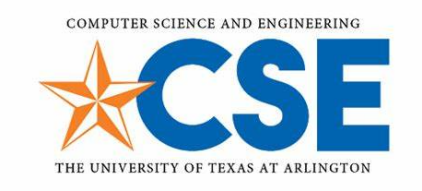

Introduction on Machine Learning

University of Texas at Arlington

Author: Farnaz Farahanipad

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What is Machine Learning?

Arthur Samuel described it as: ”the field of study that gives computers the ability to learn without being explicitly programmed.” This is an older, informal definition.

What is Machine Learning?

Tom Mitchell provides a more modern definition: ”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.“

- Example: playing checkers.
  - E = the experience of playing many games of checkers
  - T = the task of playing checkers.
  - P = the probability that the program will win the next game.

What is Machine Learning? Question

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

- Classifying emails as spam or not spam.
- Watching you label emails as spam or not spam.
- The number (or fraction) of emails correctly classified as spam/not spam.

AI VS. ML VS. DL

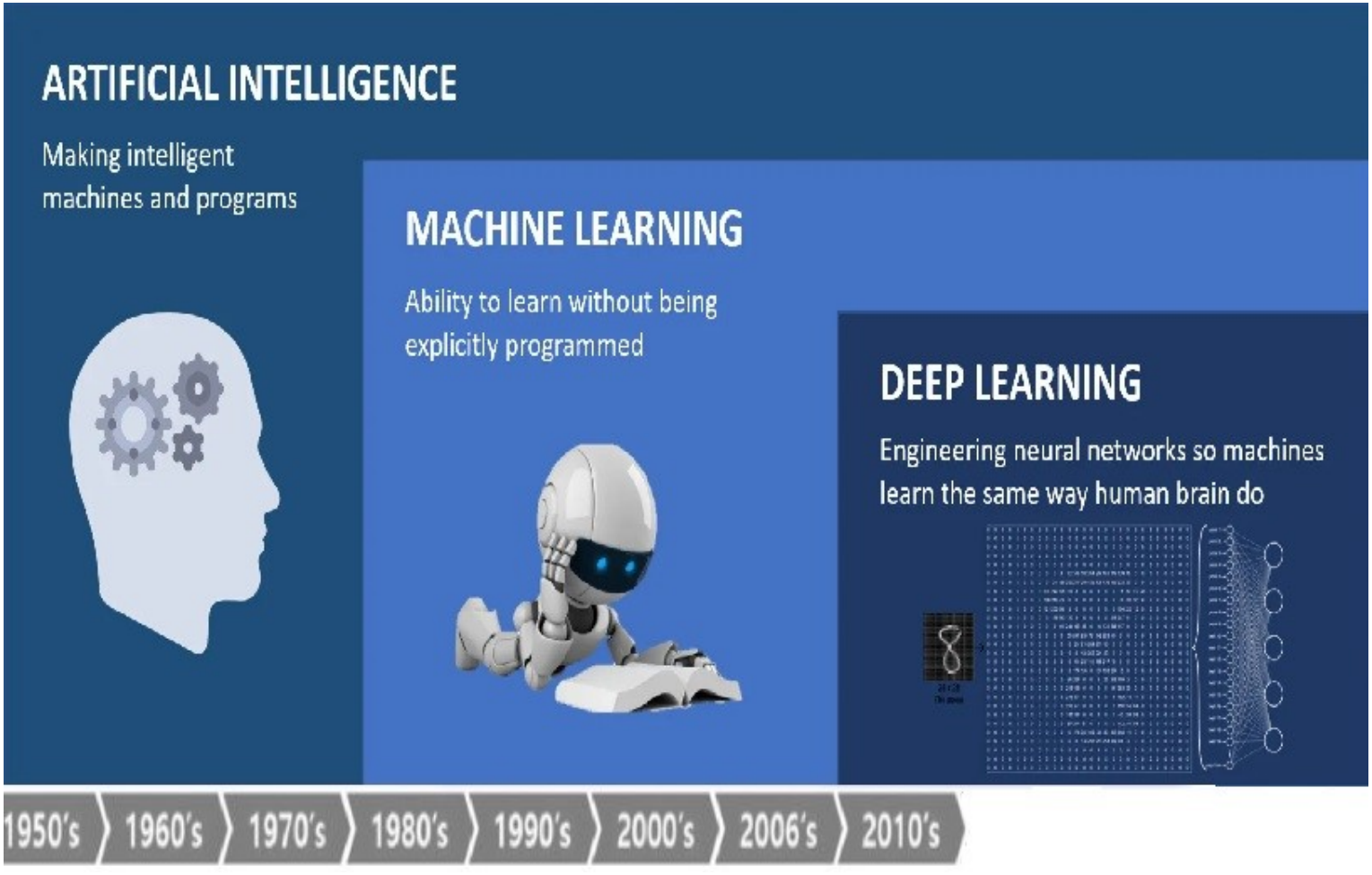


Figure 1: Releation of AI, ML and DL

Application of ML

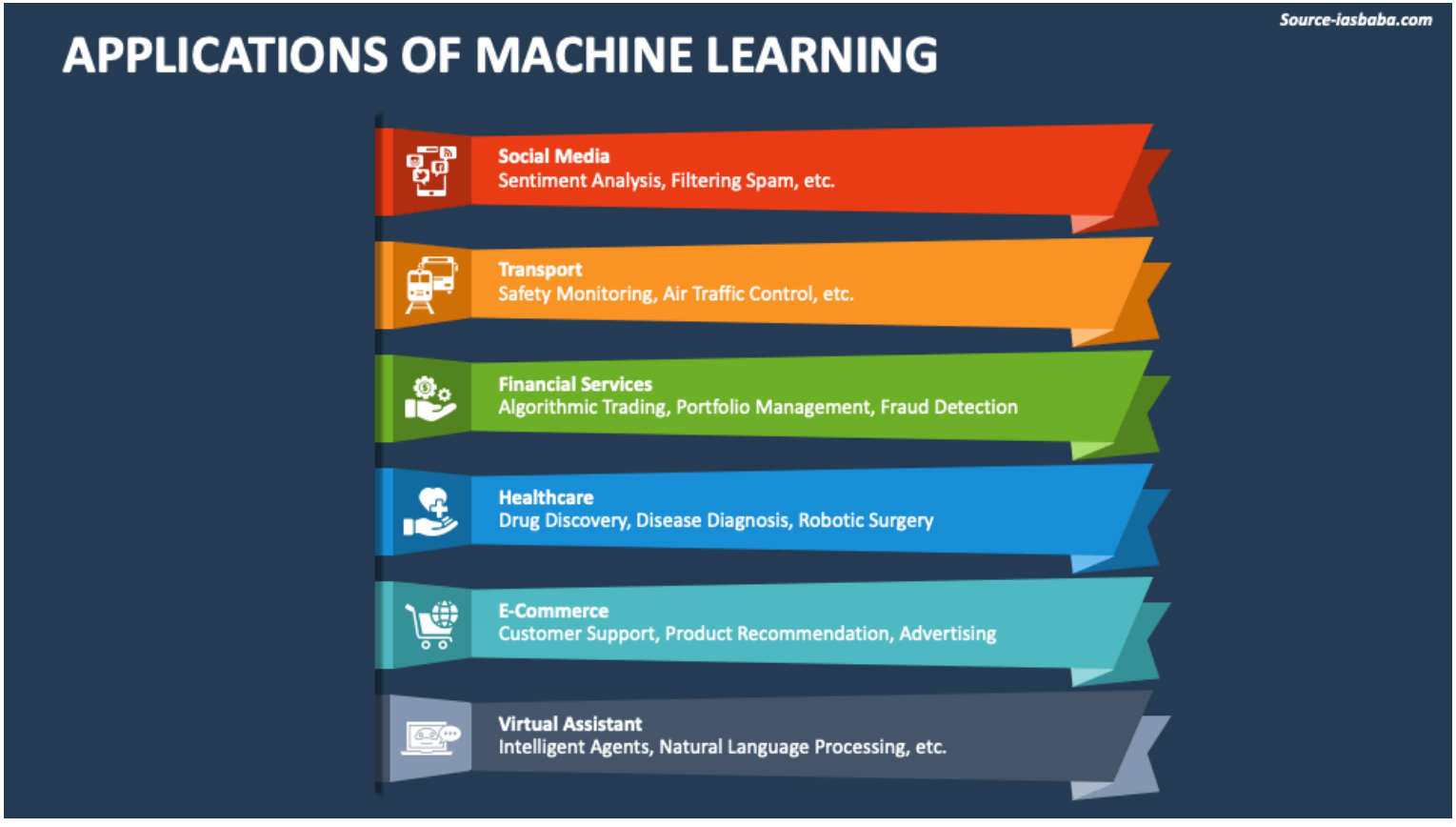


Figure 2: Application of ML

ML's Successes

- **Vision**: Identify faces/ objects in a video or image, etc.
- **Natural language**: Translate a sentence from Hindi to English, question answering, identify sentiment of text, etc.
- **Speech**: Recognize spoken words, speaking sentences naturally
- **Game playing**: Play games like chess.
- **Robotics**: Walking, jumping, displaying emotions, etc.
- **Driving a car**, **navigating a maze**, etc

Why Machine Learning?

