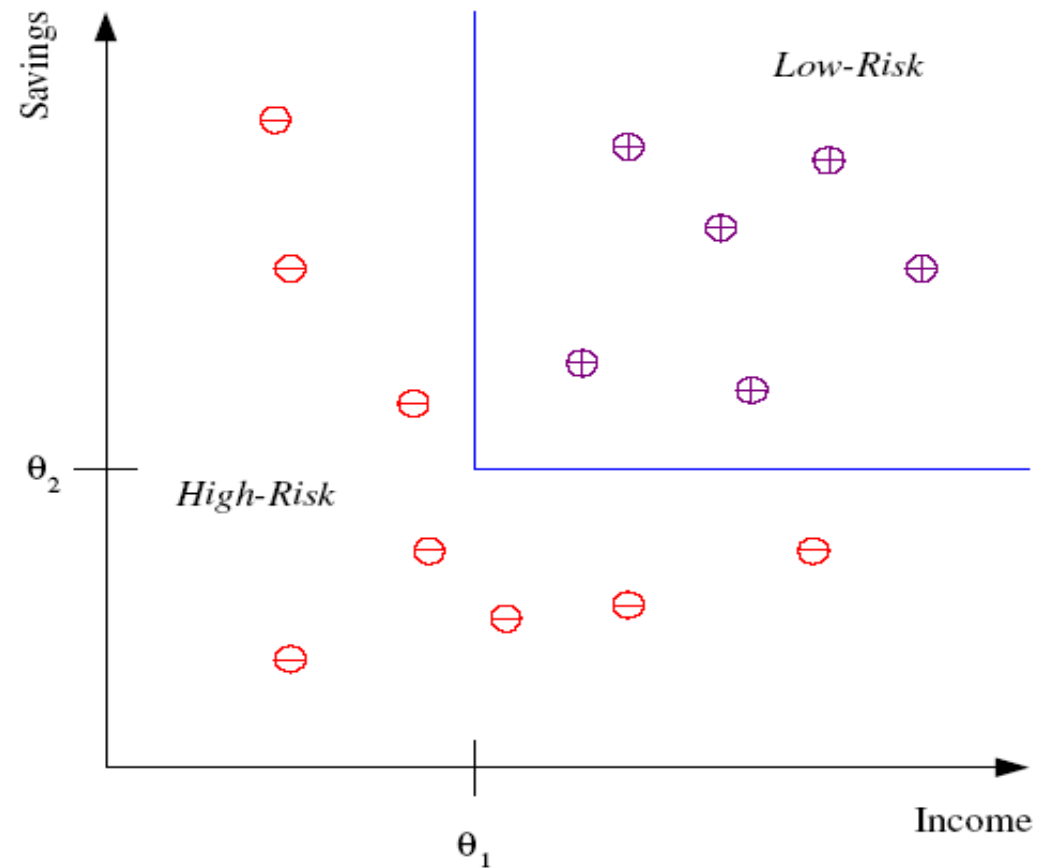


# Classification Example

Differentiate between  
**low-risk** and **high-risk**  
customers from their  
*income* and *savings*



