Introduction to Machine Learning

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Chapter One: Introduction to Machine Learning

1. Introduction to Machine Learning

- We will learn about
  - State of the art
  - How to do the implementation
- Applications of machine learning include
  - Search
  - Photo tagging
  - Spam filters
- The AI dream of building machines as intelligent as humans
  - Many people believe best way to do that is mimic how humans learn
  - ML is : A branch of **artificial intelligence**, concerned with the design and development of algorithms that allow computers to evolve behaviors based on empirical data.
- Why is ML so prevalent?
  - Grew out of AI
  - Build intelligent machines
    - You can program a machine how to do some simple thing
      - For the most part hard-wiring AI is too difficult
    - Best way to do it is to have some way for machines to learn things themselves
      - A mechanism for learning - if a machine can learn from input then it does the hard work for you

Examples

1. Database mining

a. Machine learning has recently become so big party because of the huge amount of data being generated
b. Large datasets from growth of automation web
c. Sources of data include
   i. Web data (click-stream or click through data)
      1. Mine to understand users better
      2. Huge segment of silicon valley
   ii. Medical records
      1. Electronic records -> turn records in knowledges
   iii. Biological data
      1. Gene sequences, ML algorithms give a better understanding of human genome
   iv. Engineering info
      1. Data from sensors, log reports, photos etc

2. Applications that we cannot program by hand

a. Autonomous helicopter
b. Handwriting recognition
   i. This is very inexpensive because when you write an envelope, algorithms can automatically route envelopes through the post
c. Natural language processing (NLP)
   i. AI pertaining to language
d. Computer vision
   i. AI pertaining vision

