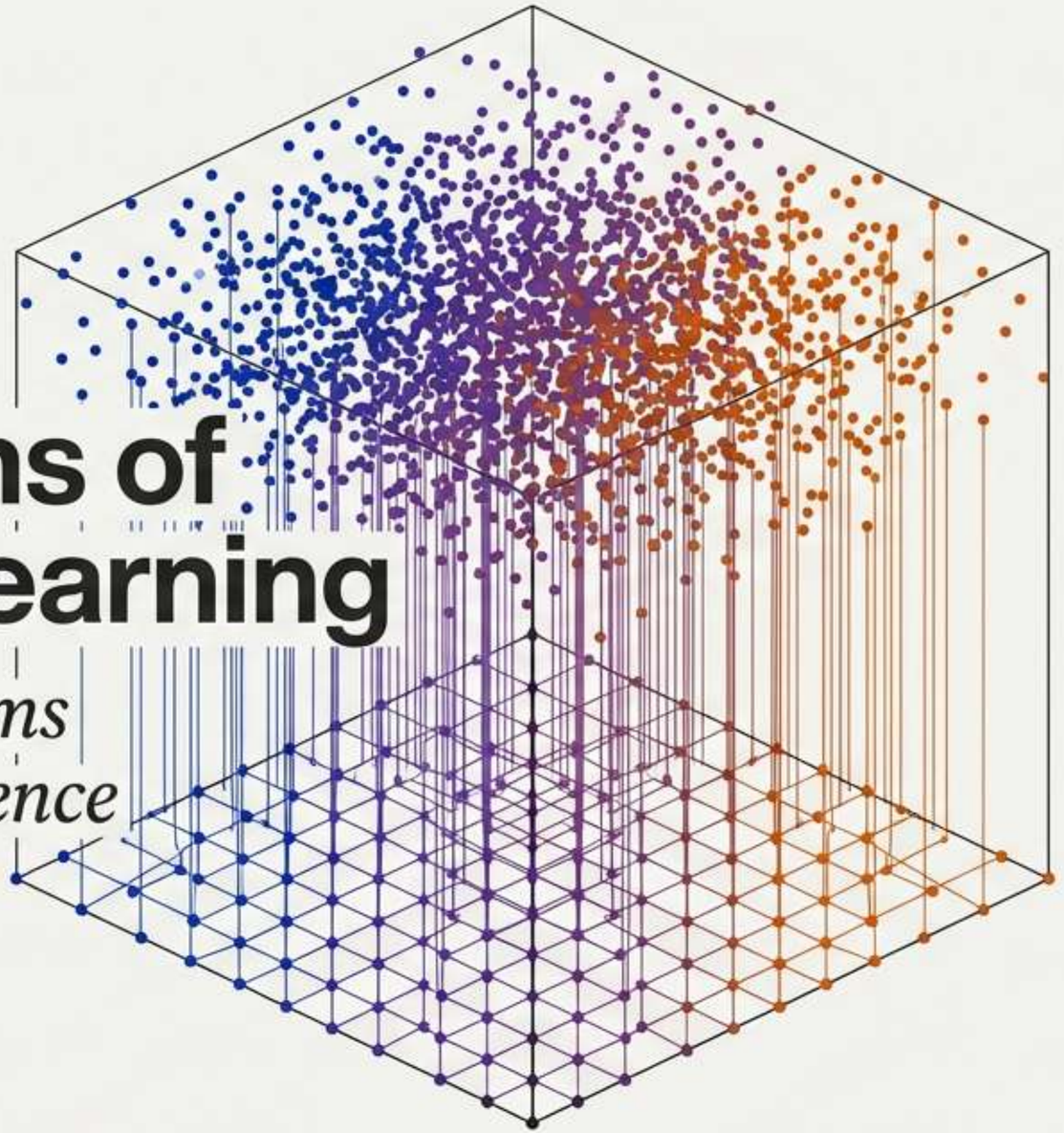


Foundations of Machine Learning

The Three Paradigms of Artificial Intelligence

A guide to Supervised, Unsupervised, and Reinforcement Learning.

The Shift from Rules to Patterns

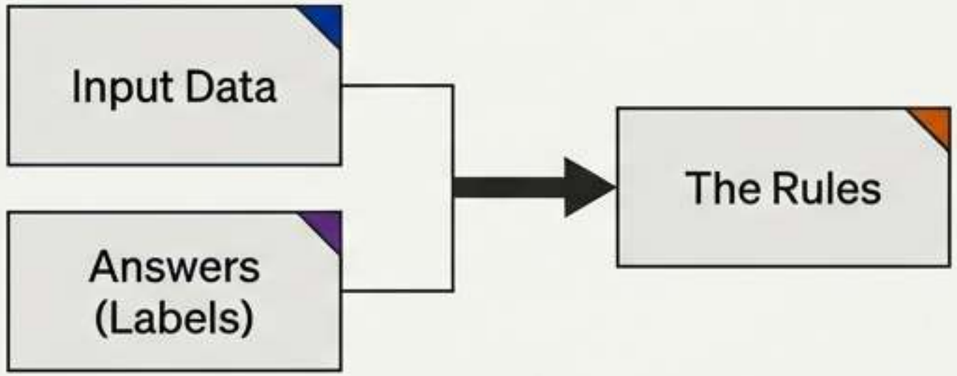
Machine Learning enables systems to identify patterns and make decisions with minimal human intervention. Instead of explicitly programming rules for every scenario, algorithms discover these rules through exposure to data.

