From Search Algorithms and Logic to Learning Systems

Faculty of DS & AI
Autumn semester, 2025

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Business AI Lab

2025-10

Content

- Learned Algorithm
- Machine Learning
- Deep Learning

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From Search Algorithms and Logic to Learning Systems

Learned Algorithms

- Search Algorithms: BFS, DFS, A*, Greedy Search

- Propositional Logic: Knowledge representation, inference, resolution

- First-Order Logic: Predicates, quantifiers, CNF conversion, resolution refutation

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Learned Algorithms

- 8-Puzzle: Solved with A* search using Manhattan distance heuristic
- Missionaries and Cannibals: BFS found optimal path
- Chess/Game Playing: Minimax with alpha-beta pruning

- *Key: Well-defined state spaces, clear goals, computable heuristics*

Logic Systems

- Propositional Logic: "If it rains, then the ground is wet"
- First-Order Logic: "All dogs bark" → "John's dog barks"

- *Key: Explicit rules, logical inference, resolution refutation*

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Image Recognition - "What is in this picture?"

- **Task:** Identify whether an image contains a cat or a dog
- **Input:** Digital image (e.g., 256×256 pixels, RGB color)
- **Output:** Classification label: "cat" or "dog"

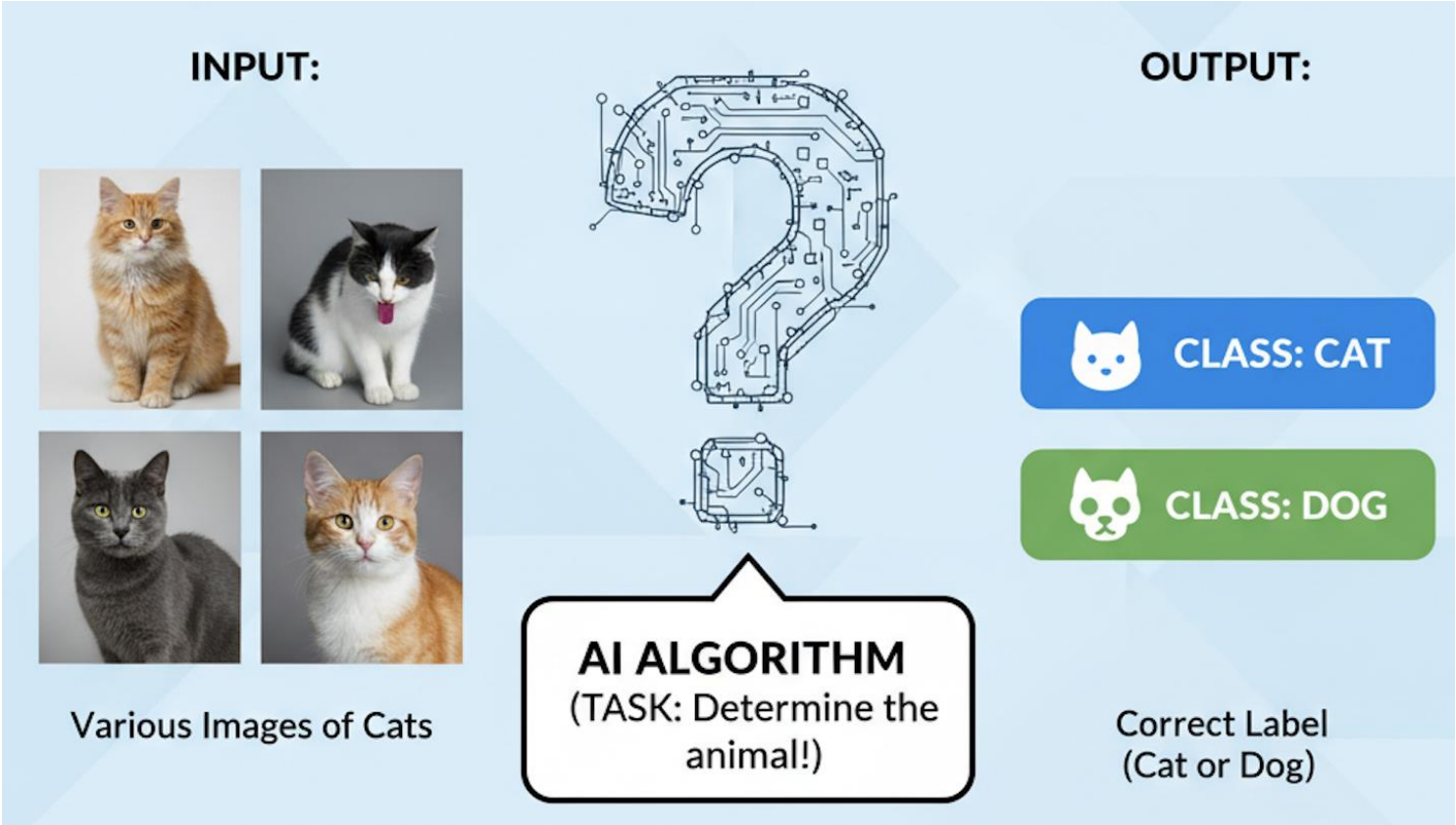

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Image Recognition - "What is in this picture?"

Attempt 1: State Space Search

- State: Each possible image configuration
- Problem: 256 × 256 × 3 = 196,608 pixels
- Each pixel: 256^3 possible color values
- Total states: $(256^3)^{196,608} \approx 10^{1,420,000}$ states
- Our experience: Even 8-puzzle has only 9! = 362,880 states
- Result: ❌ State space explosion makes exhaustive search impossible