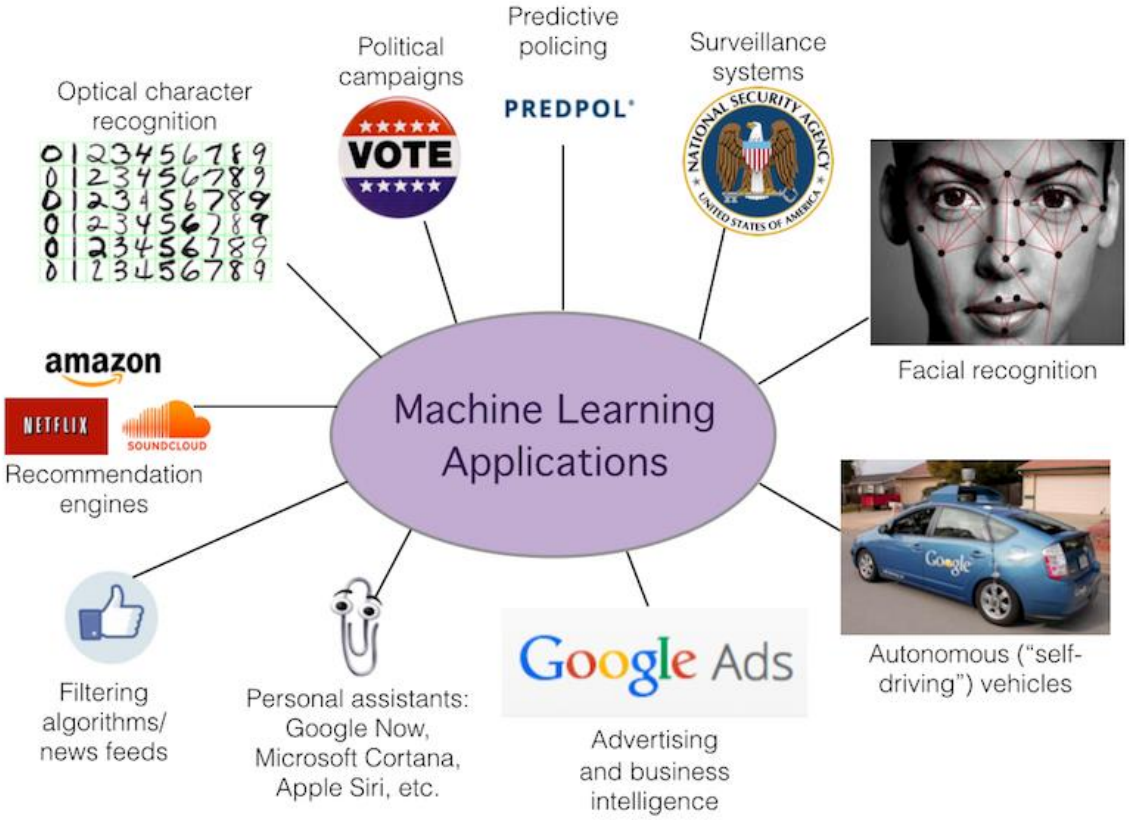

Figure 1 Machine Learning Application

3. *Self customizing programs (Learn based on your behaviour)*

a. Netflix
b. Amazon
c. iTunes genius
d. Take users info

4. *Understand human learning and the brain*

a. If we can build systems that mimic (or try to mimic) how the brain works, this may push our own understanding of the associated neurobiology

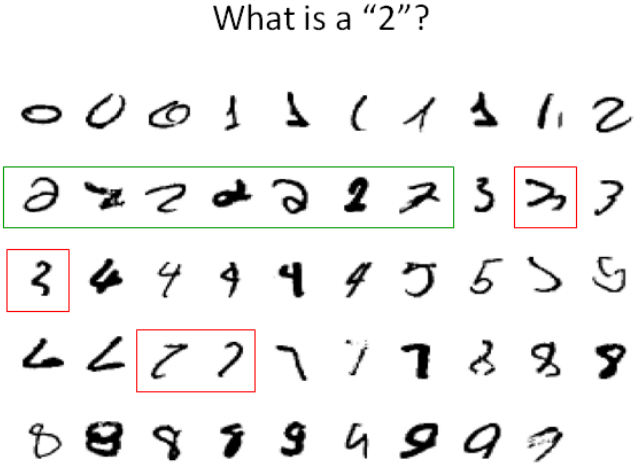

Figure 2 How to recognize a "2" digit?

2. What is machine learning?

1. Definition

- Arthur Samuel (1959)
  - **Machine learning: "Field of study that gives computers the ability to learn without being explicitly programmed"**
    - Samuels wrote a checkers playing program
      - Had the program play 10000 games against itself
      - Work out which board positions were good and bad depending on wins/losses
- Tom Michel (1999)
  - **Well posed learning problem: "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E."**
    - The checkers example,
      - E = 10000s games
      - T is playing checkers
      - P if you win or not
  - The complexity in traditional computer programming is in the code (programs that people write). In machine learning, algorithms (programs) are in principle simple and the complexity (structure) is in the data. Is there a way that we can automatically learn that structure? That is what is at the heart of machine learning. -- @ **Andrew Ng**
    - That is, machine learning is the about the construction and study of systems that can learn from data. This is very different than traditional computer programming.

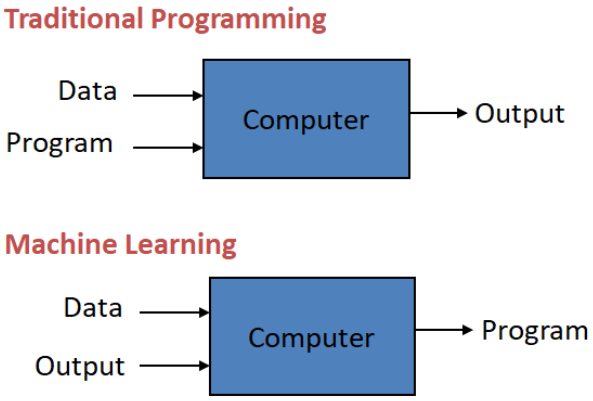

Figure 3 Programming VS. Machine Learning

2. Types of Learning Algorithms

-
- Several types of learning algorithms
  - **Supervised learning**
    - Teach the computer how to do something, then let it use it;s new found knowledge to do it
  - **Unsupervised learning**
    - Let the computer learn how to do something, and use this to determine structure and patterns in data
  - Reinforcement learning
  - Recommender systems

