

ECE 469/ECE 568 Machine Learning

Textbook:

Machine Learning: a Probabilistic Perspective by Kevin Patrick Murphy

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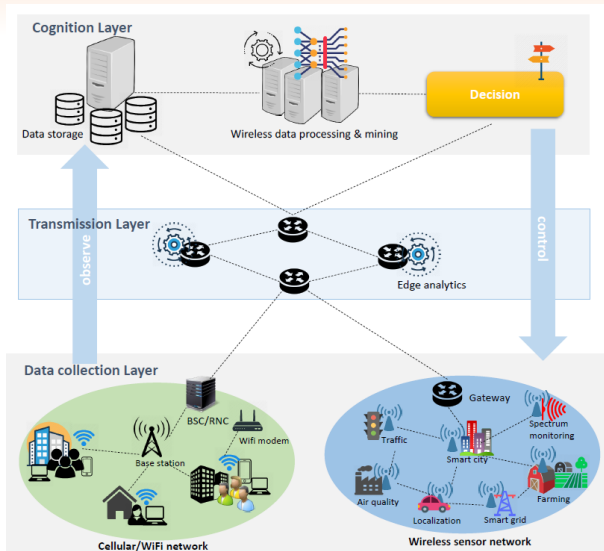
Lecture 01 - Introduction

- Big Data
- Data Mining
- Machine Learning
- Difference between Data Mining and Machine Learning
- Distinguishing Deep Learning, Machine Learning and AI
- Definitions of Machine Learning
- Types of machine learning
- Overview of applications

Big Data

- In this era, data are being collected and stored at an unprecedented rate.
- This happens in almost everywhere during 24 by 7.
 - Phone call records
 - Video streaming sites, social media sites, E-marketing, news sites, and video gaming sites
 - Speech recognition results
 - Transportation data, maps and satellite data
 - Credit cards transactions and online purchases.

Big Data



Source: A survey on Machine Learning-based Performance Improvement of Wireless Networks: PHY, MAC and network layer by Merima Kulin et. al.

An architecture for big data analysis in wireless communications

Big Data

- What is the purpose of collecting this much of data?
- Big data is too much to search manually!
- Nevertheless, valuable/important information is embedded within big data.
- One can use it for fun, profit, and/or the greater good!
- What are the key tools that one can use to make sense of large data-sets?
 - Data mining
 - Machine learning

Big Data Mining

- Basically, data mining is the process of automatically extracting useful information from large data sets.
- Typically, the useful information that is extracted from data mining is used for human decision making.

Data Mining

Data mining is used on an existing data set to find patterns.

Machine Learning

- One can use a computing device or computer to automatically detect patterns in big data.
- These patterns can then be used to make predictions or decisions.
- For example, patterns detected from big data can be used to
 - automate tasks that typically carried out by humans
 - accomplish tasks that humans cannot perform

Machine Learning

- More specifically, machine learning is at the core of
 - comprehending high level cognition
 - conducting knowledge intensive inferences
 - designing adaptive, intelligent systems
 - working with complicated real world data
 - predictive analytics

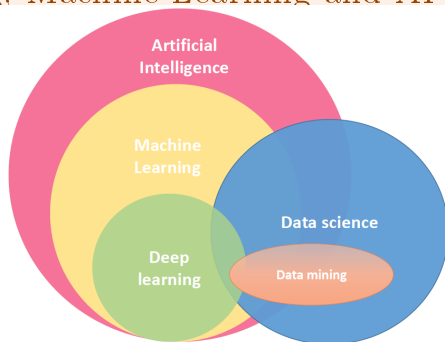
Machine Learning

Machine learning is trained on a "training" data set, which instructs a computer on how to make sense of data, and then to make predictions about new data sets.

Machine Learning

- Main purposes of machine learning includes:
 - Acquisition of knowledge and facts
 - Ensuring robust behavior through integration of various knowledge sources
 - Human and system adaptation
 - Decision making through predictions

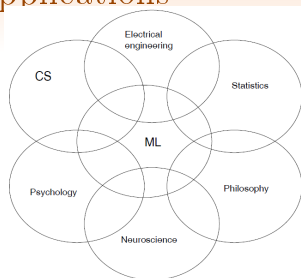
Deep Learning, Machine Learning and AI



Source: A survey on Machine Learning-based Performance Improvement of Wireless Networks: PHY, MAC and network layer by Marima Kuln et. al.

- Artificial intelligence is the simulation of human intelligence processes by machines, especially computer systems.
- Machine learning is a subset of AI.
- Deep learning can be viewed as a subset of machine learning.
- Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction.

Machine learning applications



Top ML applications:

- Social Media
- Traffic Alerts, Transportation and Commuting
- Products Recommendations
- Virtual Personal Assistants
- Self Driving Cars
- Dynamic Pricing
- Google Translate

Definitions of ML

- What is machine learning? There are multiple definitions.
- The following definition was given by Tom Mitchell in 1998.