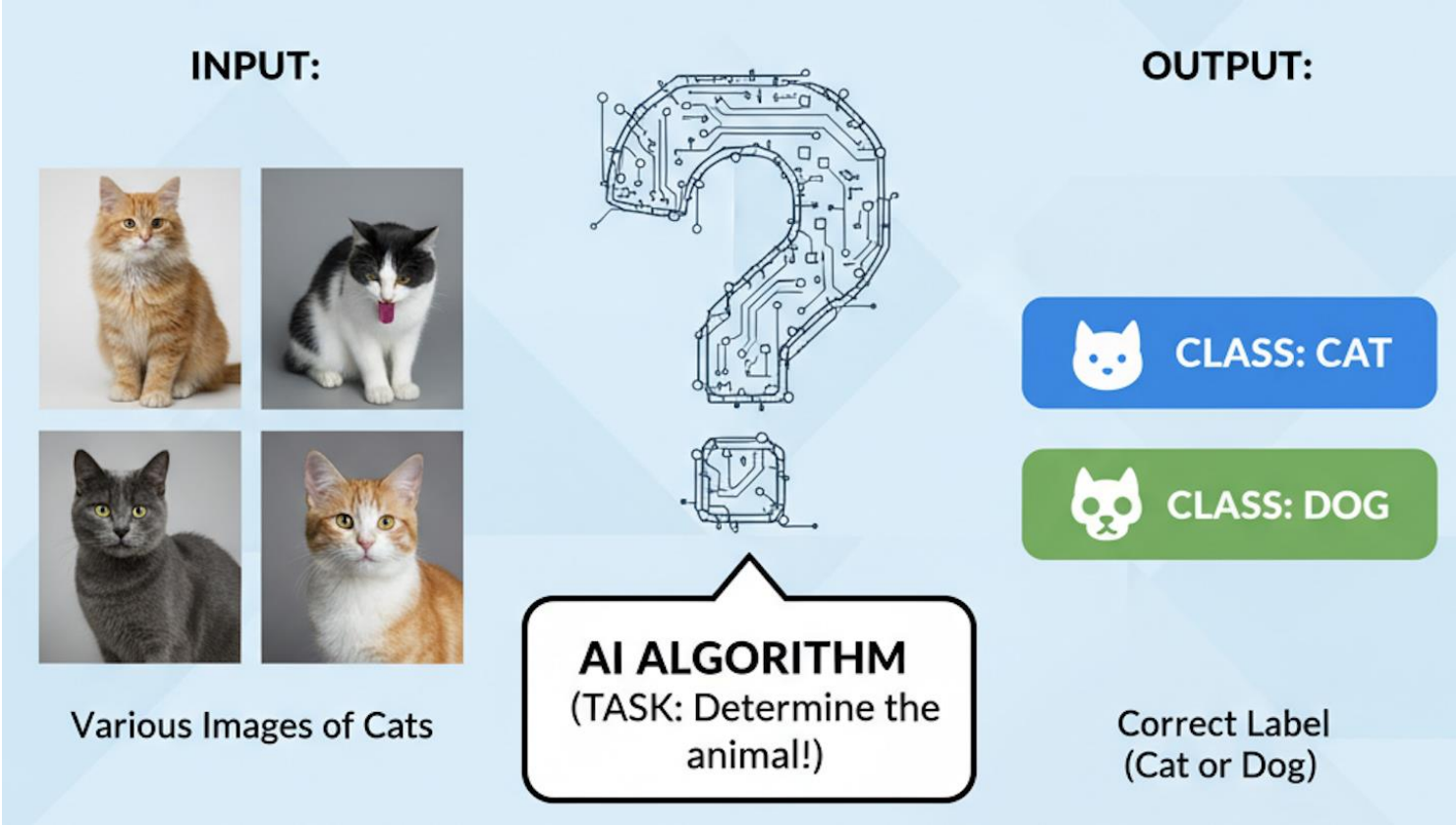

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Image Recognition - "What is in this picture?"

Attempt 2: Heuristic Search (A*)
- Question: What's the heuristic function h(n)?
- Need: Distance estimate from current image to "cat" or "dog"
- Problem: How do we measure "distance to cat"?
- Our experience: Manhattan distance worked perfectly for 8-puzzle
- Result: ❌ No meaningful heuristic function exists

Attempt 3: Greedy Search
- Need: Clear evaluation function
- Problem: What makes an image "more cat-like"?
- Result: ❌ Cannot define evaluation function

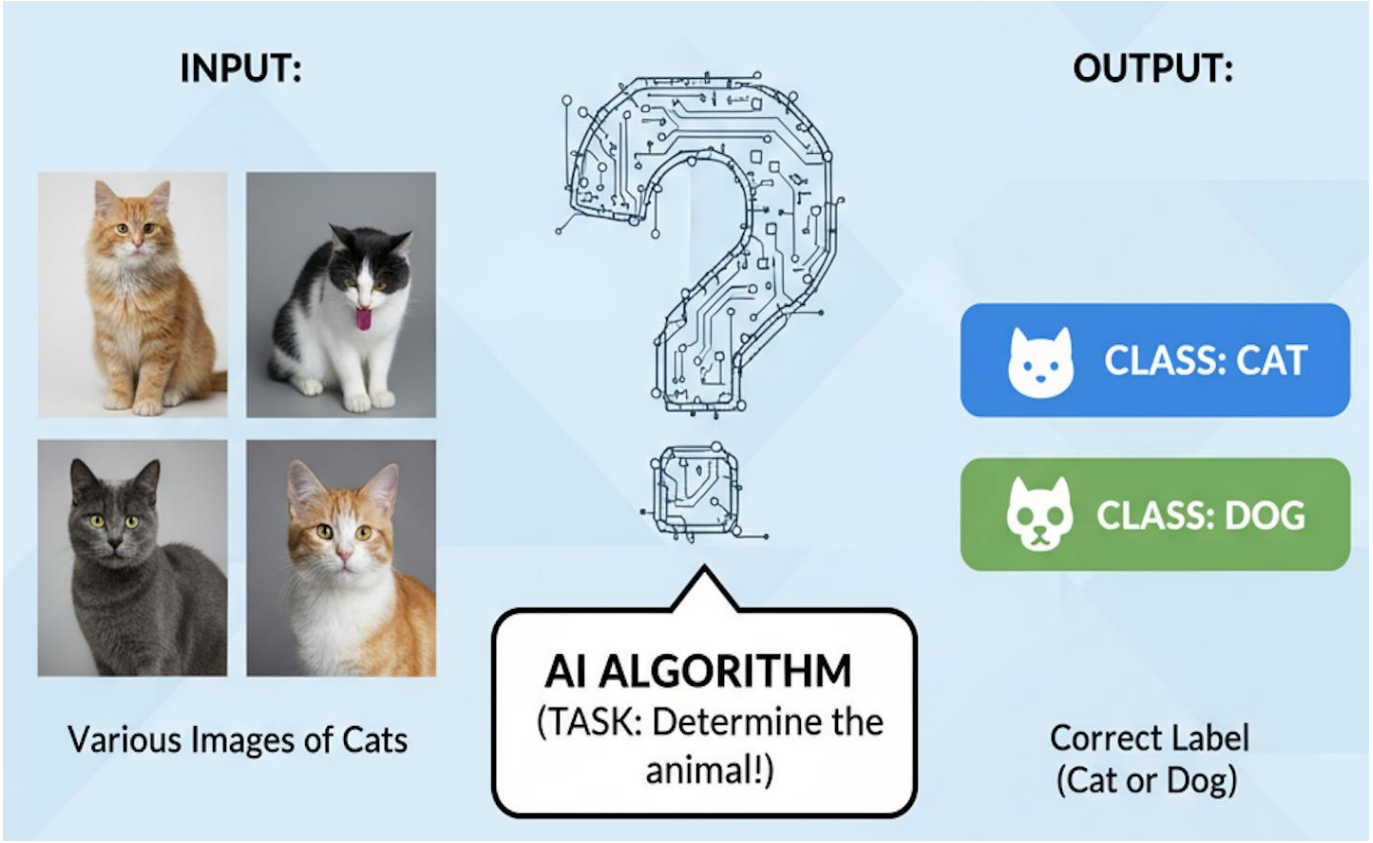

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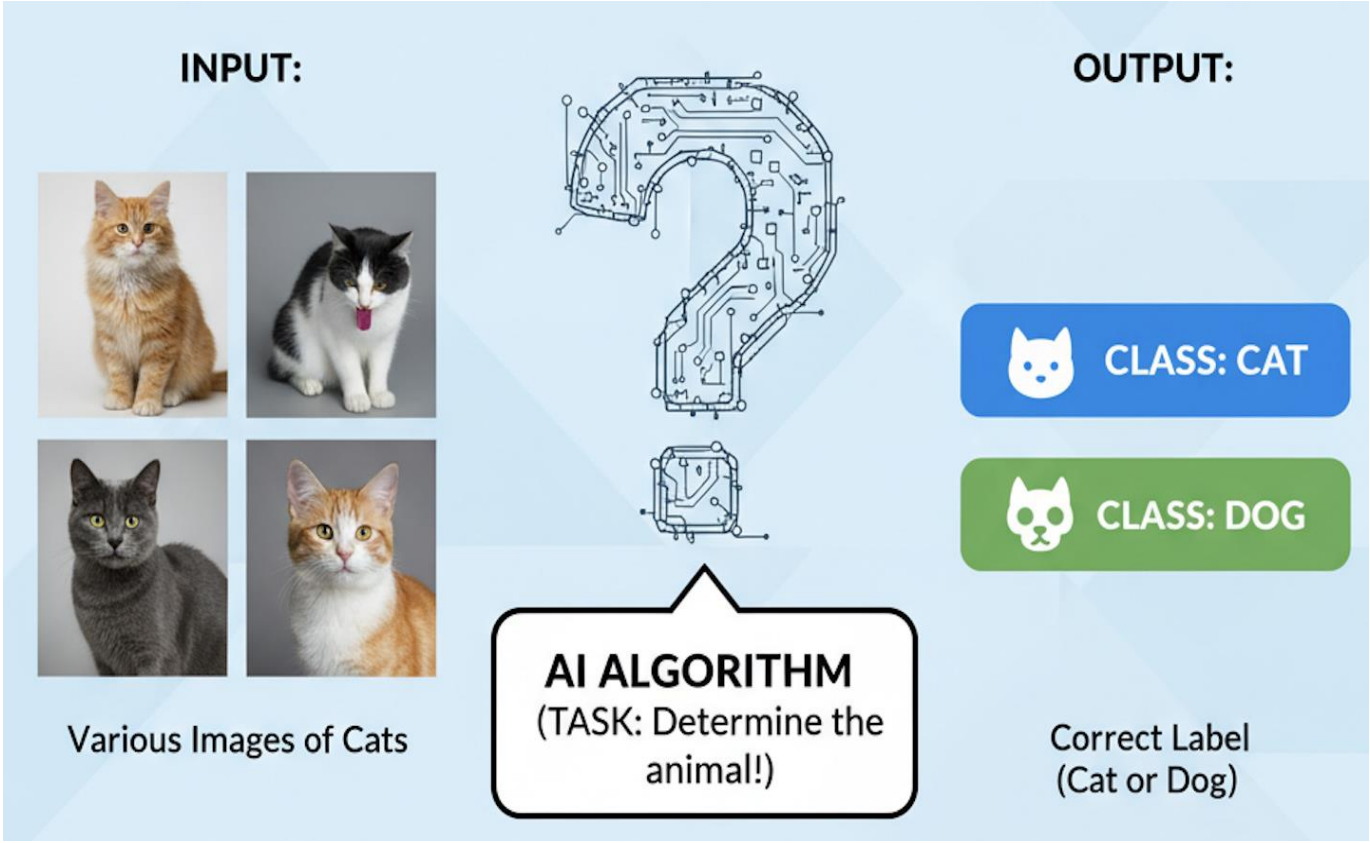
Image Recognition - "What is in this picture?"