Core Idea: Generalize from past observations to predict future outcomes.

Traditional Programming

Example: If email contains "free money", mark as spam.

Machine Learning



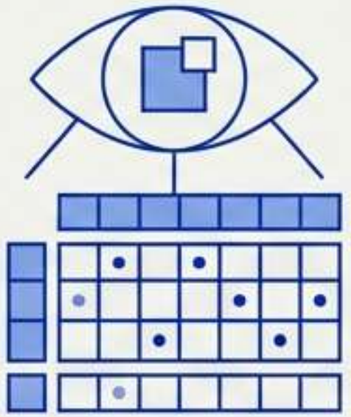
Example: System analyzes labeled emails to discover "free money" is a trigger.

The Landscape of Learning

Machine learning is not a monolith; it is divided into three primary paradigms based on how the system learns and the nature of the data provided.

1. Supervised Learning

The Teacher



Learning from labeled data to map inputs to outputs.

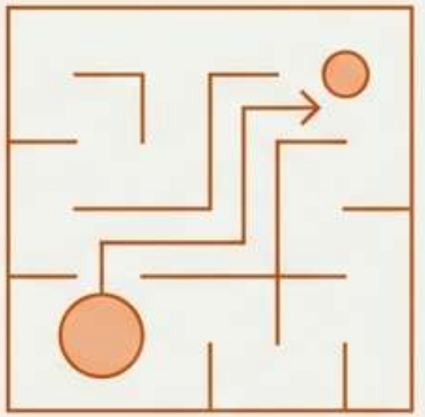
2. Unsupervised Learning

The Explorer

Learning from unlabeled data to discover hidden structures.

3. Reinforcement Learning

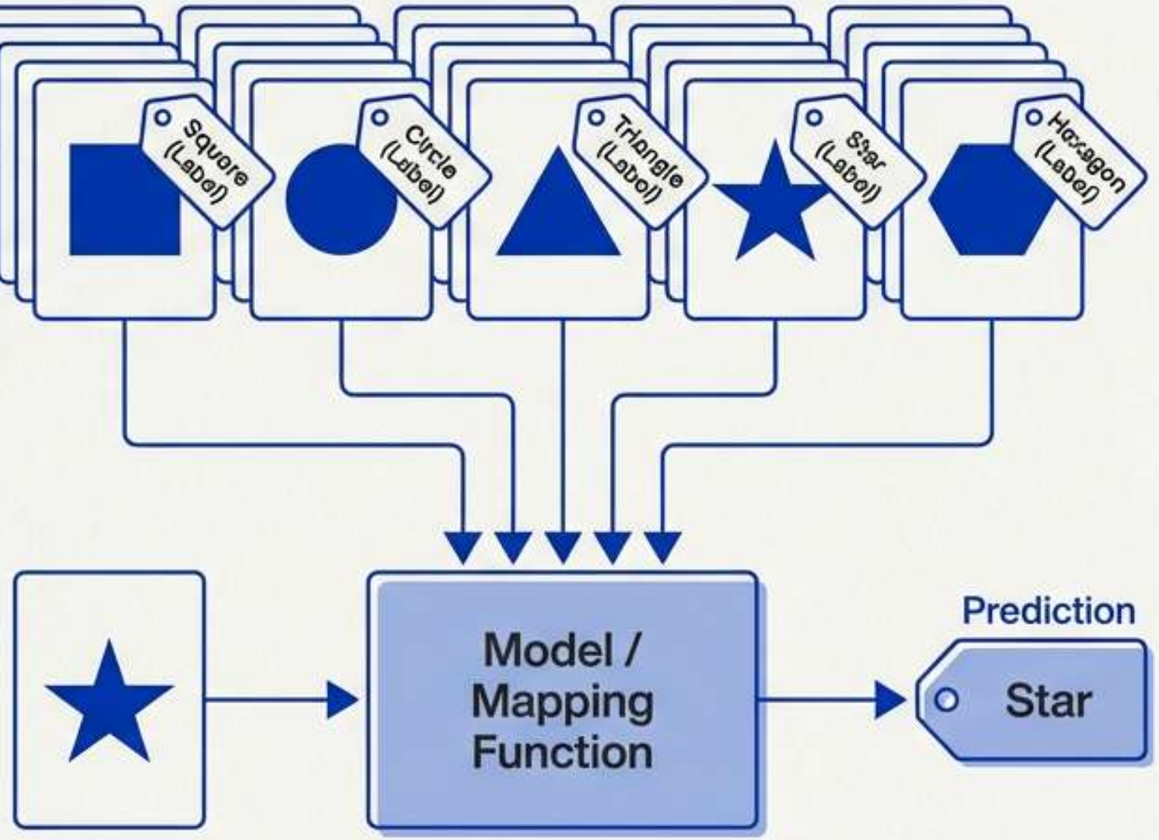
The Agent



Learning through trial, error, and interaction with an environment.

