

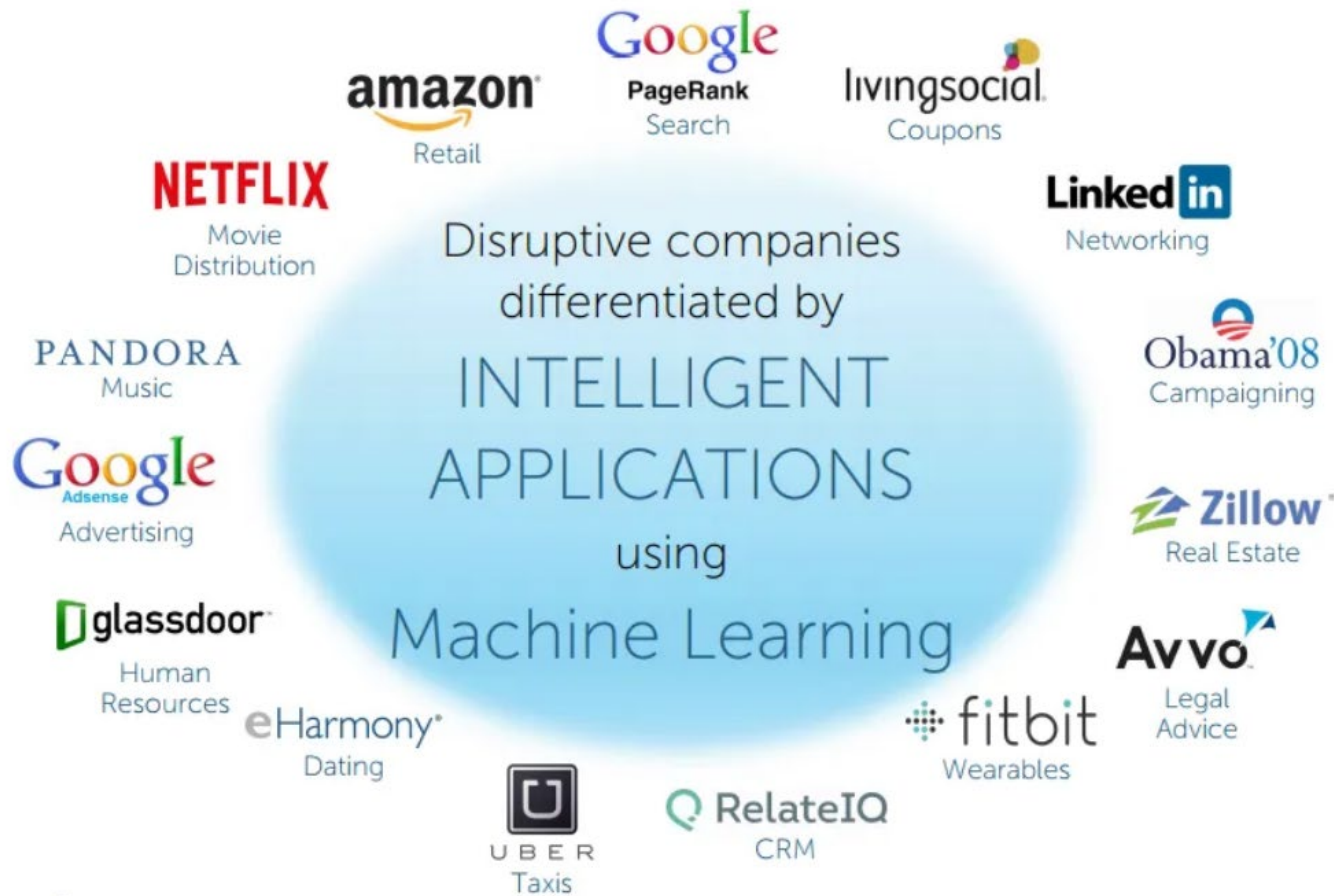
# Introduction to NN/ML

## What is machine learning

- Machine learning is programming computers to optimize a performance criterion using example data or past experience.