Solution:
- Learn patterns from examples (not rules)
- Generalize to new, unseen images
- Handle high-dimensional, complex inputs
- Adapt and improve with experience

=> **Machine Learning** — systems that learn from data



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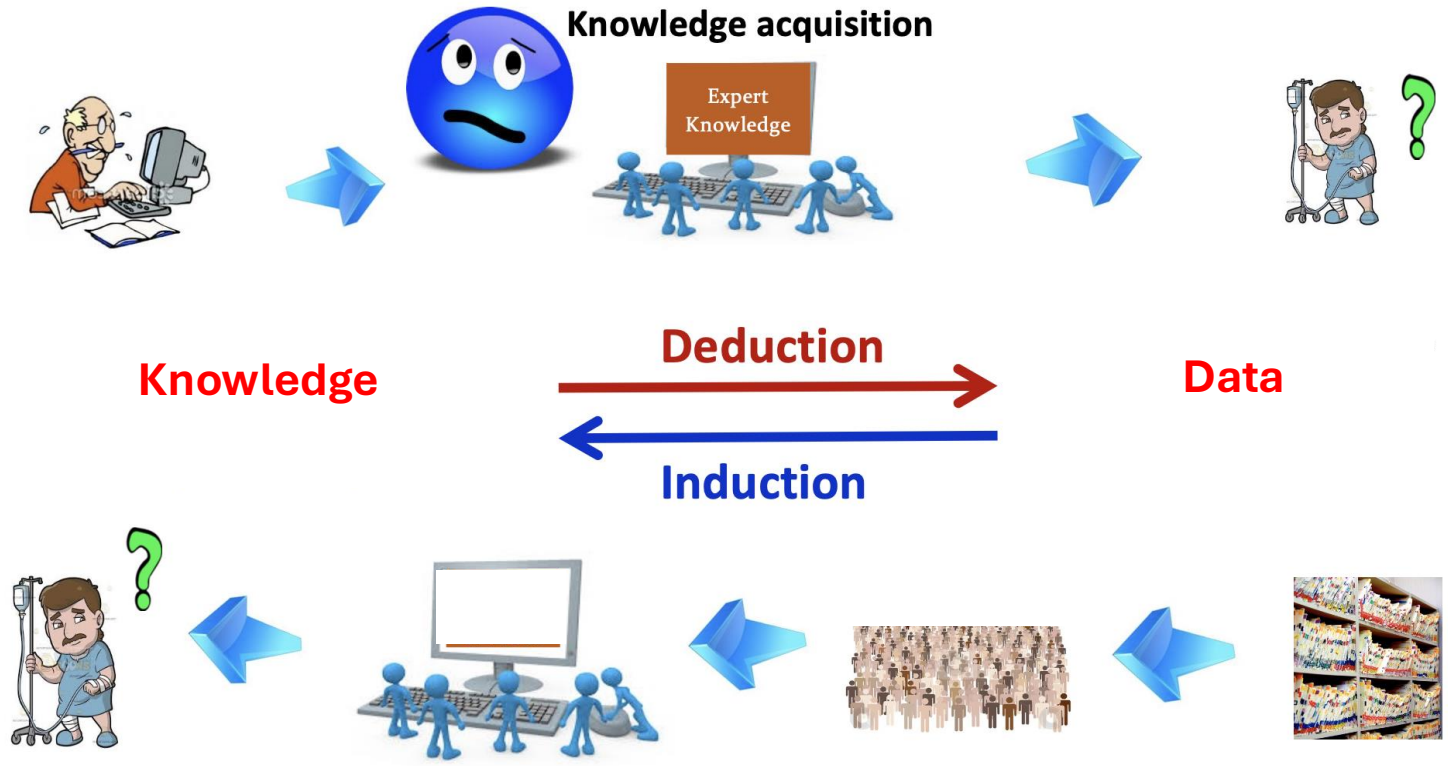
AI with Machine Learning

Machine Learning is a method of data analysis that automates analytical model building. It is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention.



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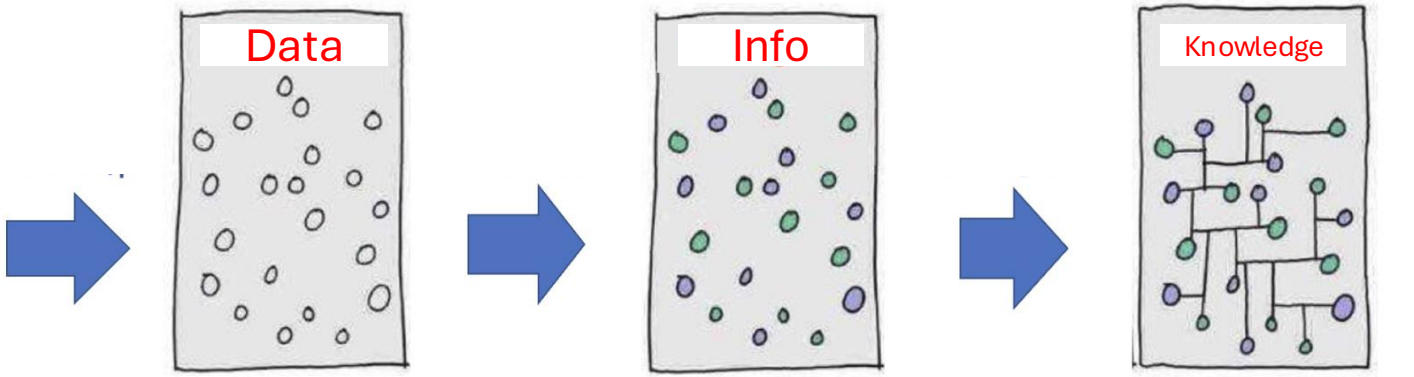
AI with Machine Learning