Supervised Learning: The Teacher

The algorithm learns from a “labeled” dataset. The training data includes both the input features (independent variables) and the correct output (dependent variable).



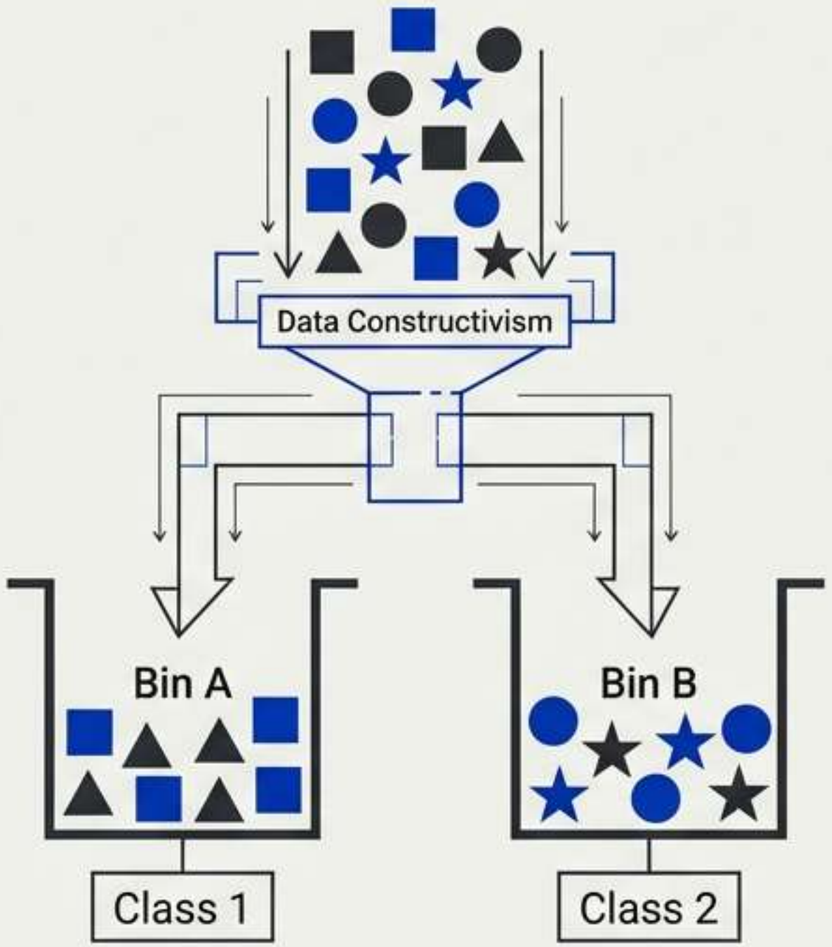
The Goal

The Goal: To learn a mapping function from input to output so accurate predictions can be made on new, unseen data.

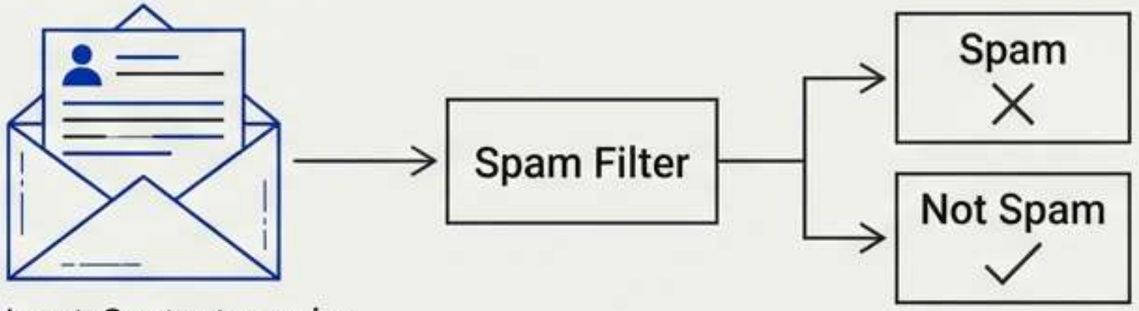
Task Type A: Classification

Sorting into Buckets

Concept: Predicting a categorical output label. The model assigns data points to predefined classes.