# Classification Applications

## Aka Pattern recognition

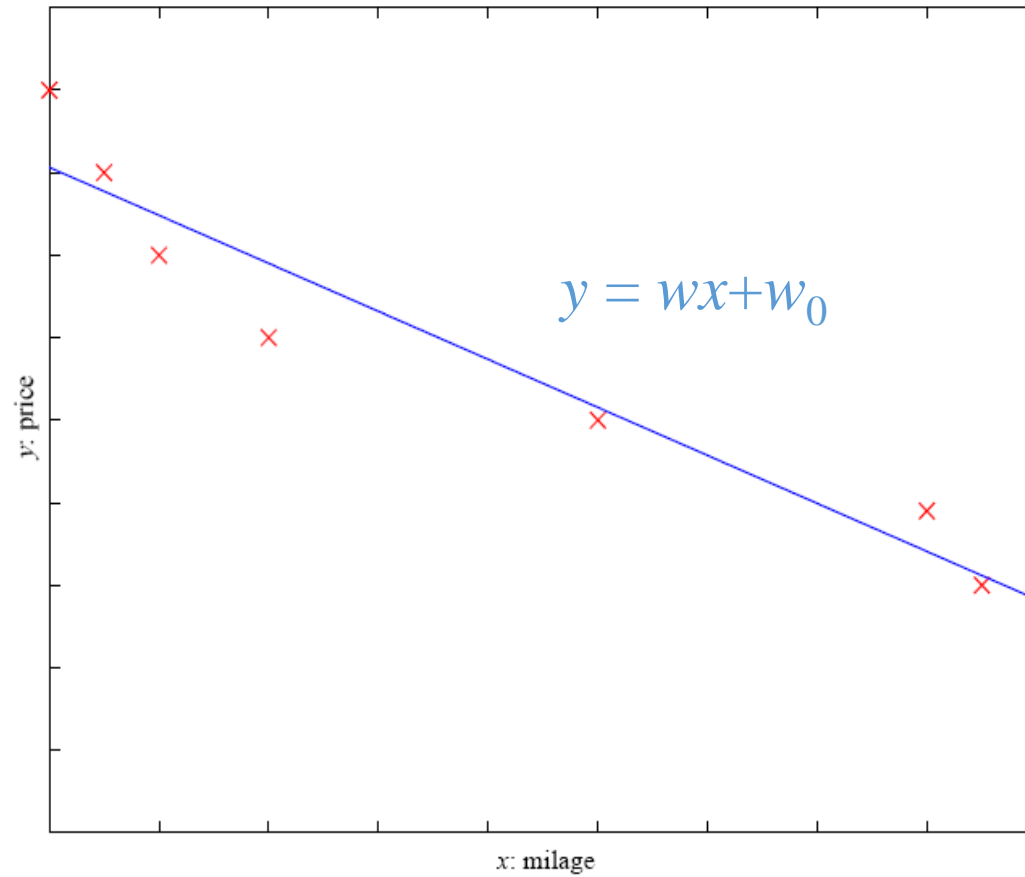
- Face recognition: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- Character recognition: Different handwriting styles.
- Spam Detection: Emails spam/no spam
- Speech recognition: Temporal dependency.  
Use of a dictionary or the syntax of the language.  
Sensor fusion: Combine multiple modalities; eg, visual (lip image) and acoustic for speech
- Medical diagnosis: From symptoms to illnesses
- Web Advertising: Predict if a user clicks on an ad on the Internet.
- Biometrics: Recognition/authentication using physical and/or behavioral characteristics: Face, iris, signature, etc

# Regression Example

Price of a used car

$x$  : car attributes  
(e.g. mileage)

$y$  : price



# Regression Applications

Economics/Finance: predict the value of a stock

Epidemiology (high blood pressure, mental illness and obesity)

Car/plane navigation: angle of the steering wheel, acceleration, ...

Temporal trends: weather over time

# Unsupervised learning applications

- Customer/Market Segmentation (i.e. grouping)
- Social Network Analysis
- Astronomical Data Analysis