Raw signal not interpreted

Meaning of data

Integrated information and their relationships

MACHINE LEARNING

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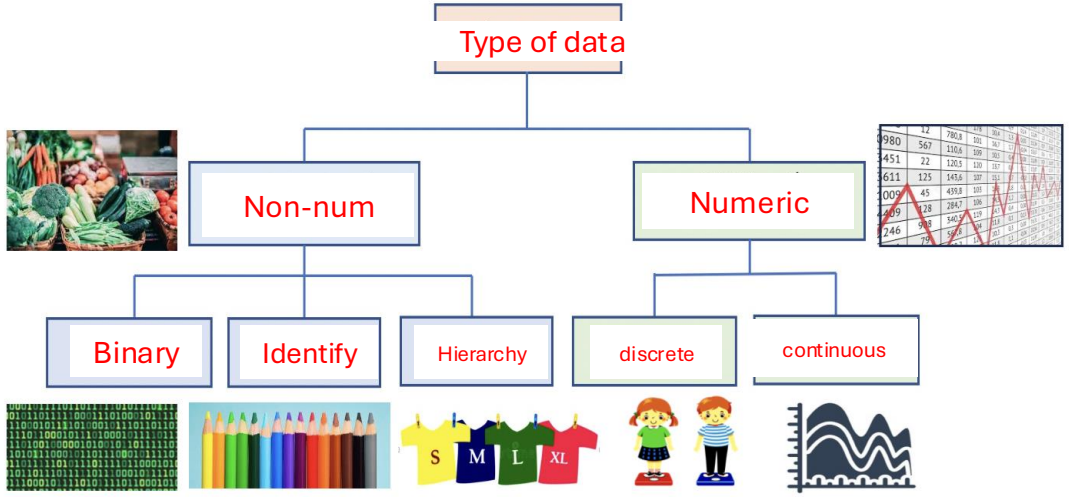
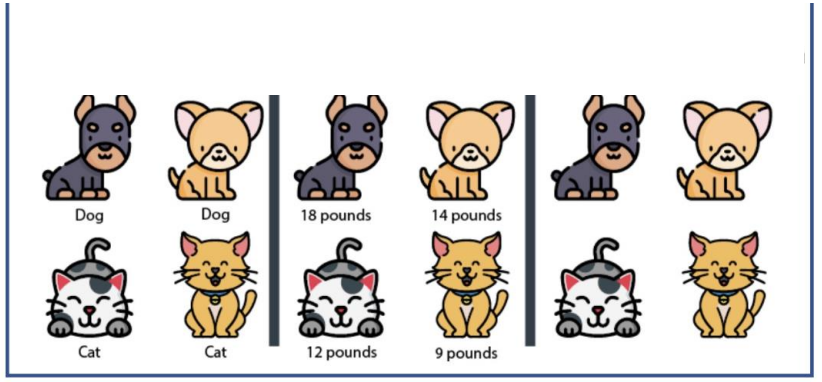
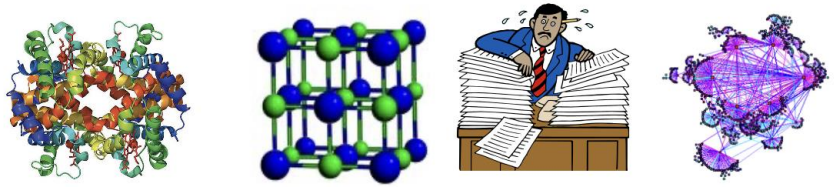
AI with Machine Learning





Labeled or unlabeled data



Unstructured data

TT	TÊN	GIỚI TÍNH	TOÁN	VĂN
1	Huy	Nam	8	7
2	Huyền	Nữ	9	8
3	Trung	Nam	4	7
4	Hương	Nữ	6	5
5	Linh	Nữ	8	7
6	Hoà	Nam	7	8

Structured data

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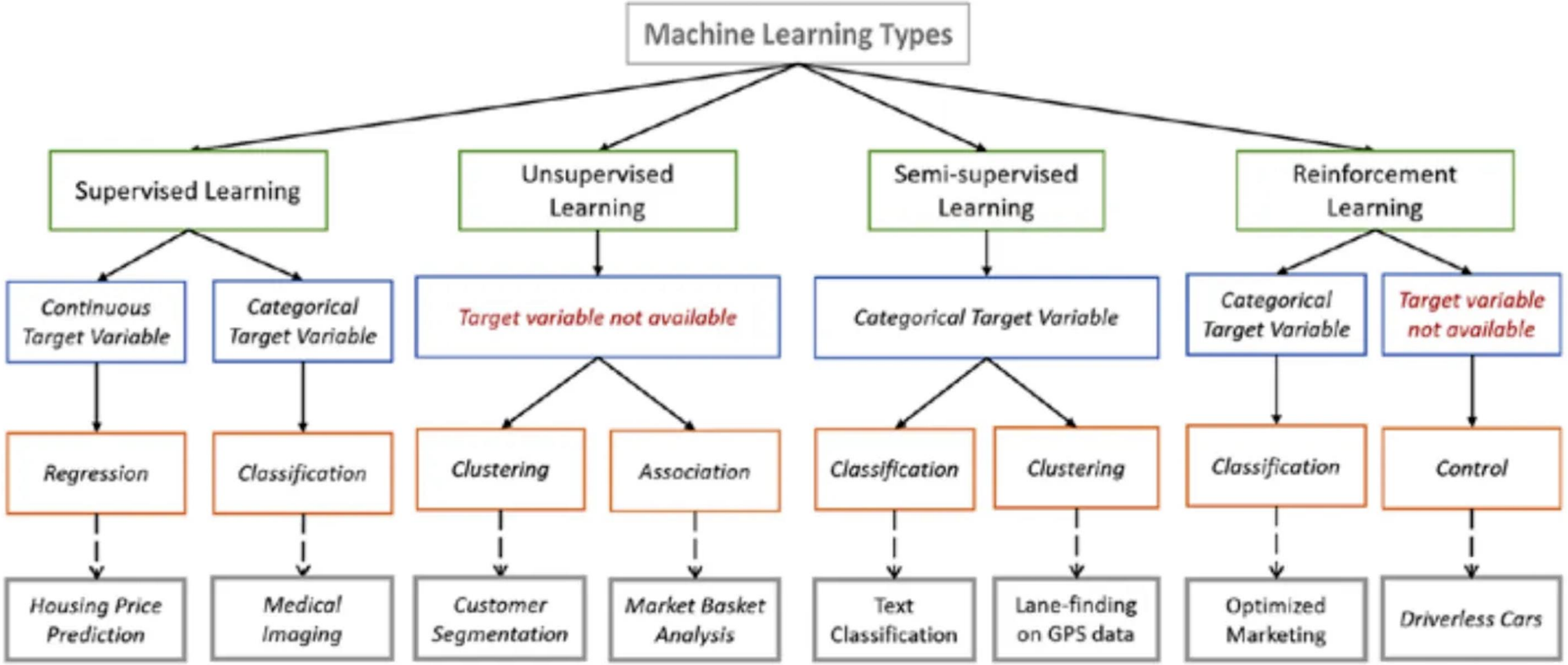
AI with Machine Learning



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AI with Machine Learning

Key Characteristics:

- **Learning from Experience:** Improves performance on a task with experience
- **Pattern Recognition:** Discovers patterns in data automatically
- **Generalization:** Makes predictions on new, unseen data
- **Adaptation:** Adjusts behavior based on feedback

Machine Learning Paradigms

1. Supervised Learning

- **Definition:** Learning with labeled examples
- **Input:** Labeled training data $\{(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)\}$
- **Goal:** Learn a function $f: X \rightarrow Y$ that maps inputs to outputs
- **Examples:**
  - **Classification:** Spam detection (input: email, output: spam/not spam)
  - **Regression:** House price prediction (input: features, output: price)

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AI with Machine Learning

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AI with Machine Learning

2. Unsupervised Learning

- **Definition:** Learning from unlabeled data
- **Input:** Unlabeled data $\{x_1, x_2, ..., x_n\}$
- **Goal:** Discover hidden patterns or structures
- **Examples:**
  - **Clustering:** Customer segmentation
  - **Dimensionality Reduction:** Data visualization