## 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)



# AI/Machine learning in daily life

- Virtual Personal Assistants
- Predictions while Commuting
- Videos Surveillance
- Social Media Services
- Email Spam and Malware Filtering
- Online Customer Support
- Search Engine Result Refining
- Matching ads with individual users
- Product Recommendations
- Online Fraud Detection

Essence: build a model that is a good and useful approximation to the data

- Data is cheap and abundant (data warehouses, data marts); knowledge is expensive and scarce.
- Learning general models from a data of particular examples
- Example in retail: Customer transactions to consumer behavior:  
People who bought “Da Vinci Code” also bought “The Five People You Meet in Heaven” ([www.amazon.com](http://www.amazon.com))

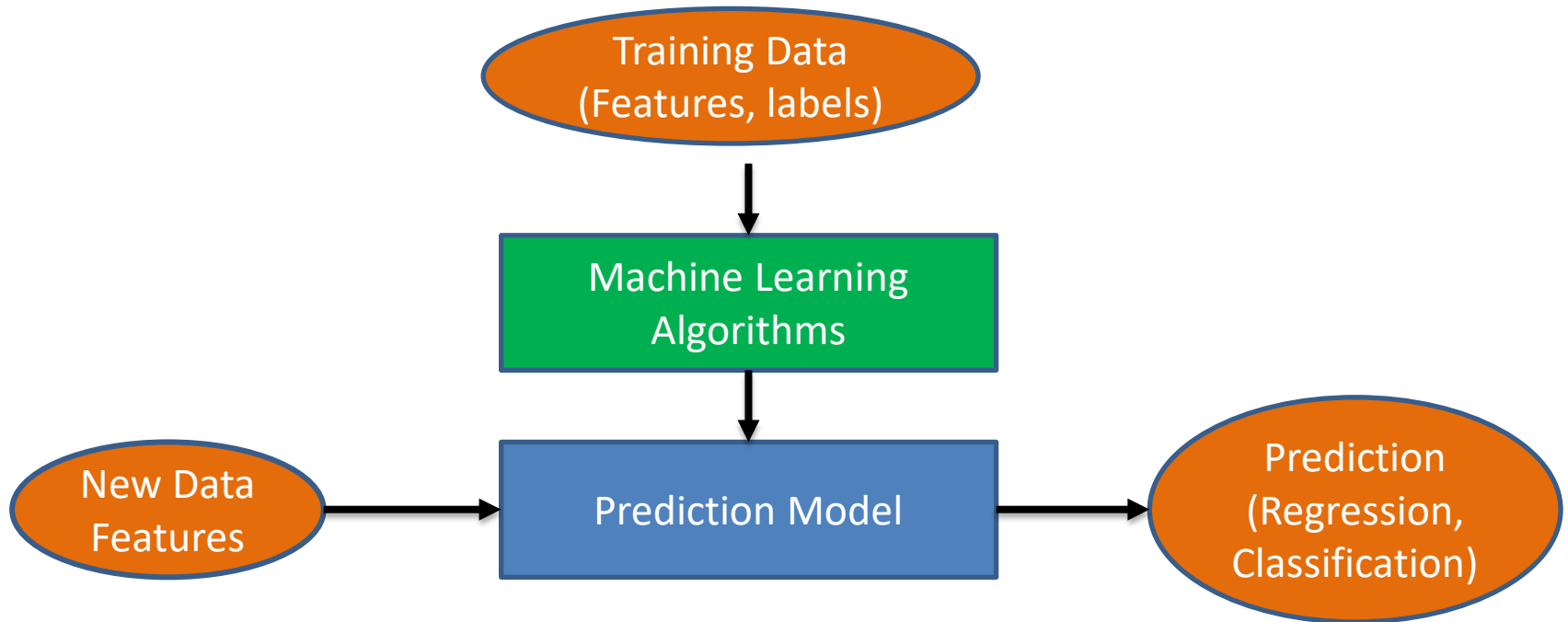
## How to build a machine learning model