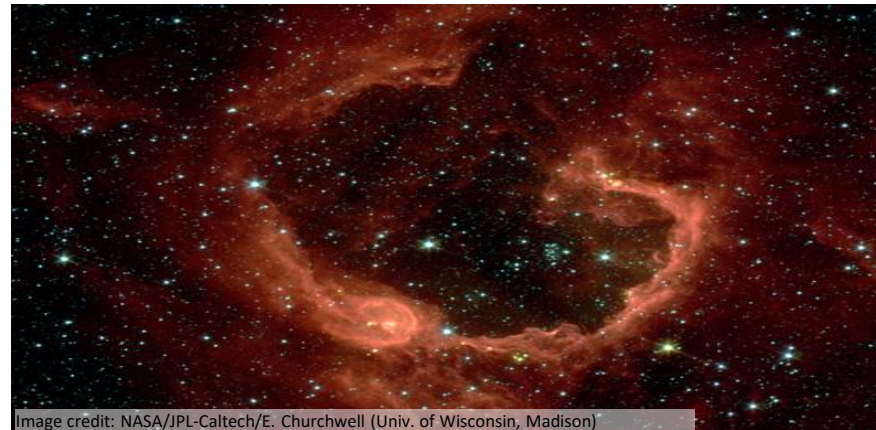
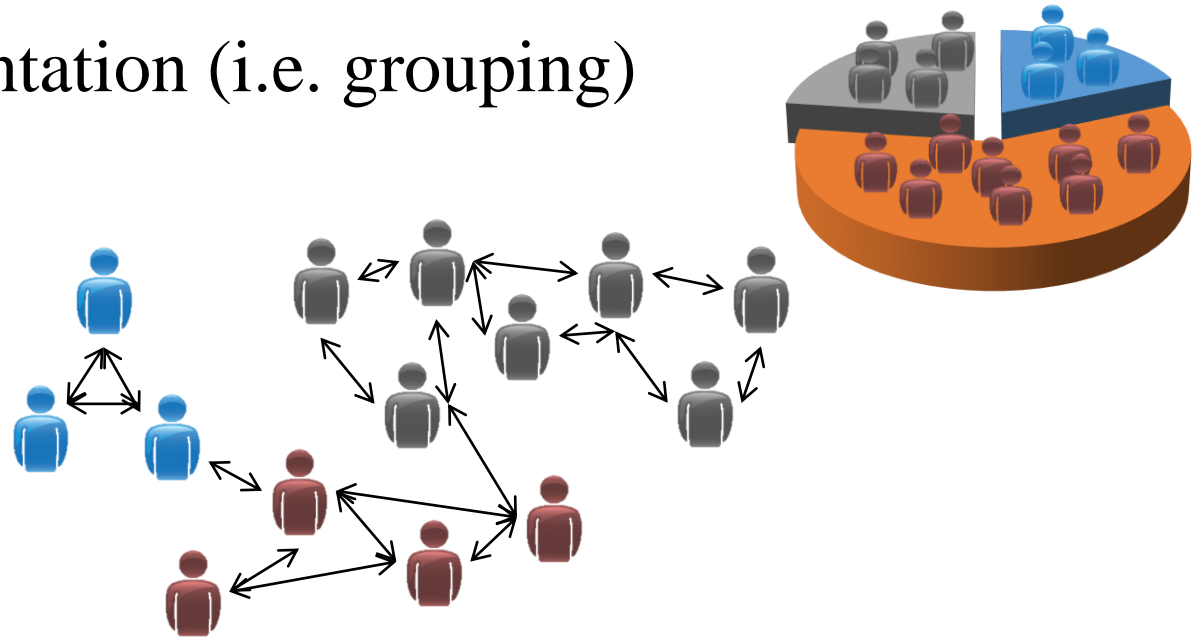


Image credit: NASA/JPL-Caltech/E. Churchwell (Univ. of Wisconsin, Madison)