- Automation of complex tasks: Tasks that are hard to explicitly program (e.g., speech recognition, language translation).
- Handling large datasets: ML algorithms can process and analyze massive datasets quickly, helping in data-driven decision making.
- Human Expertise does not exist.

The essence of machine learning

- A pattern exist.
- We donot know it mathematically.
- We have data on it.

Types of Learning

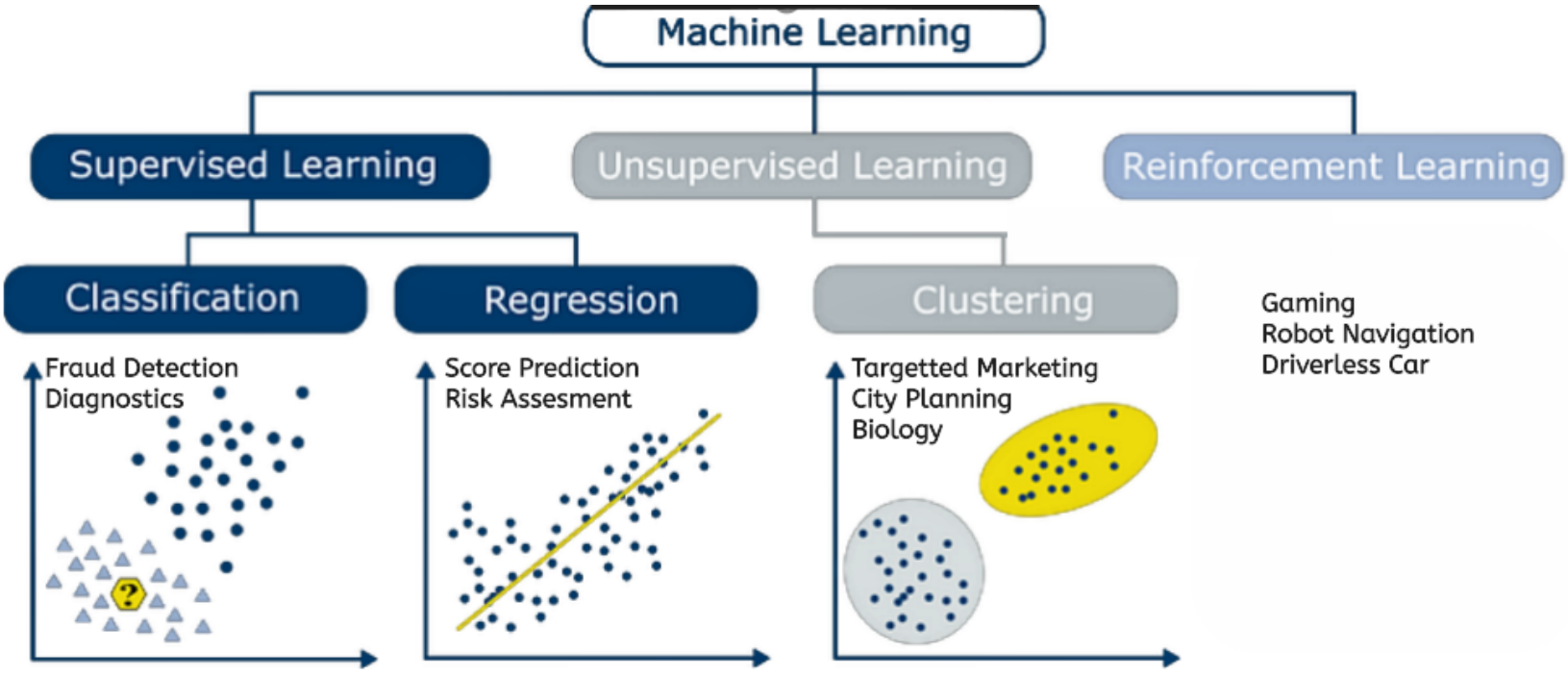


Figure 3: Machine Learning Algorithm

Types of Learning

Consider observing a series of input vectors:
$X_1, X_2, X_3, X_4, \ldots$

- **Supervised Learning**: We are also given target outputs (labels, responses): $y_1, y_2, \ldots$, and the goal is to predict correct output given a new input.
- **Unsupervised Learning**: The goal is to build a statistical model of x, which can be used for making predictions, decisions.
- **Reinforcement Learning**: the model (agent) produces a set of actions: $a_1, a_2, \ldots$ that affect the state of the world, and received rewards $r_1, r_2 \ldots$ The goal is to learn actions that maximize the reward (we will not cover this topic in this course).