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AI with Machine Learning

3. Reinforcement Learning

- **Definition:** Learning through interaction with environment
- **Components:** Agent, Environment, Actions, Rewards
- **Goal:** Learn optimal policy to maximize cumulative reward
- **Examples:**
  - Game playing (Chess, Go)
  - Autonomous vehicle control
  - Robot navigation

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AI with Machine Learning

Applications of Machine Learning

1. Computer Vision

- Image classification
- Object detection
- Facial recognition

2. Natural Language Processing

- Machine translation
- Sentiment analysis
- Chatbots

3. Healthcare

- Medical diagnosis
- Drug discovery
- Personalized treatment

4. Finance

- Fraud detection
- Credit scoring
- Algorithmic trading

5. Recommendation Systems

- E-commerce (Amazon, eBay)
- Streaming services (Netflix, Spotify)
- Social media (Facebook, LinkedIn)

From Search Algorithms and Logic to Learning Systems

From Machine Learning to Deep Learning

The Relationship

Deep Learning ⊂ Machine Learning ⊂ Artificial Intelligence

Deep Learning is a **subset** of Machine Learning that uses neural networks with multiple layers

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From Machine Learning to Deep Learning

Limitations of Traditional Machine Learning:

- ❌ **Manual Feature Engineering:** Experts must hand-craft features
- ❌ **Limited Complexity:** Struggles with high-dimensional data (images, audio)
- ❌ **Shallow Representations:** Cannot learn hierarchical features automatically
- ❌ **Performance Plateau:** Hit accuracy limits on complex tasks

Example: Image recognition with traditional ML required experts to define features like "edges," "corners," "textures" manually

What Deep Learning Offers:

- ✅ **Automatic Feature Learning:** Discovers features from raw data
- ✅ **Hierarchical Representation:** Learns features at multiple levels of abstraction
- ✅ **End-to-End Learning:** Raw input → Final output (no manual steps)
- ✅ **Breakthrough Performance:** Achieves state-of-the-art results

Example: Deep Learning automatically learns that edges → shapes → objects → scenes

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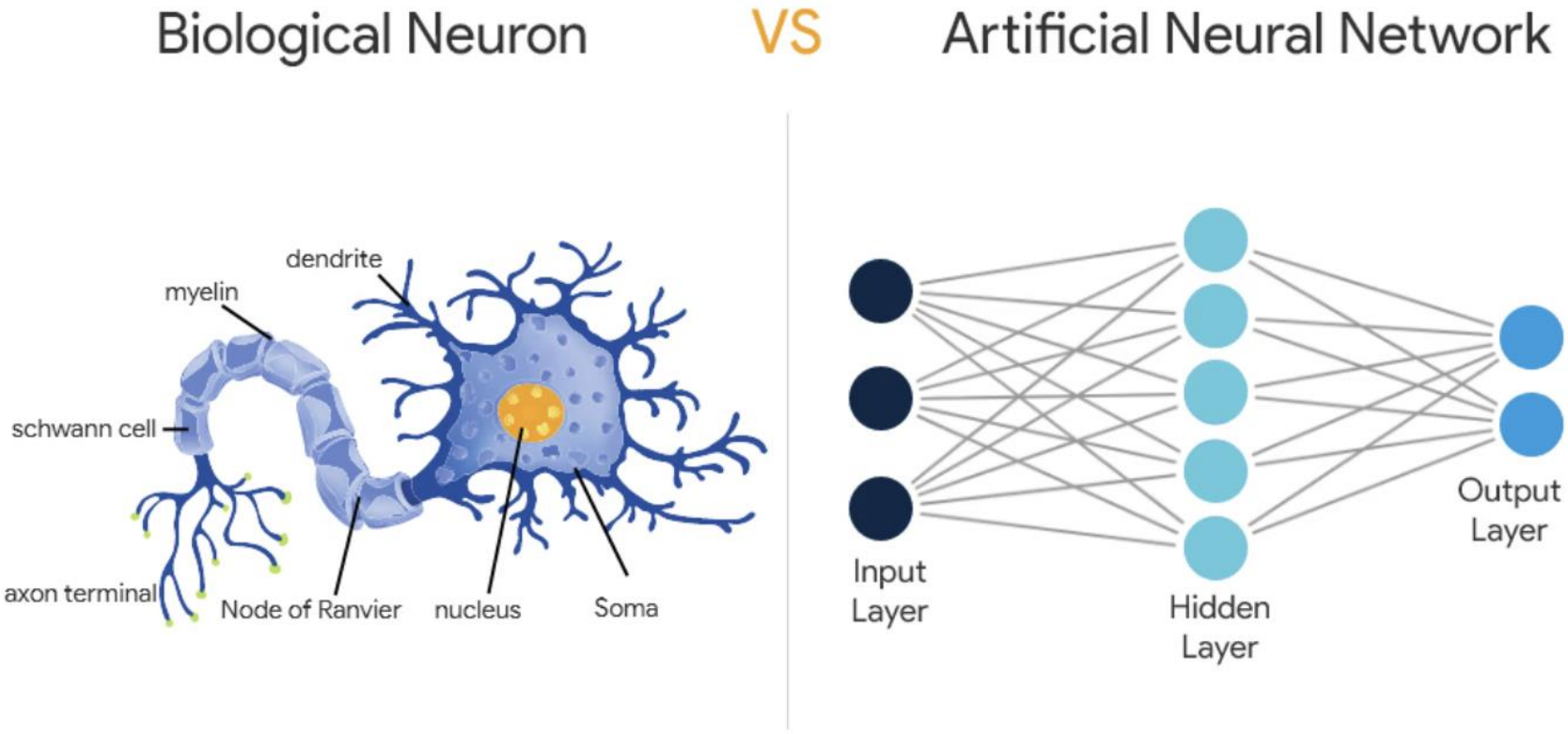
AI with Deep Learning

Deep Learning is a subset of machine learning that uses artificial neural networks with multiple layers (deep architectures) to learn representations of data with multiple levels of abstraction



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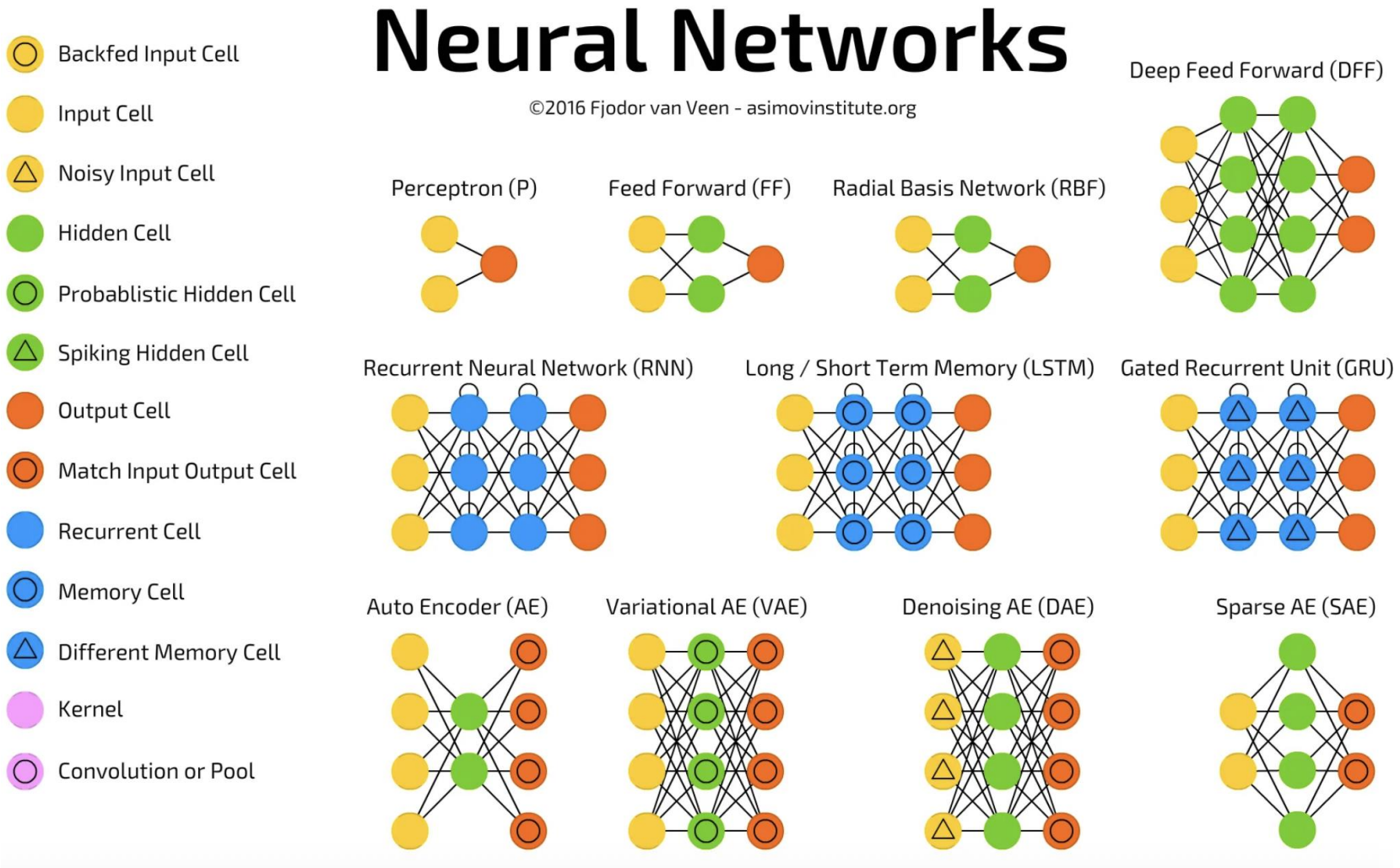
AI with Deep Learning



