Introduction

Machine Learning

Some slides were adapted/taken from various sources, including Prof. Andrew Ng's Coursera Lectures, Stanford University, Prof. Kilian Q. Weinberger's lectures on Machine Learning, Cornell University, Prof. Sudeshna Sarkar's Lecture on Machine Learning, IIT Kharagpur, Prof. Bing Liu's lecture, University of Illinois at Chicago (UIC), CS231n: Convolutional Neural Networks for Visual Recognition lectures, Stanford University and many more. We thankfully acknowledge them. Students are requested to use this material for their study only and **NOT** to distribute it.

Today

- Define Machine Learning
- Applications
- Different types of learning
- Brief introduction of
  - Supervised learning
  - Unsupervised learning
  - Reinforcement learning

Machine Learning

Field of study that gives computers the ability to learn without being explicitly programmed.

By: Arthur Samuel (1959)

Applications

- Database mining:
  - Web click data, medical records, biology, engineering etc.
- Application that can't be programmed by hand
  - Autonomous helicopter, handwriting recognition, NLP, computer vision
- Self Customizing Programs Recommendation
  - Amazon, Netflix
- Understanding human learning
  - Brain, real AI

Learning Problem

- Well-posed learning problem:

  A computer program is said to *learn* from *experience* E with respect to some *task* T and some *performance measure* P, if its performance on T, as measured by P, improves with *experience* E.

- By Tome Mitchell (1998)

Example

Your Email program watches which emails you do or do not mark as a spam and based on that learns how to better filter spam.

- Task (T): Classifying the emails as spam or not
- Experience (E): Watching you label emails as spam or not spam
- Performance (P): The number of emails correctly classified as spam / not spam

Different Types of Learning

- **Supervised Learning**: Data and corresponding labels are given

- **Unsupervised Learning**: Only data is given, no labels provided

- **Semi-supervised Learning**: Some (if not all) labels are present

- **Reinforcement Learning**: An agent interacting with the world makes observations, takes actions, and is rewarded or punished; it should learn to choose actions in such a way as to obtain a lot of reward

Supervised Learning

- Supervised learning: classification is seen as supervised learning from examples.
  - Supervision: The data (observations, measurements, etc.) are labeled with pre-defined classes. It is like that a "teacher" gives the classes (supervision).
  - Test data are classified into these classes too.

Supervised learning

- Like human learning from past experiences.
- A computer does not have "experiences".
- A computer system learns from data, which represent some "past experiences" of an application domain.
- Our focus: learn a target function that can be used to predict the values of a discrete class attribute, e.g., approve or not-approved, and high-risk or low risk.
- The task is commonly called: Supervised learning, classification, or inductive learning.

The data and the goal

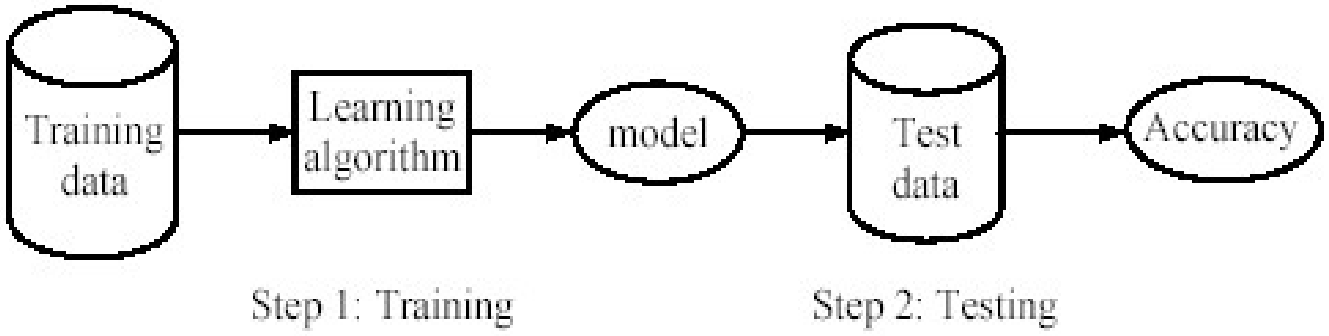
- Data: A set of data records (also called examples, instances or cases) described by
  - k attributes: $A_1, A_2, \ldots A_k$.
  - a class: Each example is labelled with a pre-defined class.

- Goal: To learn a classification model from the data that can be used to predict the classes of new (future, or test) cases/instances.

Supervised learning process: two steps

- Learning (training): Learn a model using the training data
- Testing: Test the model using unseen test data to assess the model accuracy

$$Accuracy = \frac{\text{Number of correct classifications}}{\text{Total number of test cases}},$$

