

# Introduction to AI, ML & Data Analytics

[https://github.com/Dr-AlaaKhamis/ISE518/tree/main/4 Intro DA](https://github.com/Dr-AlaaKhamis/ISE518/tree/main/4%20Intro%20DA)

Lecture 5 – Monday September 8, 2025

# Outline

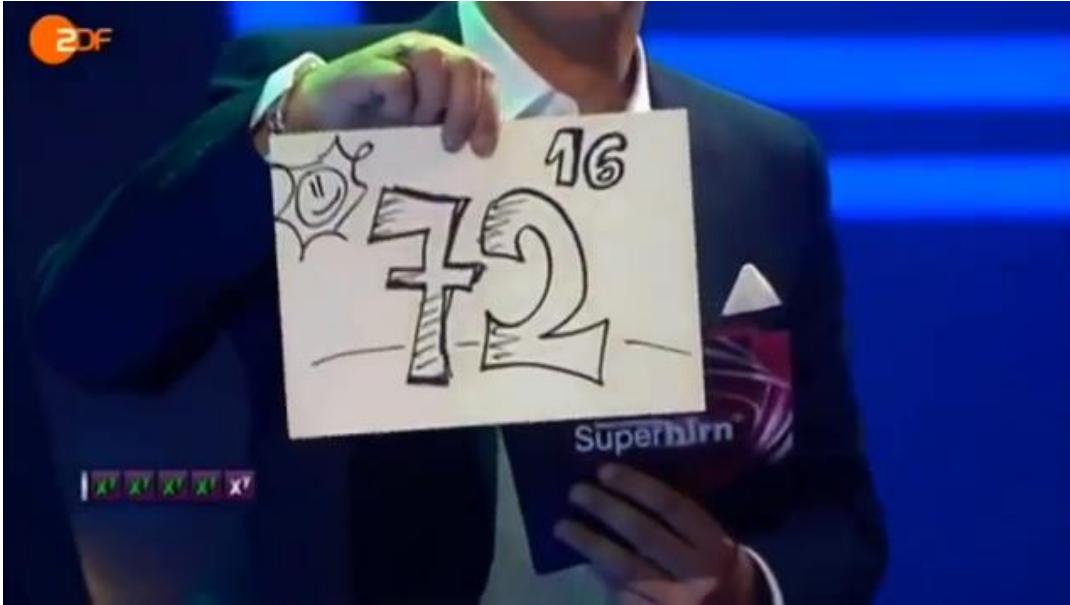
- Introduction to Artificial Intelligence
- Introduction to Machine Learning
- Responsible AI
- Data Analytics

# Outline

- Introduction to Artificial Intelligence
- Introduction to Machine Learning
- Responsible AI
- Data Analytics

# Introduction to Artificial Intelligence

## • Human vs. Machine Intelligence



# Introduction to Artificial Intelligence

## • Human vs. Machine Intelligence

	<b>Human</b>	<b>Machine</b>
<b>Cost</b>	Low initial cost and high running cost.	High initial cost (in case of robots) and low running cost (work 24/7).
<b>Creativity</b>	Creative	Uninspired
<b>Permanency of Intelligence</b>	Human intelligence is perishable. We could not preserve Einstein's intelligence after his death.	Machine intelligence is permanent. It is easy to preserve intelligent tools like Siri and Watson.
<b>Ease of duplication and dissemination of knowledge</b>	Slow language-based communication process, some expertise can never be duplicated.	Knowledge can be copied from a machine and easily moved to another one.
<b>Better in</b>	<ul style="list-style-type: none"> <li>• fusing data from multiple sources and interpreting the outside world</li> <li>• distinguishing faces</li> <li>• identifying objects</li> <li>• recognizing language sounds</li> <li>• learning from few examples. A kid can differentiate between a man and a tree just by showing him/her one example.</li> <li>• develop new concepts/ imagination and creative reasoning.</li> </ul>	<ul style="list-style-type: none"> <li>• faster at performing arithmetic and logical operations</li> <li>• dealing with multi-dimensional data</li> <li>• discovering complex patterns such as that exist in financial, scientific, or product data.</li> <li>• operations that require fast, precise, highly repeatable actions</li> <li>• working in harsh environments (in case of robots).</li> </ul>

# Introduction to Artificial Intelligence

Any sufficiently advanced technology  
is indistinguishable from magic.

Arthur C. Clarke  
(1917-2008)



# Introduction to Artificial Intelligence

## • A day in the life of AI-empowered daily routines

### Home



- Voice Assistant
- Smart Appliances
- Smart Thermostat
- Smart Meter



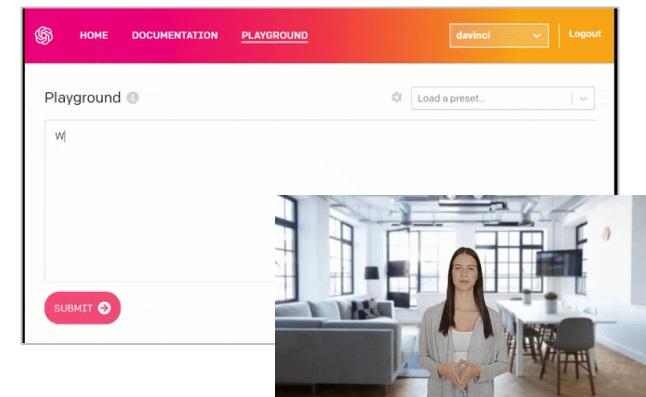
- Navigation Apps
- Location Intelligence Apps
- Shared Mobility
- Advanced Driver Assistance
- Self-driving Shuttles



### Education/Work



- AI Coding Assistant (Copilot)
- Summarization (e.g., genie), Check Grammar (e.g., Grammarly), Translation (e.g., DeepL translate) and Excel AI formula generator (ExcelFormulaBot), NotebookLLM
- Human-like text generation (ChatGPT, Gemini, Grok, LeChat, Claude, DeepSeek,..)
- Image generation from text (Dall-e 2)
- Video generation (e.g., Synthesia, Google Transframer, CoDi)



### Shopping



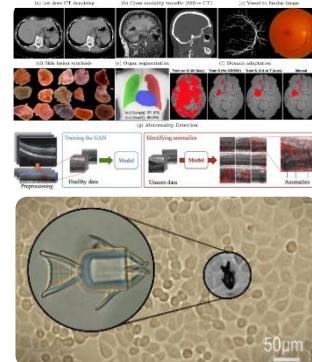
- Voice search
- Search by images
- Semantic search
- Recommendation engines
- Online shopping behavior
- Last-mile delivery



### Health

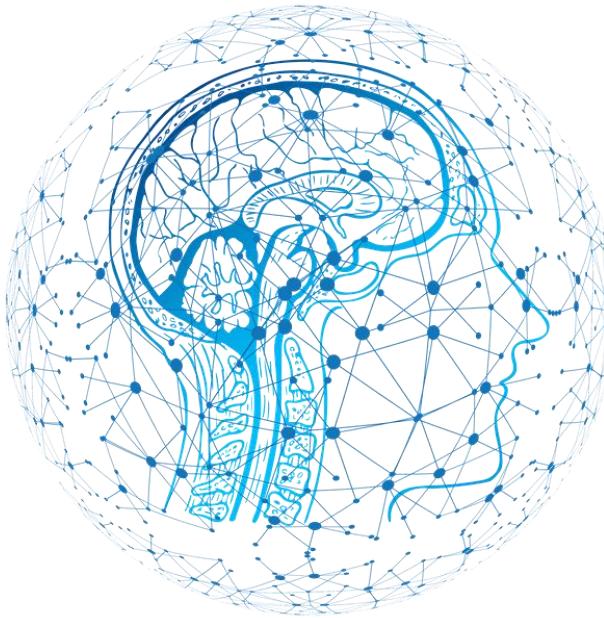


- Personalized Healthcare
- Diagnosis
- Treatment planning
- Rehabilitation
- Lab automation
- Drug discovery and delivery

