Introduction to ML and Classical ML Models

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Machine Learning: an Overview

- **What is Machine Learning?**

  Machine learning is the field of study that gives computers the ability to learn without being explicitly programmed.

- **Applications of Machine Learning**

  - ▶ This Person Does not Exist!

  - ▶ Github Copilot

  - ▶ Imagen

  - ▶ Dall-E Open AI

  - ▶ DocQuery

  - ▶ Zero Shot Object Detection!
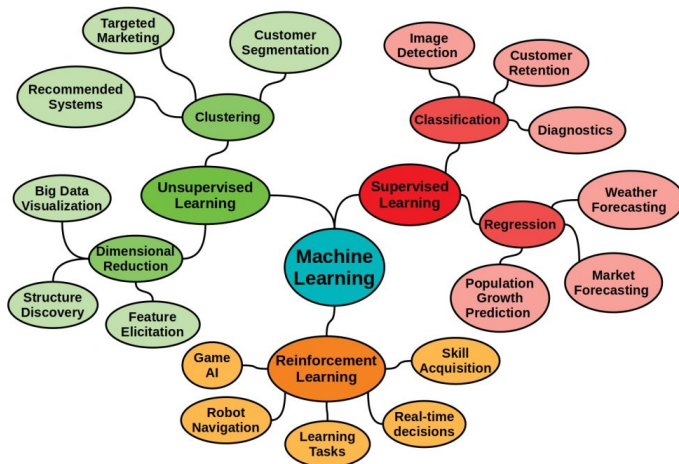
Machine Learning Categories

Figure: Classical Machine Learning Paradigm, Source

Machine Learning Categories

- The three broad categories of ML are summarized in:
  - ▶ **Supervised Learning**
  - ▶ **Unsupervised Learning**
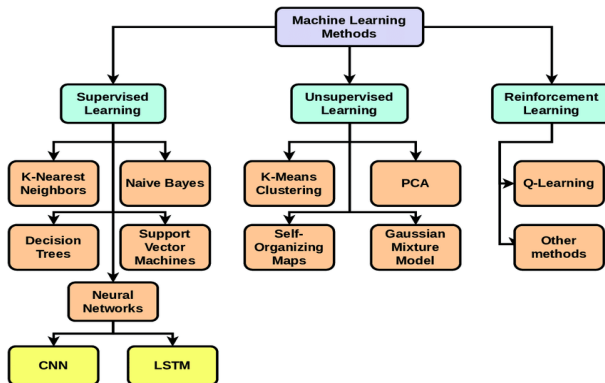 - ▶ **Reinforcement Learning**

Figure: Categories of ML, Source

Supervised Learning

■ Whats is Supervised Learning?

Supervised Learning is the subcategory of machine learning that focuses on learning from labeled training data, which can be divided to two main categories:

▶ Classification: Predicting the discrete values such as male/female, etc.
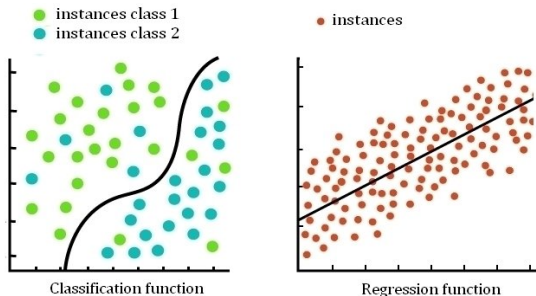▶ Regression: Predicting the continuous values such as price, age, etc.

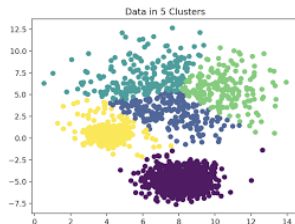Figure: Classification vs Regression, Source

Unsupervised Learning
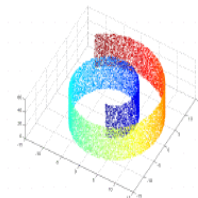
- What is Unsupervised Learning?

  Unsupervised Learning, in contrast to supervised learning, is concerned with unlabeled data.

- Common tasks in unsupervised learning are:
  - ▶ Clustering
  - ▶ Dimensionality Reduction

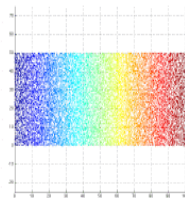(a) Clsutering, Source   (b) Dimensionality Reduction, Source

Figure: Clustering vs Dimensionality Reduction

Reinforcement Learning

- Reinforcement is the process of learning from rewards while performing a series of actions.
- An agent in this context is a learning system that observes the environment, selects and performs actions, and receives rewards.
- As time goes on, it must learn how to get the most rewards using the best strategy, called a policy.

Figure: Reinforcement Learning, Source.

ML Categorization Schemes

- Eager vs Lazy:
  - ▶ Eager learners are algorithms that process training data immediately.
  - ▶ Lazy learners, however, defer the processing step until the prediction.

- Batch vs Online:
  - ▶ Batch learning refers to the fact that the model is learned on the entire set of training examples.
  - ▶ Online learners, in contrast, learn from one training example at the time.

- Generative vs Discriminative:
  - ▶ Generative models (classically) describe methods that model the joint distribution $\mathbb{P}(X, Y) = \mathbb{P}(Y)\mathbb{P}(X|Y) = \mathbb{P}(X)\mathbb{P}(Y|X)$ for training pairs (x_i, y_i).
  - ▶ Discriminative Discriminative models are taking a more "direct" approach, modeling $\mathbb{P}(Y|X)$ directly.

ML Categorization Schemes

- Instance-based vs Model-Based:
  - ▶ Instance-Based learners learn the training examples by heart and then generalizes to new instances based on some similarity measure.
    - Here, the algorithm looks at a set of training data and tries to find a pattern that can be generalized to new data.
    - This pattern is then used to make predictions on new data.
  - ▶ Model-Based learners, on the other hand, learn from a model that is created from the training data.
    - This model can be thought of as a mathematical representation of the training data.
    - The model is then used to make predictions on new data.

- Parametric vs Non-parametric:
  - ▶ Parametric models have "fixed" number of parameters.
  - ▶ Non-Parametric models are more "flexible" and do not have a pre-specified number of parameters.

How to Solve a Machine Learning Problem

- Collect data.
- Preprocess the data.
- Select a suitable model and train it.
- Evaluate the generalization error on the test dataset.
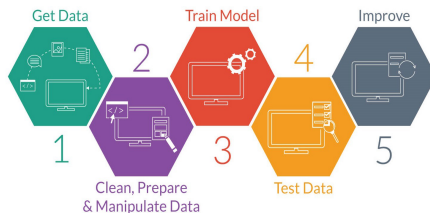- Improve the model using various techniques.

Figure: Required steps to solve an ML problem, Source

Thank You!

Any Question?