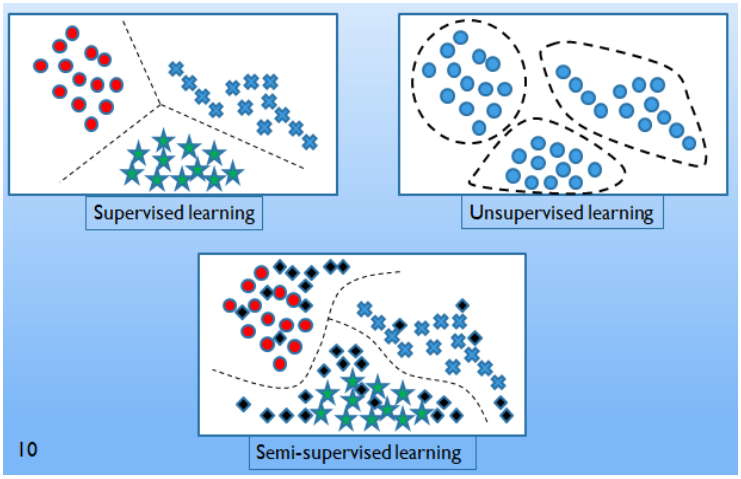

Figure 4 Machine Learning algorithms types

3. Supervised learning - introduction

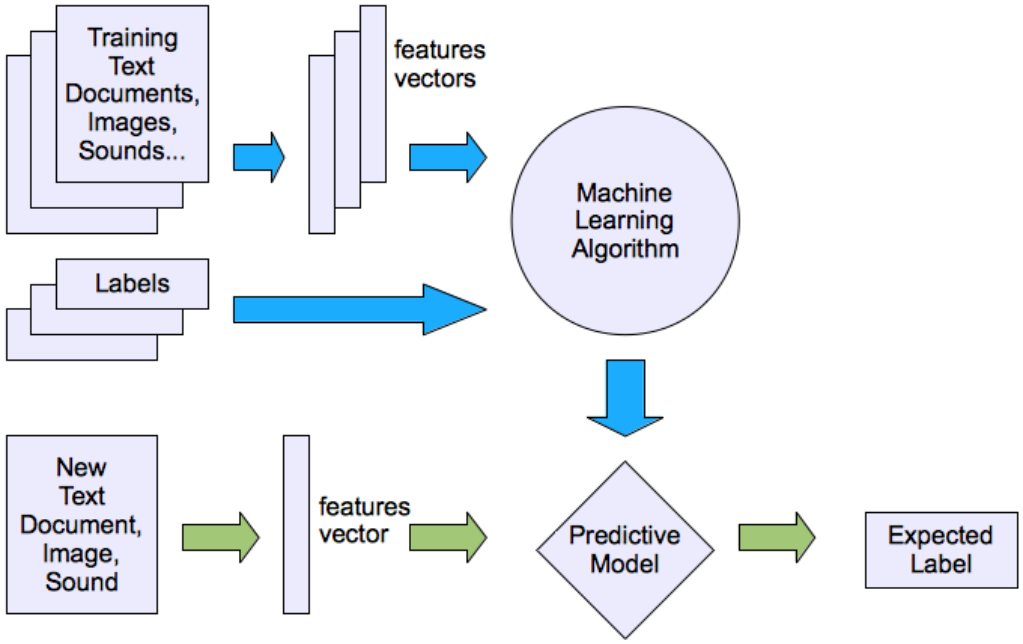

Figure 5 Supervised Learning

- Probably the most common problem type in machine learning

Example

- How do we predict housing prices
  - Collect data regarding housing prices and how they relate to size in feet