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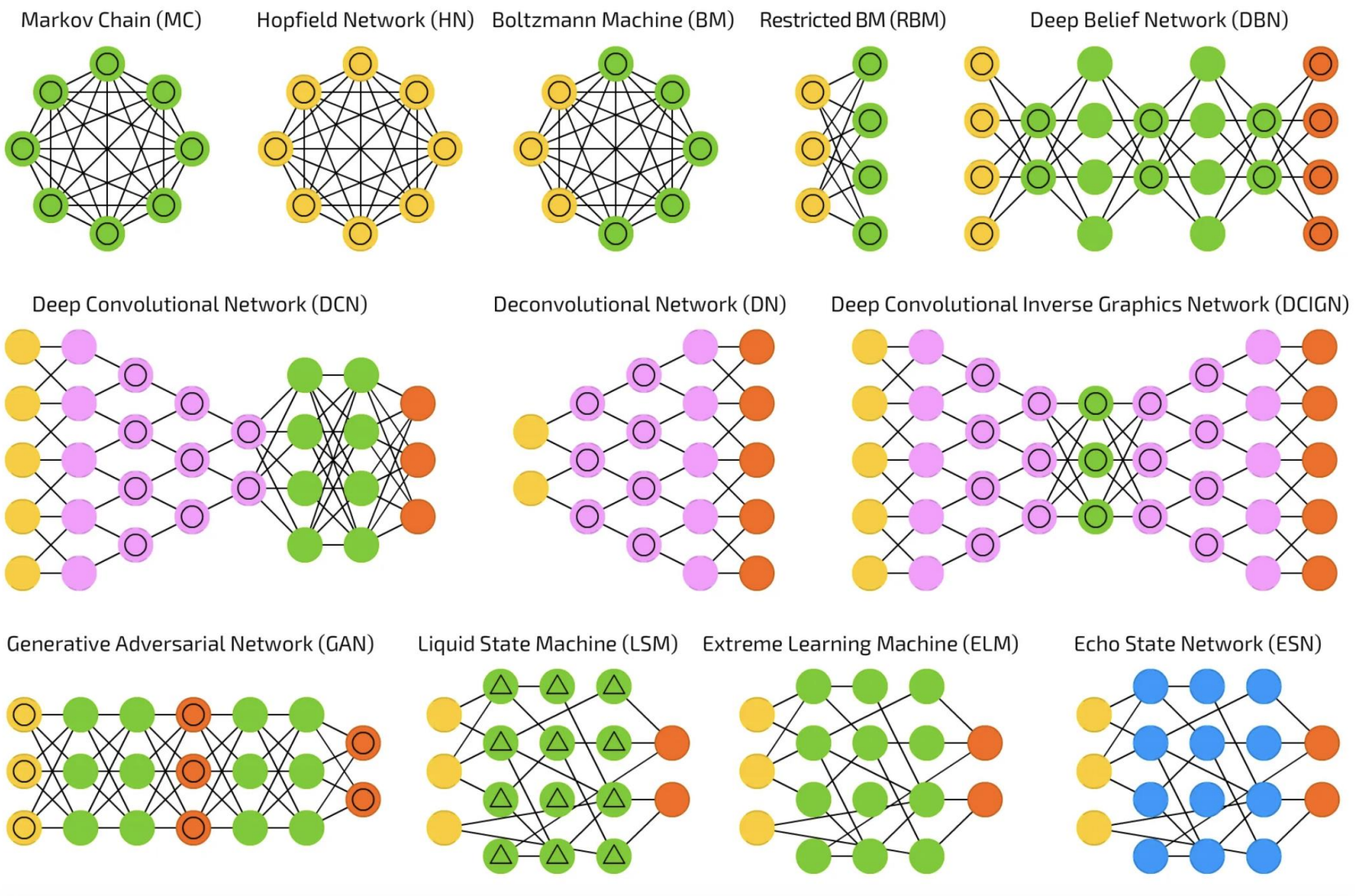
AI with Deep Learning