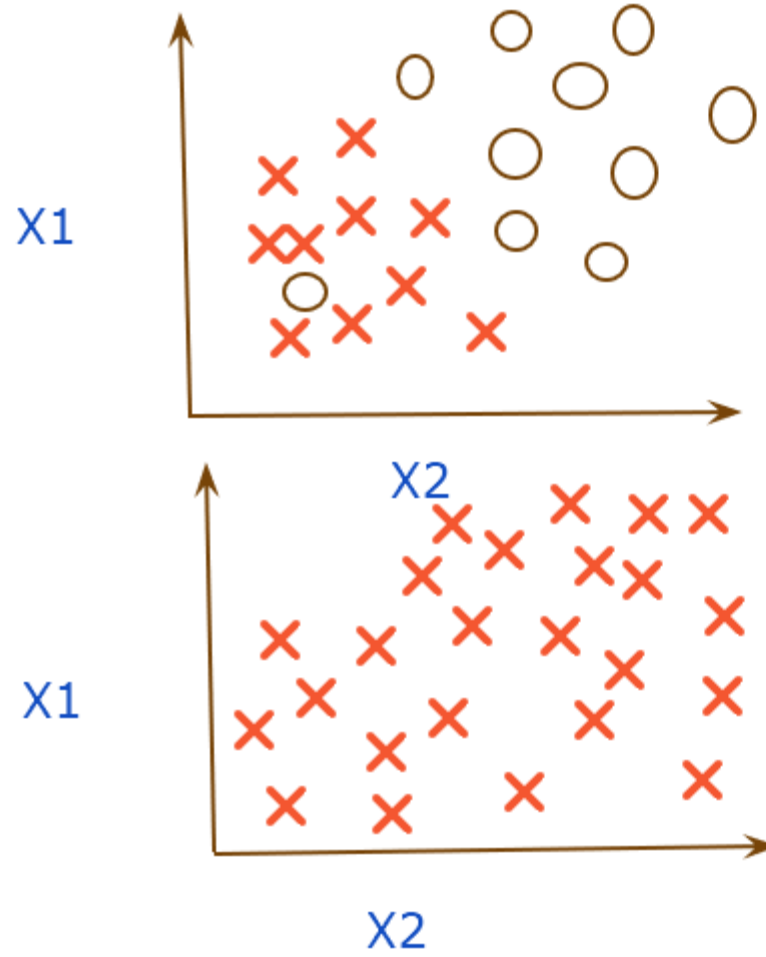
## Unsupervised learning

## Unsupervised learning

- unlabeled data/ No right answer
- do not need to supervise
-

## Unsupervised learning

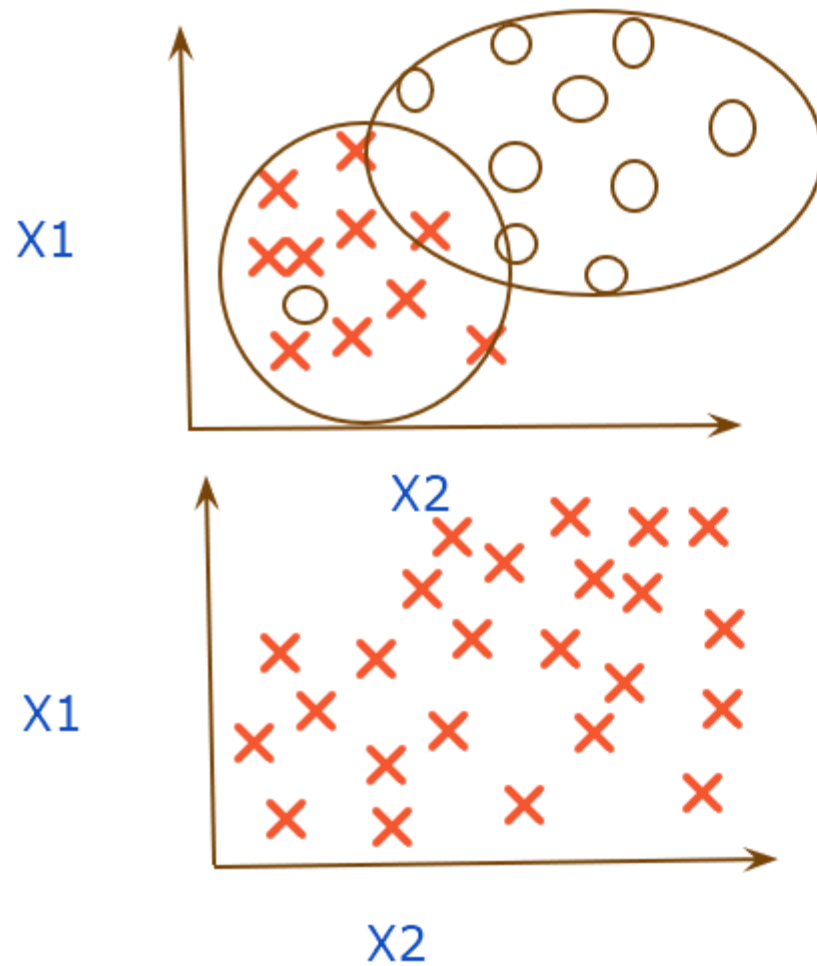
- unlabeled data/ No right answer
- do not need to supervise
- 