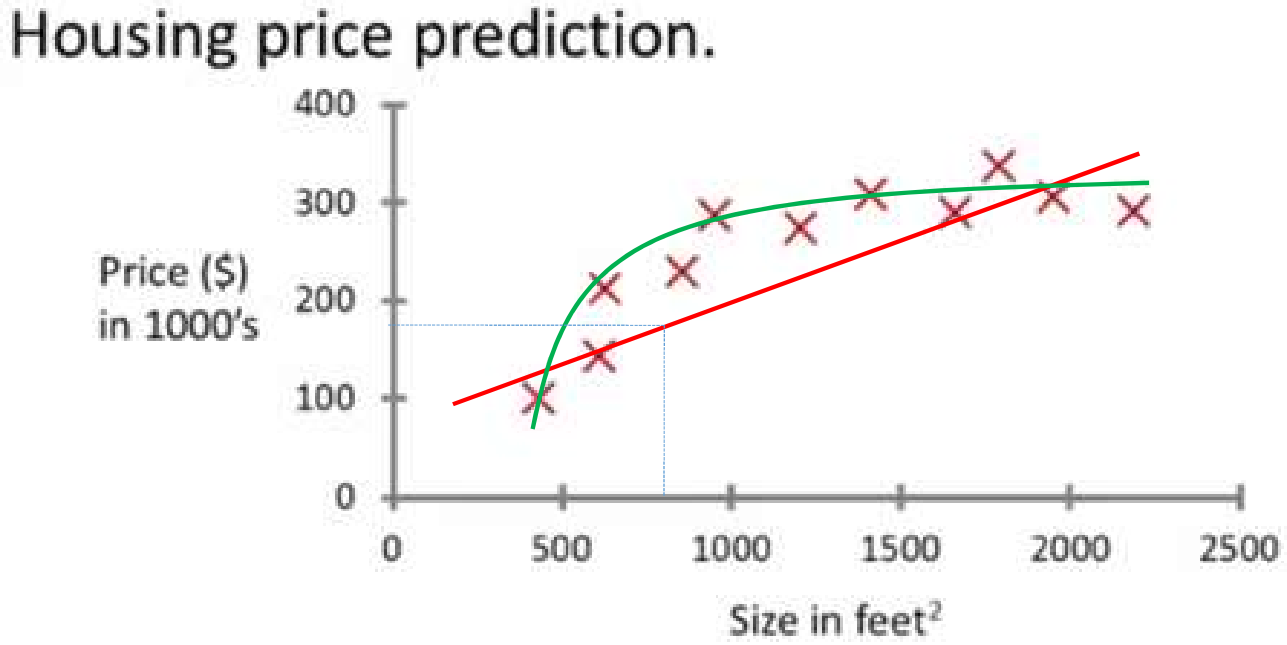


Fundamental assumption of learning

- Assumption: The distribution of training examples is identical to the distribution of test examples (including future unseen examples).

- In practice, this assumption is often violated to certain degree.
- Strong violations will clearly result in poor classification accuracy.
- To achieve good accuracy on the test data, training examples must be sufficiently representative of the test data.

