# Machine Learning Overview

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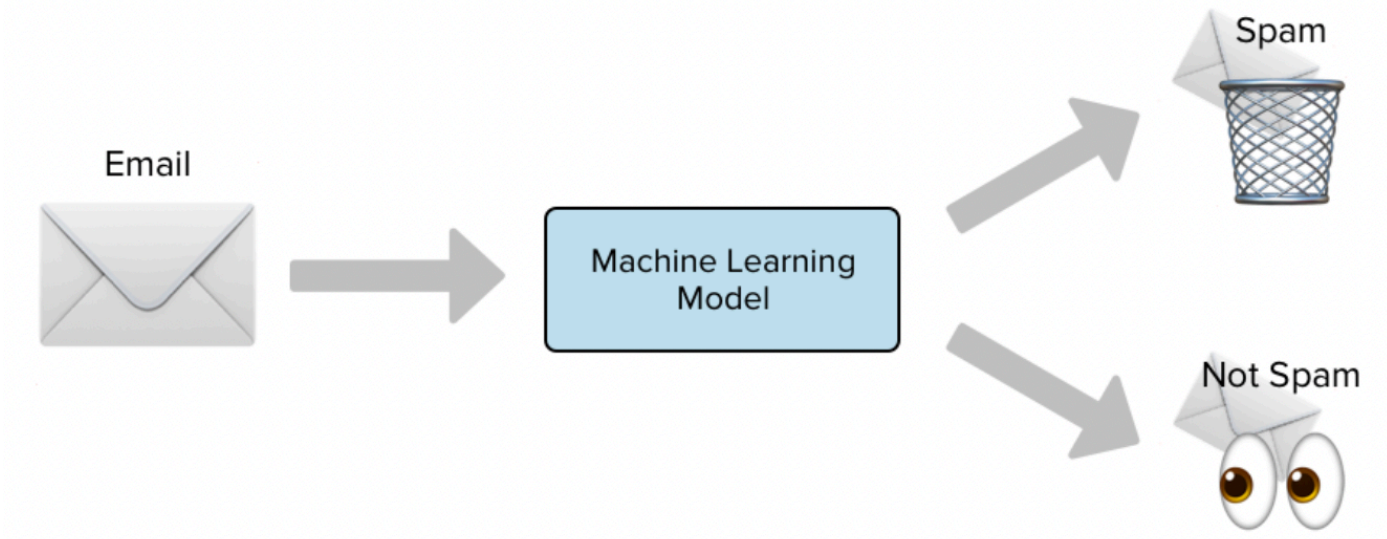
# What is Machine Learning?

- **Machine Learning (ML) is the training of computers to perform a task by *automated* learning of *model parameters* that govern the observed data process**
  - 3 core concepts: data, model, and learning
  - The computations are inherent to the model, not programmed by the model user
- **Critical for practitioners to understand advantages and disadvantages to various models**
    - Which tasks and data characteristics are the models best suited to?

# Example: Spam detection




Courtesy : Google images(Medium post)

- **Compare with the problem of sorting a set of numbers**

# Applications

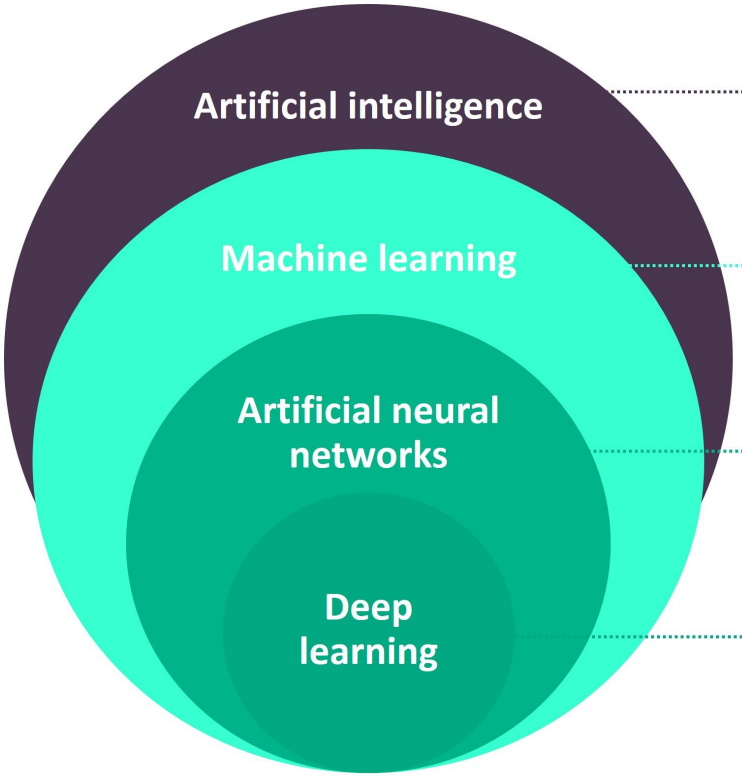
- Scientific applications
- eCommerce
- HealthCare
- Internet technologies
- Finance
- Robotics
- …

