Introduction to AI/ML

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Goal

- The goal of this module is to provide a high-level introduction of the foundations of Artificial Intelligence and Machine Learning (ML)
- By the end of this module, you will be able to:
  - Understand the principles of AI and ML
  - Provide key distinctions between both concepts
  - Hands on experience on the ML workflow

Agenda

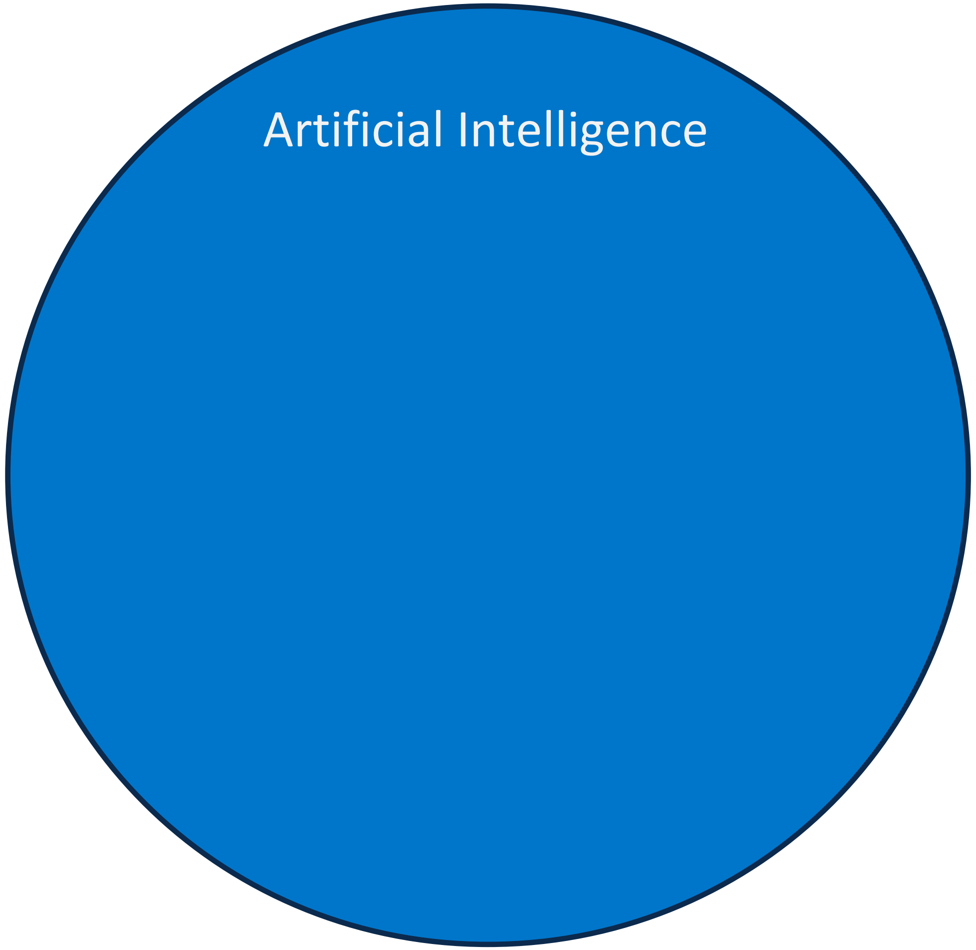
- Module 1 (Jan 31): Introduction to AI and ML
  - What is Artificial Intelligence
  - Understanding Machine Learning
  - Types and Applications of AI
    - Real World Case Studies of AI/ML in Healthcare
  - Ethical Considerations in AI
  - Emerging Trends and Future of AI
  - Discussions

Agenda

- Module 2 (Feb 1): Introduction to AI and ML Algorithms
  - Supervised Learning (e.g. Linear Regression, Decision Trees)
  - Unsupervised Learning Algorithms (e.g. Clustering, PCA)
  - Basics of Neural Networks and Deep Learning
  - Training ML models
  - Model Evaluation and Validation Techniques
  - Overfitting, Underfitting, and Model tunning

What is Artificial Intelligence?