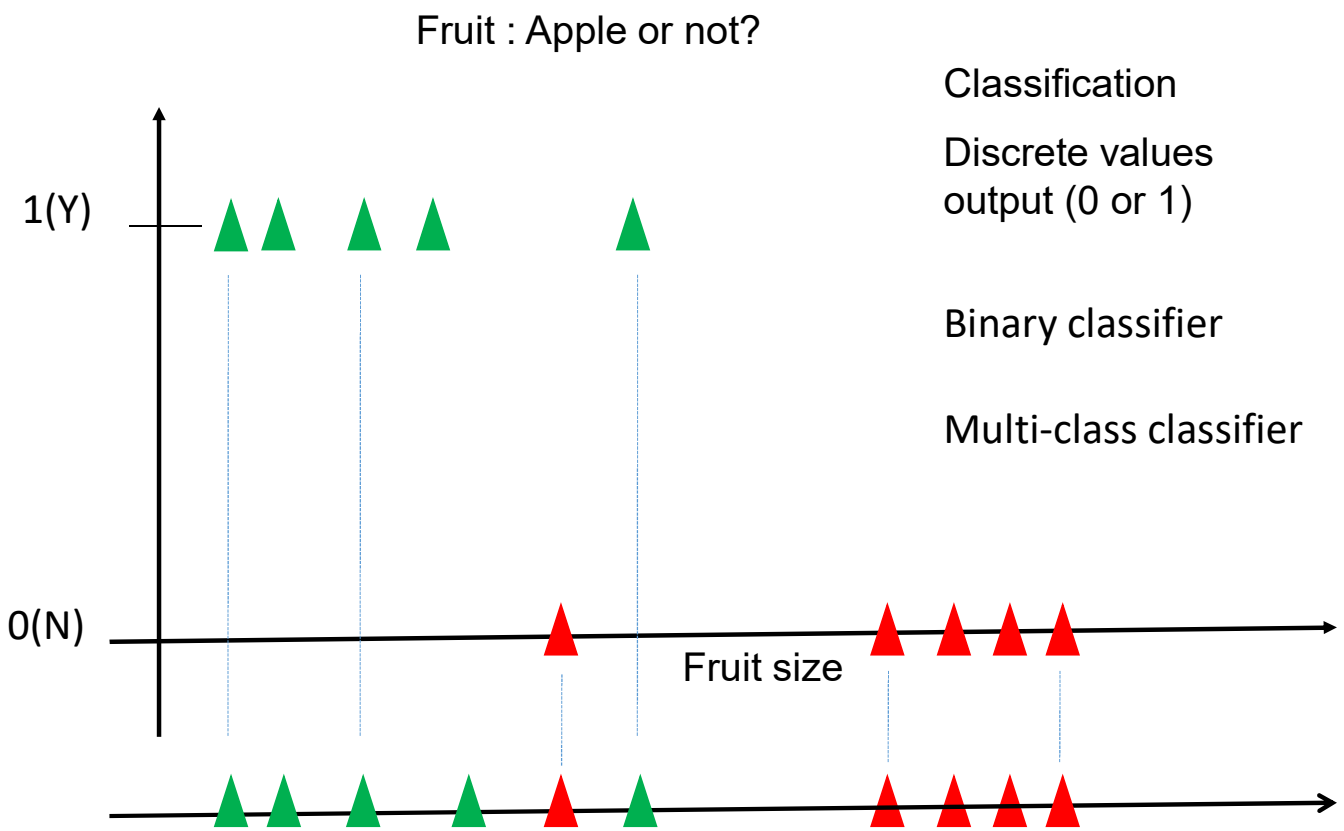
Supervised Learning: An example



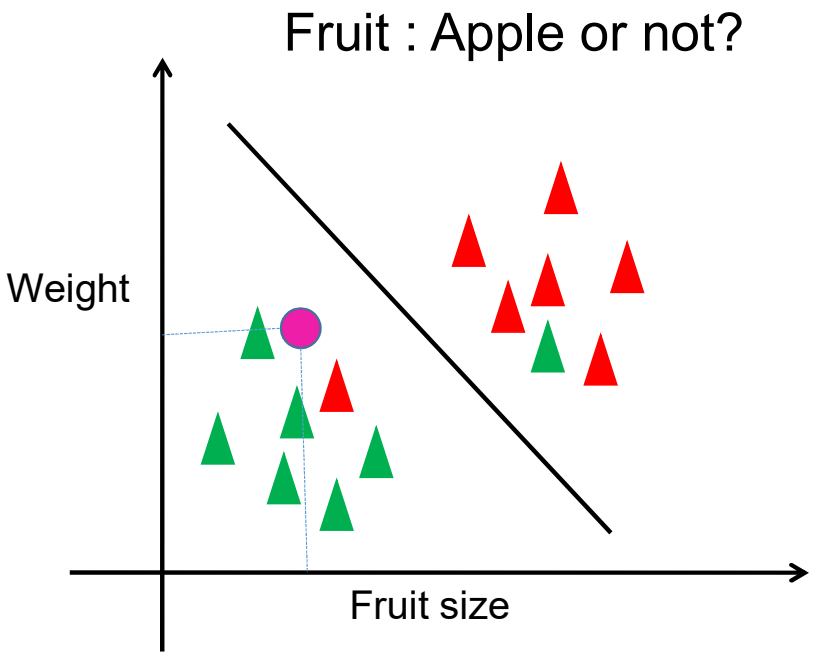
Supervised Learning:
Right answer given

Regression:
Predict continuous valued output

Supervised Learning: An example



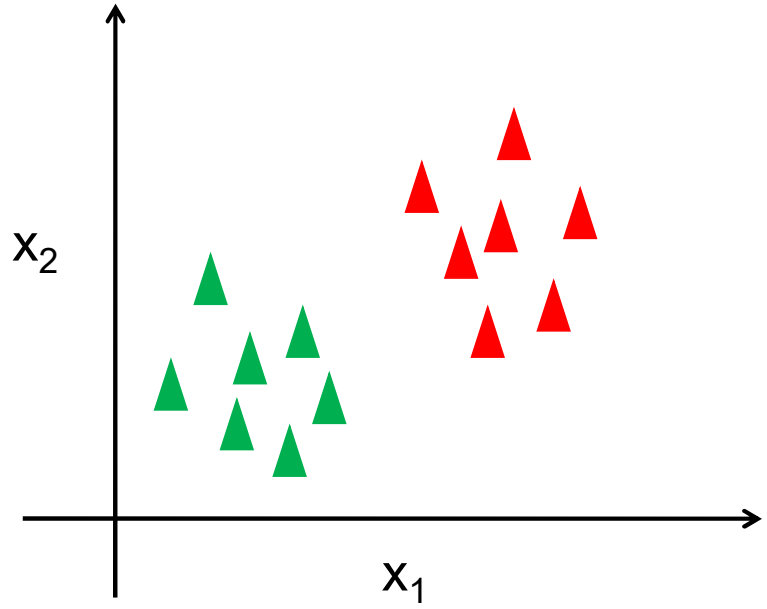
Supervised Learning: An example



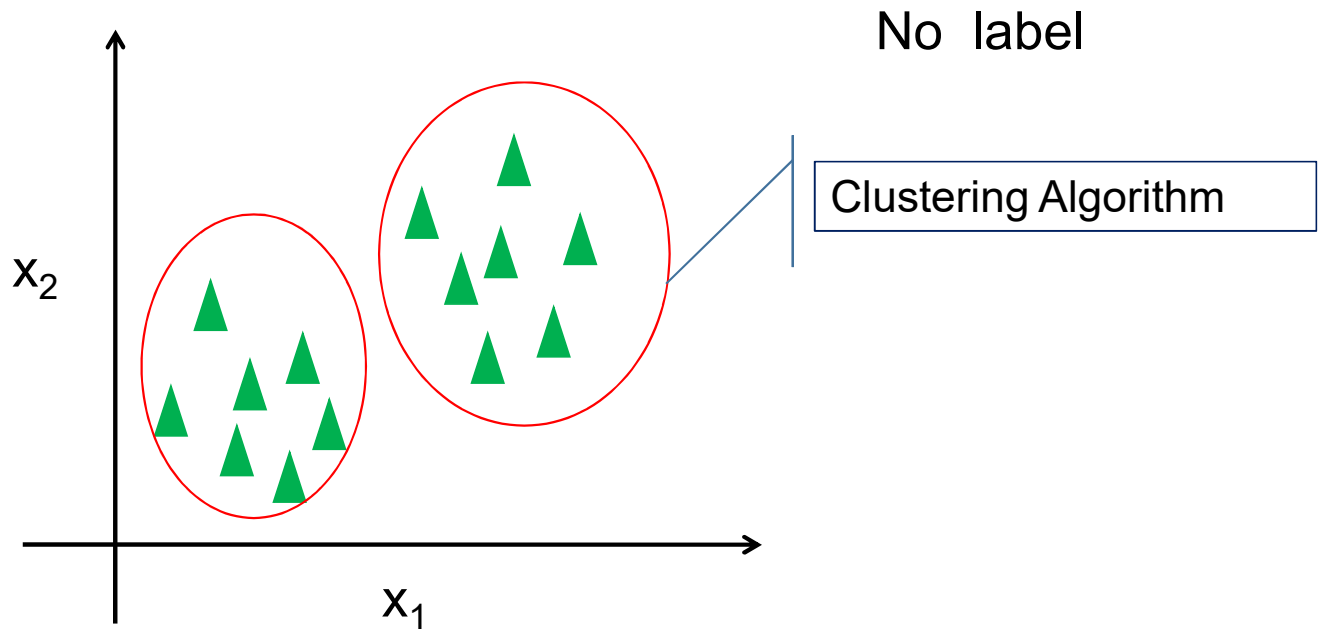
Two features examples

- Features:
  - color
  - texture
  - cost
  - …..

Supervised Learning