**An exciting field to be working in!**

# Little bit of history

- **Developing models given observation data is nothing new**
  - Weather forecast
    - Babylonians predicted the weather from the cloud patterns (650 BCE)
  - Astronomy
    - Tyco Brahe recorded observations of planets over the years (16$^{th}$ century)
    - Johannes Kepler discovered the empirical laws of planetary motions given the data
- **Then, why learn ML?**
  - Automated discovery, scalability

# ML vs AI/Deep Learning




**Artificial intelligence (AI)**
Any techniques that enable machines to solve a task in a way like humans do

**Machine learning (ML)**
Algorithms that allow computers to learn from examples without being explicitly programmed

**Artificial neural networks (ANN)**
Brain-inspired machine learning models

**Deep learning (DL)**
A subset of ML which uses deep artificial neural networks as models and automatically builds a hierarchy of data representations

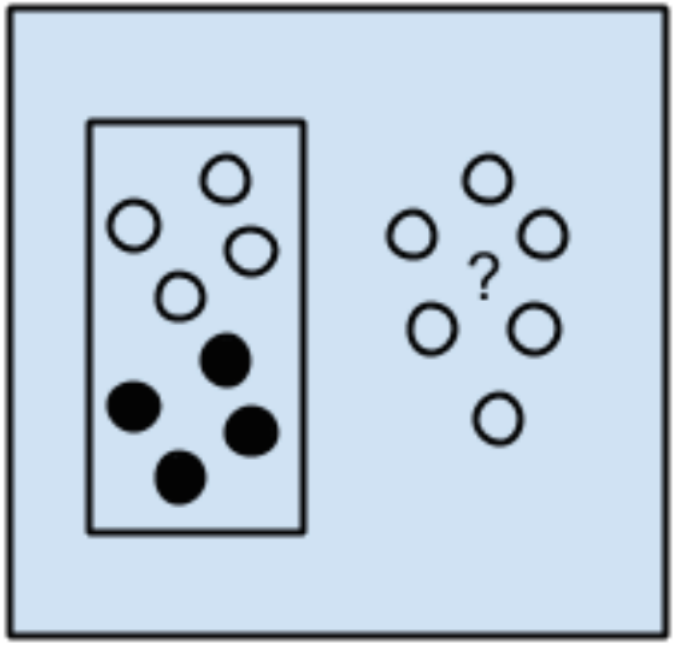
# ML and its relatives

- **Statistical Modeling**
  - Using mathematical models from statistics and probability theory to understand, aggregate, or predict data
- **Pattern Recognition (PR)**
  - Includes statistical modeling and ML
  - ML is currently considered a subset of PR
- **Data mining**
  - Includes statistical analysis and types of ML
  - Discovering hidden patterns and relationships

# ML Types: By Learning Styles

- **Three broad categories**
  - Supervised Learning
  - Unsupervised Learning
    - Semi-supervised
  - Reinforcement Learning

# ML Types: Supervised Learning

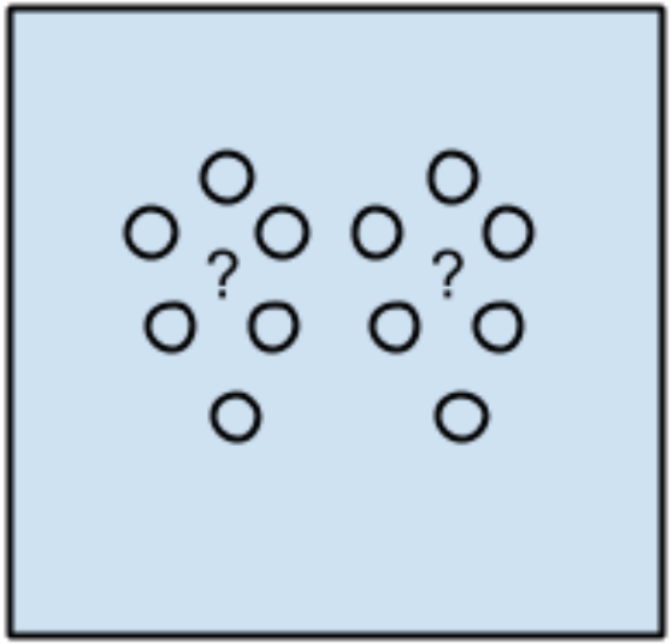



- **Input data points and associated labels are given**

# ML Types: Supervised Learning

- **The model is presented with a set of pairs**
  - Input data element
  - Expected output data element
- **The deviation from the expected output is the error in the model relative to an input data element**
  - In many models, the minimization of this error is how the model learns