- AI is a branch of computer science aimed at building machines capable of performing tasks that typically require human intelligence.
- These tasks include learning, reasoning, problem-solving, understanding natural language, and perception.



History and Evolution of AI

- **1940s-1950s:** Foundations laid with Turing's concept of a universal machine and the development of the first computers.
- **1956:** Term "Artificial Intelligence" coined at the Dartmouth Conference, marking the official birth of the field.
- **1960s-1970s:** Early enthusiasm, development of fundamental algorithms, and exploration of AI's potential.

History and Evolution of AI

- **1980s:** AI Winter due to unmet expectations, but gradual progress in machine learning and expert systems.
- **1990s:** Resurgence with the rise of the internet, improvement in algorithms, and increased computational power.
- **2000s-Present:** Breakthroughs in deep learning, neural networks, and big data analytics leading to advanced applications like autonomous vehicles, speech recognition, and AI in healthcare.

Types of AI

- Narrow AI
  - Performs specific tasks (e.g. Siri, Alexa, Netflix recommendations).
  - Task-specific systems without general understanding.
- General AI
  - Theoretical concept of AI with human-like intelligence
  - Capable of understanding, learning, and applying knowledge across various tasks.
  - No real-world examples yet; remains speculative
- Super intelligent AI
  - AI that exceeds human intelligence and capability
  - Encompasses scientific creativity, wisdom, and social skills
  - Highly theoretical and speculative with no current real-world instances.

Subfields of AI

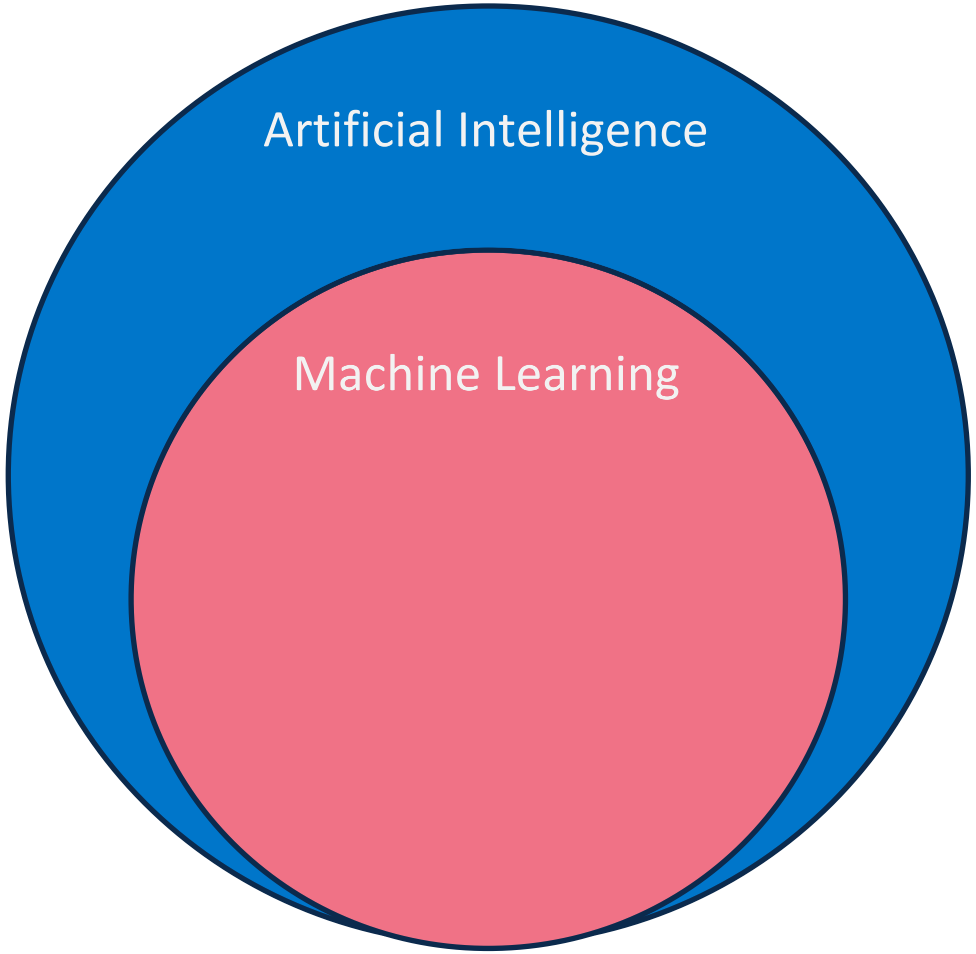
- Machine Learning (ML):
  - Algorithms that allow machines to learn from data.
- Deep Learning:
  - A subset of ML using multi-layered neural networks.
  - Recognizes complex patterns in large datasets.
- Natural Language Processing (NLP):
  - Technology enabling machines to understand human language.
- Robotics:
  - Design and creation of robots for autonomous or semi-autonomous tasks
- Computer Vision:
  - Allows machines to interpret visual data and make decisions.