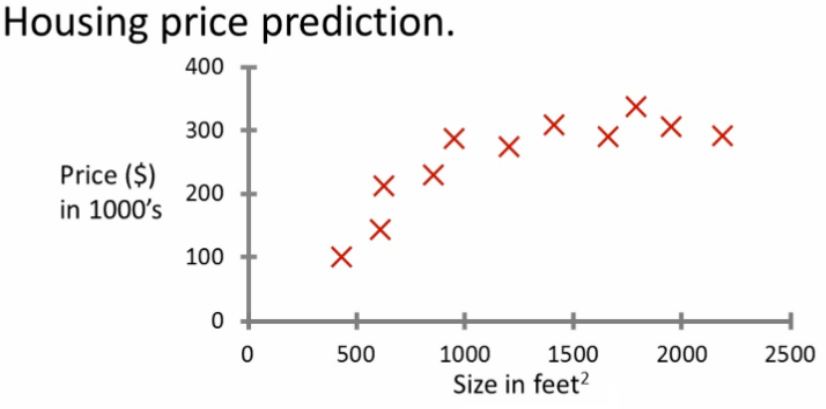

Figure 6 Housing price prediction

Example problem

- "Given this data, a friend has a house 750 square feet - how much can they be expected to get?"

What approaches can we use to solve this?

- Straight line through data
  - Maybe $150 000
- Second order polynomial
  - Maybe $200 000
- One thing we discuss later - how to chose straight or curved line?
- Each of these approaches represent a way of doing supervised learning

What does this mean?

- We gave the algorithm a data set where a "right answer" was provided
- So we know actual prices for houses
  - The idea is we can learn what makes the price a certain value from the **training data**
  - The algorithm should then produce more right answers based on new training data where we don't know the price already
    - i.e. predict the price

We also call this a regression problem

- Predict continuous valued output (price)
- No real discrete delineation

Another example

- Can we definer breast cancer as malignant or benign based on tumour size

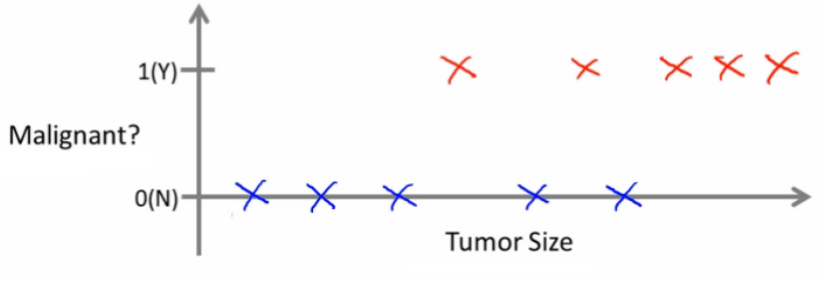

Figure 7 Tumor size - Malignant relationship

- Looking at data
  - Five of each
  - Can you estimate prognosis based on tumor size?
  - This is an example of a **classification problem**
    - Classify data into one of two discrete classes - no in between, either malignant or not
    - In classification problems, can have a discrete number of possible values for the output
      - e.g. maybe have four values
        - 0 - benign
        - 1 - type 1
        - 2 - type 2
        - 3 - type 4
- In classification problems we can plot data in a different way

Figure 8 Tumor size

- Use only one attribute (size)
  - In other problems may have multiple attributes
  - We may also, for example, know age and tumor size