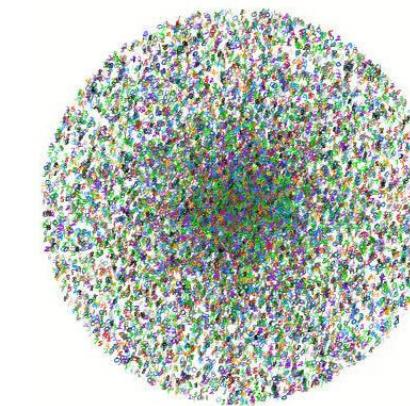


# Introduction to Artificial Intelligence

## • What is Artificial Intelligence (AI)?



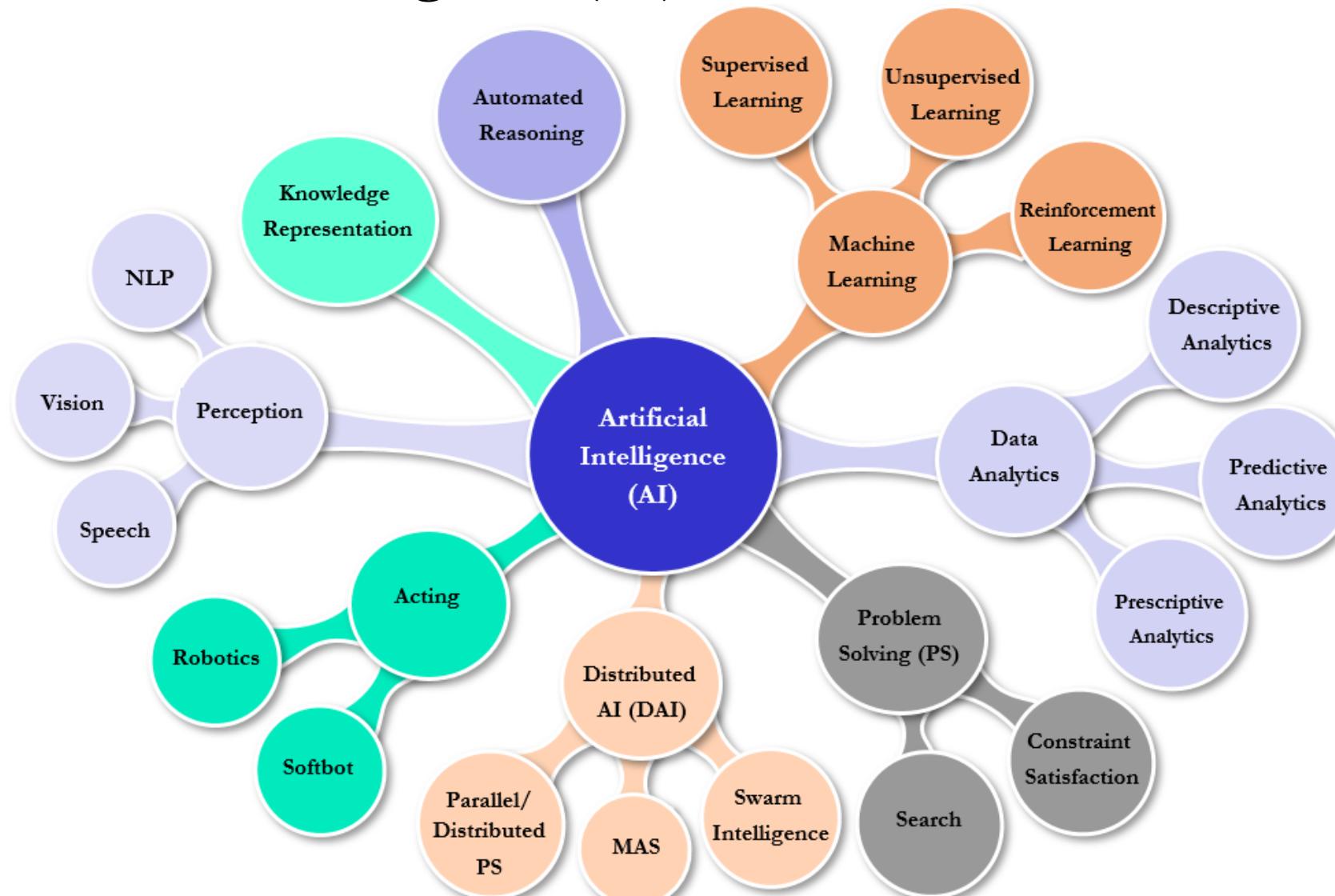
- Muscle Augmentation
- Intelligence Augmentation (IA)



AI aims to create intelligent systems or machines that can exhibit intelligent behavior, often by **mimicking or drawing inspiration from biological intelligence**. These systems can be designed to function **autonomously or with some human guidance**, and ideally, they can adapt to environments with **diverse structures, observability levels, and dynamics**.

# Introduction to Artificial Intelligence

## • What is Artificial Intelligence (AI)?



# Introduction to Artificial Intelligence

## • What is Artificial Intelligence (AI)?: Automotive AI as an example

### Manufacturing

- Industry 4.0, Mass Customization
- Additive Manufacturing
- Robotic Process Automation (RPC)
- Quality Control, Calibration, Test Automation, Assembly Line Balancing, etc.

### Design

- Generative Design
- Engine Efficiency
- Crash Analysis
- New material discovery and characterization
- Battery Design, etc.

### Disposal and Recycling

- Predicting Battery Life
- Reduce Battery Ownership Cost
- Battery Recycling and AI-based Sorting
- Waste Management and Recycling, etc.



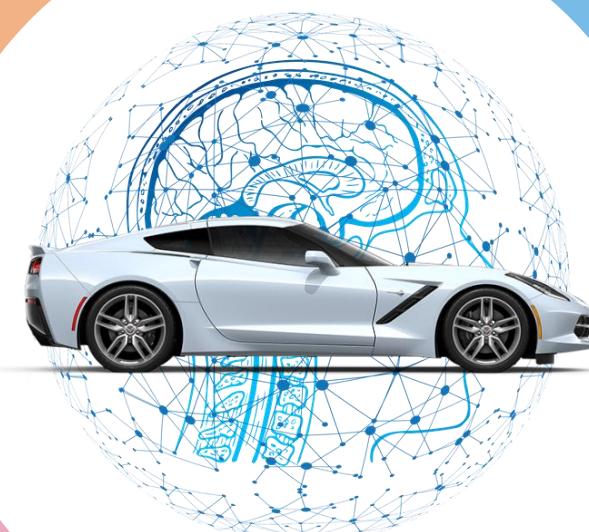
### Disposal and Recycling

Manufacturing

Operation

Design

Feedback & Updates



### Operation

- Diagnostics & Prognostics
- Perception
- Localization
- Mapping
- Behavioral Control
- Planning
- ADAS and ADS
- Predictive Infotainment