Machine Learning

What is Machine Learning?

- Machine Learning is a subset of AI that focuses on the development of algorithms that can learn to make predictions or decisions based on data.

- This learning can improve over time with more data and experiences.

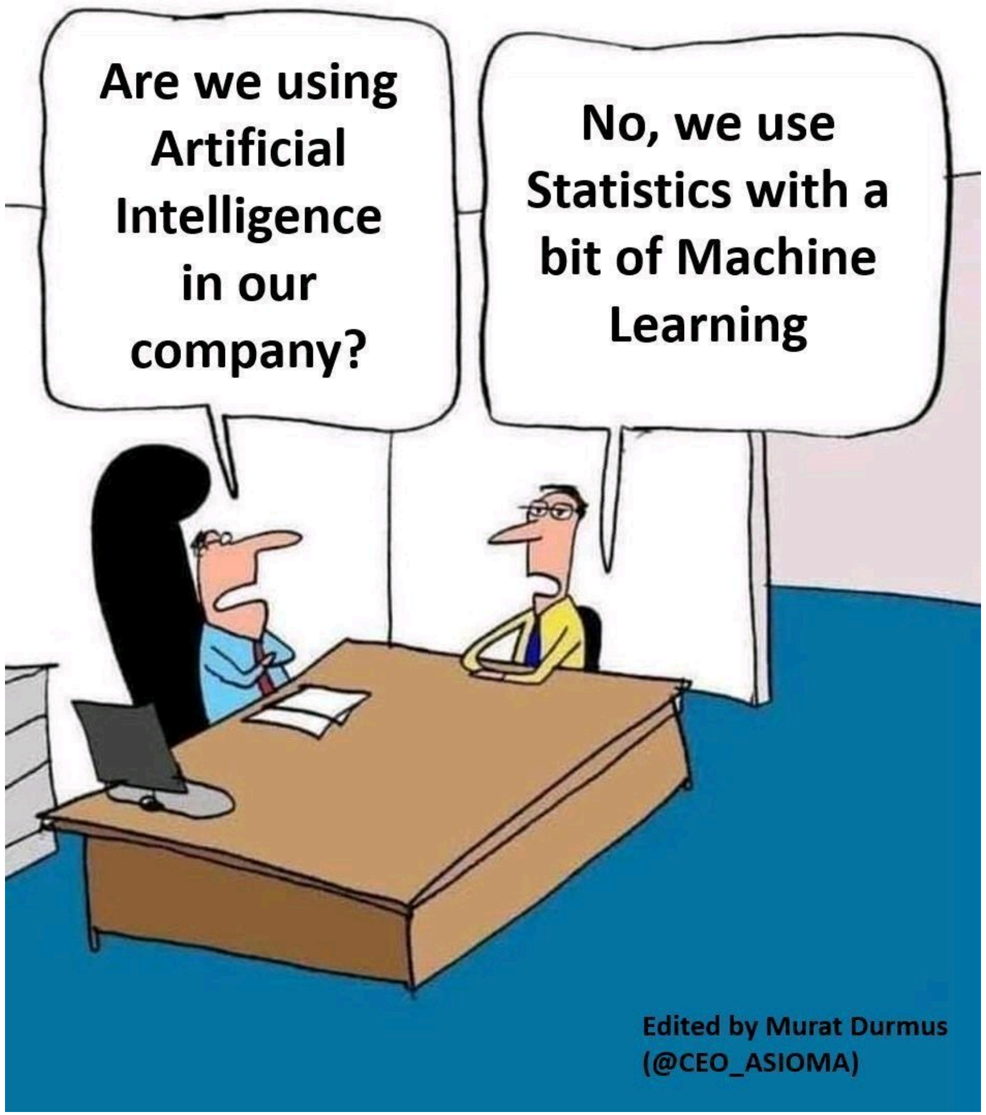


ML vs. Traditional Programming

- Traditional Programming
  - Relies on explicit rules and instructions defined by developers
  - Works well for tasks with clear, deterministic algorithms.

- Machine Learning
  - Learns patterns from data and makes decisions or predictions
  - Ideal for complex tasks where rules are not easily definable.

ML uses a lot of statistics…



Let's see who you really are machine learning

AI vs ML – What's the difference?

- AI (Artificial Intelligence)
  - Broad field aiming to create machines capable of intelligent behavior
  - Encompasses reasoning, learning, perception, and language understanding
  - The goal is to achieve both narrow (task-specific) and general (human-like) intelligence.

- ML (Machine Learning)
  - A subset of AI focused on algorithms that learn from data
  - Employs statistical methods to enable machines to improve tasks with experience
  - Primarily concerned with prediction and pattern recognition

What part of AI is not ML?

- Expert Systems
  - Mimic the decision-making ability of human experts
- Robotics
  - Designing and building robots to perform tasks which may not always incorporate learning algorithms
- Search Algorithms
  - Algorithms like A* or Dijkstra's for pathfinding and optimization, which don’t learn from data but are designed to solve specific problems
  - Evolutionary Algorithms

Applications of Machine Learning - Finance