A 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 .

- Consider learning how to better filter spam emails.
- Can you identify T , E and P ?

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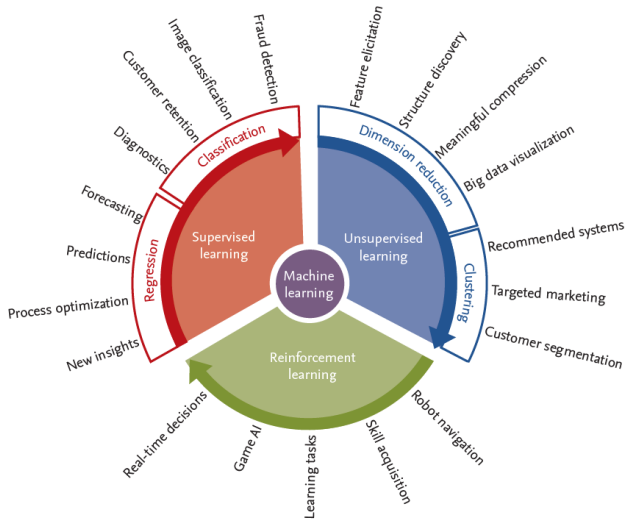
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- Consider learning how to better filter spam emails.
- Can you identify T , E and P ?
 - T = Classifying emails as spam or legitimate (not spam)
 - E = Observing the process of labeling spam or legitimate
 - P = The number of correct classification of spams

Types of Machine Learning

- Supervised Learning - Predict output from input
- Unsupervised Learning - Find patterns in data
- Reinforcement Learning - Learn how to behave in novel environments
- Deep Learning - Part of a broader family of machine learning methods based on artificial neural networks having many layers via representation learning. Learning can be supervised, unsupervised, or reinforcement.

Types of Machine Learning

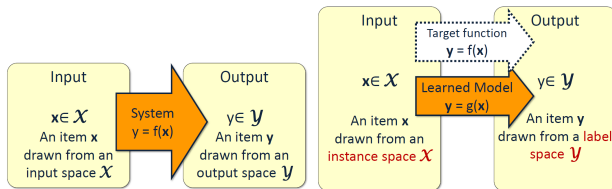


Source: Application of machine learning in rheumatic disease research by Ki-Jo Kim et. al. (<https://doi.org/10.3904/kjim.2018.349>)

Types of Machine Learning - Supervised Learning

Supervised Learning

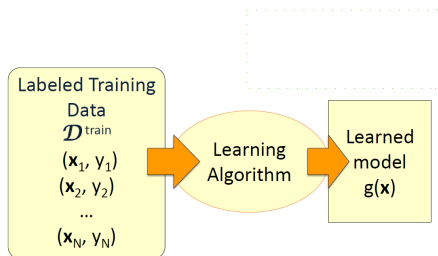
In the predictive or supervised learning approach, the goal is to learn a mapping from inputs x to outputs y , given a labeled set of input-output pairs $\mathcal{D} = \{(x_i, y_i)\}_{i=1}^N$. Here \mathcal{D} is called the training set, and N is the number of training examples.



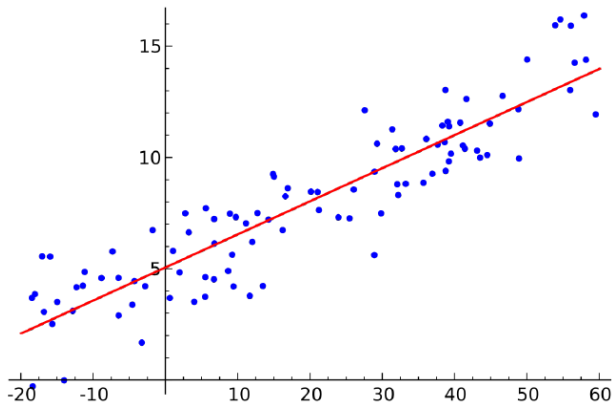
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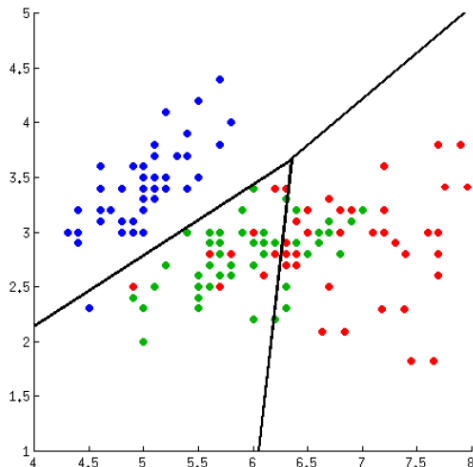


Supervised Learning - Linear regression



Source: A survey on Machine Learning-based Performance Improvement of Wireless Networks: PHY, MAC and network layer by Merima Kulin et. al.

Supervised Learning - Logistic regression or classification



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