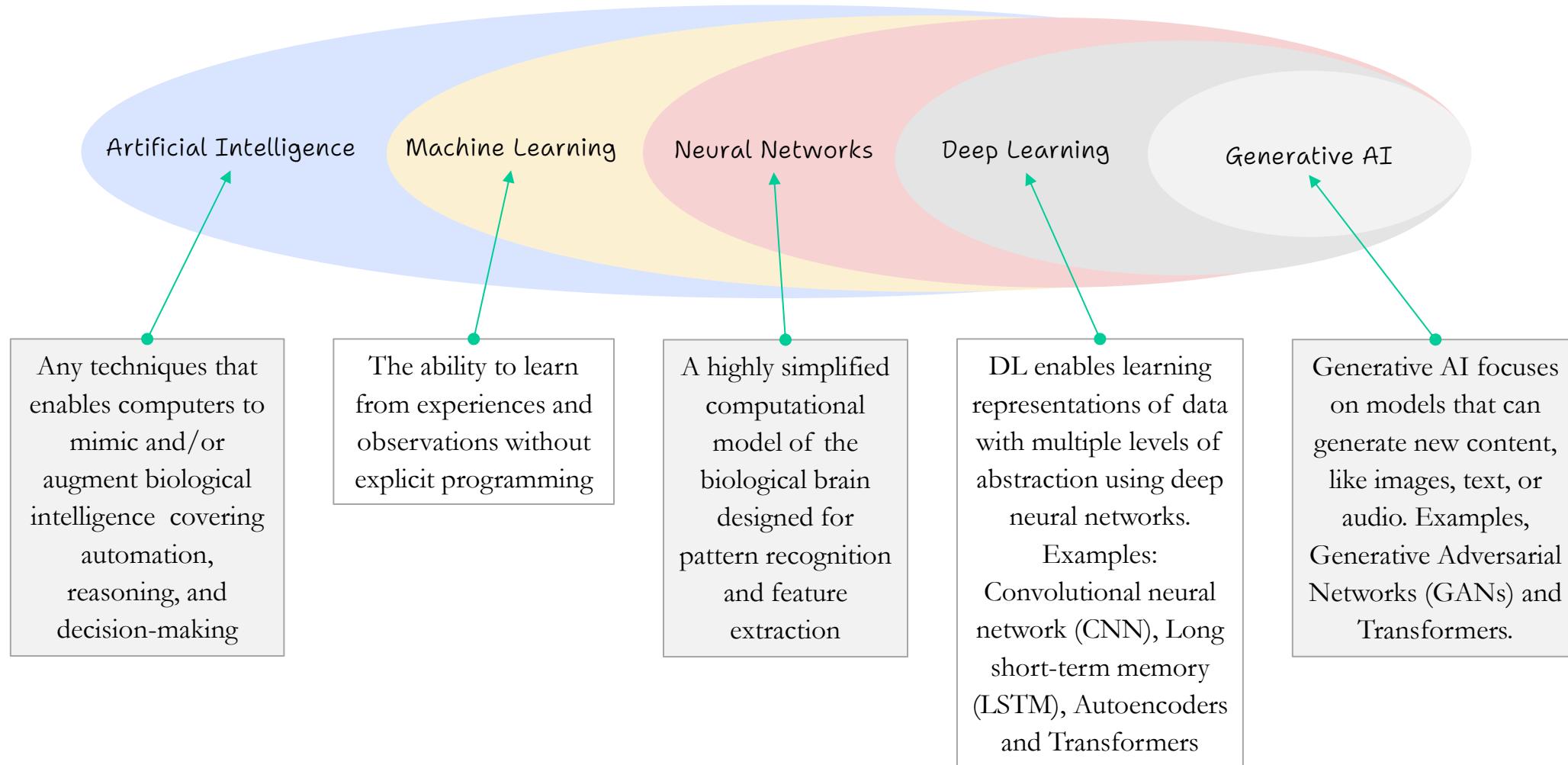
### Feedback and Updates

- Intelligent Agent Assistants
- Sentiment Analysis
- Customer Churn Prediction
- Automated Claims Processing
- Dynamic Pricing
- Incentive Optimization

- Personalized Loyalty
- Personalized Marketing
- Retail Support Bots
- Demand Planning
- Supply Chain Management
- Legal Analytics, etc.

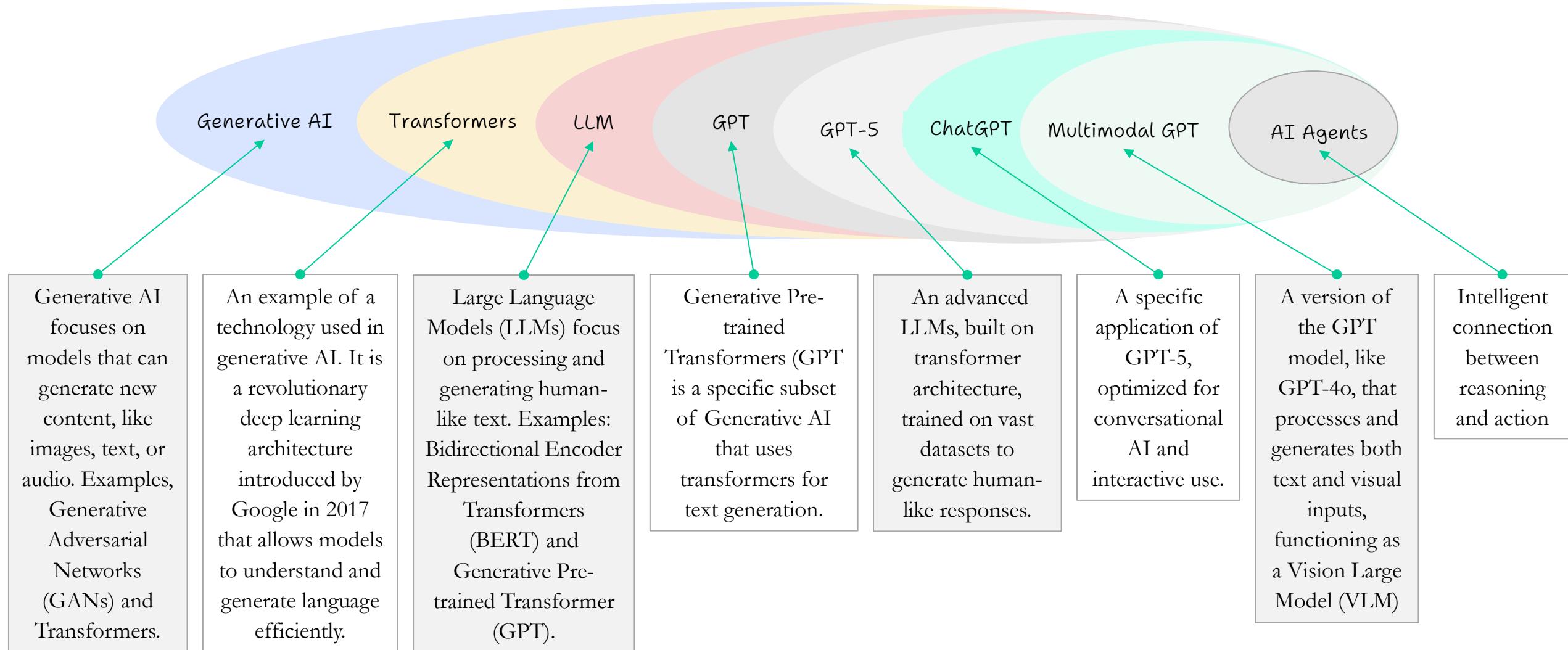
# Introduction to Artificial Intelligence