Un-supervised Learning



Supervised vs. unsupervised learning

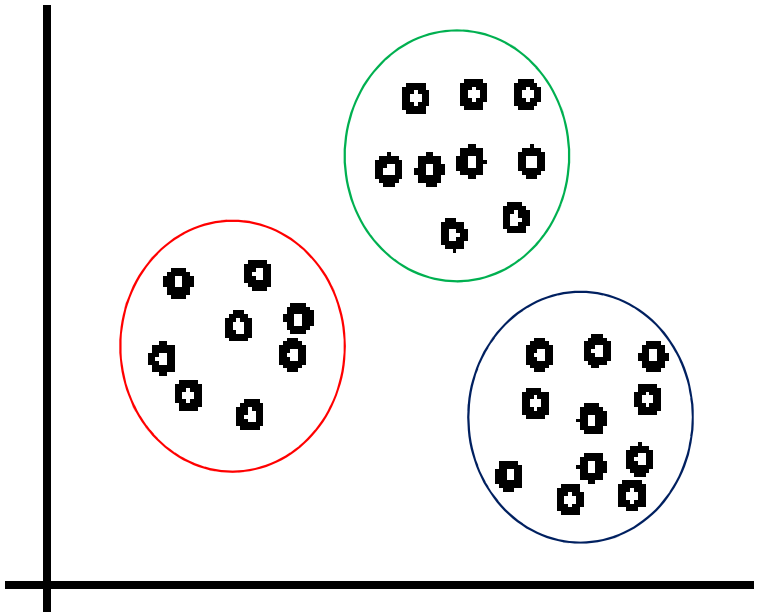
- Supervised learning: discover patterns in the data that relate data attributes with a target (class) attribute.
  - These patterns are then utilized to predict the values of the target attribute in future data instances.
- Unsupervised learning: The data have no target attribute.
  - We want to explore the data to find some intrinsic structures in them.