- **Application:** PayPal uses ML algorithms to combat fraud by analyzing millions of transactions. These algorithms learn to distinguish between legitimate and fraudulent transactions based on patterns and anomalies.

- **Impact:** Reduces false positives, enhances customer experience, and minimizes financial losses due to fraud.

Applications of Machine Learning - Healthcare

- **Application:** Google Health developed a machine learning model to screen for diabetic retinopathy (DR), a condition that can lead to blindness if untreated. The model analyzes retinal images to detect signs of the disease.

- **Impact:** The automated screening tool can assist doctors in diagnosing and treating diabetic retinopathy more efficiently, especially in underserved communities with limited access to ophthalmologists.

AI

Detecting diabetic eye disease with machine learning

Nov 29, 2016 · 2 min read

L Lily Peng
MD Ph.D., Product Manager

Diabetic retinopathy — an eye condition that affects people with diabetes — is the fastest growing cause of blindness, with nearly 415 million diabetic patients at risk worldwide. The disease can be treated if detected early, but if not, it can lead to irreversible blindness.

One of the most common ways to detect diabetic eye disease is to have a specialist examine pictures of the back of the eye and determine whether there are signs of the disease, and if so, how severe it is. While annual screening is recommended for all patients with diabetes, many people live in areas without easy access to specialist care. That means millions of people aren't getting the care they need to prevent loss of vision.

Examples of retinal photographs that are taken to screen for DR. A healthy retina can be seen on the left; the retina on the right has lesions, which are indicative of bleeding and fluid leakage in the eye.