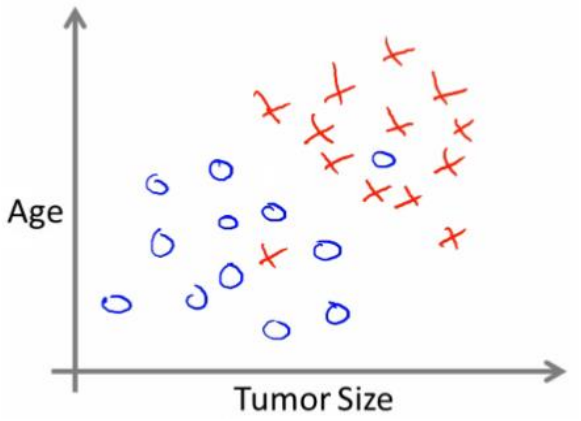

Figure 9 Tumor size and age relationship

- Based on that data, you can try and define separate classes by
  - Drawing a straight line between the two groups
  - Using a more complex function to define the two groups (which we'll discuss later)
  - Then, when you have an individual with a specific tumor size and who is a specific age, you can hopefully use that information to place them into one of your classes
- You might have many features to consider
  - Clump thickness
  - Uniformity of cell size
  - Uniformity of cell shape
- The most exciting algorithms can deal with an infinite number of features
  - How do you deal with an infinite number of features?
  - Neat mathematical trick in support vector machine (which we discuss later)
    - If you have an infinitely long list - we can develop and algorithm to deal with that
- **Summary**
  - Supervised learning lets you get the "right" data.
  - Regression problem
  - Classification problem

4. Unsupervised learning - introduction

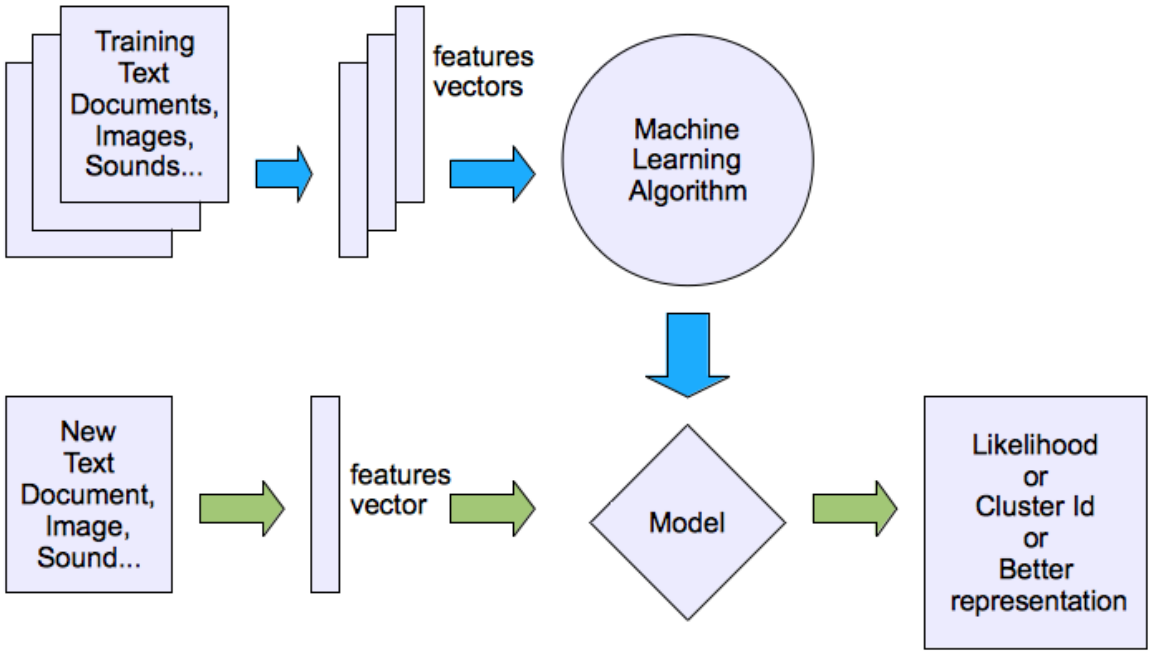

Figure 10 Unsupervised Learning

- Second major problem type
- In unsupervised learning, we get unlabeled data
  - Just told - here is a data set, can you structure it
- One way of doing this would be to cluster data into to groups
  - This is a **clustering algorithm**

Clustering algorithm

- Example of clustering algorithm
  - Google news
    - Groups news stories into cohesive groups
  - Used in any other problems as well
    - Genomics
    - Microarray data
      - Have a group of individuals
      - On each measure expression of a gene
        - Run algorithm to cluster individuals into types of people