Clustering

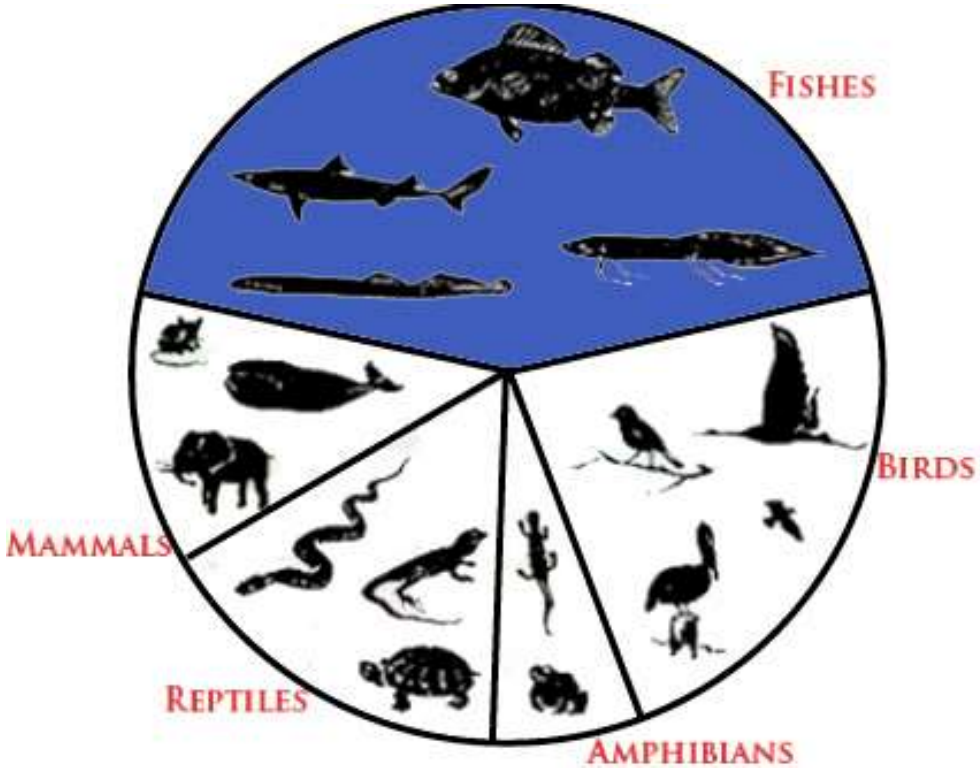
- Clustering is a technique for finding similarity groups in data, called **clusters**. i.e.,
  - it groups data instances that are similar to (near) each other in one cluster and data instances that are very different (far away) from each other into different clusters.
- Clustering is often called an **unsupervised learning** task as no class values denoting an *a priori* grouping of the data instances are given, which is the case in supervised learning.
- Due to historical reasons, clustering is often considered synonymous with unsupervised learning.
  - In fact, association rule mining is also unsupervised

An illustration

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



What is clustering for?



Clustering for Animal Kingdom

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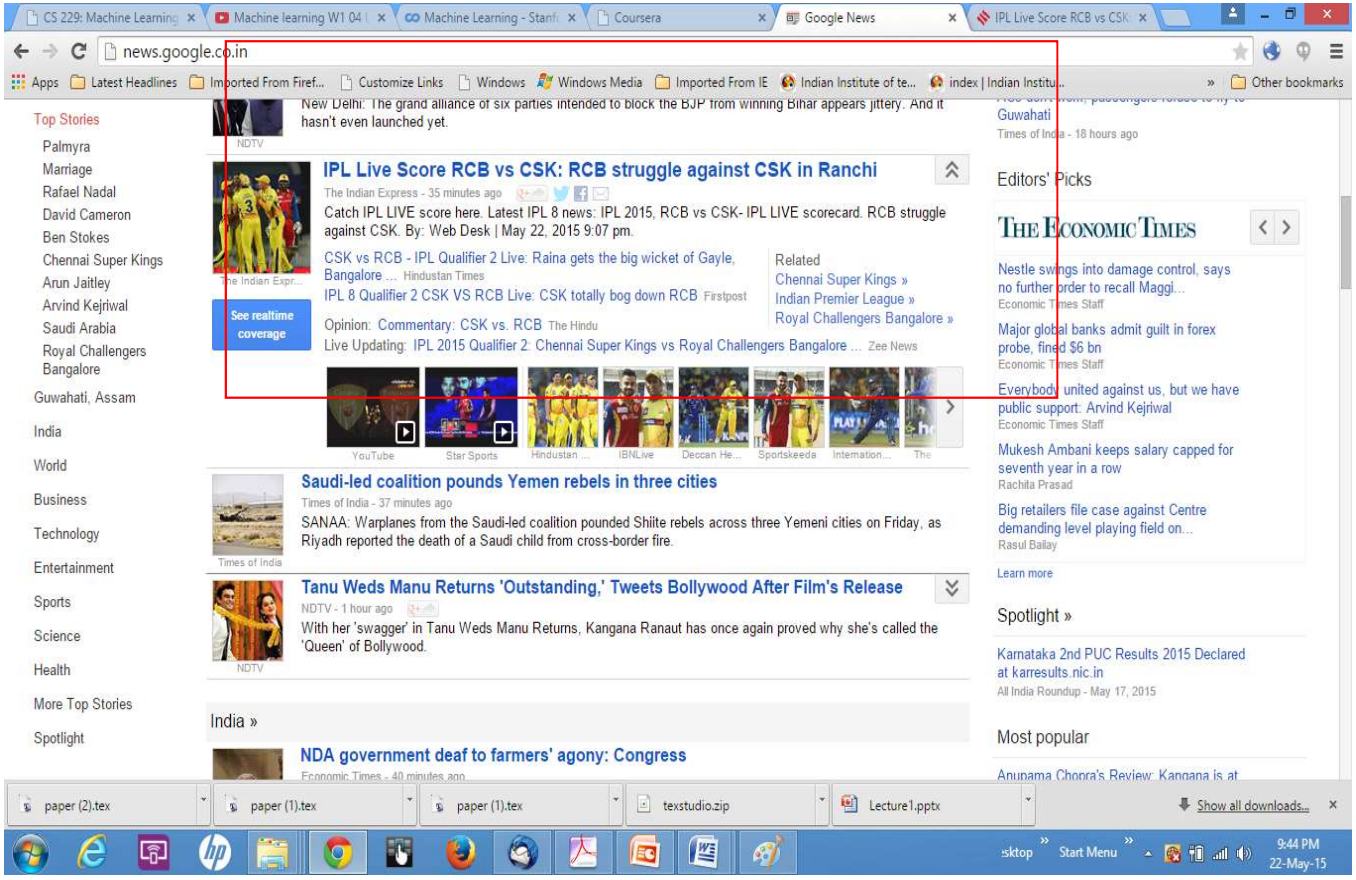
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Manoj Bhagavatula and Abhimanyu Kulkarni, Hindustan Times, New Delhi | Updated: May 22, 2015 18:51 IST
Chennai Super Kings (CSK) players celebrate their win over Royal Challengers Bangalore (RCB) during their IPL 2015 match at MA Chidambaram Stadium in Chepauk, Chennai. (PTI Photo)