- Optimize a performance criterion using example data or past experience.
- Role of Statistics: Inference from a sample
- Role of Computer science: Efficient algorithms to Solve the optimization problem
- Representing and evaluating the model for inference

## Major machine learning paradigms:

- Supervised Learning
  - Classification
  - Regression
- Unsupervised Learning
- Reinforcement Learning

# Supervised Learning – making predictions about future





# Example of supervised learning – face recognition

Training examples of a person



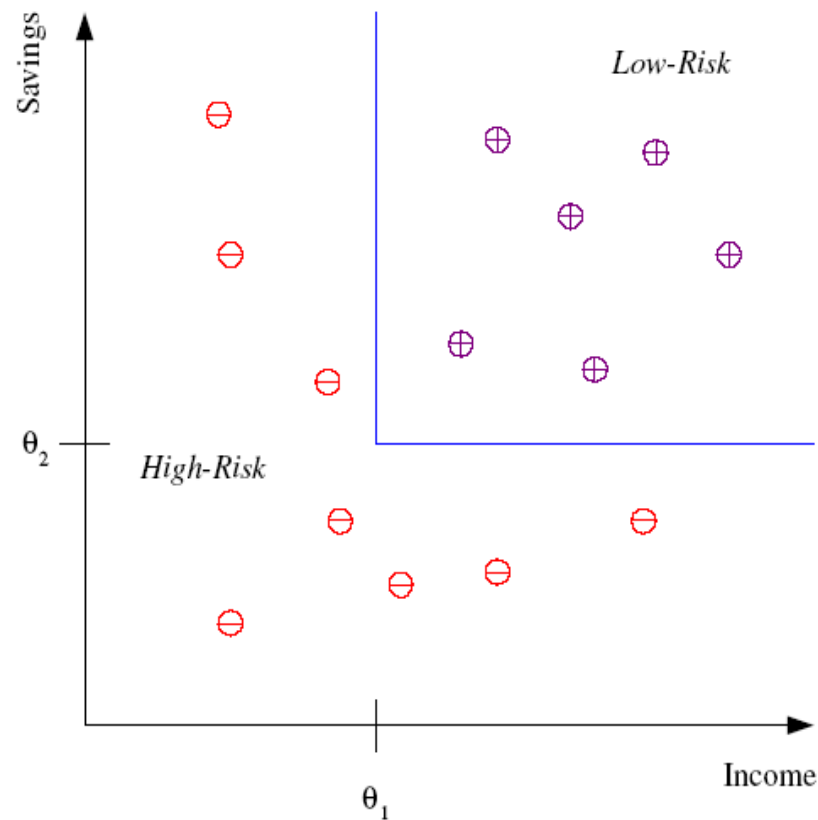
Test images



AT&T Laboratories, Cambridge UK  
<http://www.uk.research.att.com/facedatabase.html>

## Example of supervised learning – credit scoring

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



Discriminant: IF *income*  $> \theta_1$  AND *savings*  $> \theta_2$   
THEN **low-risk** ELSE **high-risk**