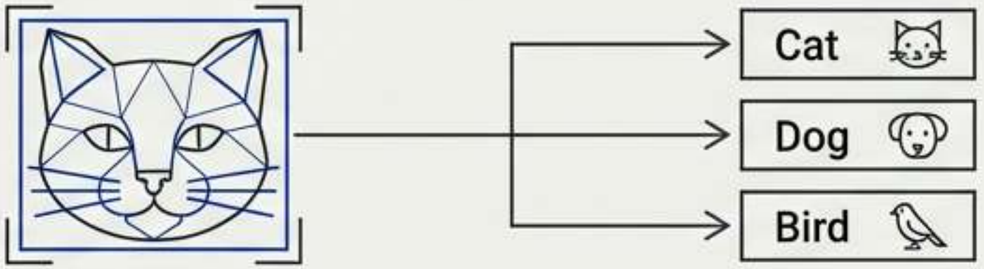


Example 1: Email Spam Detection



Input: Content, sender.
Output: 'Spam' or 'Not Spam'.
Process: Identifying trigger words.

Example 2: Image Recognition



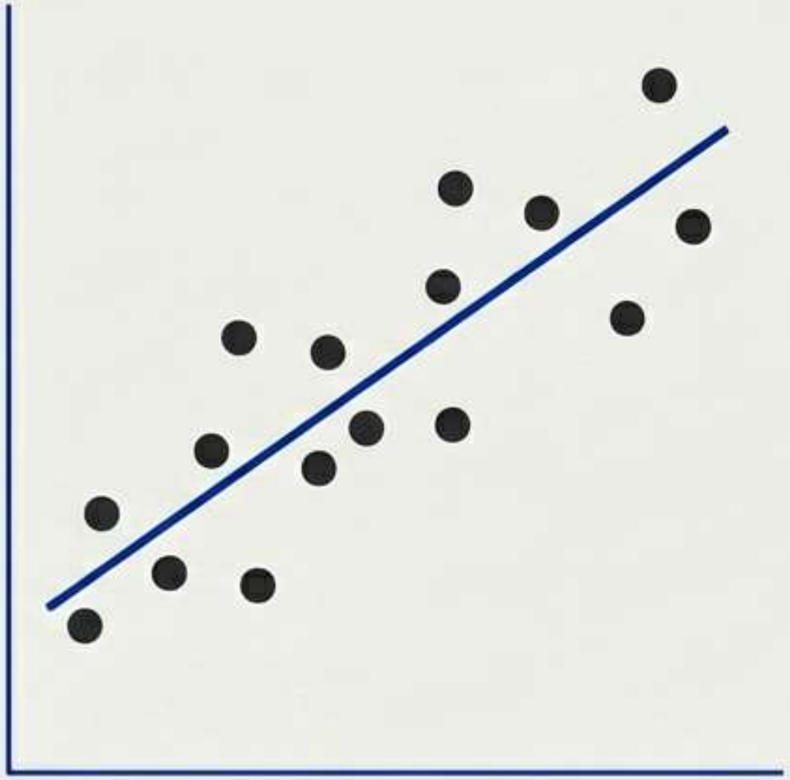
Input: Pixel data.
Output: Cat, Dog, Bird.
Process: Extracting edges and textures.

Application: Credit Card Fraud (Fraudulent vs. Legitimate).

Task Type B: Regression

Predicting Values

Concept: Predicting a continuous numerical output. The model estimates a value rather than assigning a category.



Example 1: House Price Prediction

Input: Sq. ft, bedrooms, year built.
Output: Estimated price.
Process: Learning relationship between features and value.