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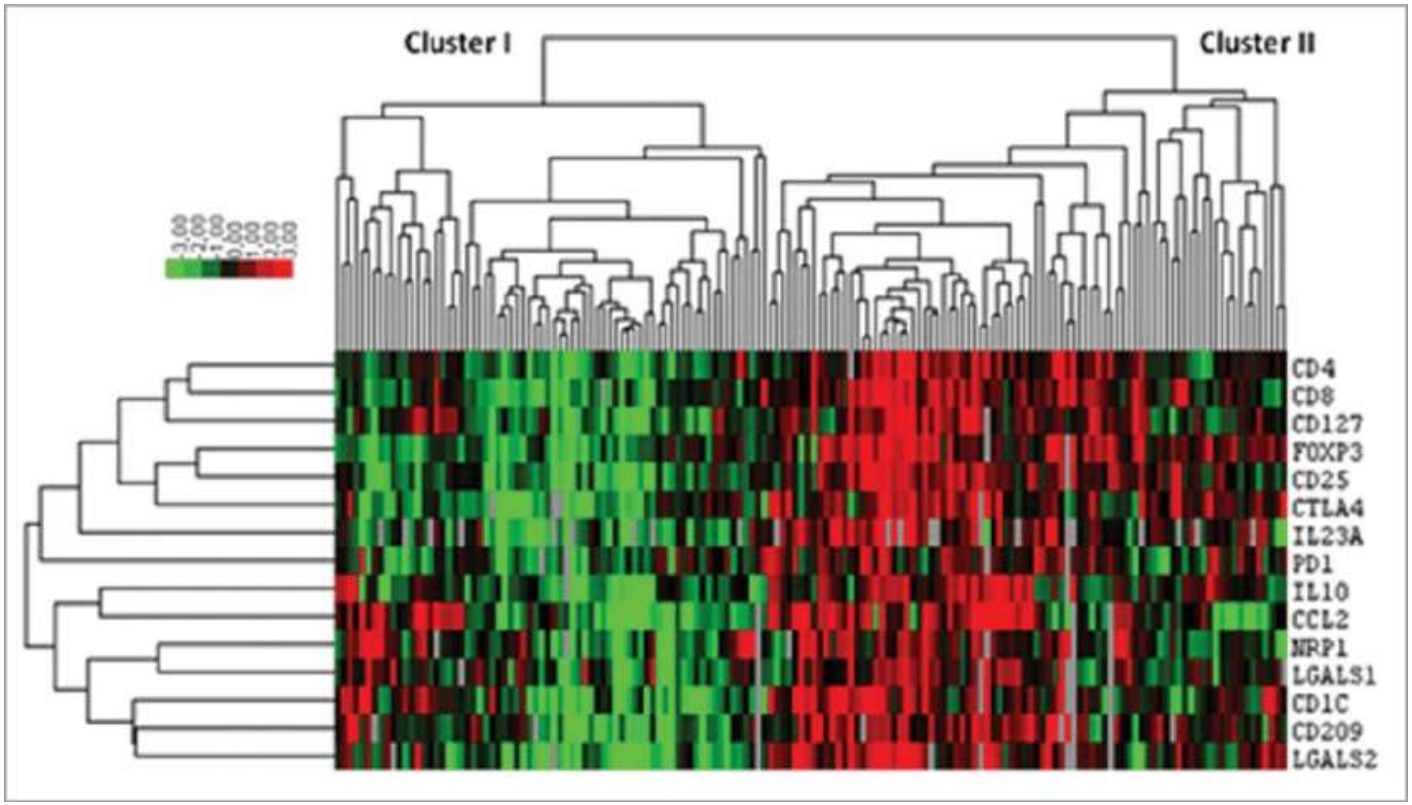
Clustering for Gene Expression