# Example of supervised learning – prediction of used car price (a regression problem)

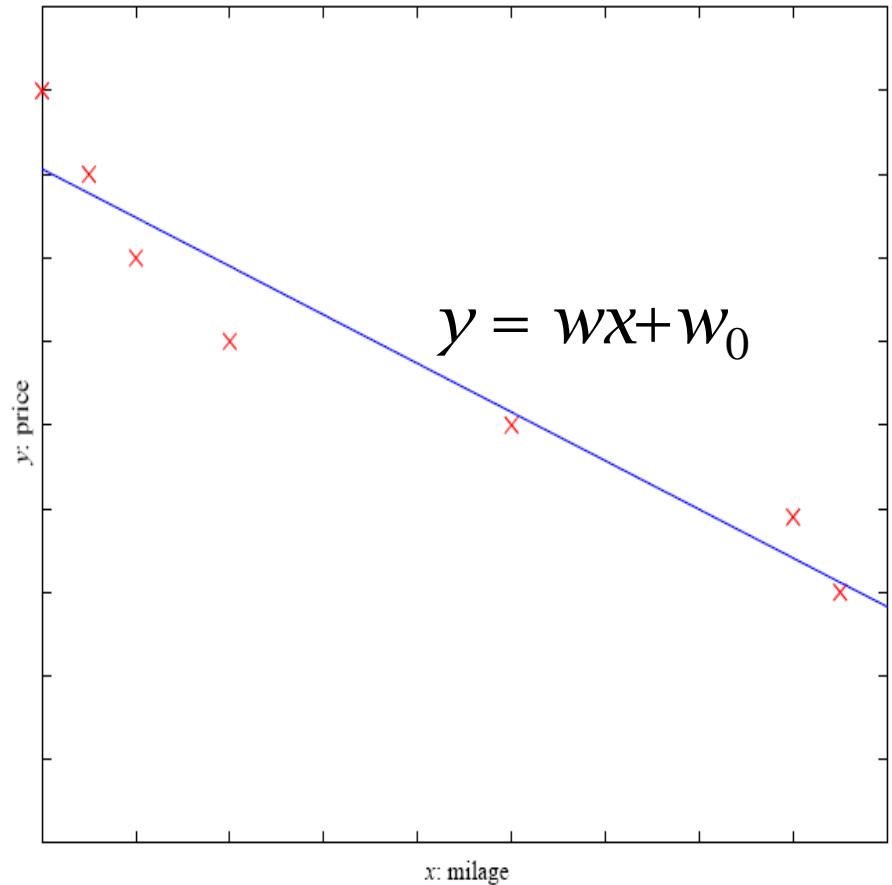
- $x$  : car attributes

$y$  : price

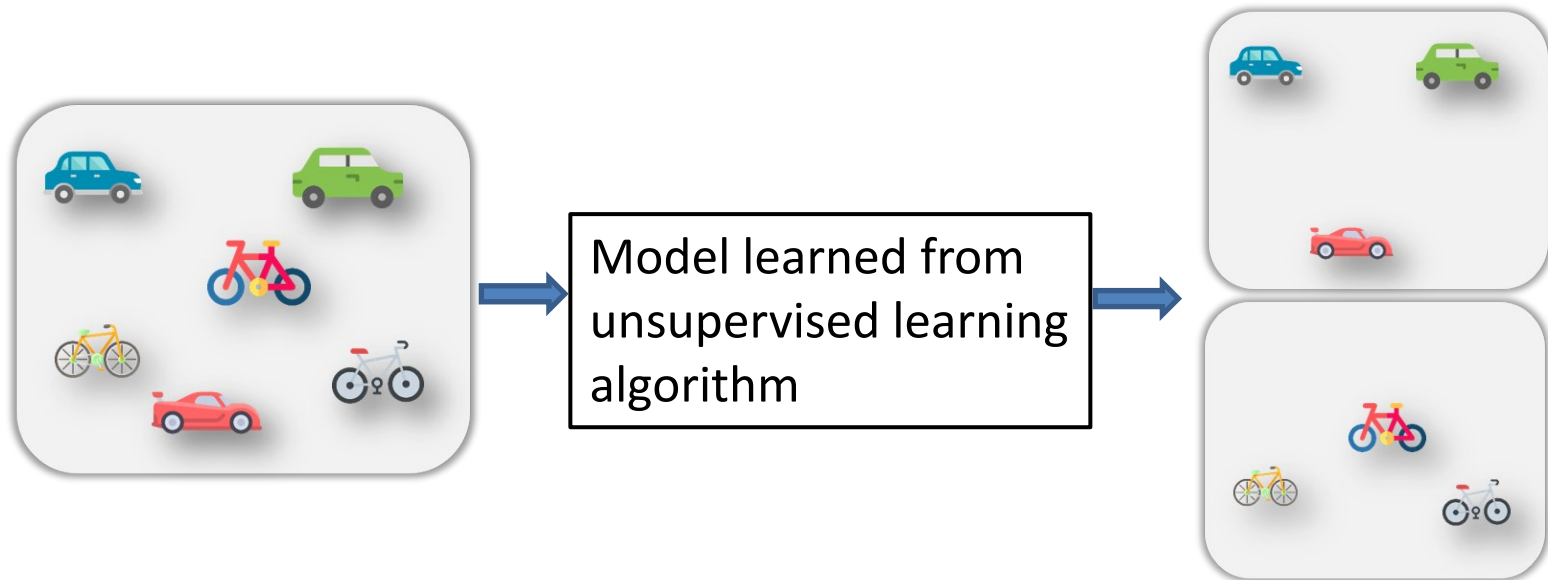