Example 2: Stock Forecasting

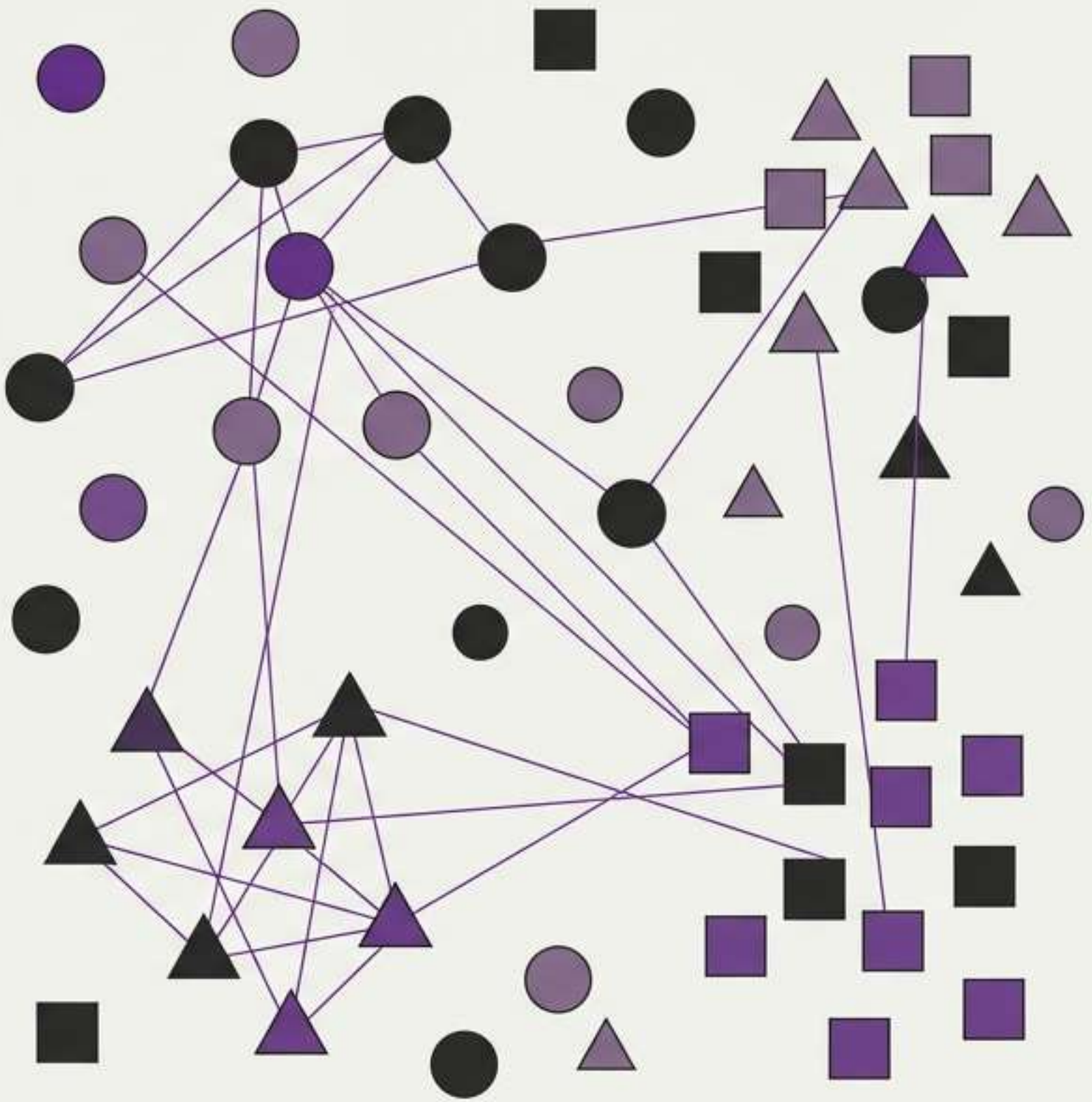
Input: Historical prices, volume.
Output: Predicted future price.

Application: Ride-sharing ETA (Distance -> Minutes).

Unsupervised Learning: The Explorer

Training models on unlabeled data. There are no predefined targets or answer keys.

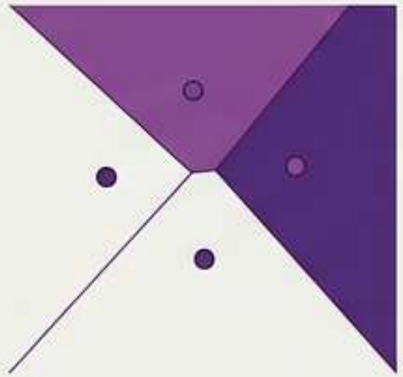
The Goal: To discover hidden patterns, structures, or relationships within the data itself. Used for exploratory analysis and compression.

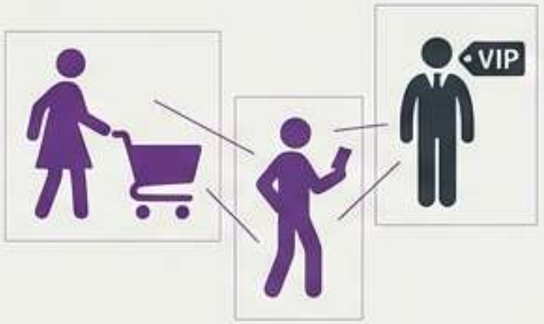


Task Type A: Clustering

Finding Natural Groups

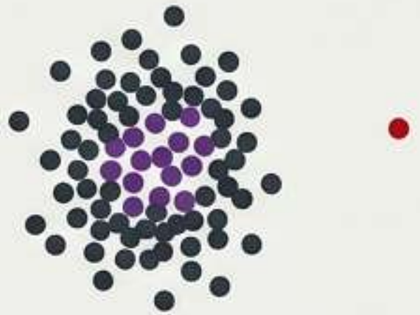
Concept: Grouping data points based on similarity. Items in a cluster are more like each other than they are to items in other clusters.





Example 1: Customer Segmentation

Input: Purchase history
Outcome: Discovering groups like “High-value frequent shoppers” or “Occasional bargain hunters”.