## • What is Artificial Intelligence (AI)?



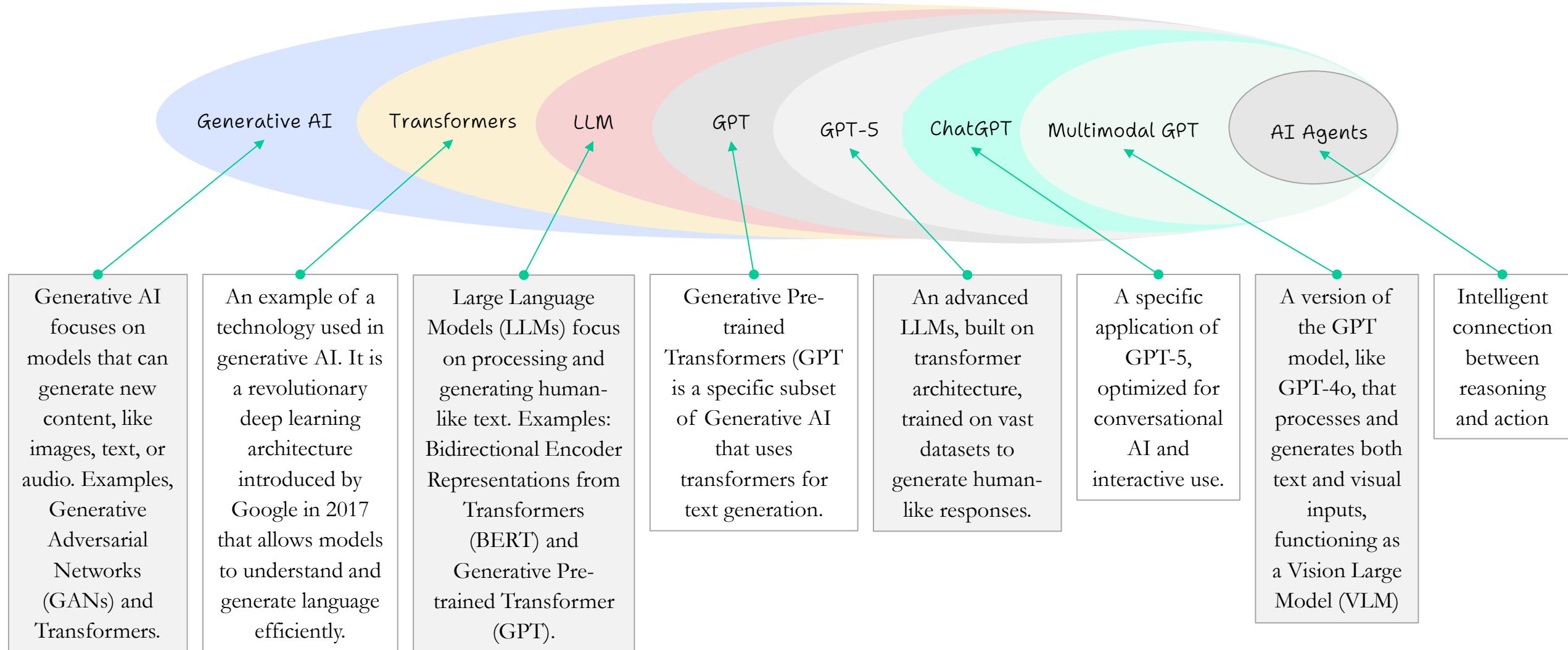
# Introduction to Artificial Intelligence