$$y = g(x \mid \vartheta)$$

$g$ : ( ) model,

$\vartheta$ : parameters



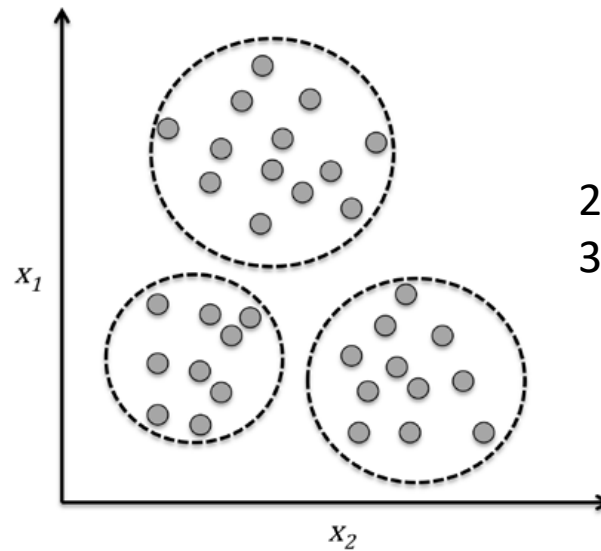
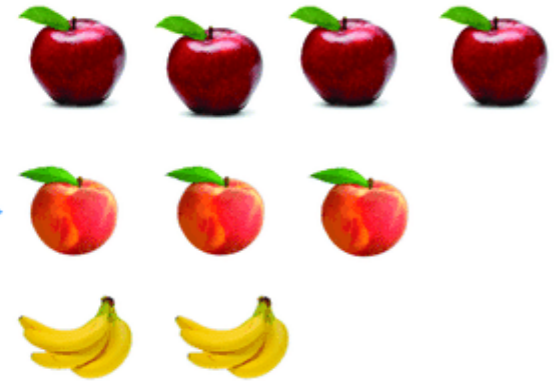
# Unsupervised Learning – discovering hidden structure in data