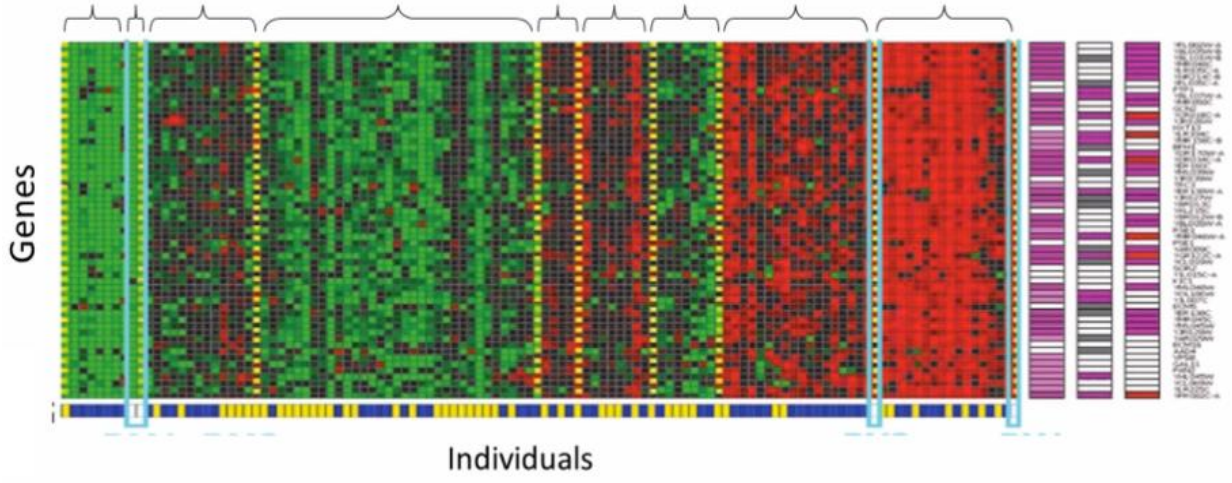

Figure 11 Gene Expression of different individuals

    - Organize computer clusters
      - Identify potential weak spots or distribute workload effectively
    - Social network analysis
      - Customer data
    - Astronomical data analysis
      - Algorithms give amazing results
- Basically
  - Can you automatically generate structure
  - Because we don't give it the answer, it's unsupervised learning

Cocktail party algorithm

- Cocktail party problem
  - Lots of overlapping voices - hard to hear what everyone is saying
    - Two people talking
    - Microphones at different distances from speakers

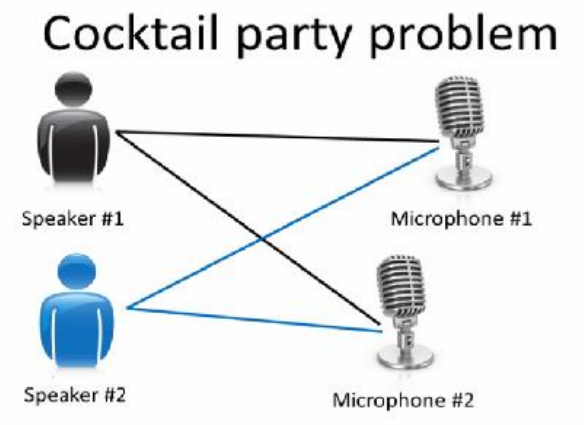

Figure 12 How to tell who is speaking what?