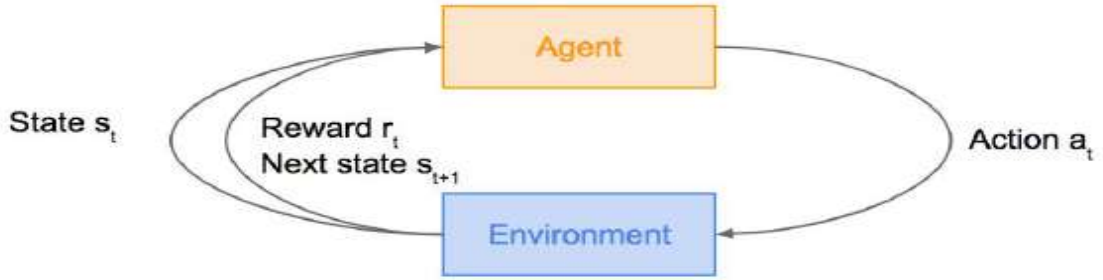
Application of Clustering Algorithms

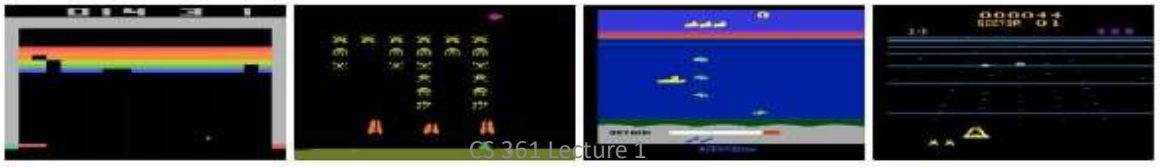
- Organizing computer clusters
- Social network analysis
- Market segmentation
- Astronomical image/data analysis
- Speaker recognition and many more…

Reinforcement Learning

Problems involving an **agent** interacting with an **environment,** which provides numeric **reward** signals

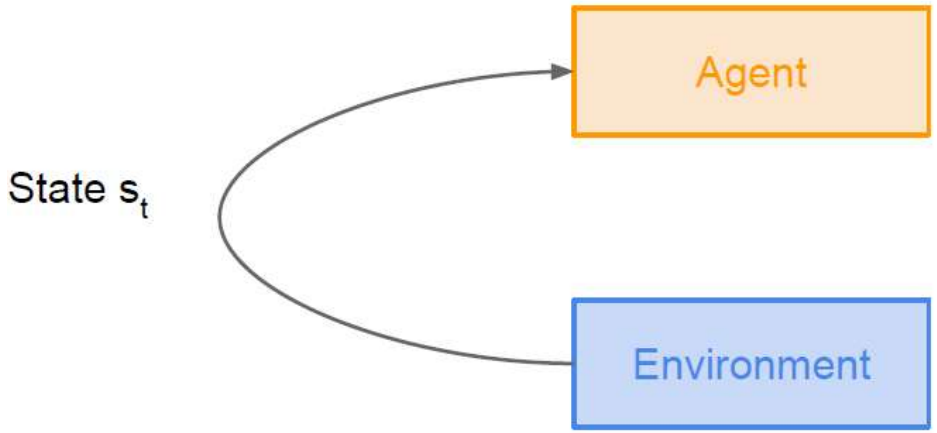
Goal: Learn how to take actions in order to maximize reward