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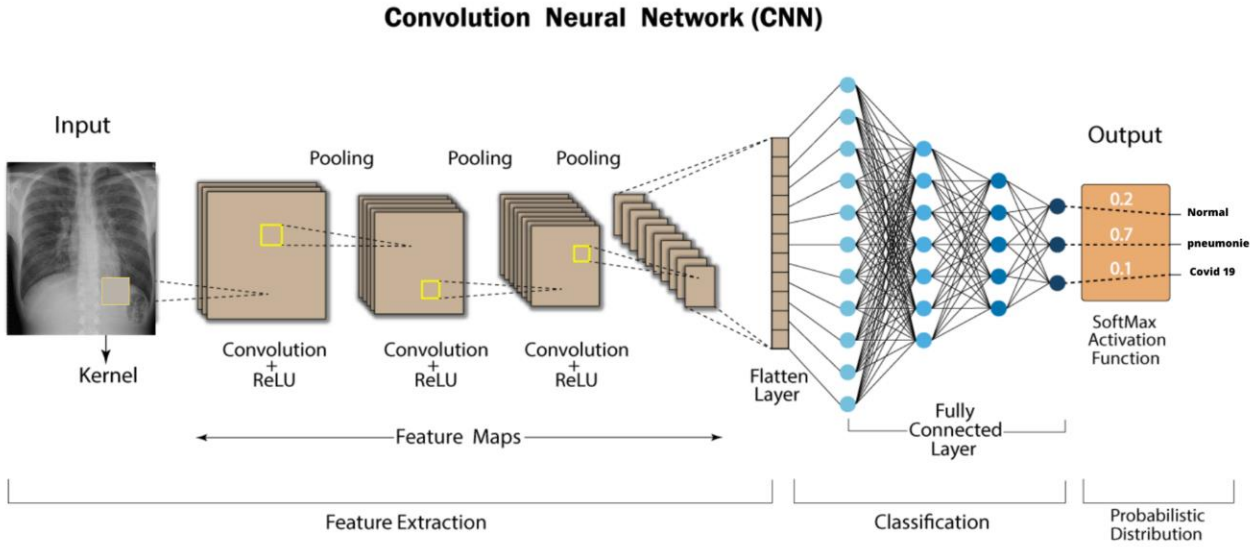
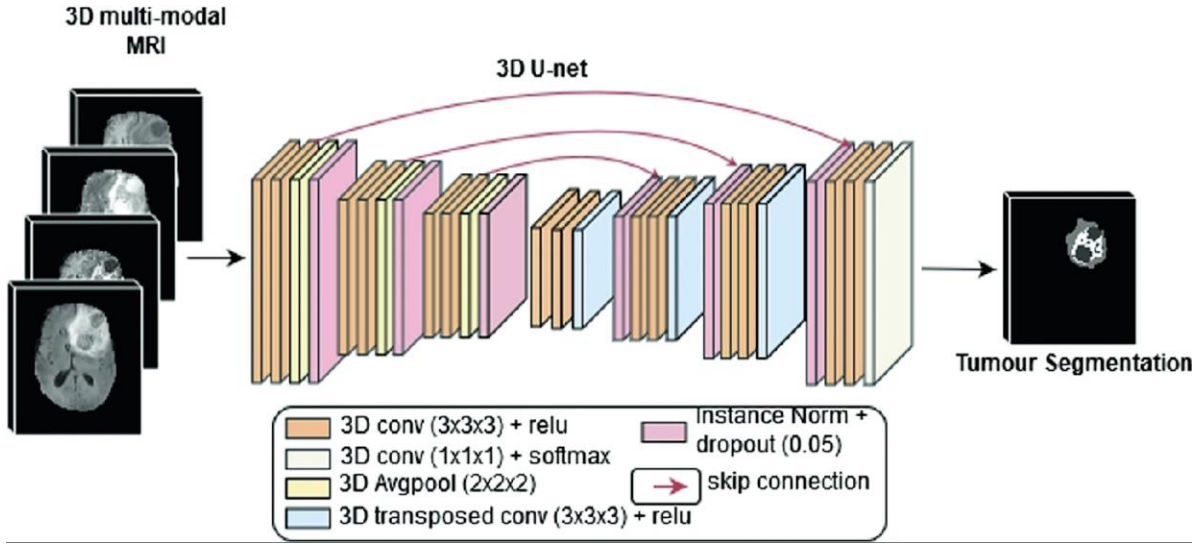
Some research topics of Deep Learning





Computer vision

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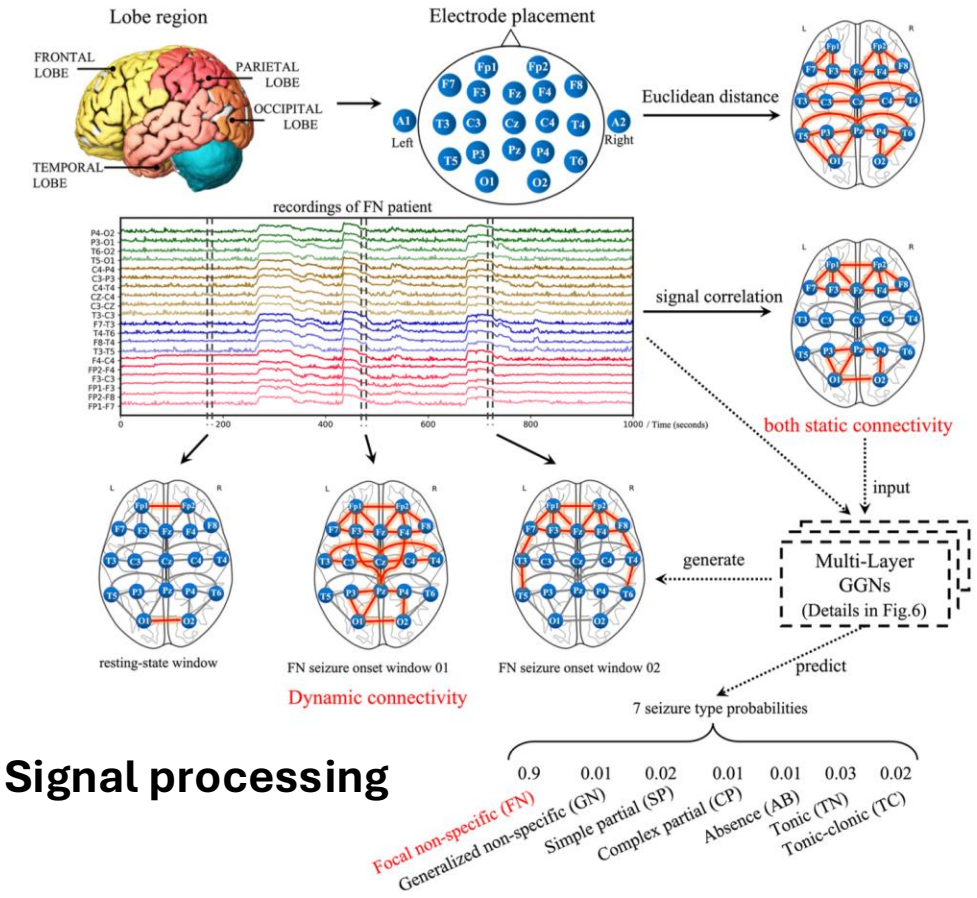
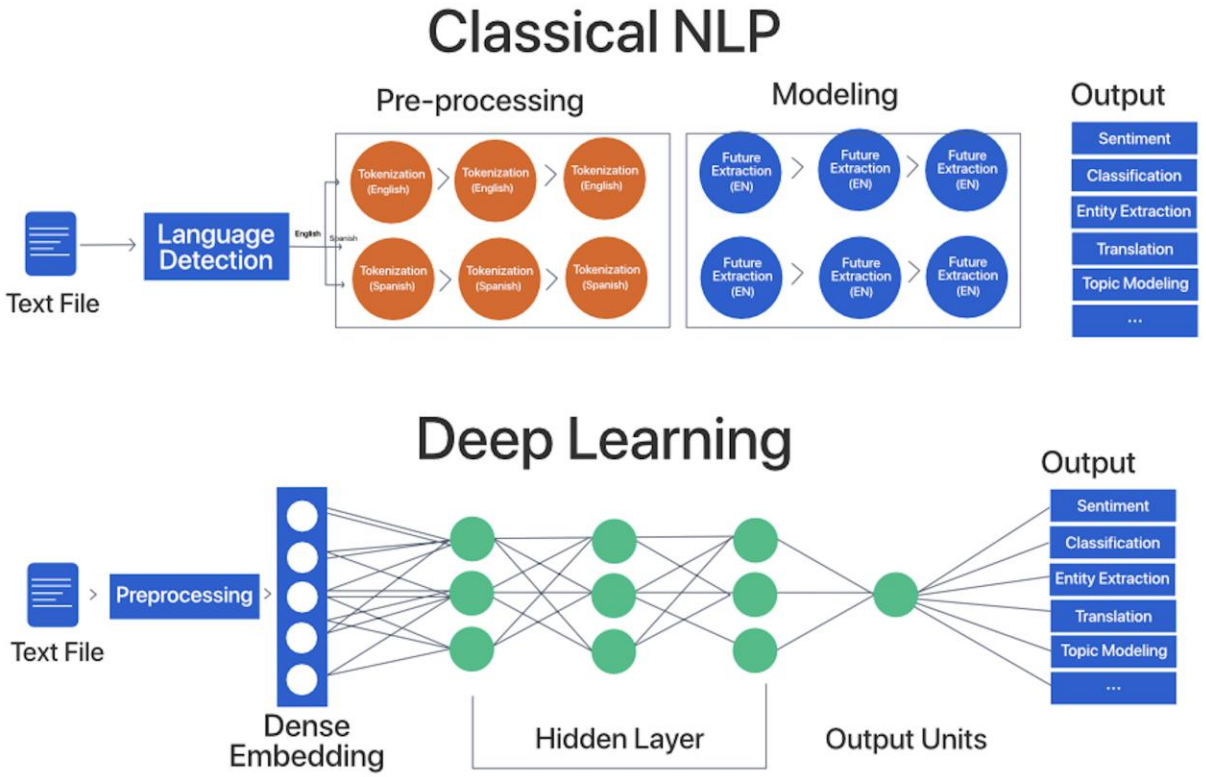