## • What is Artificial Intelligence (AI)?



# Introduction to Artificial Intelligence

## • What is Artificial Intelligence (AI)?

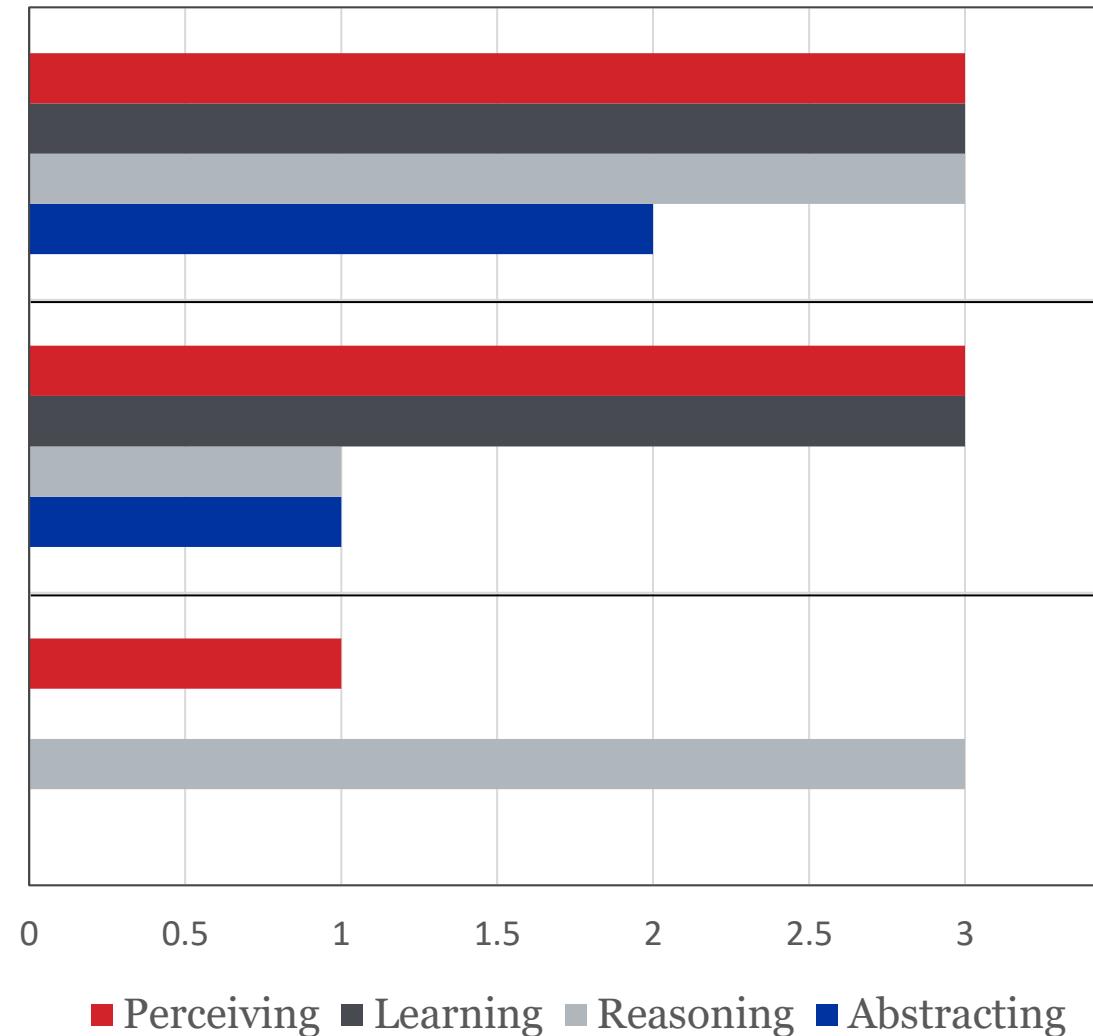


## • AI Waves: A DARPA Perspective

Explain  
3rd Wave Contextual Adaptation

Recognize  
2nd wave Statistical Learning

Describe  
1st wave Handcrafted Knowledge



# Introduction to Artificial Intelligence

## • AI Waves: Weak/Narrow AI versus Strong/AGI and ASI

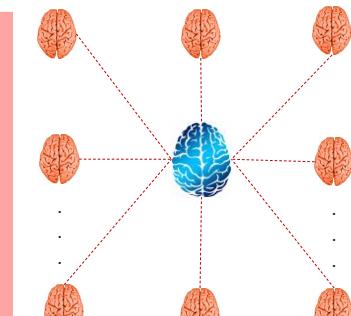
AI Wave	Domain	Brain Power
Artificial Narrow Intelligence (AI)	Domain-specific (image recognition, speech recognition, text mining, etc.)	Looks similar but not at the same level (suppresses brainpower of <b>mouse</b> )
Artificial General Intelligence (AGI)	Cross-domain capability <b>(<i>i</i>-level intelligence)</b>	Suppresses brainpower of human
Artificial Superintelligence (ASI)	Cross-domain capability <b>(<i>i</i>-level and <i>g</i>-level intelligence)</b>	Suppresses brainpower equivalent to all human brains combined



Mouse brain



Human brain



Super brain

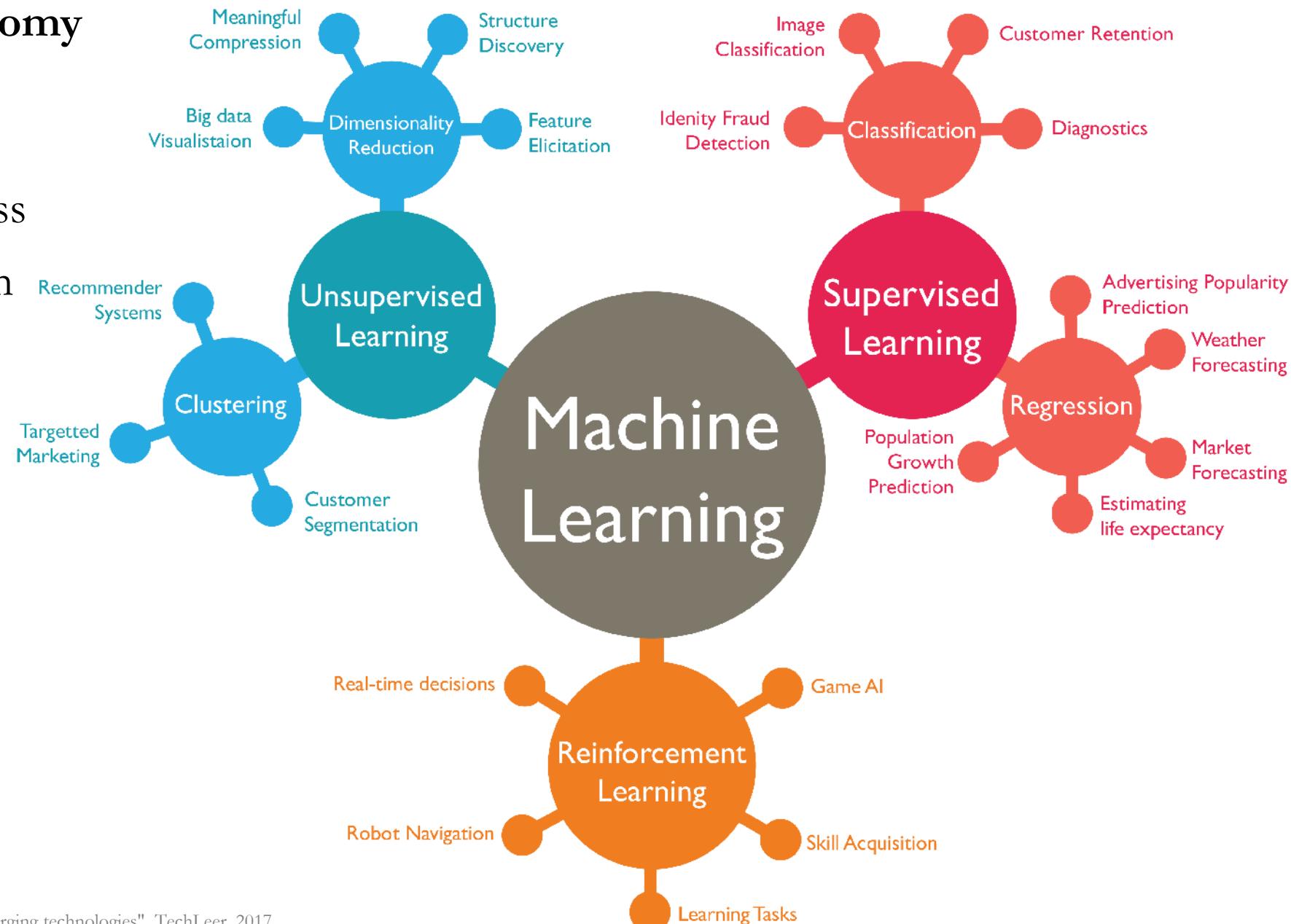
# Outline

- Introduction to Artificial Intelligence
- **Introduction to Machine Learning**
- Responsible AI
- Data Analytics

# Introduction to Machine Learning

- Machine Learning Taxonomy

Machine learning (ML) is a subfield of AI that endows an artificial system or process with the ability to learn from experience and observation without being explicitly programmed.



# Introduction to Machine Learning

- Why is ML taking off?

## 1 Big data availability



Facebook: 350 M images uploaded per day



Twitter community generates more than 12 terabytes of data per day



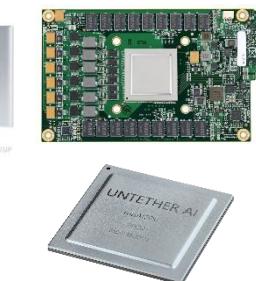
YouTube: 300 hours of video uploaded every minutes



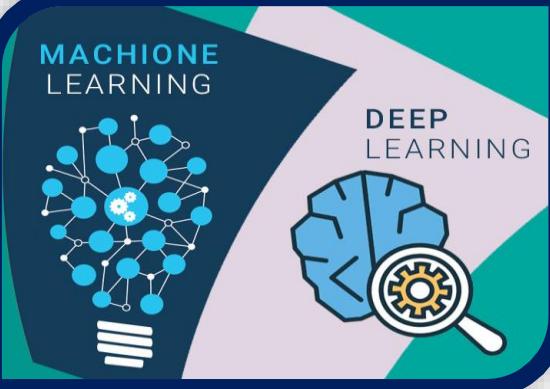
Walmart: 2.5 Petabytes of customer data hourly