# ML Types: Unsupervised Learning

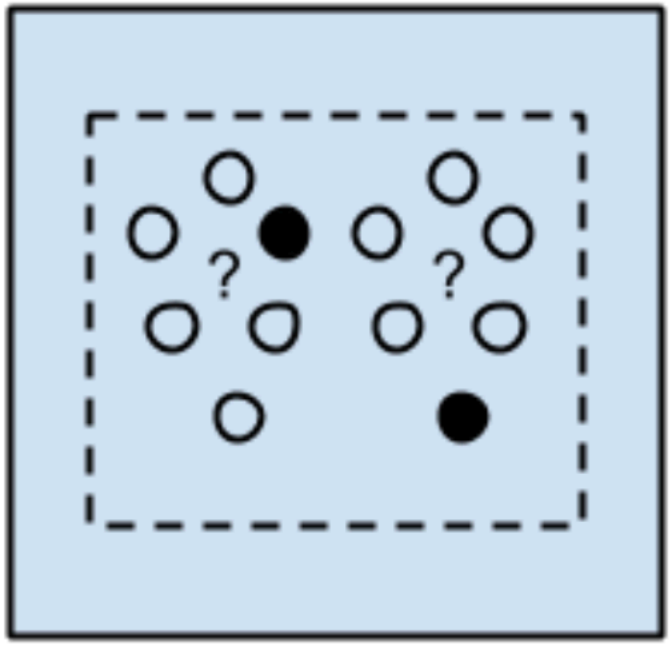



- **Input data points are given**
- **No associated labels**

# ML Types: Unsupervised Learning

- **The model learns to organize data without the knowledge of the proper organization**
- **Interpretation of correct organization depends on domain**
  - Similar in concept to factor analysis
  - Discover the hidden groups and then associate data elements to those groups
  - Often "degree of belonging" attached to grouping

# ML Types: Semi-supervised Learning

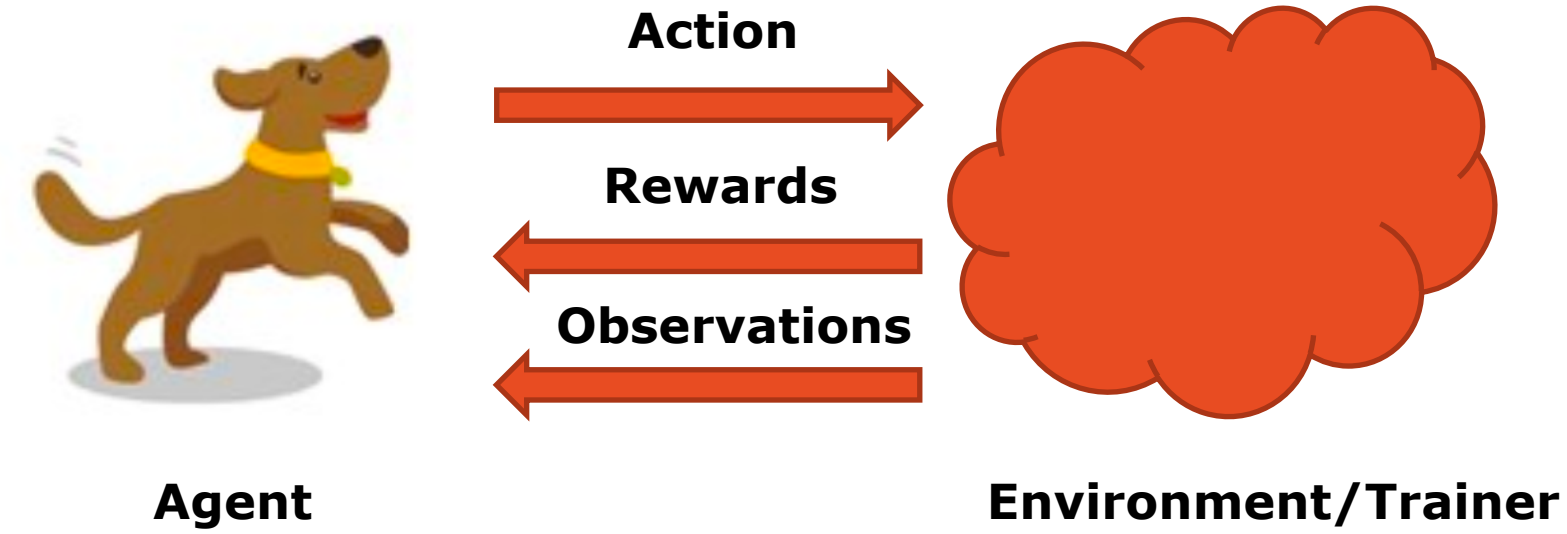



- **Input data points are given**
- **Associated labels are given for few points**

# ML Types: Semi-supervised Learning

- **Variations that combine supervised and unsupervised**
  - Learning on a small subset of labeled data, then using learned model(s) to automate labeling of remaining massive amount of data.
- **Learning a data grouping, assigning a semantic label (new nominal variable to data elements) then training a new model to predict the semantic assignment**

# ML Types: Reinforcement Learning



# ML Types: Reinforcement Learning

- **Quite different from the SL and USL**
- **An agent is trained for a task within an environment**
- **Agent receives rewards for its actions and observes the state of the environment**
- **Based on rewards and observed states the agent performs an action**
  - If action = desired behavior: reward
    - Else: no reward or negative reward

# Machine Learning Workflows

- **Workflow:**
  - The sequence of processes through which a task is accomplished
- **How do we go from raw data to a predictive analytics data science product?**
- **How can we incorporate a trained model into an operational system?**

# Machine Learning Workflows