Source: https://blog.google/technology/ai/detecting-diabetic-eye-disease-machine-learning/

Applications of Machine Learning - Agriculture

- **Application:** John Deere integrates ML into its agricultural equipment to enable precision farming, using data from sensors and satellites to make informed decisions about planting, fertilizing, and harvesting.

- **Impact:** Increases crop yields and sustainability by optimizing resource use.

Applications of Machine Learning - Marketing

- **Application:** Coca-Cola uses ML to analyze data from various sources to gain insights into consumer preferences and trends, influencing marketing strategies and product development.

- **Impact:** Drives innovation and targeted marketing, leading to more effective campaigns and product offerings.

Applications of Machine Learning – Predictive Maintenance

- **Application:** Siemens employs ML for predictive maintenance in its manufacturing operations, using IoT (Internet of Things) sensor data to predict equipment failures before they occur.

- **Impact:** Reduces downtime and maintenance costs, improving overall efficiency and productivity in manufacturing processes.

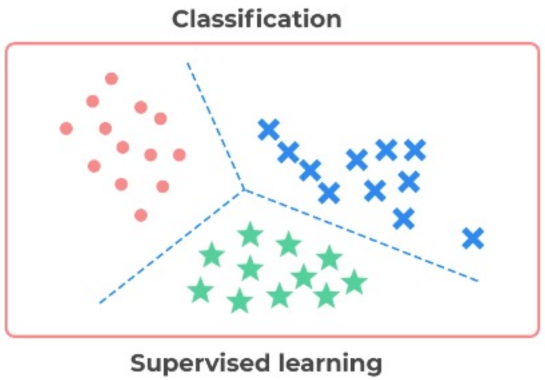
For more case studies, check out: https://pytorch.org/community-stories

In class Activity

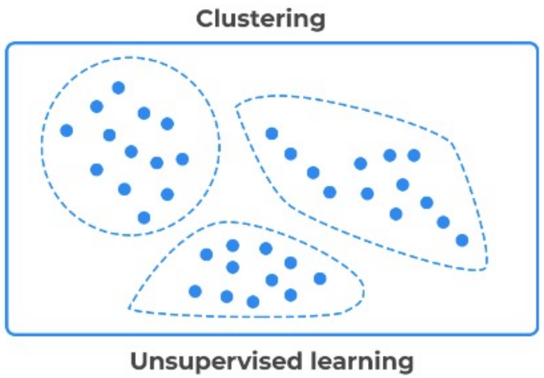
- Group discussion on AI products you use in your daily lives

Types of Machine Learning Approach

- Supervised Learning
  - Models learn from labeled data.
  - Predictions based on input-output pairs.



- Unsupervised Learning
  - Identifies patterns in unlabeled data.
  - Clusters similar data points together.



- Reinforcement Learning
  - Learns by trial and error from actions in an environment.
  - Aims to achieve defined goals.

Supervised Learning – Fruit Labeling Analogy

- Training Phase:
  - Demonstrate sorting fruits (apples, Oranges)
  - Each fruit type and its corresponding basket acts as labelled examples
- Prediction Phase
  - Machine learning model sorts a new basket of fruits independently
  - Uses knowledge from training to recognize and categorize new fruits