## Unsupervised learning

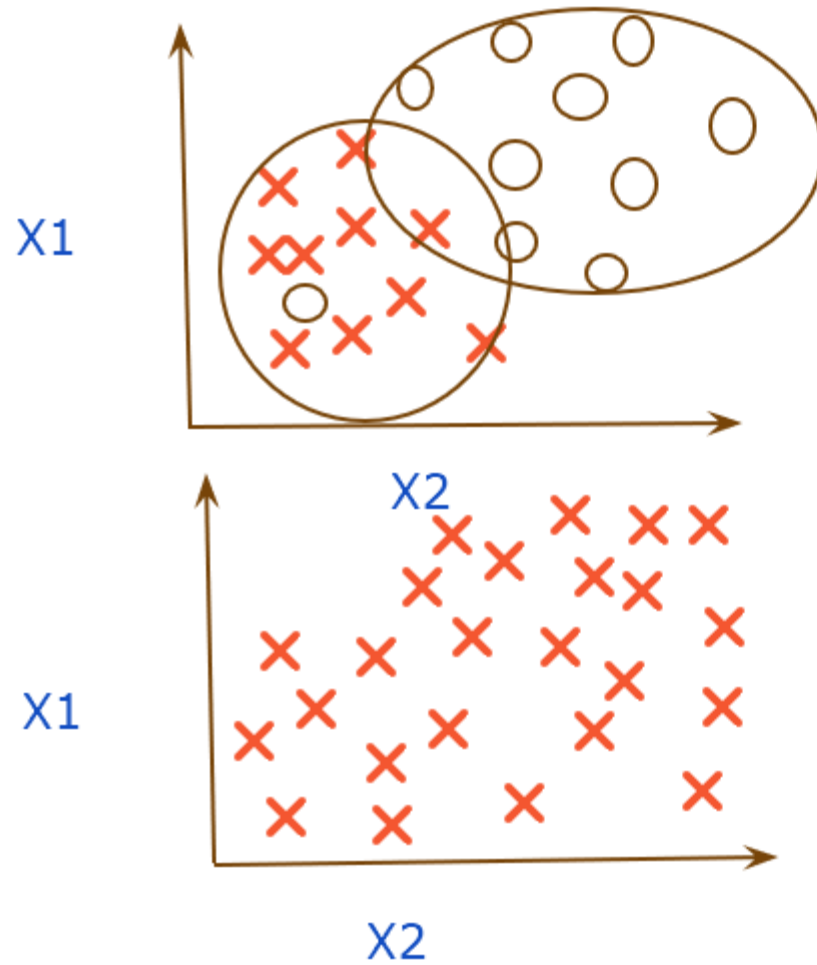
- unlabeled data/ No right answer
- do not need to supervise
- 



## Unsupervised learning

- unlabeled data/ No right answer
- do not need to supervise
- output variable: Y

Identify the patterns/structure

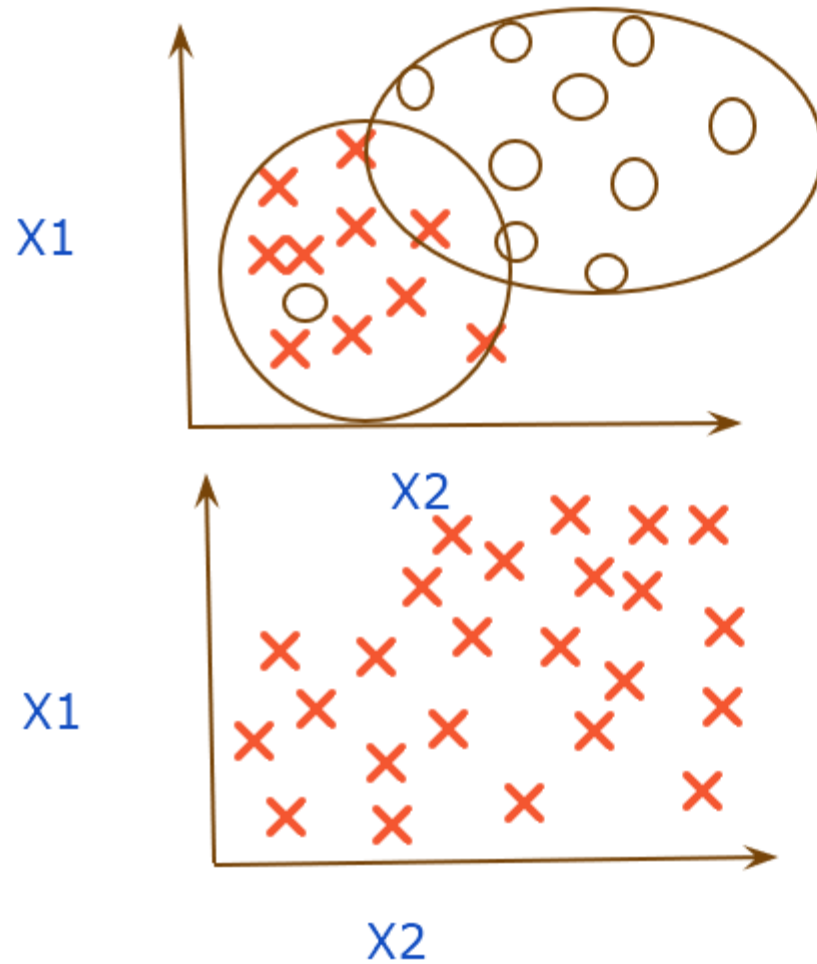


## Unsupervised learning

- unlabeled data/ No right answer
- do not need to supervise
- output variable: Y

