Module 1: Supervised vs Unsupervised Learning

1.1 What is Machine Learning?

Definition

Arthur Samuel's Definition: "The field of study that gives computers the ability to learn without being explicitly programmed"

Key Example

- Samuel's checkers program (1950s)
- Computer learned by playing thousands of games against itself
- Identified winning/losing positions through experience
- Became better than Samuel himself

Core Principle

More training opportunities → Better performance

Two Main Types

1. **Supervised Learning -** Most widely used in real-world applications
2. **Unsupervised Learning -** Second most common type

Course Structure

- Courses 1-2: Supervised Learning
- Course 3: Unsupervised Learning, Recommender Systems, Reinforcement Learning

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1.2 Supervised Learning

Definition

Learning algorithm that maps **inputs (x)** to **outputs (y)**

Key Characteristic: Training with labeled examples (correct input-output pairs)

Applications

- **Email Spam Filtering**: Email → Spam/Not Spam
- **Speech Recognition**: Audio → Text transcript
- **Machine Translation**: English → Other languages
- **Online Advertising**: User/Ad info → Click prediction
- **Self-Driving Cars**: Image/Sensor data → Position of objects
- **Manufacturing**: Product image → Defect detection

Type 1: Regression

Predicts continuous numerical values from infinitely many possibilities

Example: Housing Price Prediction

- **Input (x)**: House size (sq ft)
- **Output (y)**: Price ($)
- Can fit straight line or curve to data
- Predicts any number (e.g., $150,000, $183,000, $200,000)

Mathematical representation: $y = f(x)$ where $y \in \mathbb{R}$

Type 2: Classification

Predicts discrete categories from a small, finite set of possibilities

Example: Breast Cancer Detection

- **Input (x)**: Tumor size
- **Output (y)**: Benign (0) or Malignant (1)
- Can have 2+ categories (e.g., Type 0, Type 1, Type 2 cancer)

Key Difference from Regression:

- Classification: Small finite set of categories
- Regression: Infinitely many possible numbers

Multiple Input Features Can use multiple inputs simultaneously:

- Tumor size AND patient age
- Algorithm finds decision boundary separating categories
- Real applications use many features (thickness, uniformity, cell size, etc.)

Mathematical representation: $y \in \{0, 1\}$ or $y \in \{0, 1, 2, ..., n\}$

1.3 Unsupervised Learning

Definition

Given data with **only inputs (x)**, no output labels (y)

Goal: Find structure, patterns, or interesting relationships in data

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Type 1: Clustering

Groups similar data points together automatically

Applications **1. Google News**

- Groups related articles together
- Finds common words (e.g., "panda," "twin," "zoo")
- Adapts to new topics daily without human supervision

2. DNA/Genetic Data Analysis

- Groups individuals by genetic similarities
- Identifies "types" of people based on gene expression
- No predefined categories

3. Market Segmentation

- Groups customers by behavior/motivation
- Example: Knowledge seekers, Career developers, Industry updaters
- Enables targeted marketing strategies

Type 2: Anomaly Detection

Detects unusual events or outliers

Applications

- Fraud detection in financial systems
- Identifying unusual transactions
- Security monitoring

Type 3: Dimensionality Reduction

Compresses large datasets while preserving information

- Reduces data size
- Maintains essential patterns
- Improves computational efficiency

Key Comparisons

Aspect	Supervised Learning	Unsupervised Learning
Data	Inputs (x) + Labels (y)	Only inputs (x)

Aspect	Supervised Learning	Unsupervised Learning
Goal	Predict y for new x	Find patterns/structure
Examples	Regression, Classification	Clustering, Anomaly detection
Training	Learn from "right answers"	Discover hidden structure

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Summary

Supervised Learning

- **Regression**: Predict continuous numbers (housing prices, temperature)
- **Classification**: Predict categories (spam/not spam, disease diagnosis)

Unsupervised Learning

- **Clustering**: Group similar data (news articles, customer segments)
- **Anomaly Detection**: Find unusual patterns (fraud detection)
- **Dimensionality Reduction**: Compress data efficiently

Best Practice

Success requires both:

1. Understanding the algorithms (tools)
2. Knowing how to apply them effectively (practical skills)