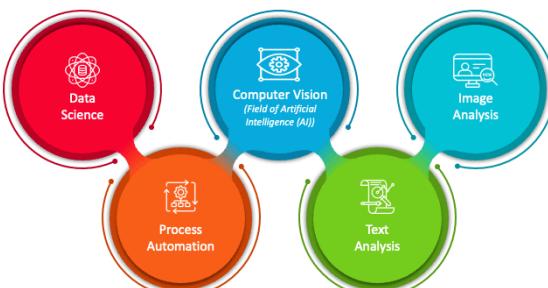
Autonomous Vehicles: 4-20 TB per day



## 2 GPU/TPU/NPU acceleration



## 4 Democratization of AI/ML



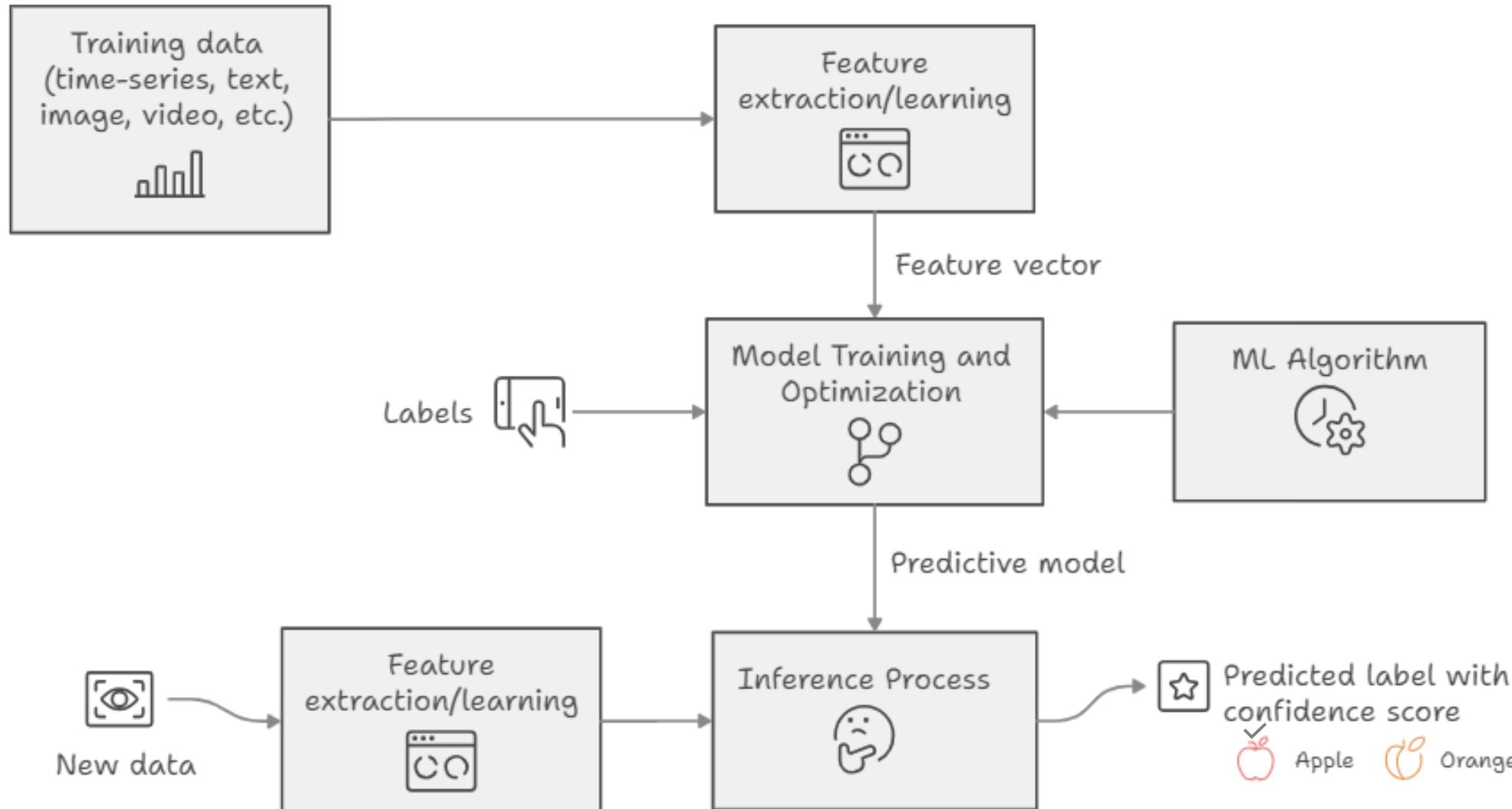
## 3 Huge investment on AI: the new space race



- China: expected to reach \$38 billion in 2027 [ref]
- European Union: \$31 billion investment by 2025 [ref]
- Canada: \$2.4 billion in AI in 2024 budget [ref]
- UK: \$1.2 billion in AI investment [ref]
- Softbank: invests \$108 billion in AI companies [ref]