Identify the patterns/structure

similarities /differences



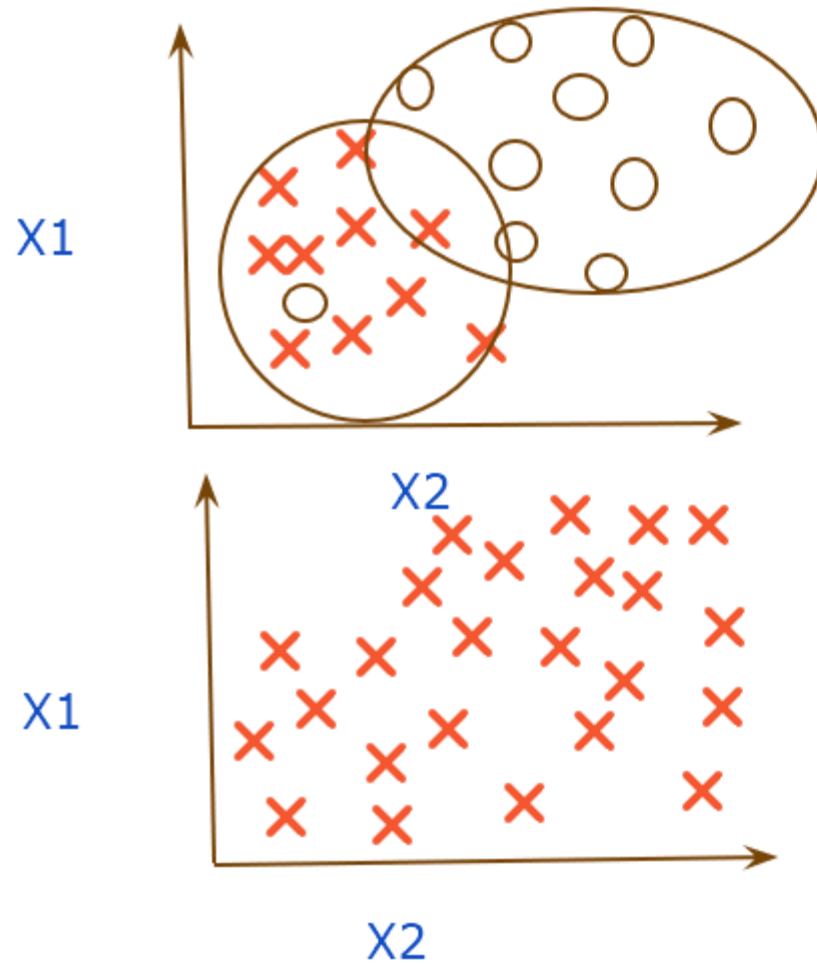
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Clustering



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Identify the patterns/structure