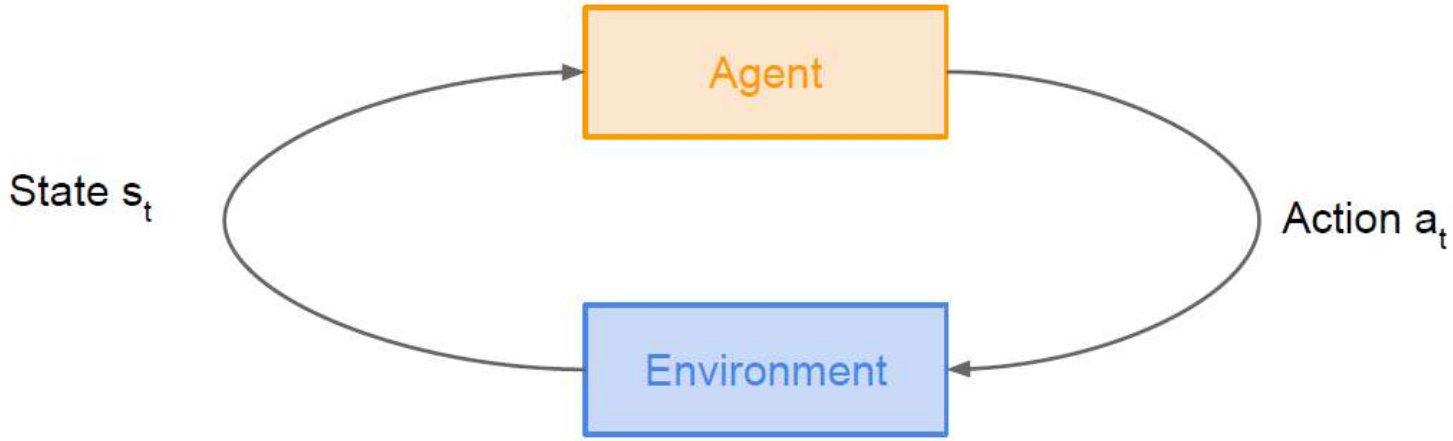


Reinforcement Learning

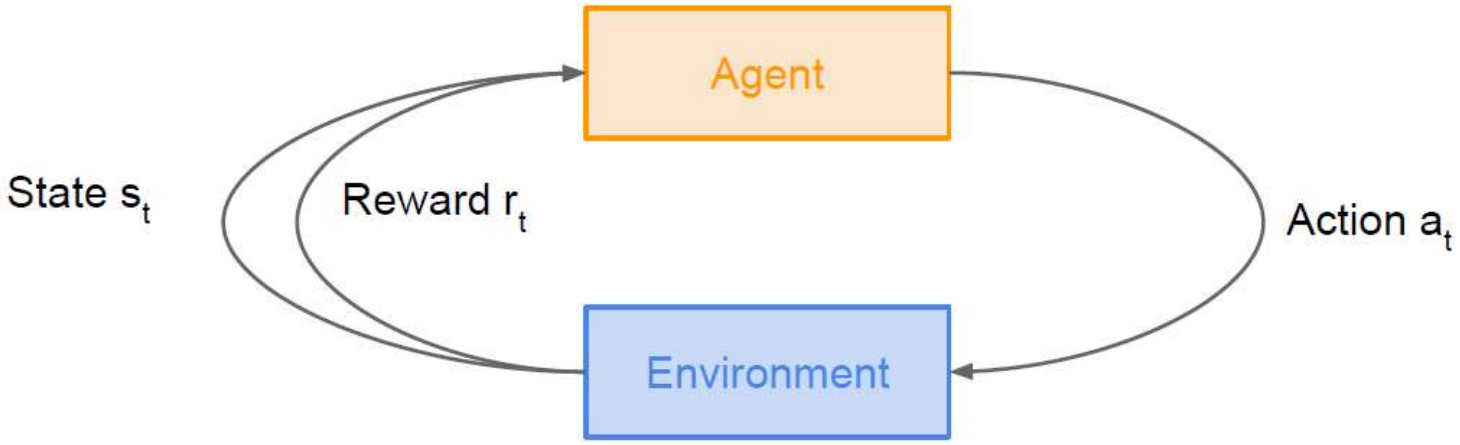
Reinforcement Learning



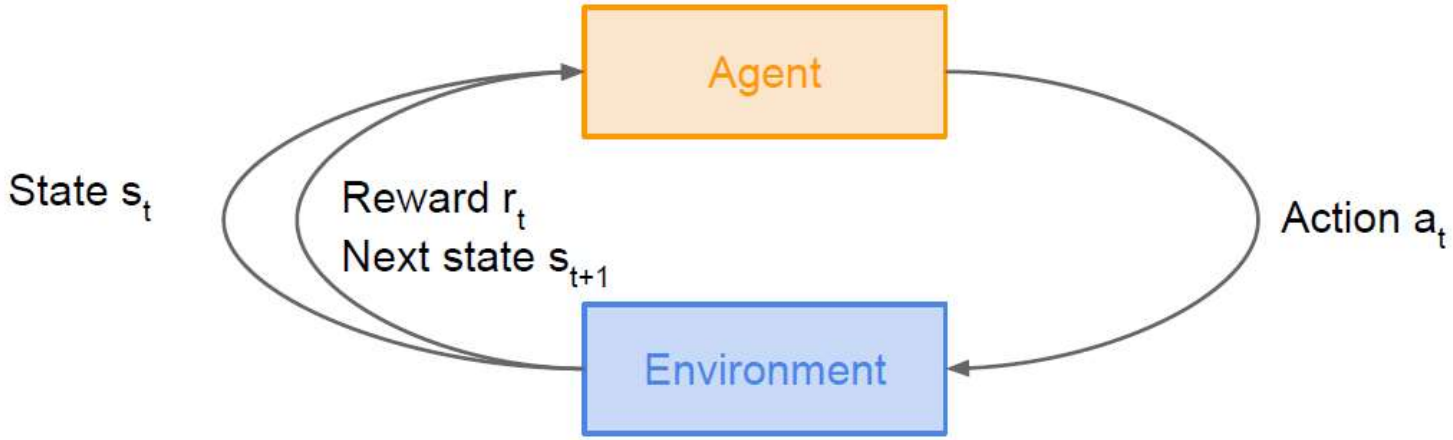
Reinforcement Learning



Reinforcement Learning

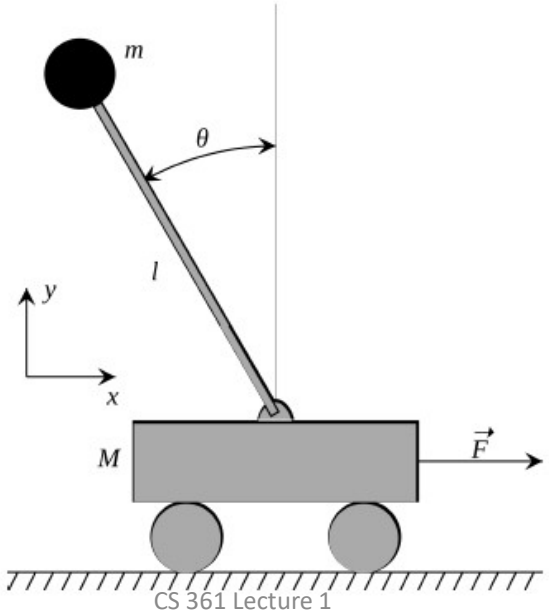


Reinforcement Learning



Cart-Pole Problem

Objective : Balance a pole on top of a movable cart
State : angle, angular speed, position, horizontal velocity
Action : horizontal force applied on the cart
Reward : 1 at each time step if the pole is upright



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