Input data



Model

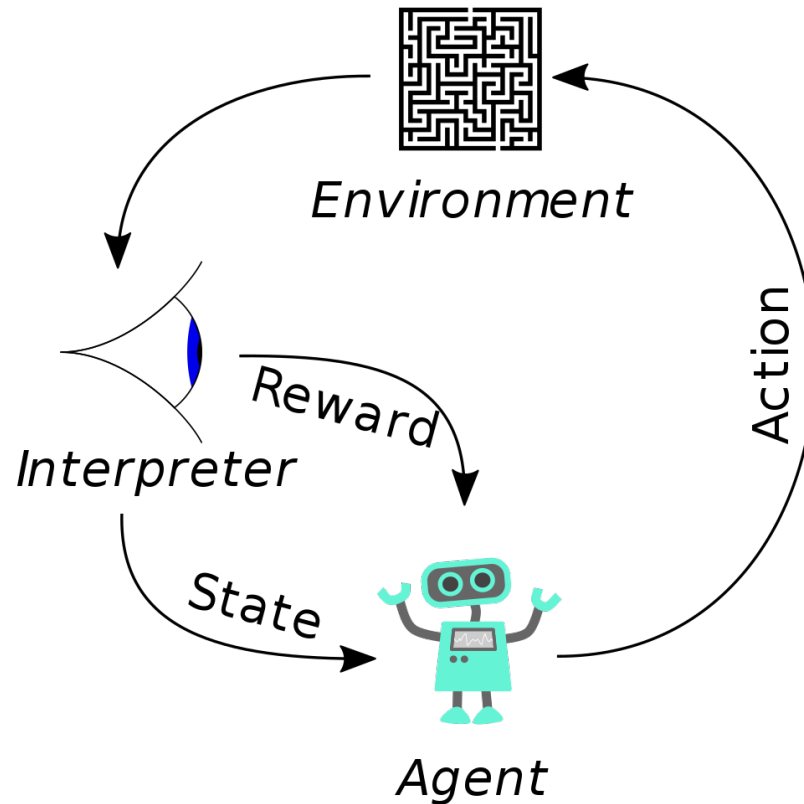


2 features  
3 clusters

# Unsupervised Learning

- No output or training data does not have labels
- Clustering: Grouping similar instances
- Other applications: Summarization, Association Analysis
- Example applications
  - Customer segmentation in CRM
  - Image compression: Color quantization
  - Bioinformatics: Learning motifs

# Reinforcement Learning – sequential decision making and control



# Reinforcement Learning

- Policy: what actions should an agent take in a particular state/situation
- Value estimation: how good is a state-action or credit assignment (what was responsible for the outcome)
- No supervised output but delayed reward
- Applications:
  - Game playing
  - Robotics
  - Real-time control of complex dynamic systems
  - Multiple agents, partial observability, ...



# Data Resources

- Kaggle.com
- Registry of Open Data on AWS: <https://registry.opendata.aws/> (from Cancer Genome, Covid-19, Japanese dictionaries, NASA Landat satellite dataset of earth, sea surface temperature, and many more ...)
- Wikipedia List of datasets for machine-learning research: [https://en.wikipedia.org/wiki/List\\_of\\_datasets\\_for\\_machine-learning\\_research](https://en.wikipedia.org/wiki/List_of_datasets_for_machine-learning_research) (from image, text, sound, to biological data...)
- Microsoft Azure Open Datasets: <https://azure.microsoft.com/en-us/services/open-datasets/#overview>
- Google public data: <https://www.google.com/publicdata/directory>
- ILSVRC (ImageNet large scale visual recognition challenge)
- UCI Repository: <http://www.ics.uci.edu/~mlearn/MLRepository.html>
- UCI KDD Archive: <http://kdd.ics.uci.edu/summary.data.application.html>
- Statlib: <http://lib.stat.cmu.edu/>
- Delve: <http://www.cs.utoronto.ca/~delve/>
- TIMIT (ASR) and MNIST (image classification)

# Open Resources

- GitHub
- TensorFlow
- PyTorch
- Scikit-learn
- Keras
- MuJoCo, ROS
- OpenAI Gym
- ...

# Publication Venues

- arXiv
- Journal of Machine Learning Research [www.jmlr.org](http://www.jmlr.org)
- Machine Learning
- IEEE Transactions on Neural Networks & Learning Systems
- IEEE Transactions on Pattern Analysis and Machine Intelligence
- Annals of Statistics
- Journal of the American Statistical Association
- ...

# Conferences

- International Conference on Machine Learning (ICML)
- European Conference on Machine Learning (ECML)
- Neural Information Processing Systems (NIPS)
- International Joint Conference on Neural Networks (IJCNN)
- International Joint Conference on Artificial Intelligence (IJCAI)
- AAAI
- ICRA
- IROS
- ...