- Record sightly different versions of the conversation depending on where your microphone is
  - But overlapping none the less
- Have recordings of the conversation from each microphone
  - Give them to a cocktail party algorithm
  - Algorithm processes audio recordings
    - Determines there are two audio sources
    - Separates out the two sources

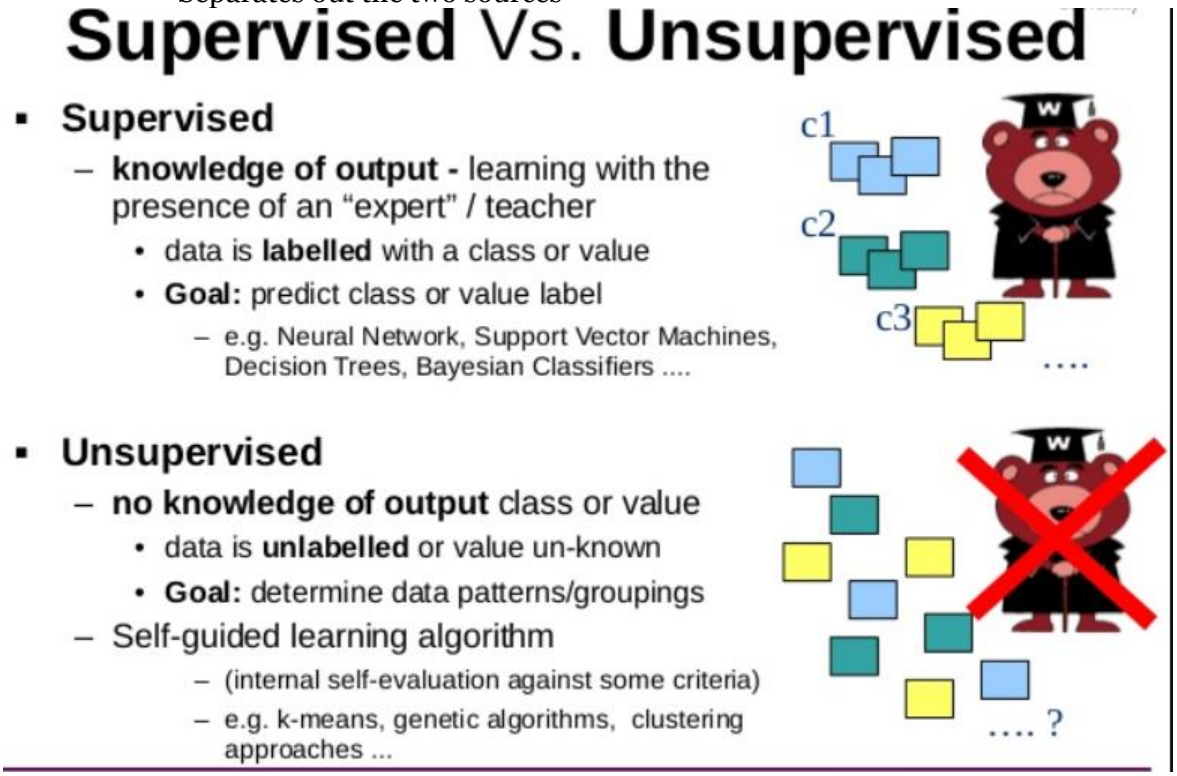

Figure 13 Supervised VS Unsupervised Learning

5. Acknowledgement

These lectures were selected from different online and textbook resources and are not belong to one resource. Aim of such action was to demonstrate ML algorithm as simple as possible to undergraduate student readers - computer science department. I would like to thank every free online source for such great distribution of science.

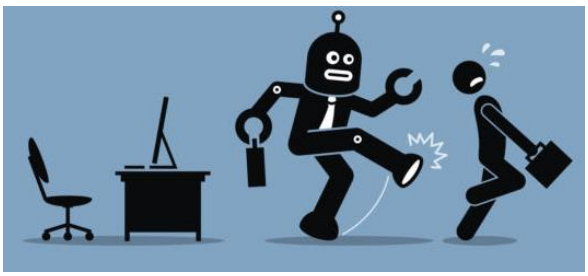

Figure 14 No More Human Is Needed :-)

6. References:

1- Stanford Machine Learning website, http://www.holehouse.org/mlclass/index.html
2- Udacity course (Intro to Machine Learning), https://www.udacity.com/course/intro-to-machine-learning--ud120