Example 2: Anomaly Detection

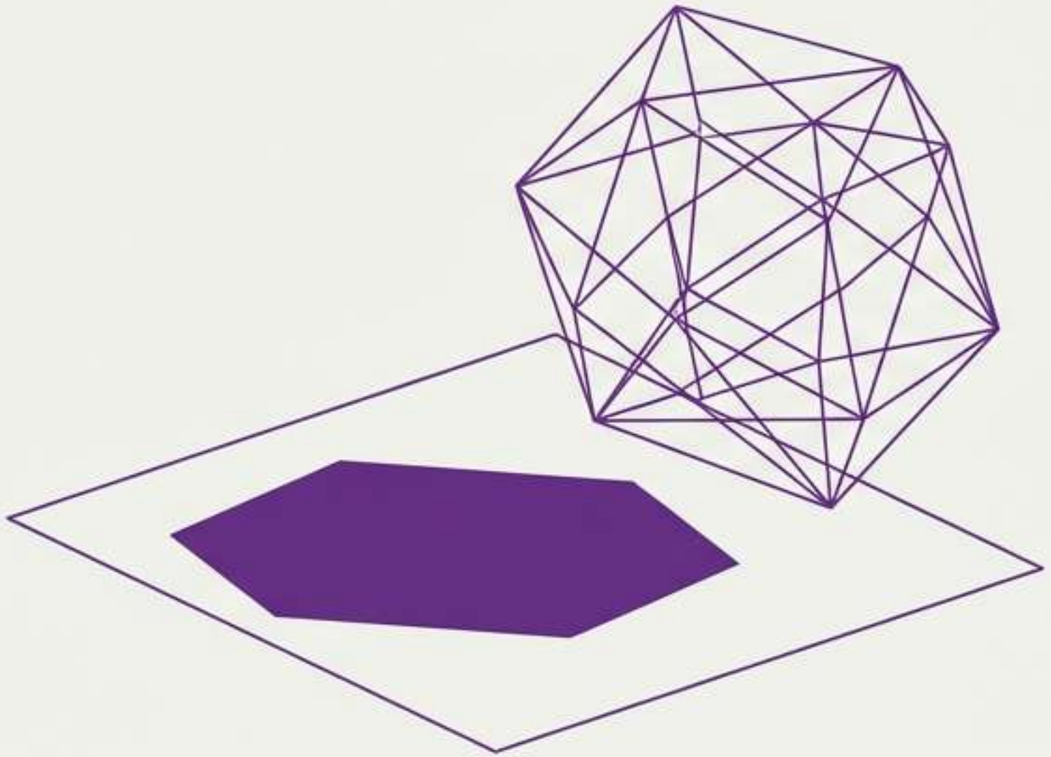
Input: Network traffic
Outcome: Flagging traffic that deviates from “normal” density (Cybersecurity threats).

Application: Genetics Lab (Grouping cells by gene expression)

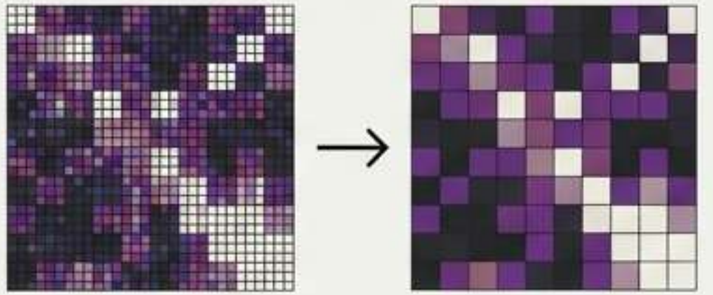
Task Type B: Dimensionality Reduction

Simplifying Complexity

Concept: *Reducing the number of input features (dimensions) while retaining critical information.*

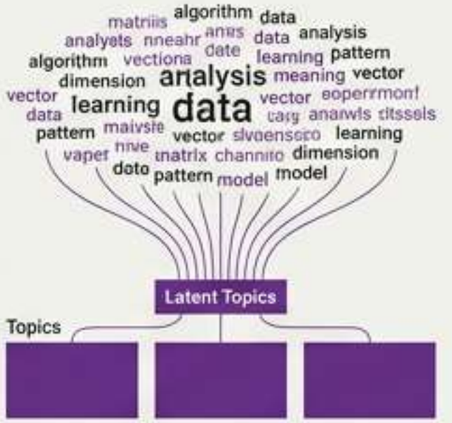


Example 1: Image Compression



Process: Reducing color channels or merging pixels to lower file size without losing essential info.

Example 2: Feature Extraction (Text)



Process: Compressing a massive vocabulary into a smaller set as set of “latent topics” to capture meaning.

Application: Sensor Analysis (Visualizing thousands of measurements).

Reinforcement Learning: The Agent

The Goal: To learn a policy—a strategy for choosing actions—that maximizes cumulative reward over time.

An “Agent” learns to make decisions by interacting with an “Environment.” It is not given a dataset but learns through trial and error.

- **Agent:** The learner.
- **Action:** What the agent does.
- **Reward/Penalty:** Feedback from the environment.
- **Policy:** The strategy developed.