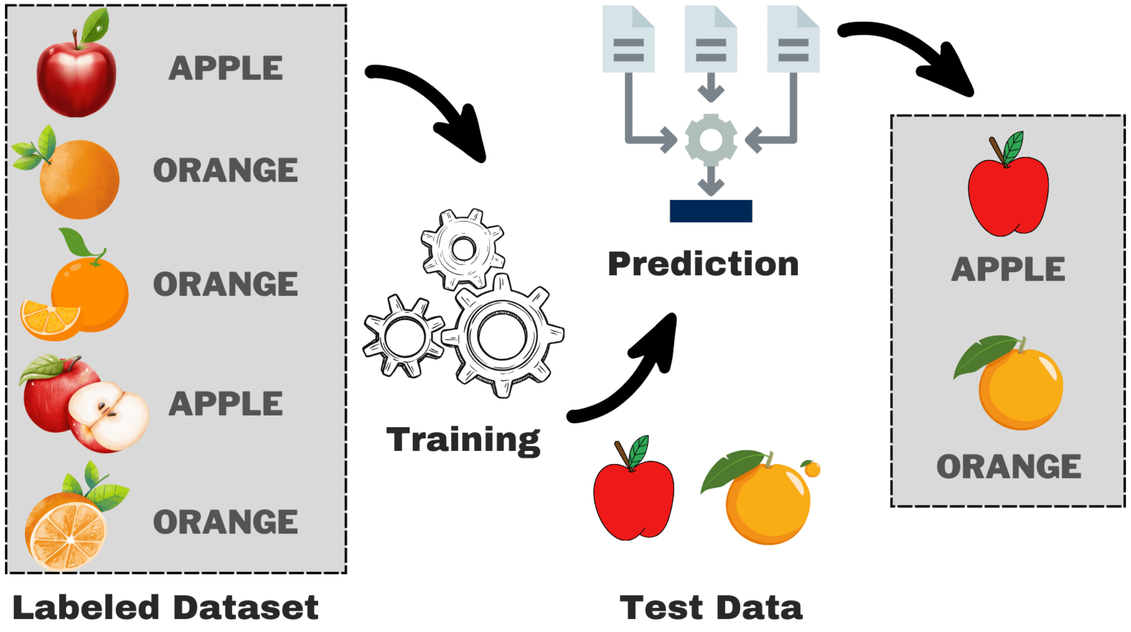


Image source: https://www.kdnuggets.com/understanding-supervised-learning-theory-and-overview

Supervised Learning Overview

- Definition:
  - Trains model on labeled dataset
  - Each example has an input vector and a corresponding output label.

- Goal:
  - Learn a function mapping inputs to outputs
  - Use this function for predictions on new data

- Types of Problems:
  - Classification:
    - Output is categorical (e.g. Spam detection, disease diagnosis)
  - Regression:
    - Output is a continuous value (e.g. house price prediction, weight estimation based on height).

Some Supervised Learning Algorithms

- Classification
  - Logistic Regression
  - Support Vector Machines
  - Random Forest

- Regression
  - Linear Regression

Unsupervised Learning – Book sorting Analogy

- No categories provided; task is to organize books logically.
- Process: Identify patterns (size, color, topic) to create groups.
- Similar to clustering algorithms finding inherent data groupings.

- Analogy Insight:
  - Unsupervised learning discovers data patterns and structures without labels.

Unsupervised Learning Overview

- Definition:
  - Machine learning without explicit labels or targets.
  - Identifies patterns and structures in input data.
- Applications:
  - Discovers hidden patters and correlations.
  - Useful for data exploration and enhancing model efficiency.
- Challenges:
  - Results can be difficult to interpret without “ground truth”
- Main Types:
  - Clustering Algorithms:
    - Groups data based on similarities
  - Dimensionality reduction:
    - Reduces variables, preserving essential features.

Some Unsupervised Learning Algorithms…

- Clustering
  - K-means
  - Hierarchal Clustering
  - Density-based Spatial Clustering of Applications with Noise (DB-SCAN)
- Dimensionality Reduction Algorithms
  - Principal Component Analysis (PCA)
  - t-SNE

Reinforcement Learning –Dog Training Analogy

- Agent:
  - The dog represents the learning agent.
  - Environment:
    - Surroundings where the agent operates, including human.
  - Actions:
    - Dog's behaviors, such as sit, fetch, or stay.
  - Observations:
    - Feedback from the environment, like human gestu or commands.
- Rewards:
  - Positive reinforcement like treats or praise when the dog performs the desired action.