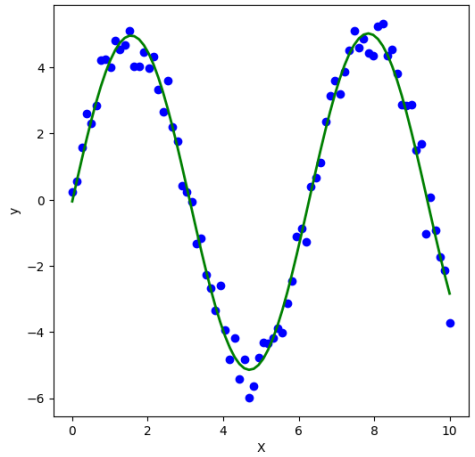
Types of Learning: Supervised Learning

Unknown target function:$f : X \rightarrow y$

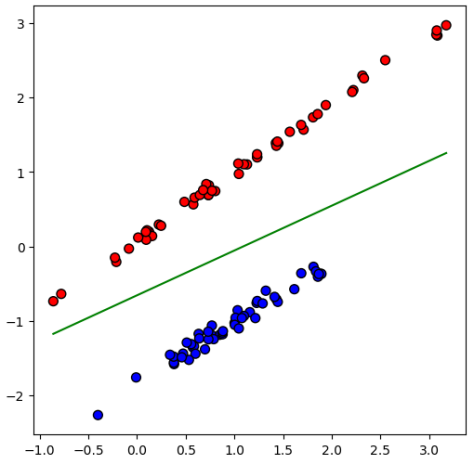
- Input space:X
- Output space:y
- Training data: $(x_1, y_1), (x_2, y_2), (x_3, y_3), ..., (x_N, y_N)$
- Pick a formula $g : X \rightarrow y$ that approximates the target function f
  - selected from a set of hypotheses H

Types of Learning: Supervised Learning

- **Regression**: target outputs y_i are continuous. The goal is to predict the output given new inputs.



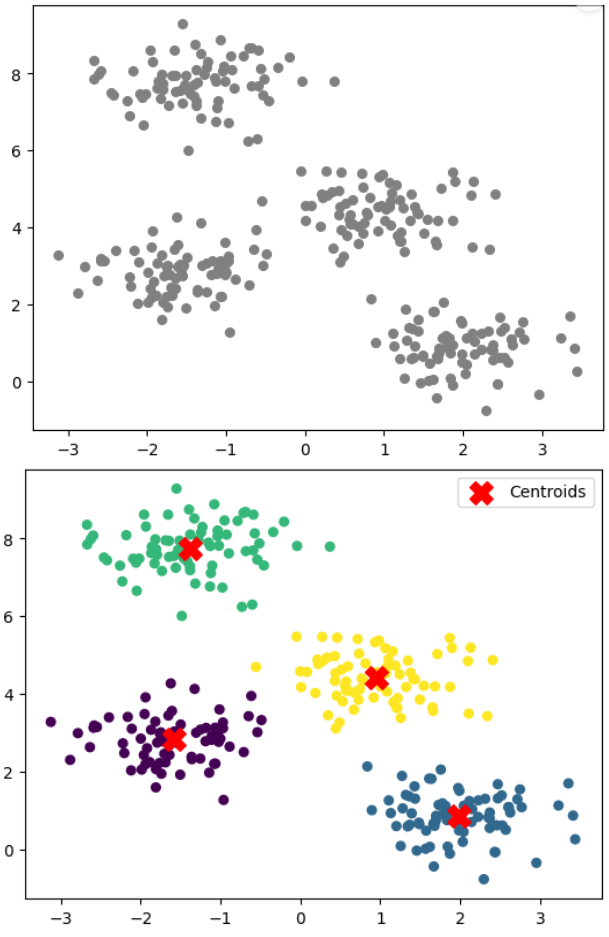
- **Classification**: target outputs y_i are discrete class labels. The goal is to correctly classify new inputs.