Signal processing



Natural language processing

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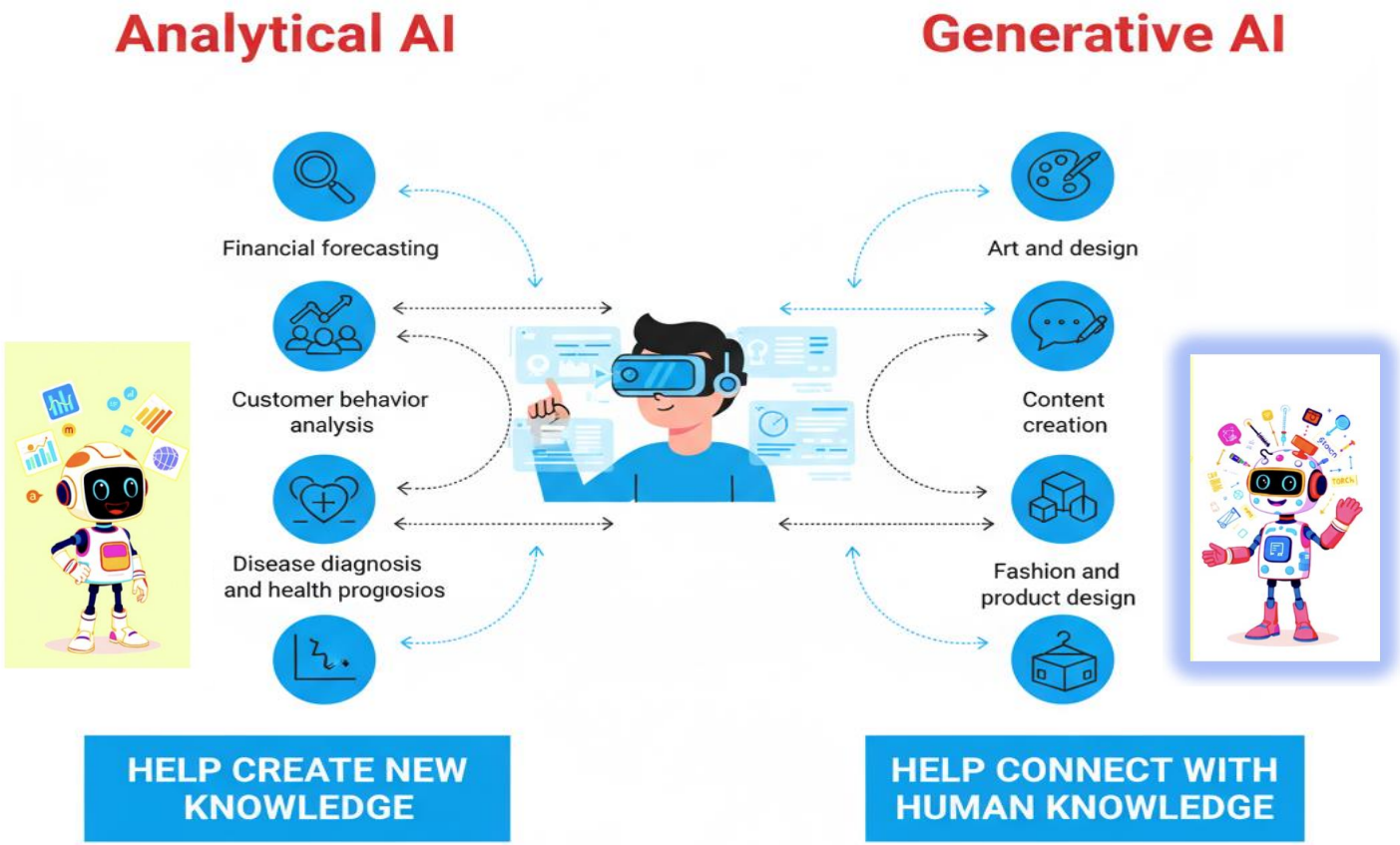
Two branches of AI



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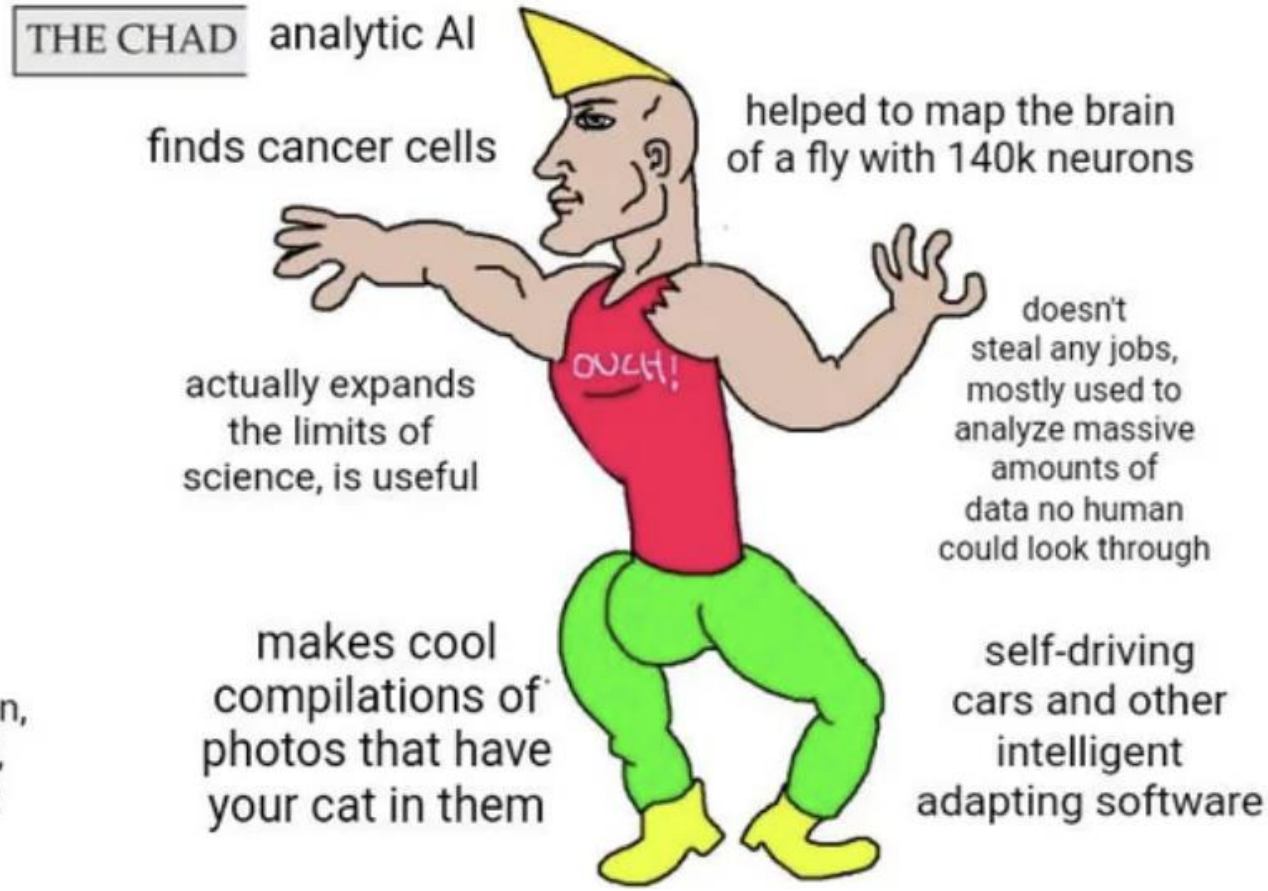

Thank you!

You're now ready to explore the exciting world of AI!