The Learning Loop in Action

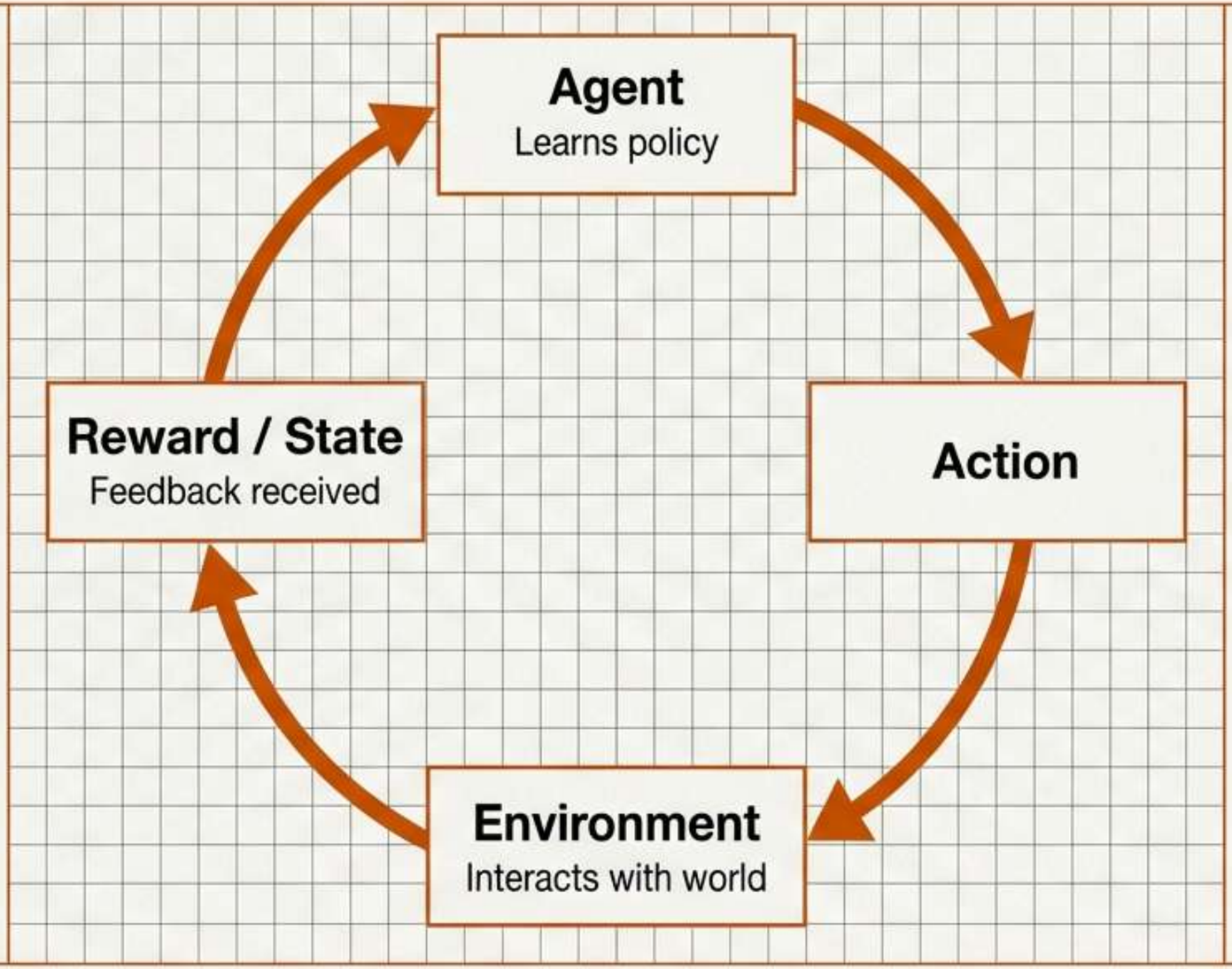
Autonomous Driving

Agent: Car control system.

Actions: Steer, brake, accelerate.

Rewards: Safety.

Penalties: Collision, speeding.



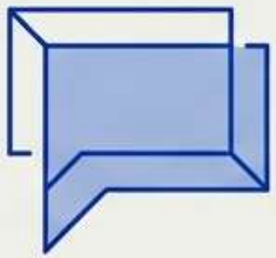
Game Playing (Chess)

Reward: Winning the game.

Process: Exploring moves to learn victory sequences.

Application: Robotic Arm (Learning to grasp irregular objects).

Applied Intelligence: Industry Use Cases



Customer Support

Type: Supervised (Classification)

Chatbots trained on customer questions to classify intent (e.g., billing vs. tech support) and route to agents.

Banking Security

Type: Unsupervised (Anomaly Detection)

Analyzing millions of transactions to learn “normal” patterns and flag deviations as novel fraud schemes.

Retail Logistics

Type: Reinforcement Learning

Optimizing inventory. An agent decides on stocking levels based on demand, receiving rewards for efficiency.