Reinforcement Learning Overview

- Definition:
  - A type of machine learning where an agent learns to make decisions by performing actins and observing rewards
- Process:
  - Agent interacts with an environment, takes actions, and receives rewards or penalties
  - Goals is to maximize the cumulative reward over time.
- Key components:
  - Agent: Learns from the environment to perform tasks.
  - Environment: The domain or situation the agent operates in
  - Actions: The set of possible moves or decisions the agent can make
  - Rewards: Feedback signals that evaluate the success of an action

Reinforcement Learning Overview (cont'd)

- Applications:
  - Gaming (e.g., AI playing chess or Go).
  - Autonomous vehicles (eg., learning to drive through simulation).
  - Robotics (e.g., robots learning to navigate obstacles).

Reinforcement learning examples

Simulated stick figure learns to walk

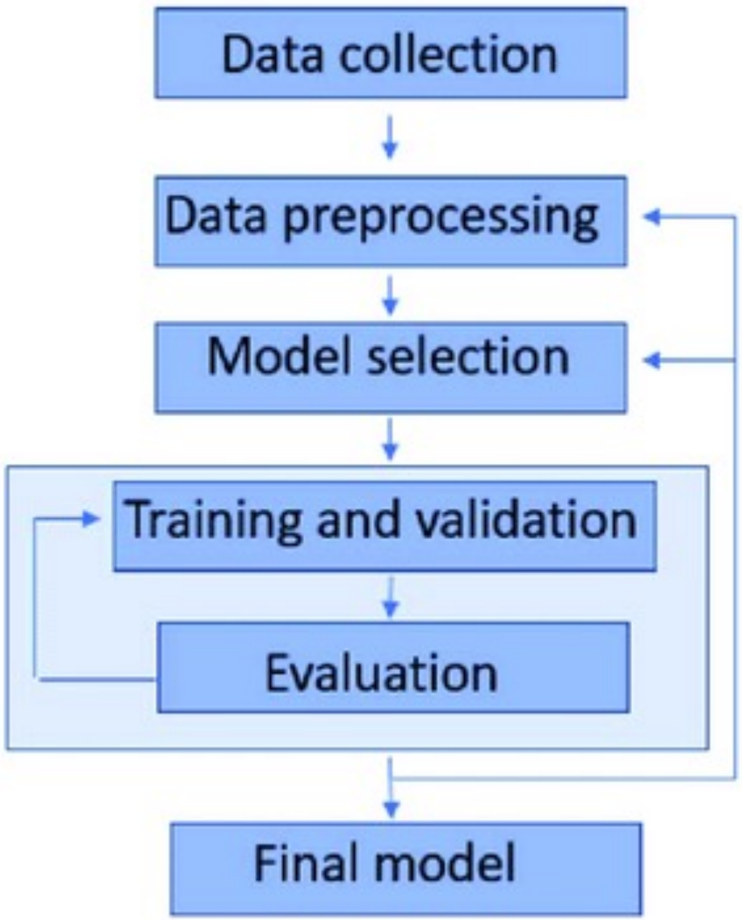
Robot learns to walk with no input

Waymo's self-driving car

Machine Learning Workflow

- Data Collection:
  - Gather diverse and representative datasets relevant to the problem
- Data Preparation:
  - Clean and preprocess data for compatibility with ML models.
- Model Training:
  - Feed prepared data into algorithms to learn and identify patterns
- Evaluation:
  - Assess model performance with metrics like accuracy, precision, recall, F1 Score
- Deployment
  - Implement the trained model for real-world predictions and decisions

Machine Learning Workflow



Data is the new oil…

- Data is the cornerstone for every machine learning approach.
- High-quality, large dataset lead to more accurate and reliable models.
- Quality includes relevance, cleanliness, and diversity of data
- But how do we ensure that we have properly sanitized our input data before machine learning is applied?

Data Preparation Techniques

- Definition:
  - The process of cleaning and transforming raw data before analysis.
- Key steps:
  - Data cleaning:
    - Handle missing values
    - Correct errors and remove outliers
  - Data Transformation:
    - Normalize or scale features
    - Encode categorical data
  - Feature Selection:
    - Identify and select the most relevant features for analysis
  - Data Splitting:
    - Divide data into training, validation, and test sets.