Types of Learning: Un-Supervised Learning

The goal is to construct statistical model that finds useful representation of data:

- Clustering
- Dimensionality reduction
- Modeling the data density
- Finding hidden causes (useful explanation) of the data



Types of Learning: Reinforcement Learning

Provides only an indication as to whether an action is correct or not.

- Algorithm learns a policy of how to act in a given environment.
- Every action has some impact in the environment, and the environment provides rewards that guides the learning system.

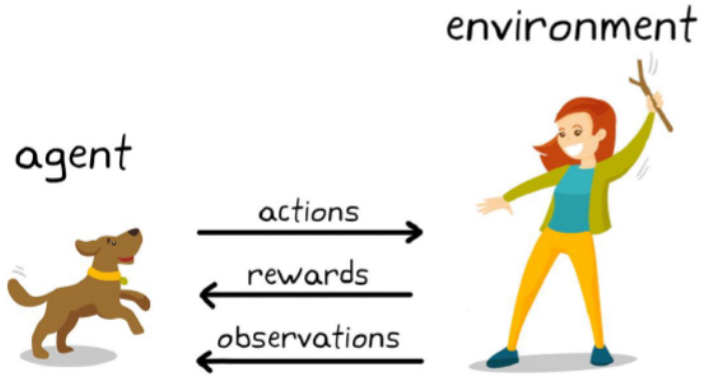


Figure 4: Reinforcement Learning

- Q-Learning
- Deep Q-networks(DQN)
- Policy Gradient Methods

Reinforcement Learning

Learning to walk via deep reinforcement learning.

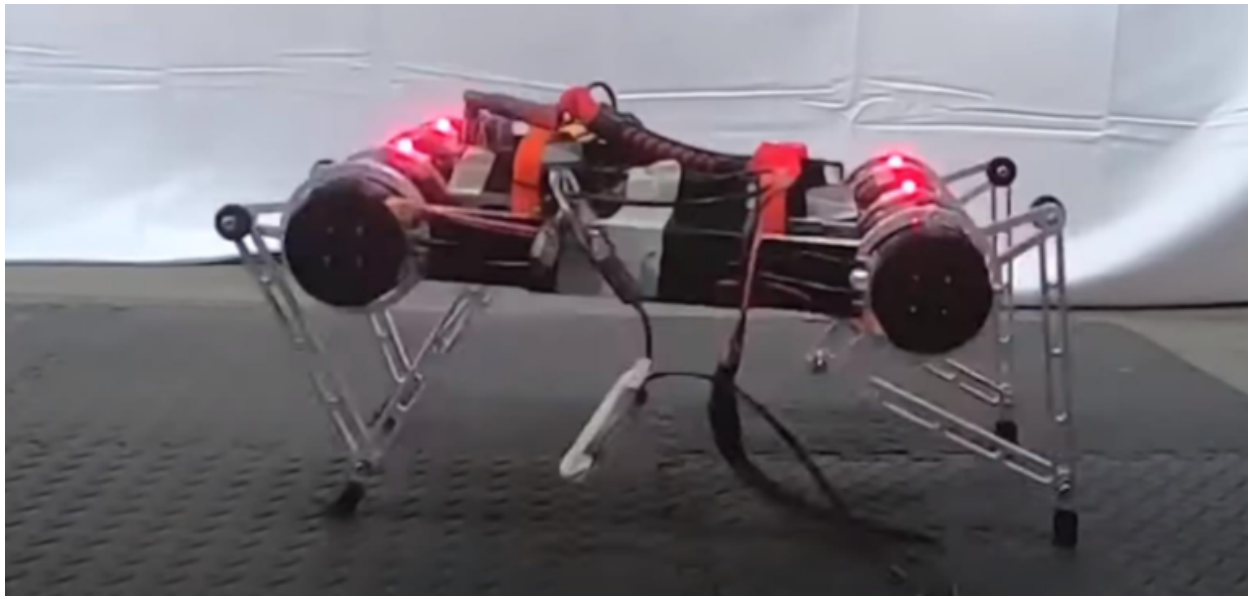


Figure 5: Borrowed fromTuomas Haarnoja, Sehoon Ha, Aurick Zhou, Jie Tan, George Tucker, Sergey Levine. Robotics: Science and Systems (RSS). 2019.

Questions?