Paradigm Reference Guide

Paradigm	Data Type	Primary Goal	Core Mechanism
Supervised	Labeled (Input + Output)	Prediction (Classify or Estimate)	Mapping Function
Unsupervised	Unlabeled (Raw Data)	Discovery (Structure or Groups)	Pattern Recognition
Reinforcement	No Dataset (Interaction)	Optimization (Best Outcome)	Trial & Error (Reward/Penalty)

Test Your Knowledge

Match the scenario to the Learning Paradigm.

A: Predicting loan default based on credit score.

B: Grouping a product catalog without pre-existing labels.

C: A drone learning to navigate an obstacle course via repeated attempts.

D: Predicting the likelihood of disease development (next 5 years).

E: Analyzing reviews to find underlying sentiment themes without specific labels.

Supervised (Classification)

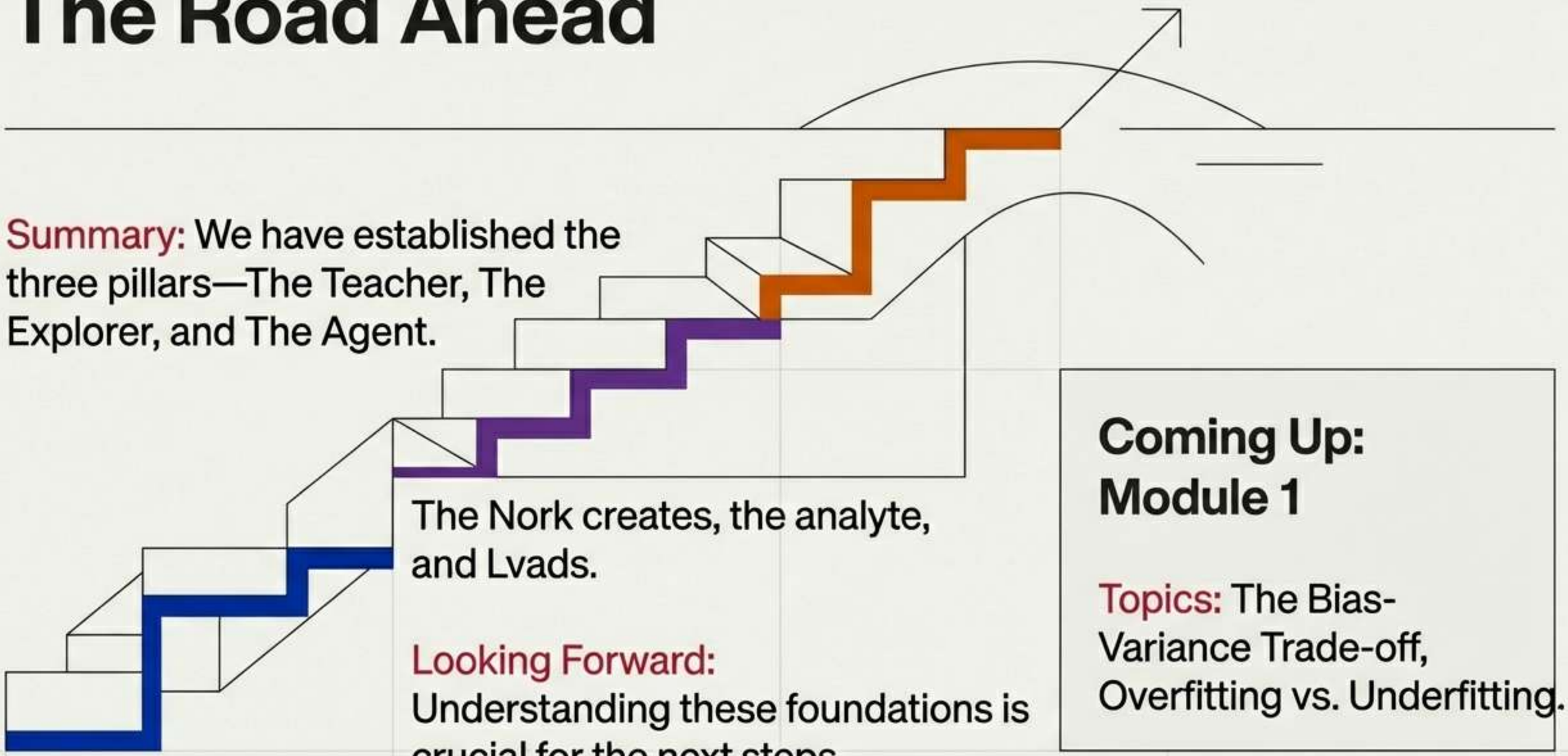
Unsupervised (Clustering)

Reinforcement Learning

Supervised (Regression)

Unsupervised (Clustering)

The Road Ahead



Summary: We have established the three pillars—The Teacher, The Explorer, and The Agent.

The Nork creates, the analyte, and Lvads.

Looking Forward:
Understanding these foundations is crucial for the next steps.

Coming Up: Module 1

Topics: The Bias-Variance Trade-off, Overfitting vs. Underfitting.