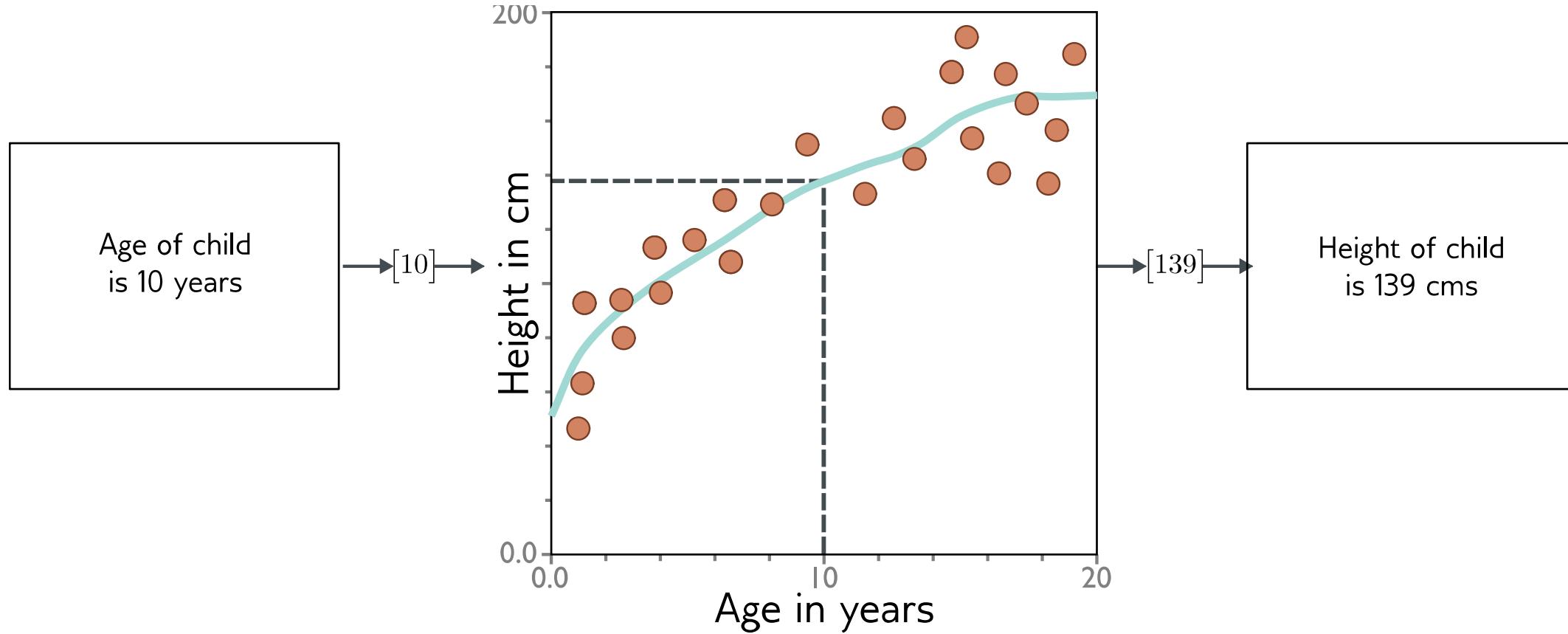
# Introduction to Machine Learning

- Supervised Machine Learning



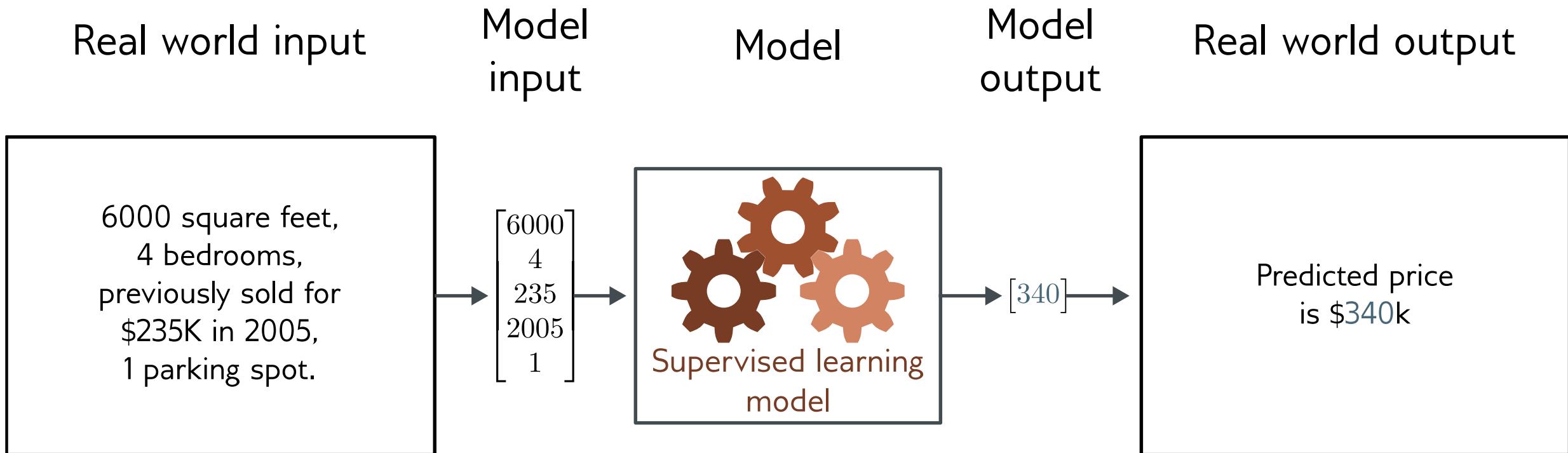
# Introduction to Machine Learning

- Supervised Machine Learning



# Introduction to Machine Learning

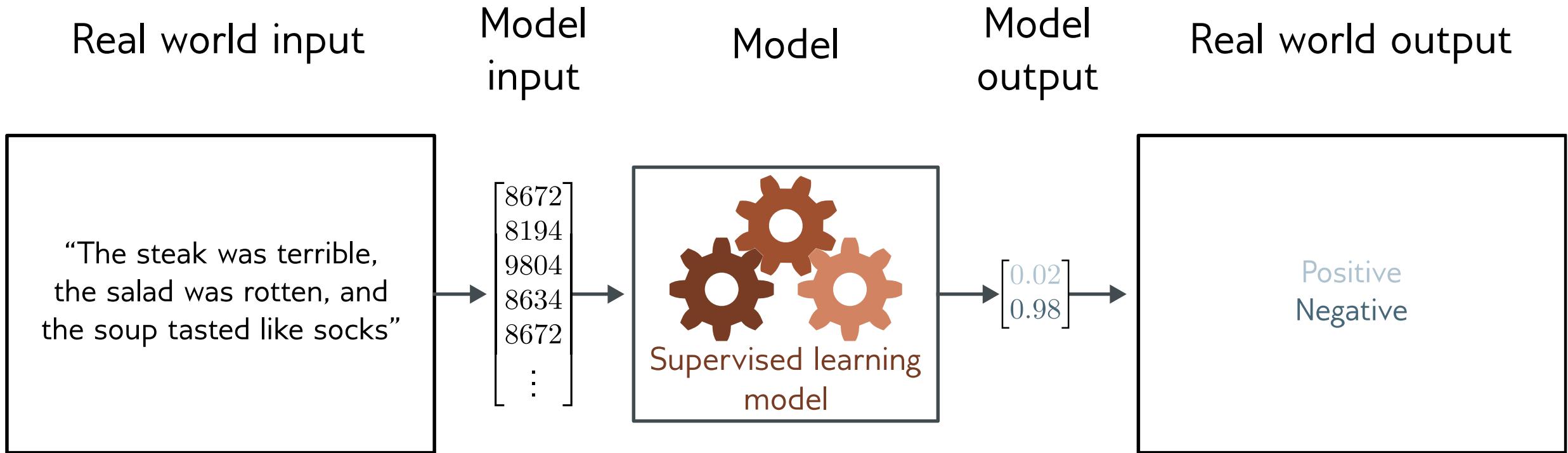
- Supervised ML Applications: Regression



- Univariate regression problem (one output, real value)
- Fully connected network

# Introduction to Machine Learning

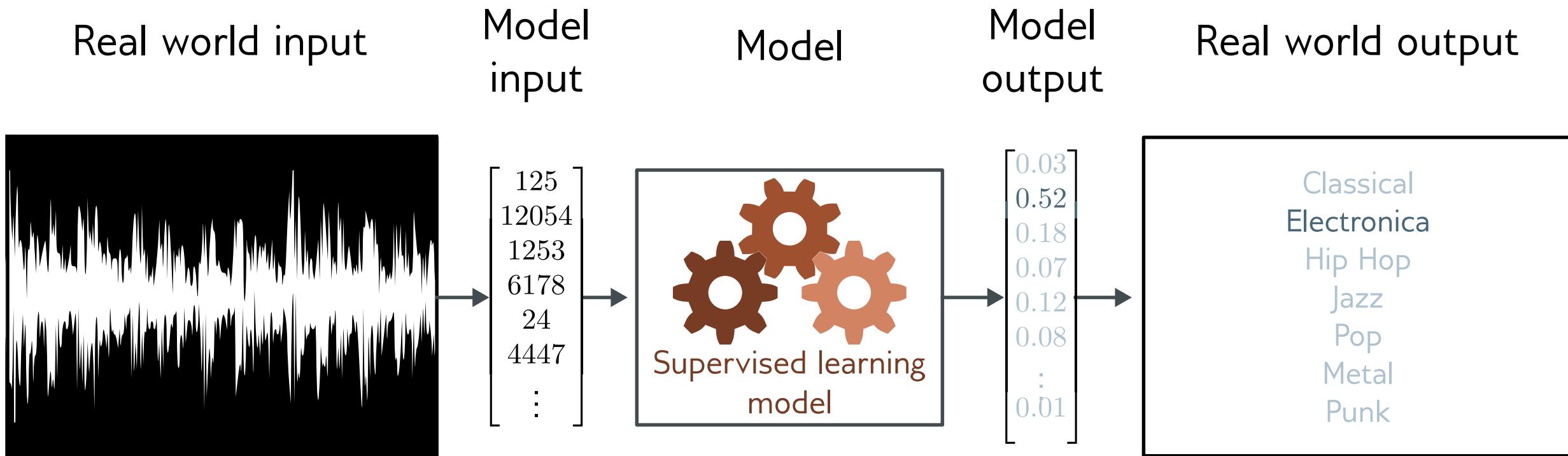
- Supervised ML Applications : Text Classification