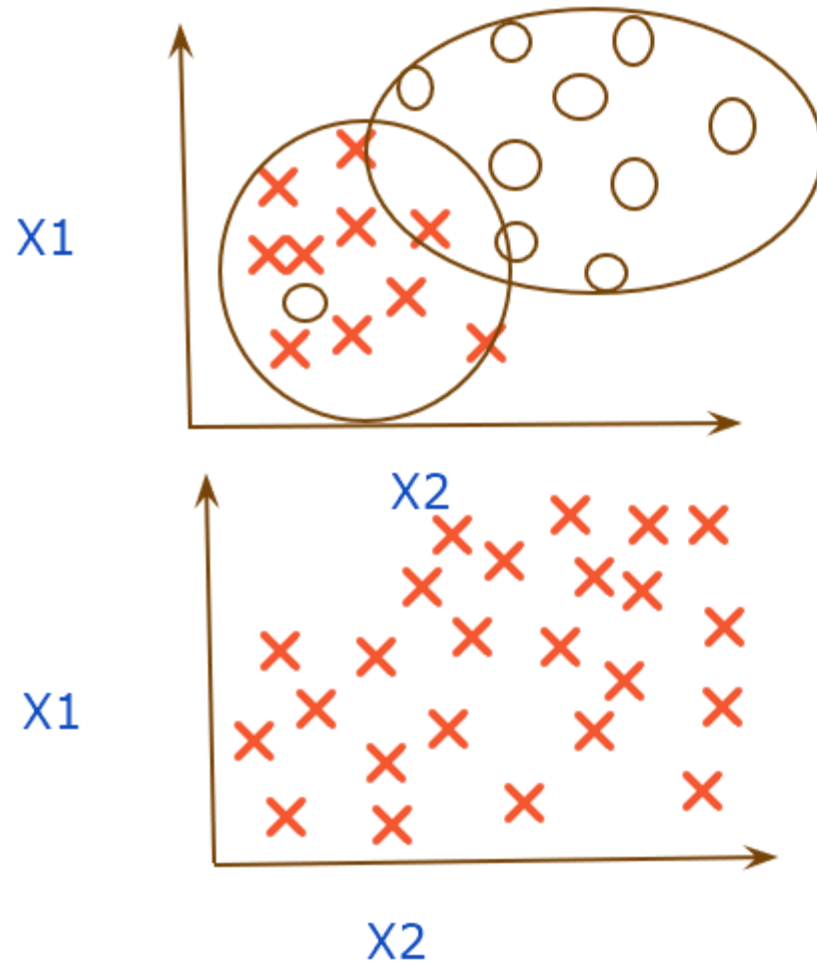
similarities /differences

Clustering

Dimensionality reduction

Used for preprocessing dataset

Recommender System



## Unsupervised learning

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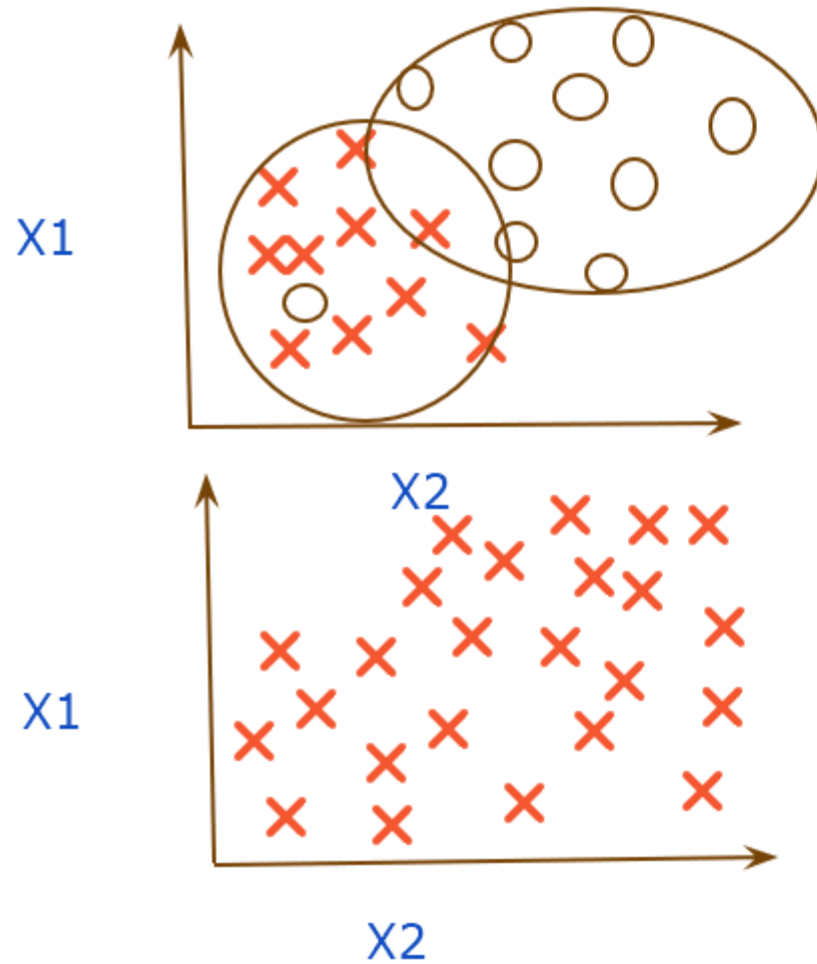
Clustering

Dimensionality reduction

Used for preprocessing dataset

Recommender System

$$Y = f(X)$$



Clustering: groups unlabeled data based on their similarity/difference

Association: Rule based method used to find the relationship between variables; Market Basket Analysis

Dimensionality Reduction: PCA

## Anomaly Detection



# Unsupervised learning applications

- **Customer segmentation**: understanding different customer groups to build marketing or other business strategies.
- **Genetics**: clustering DNA patterns to analyze evolutionary biology.
- **Recommender systems**: grouping together users with similar viewing patterns in order to recommend similar content.
- **Anomaly detection**: fraud detection or detecting defective mechanical parts (i.e., predictive maintenance).

