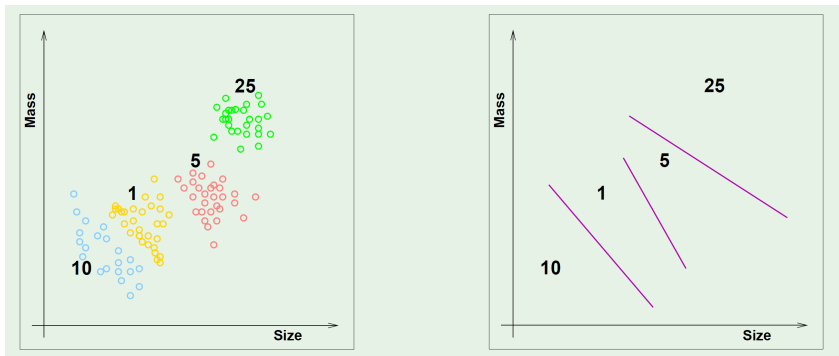
Training data includes a few desired outputs.

- ▶ **Reinforcement Learning**

Rewards/Punished from sequence of actions. Learns from this and repeats.

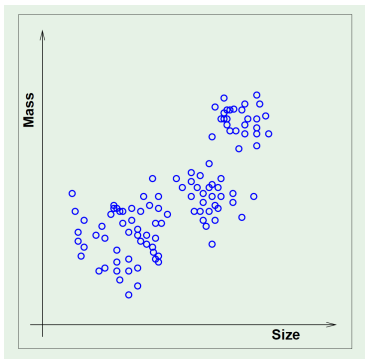
Supervised Learning

Example: Vending machine - coin recognition



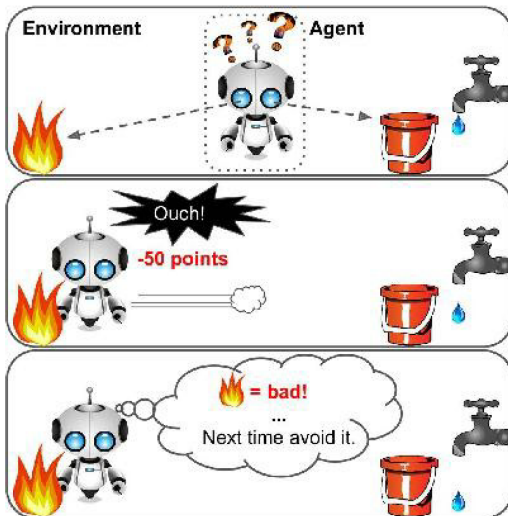
Unsupervised Learning

Example: Vending machine - coin recognition

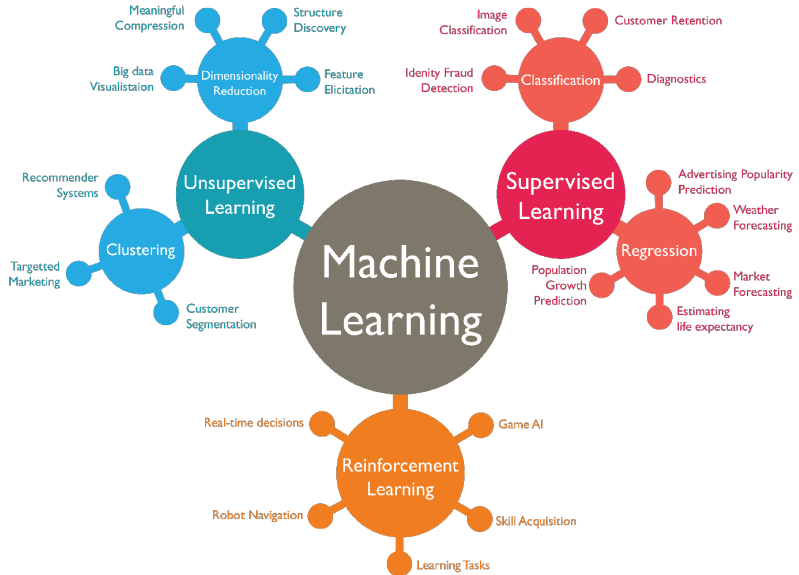


Reinforcement Learning

Example:



- 1 Observe
- 2 Select action using policy
- 3 Action!
- 4 Get reward or penalty
- 5 Update policy (learning step)
- 6 Iterate until an optimal policy is found



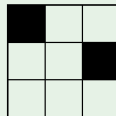
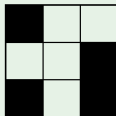
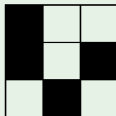
7 Steps of Machine Learning

1. Gather Data
2. Prepare Data
3. Choose Model
4. Training
5. Evaluation
6. Hyperparameter Tuning
7. Prediction

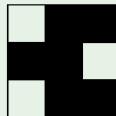
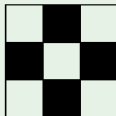
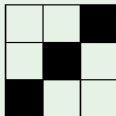


Visual Intro to Machine Learning

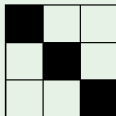
A Learning puzzle



$$f = -1$$



$$f = +1$$



$$f = ?$$