# Reinforcement learning

left, right, straight, left, left, left, straight

GOOD

left, straight, straight, left, right, straight, straight

BAD

---

left, right, straight, left, left, left, straight

18.5

left, straight, straight, left, right, straight, straight

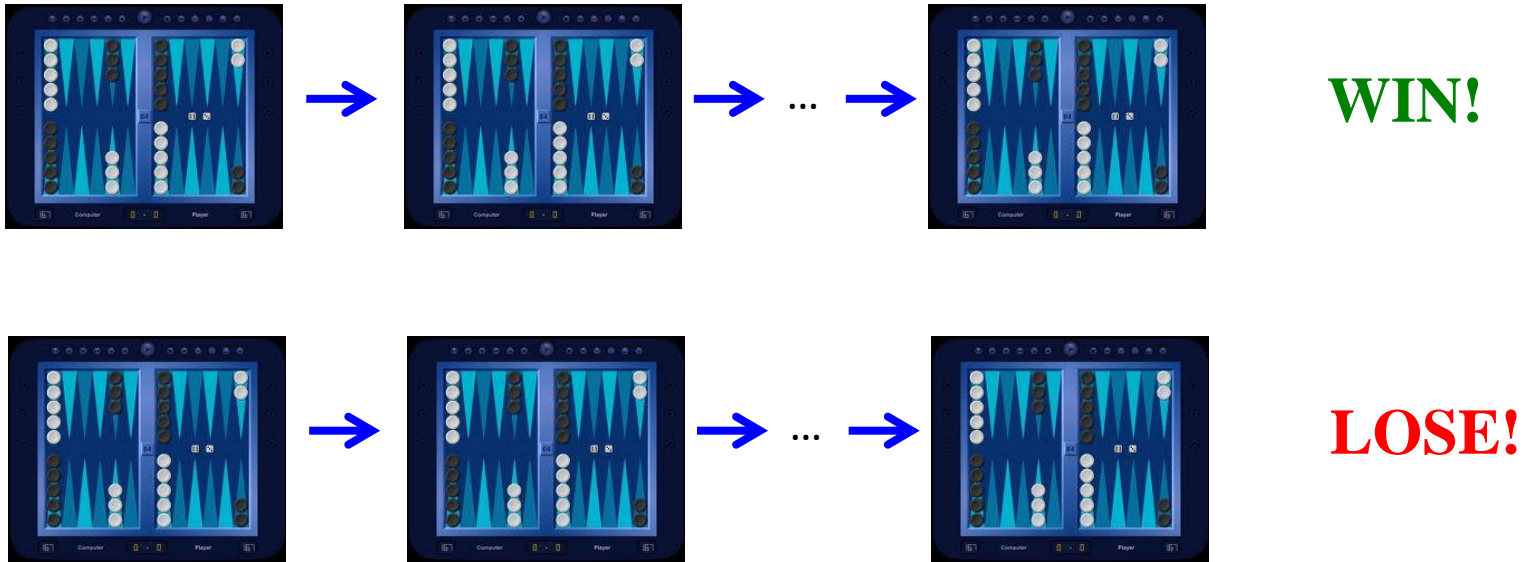
-3

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Given a *sequence* of examples/states and a *reward* after completing that sequence, learn to predict the action to take in for an individual example/state

# Reinforcement learning example

Backgammon



Given sequences of moves and whether or not the player won at the end, learn to make good moves

# Challenges in Machine Learning

- What algorithms can approximate functions well and when and how does the number of training examples influence accuracy
  - Problem representation/feature extraction
  - Intention/independent learning
  - Integrating learning with systems
- ☐ What are the theoretical limits of learnability
  - ☐ How can prior knowledge of learner help
  - ☐ What clues can we get from biological learning systems
  - ☐ How can systems alter their own representation