- Binary classification problem (two discrete classes)
- Transformer network

# Introduction to Machine Learning

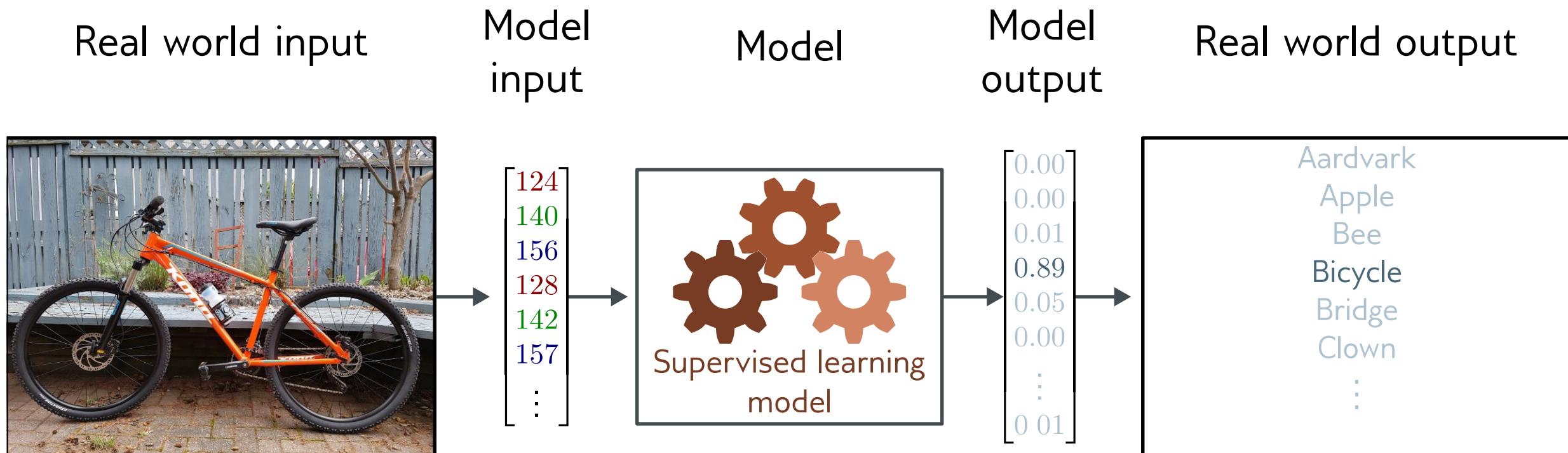
- Supervised ML Applications : Music Genre Classification



- Multiclass classification problem (discrete classes,  $>2$  possible values)
- Convolutional network

# Introduction to Machine Learning

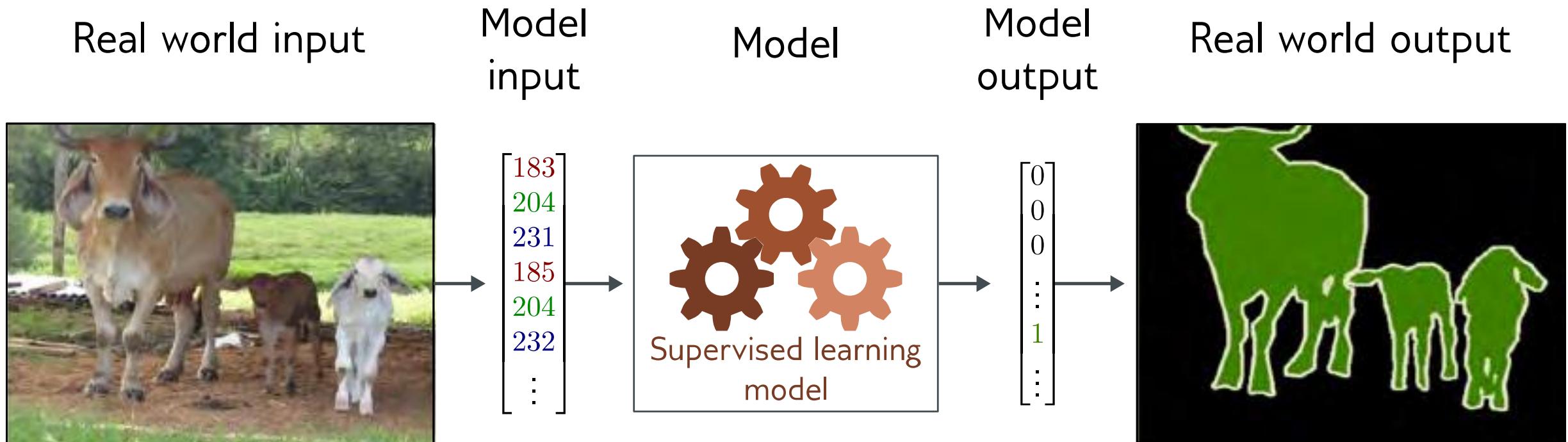
- Supervised ML Applications : Image Classification



- Multiclass classification problem (discrete classes, >2 possible classes)
- Convolutional network

# Introduction to Machine Learning

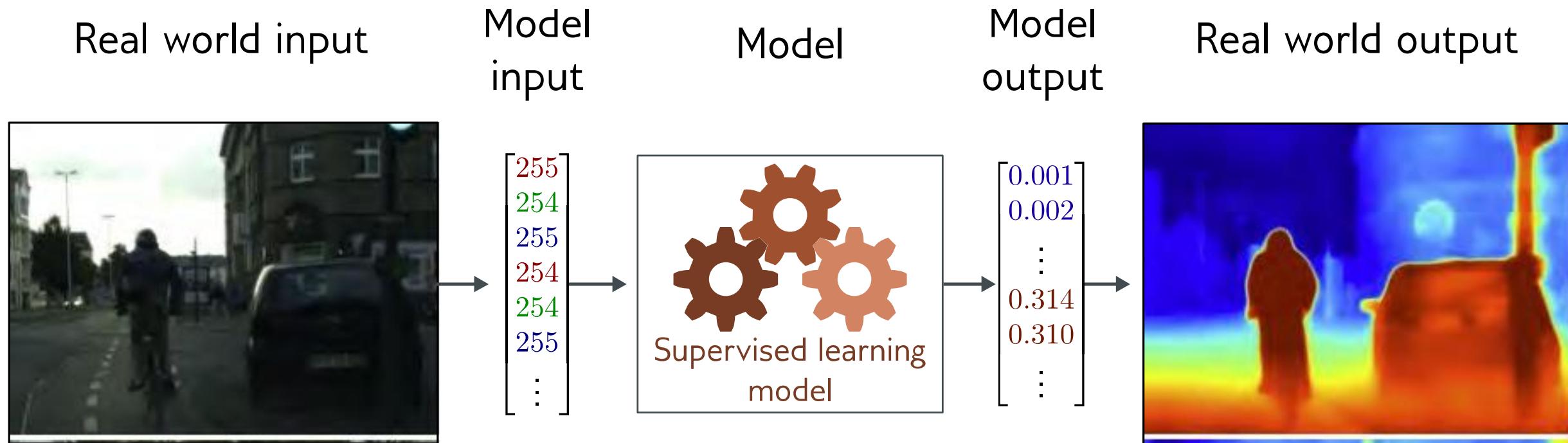
- Supervised ML Applications : Image Segmentation



- Multivariate binary classification problem (many outputs, two discrete classes)
- Convolutional encoder-decoder network

# Introduction to Machine Learning

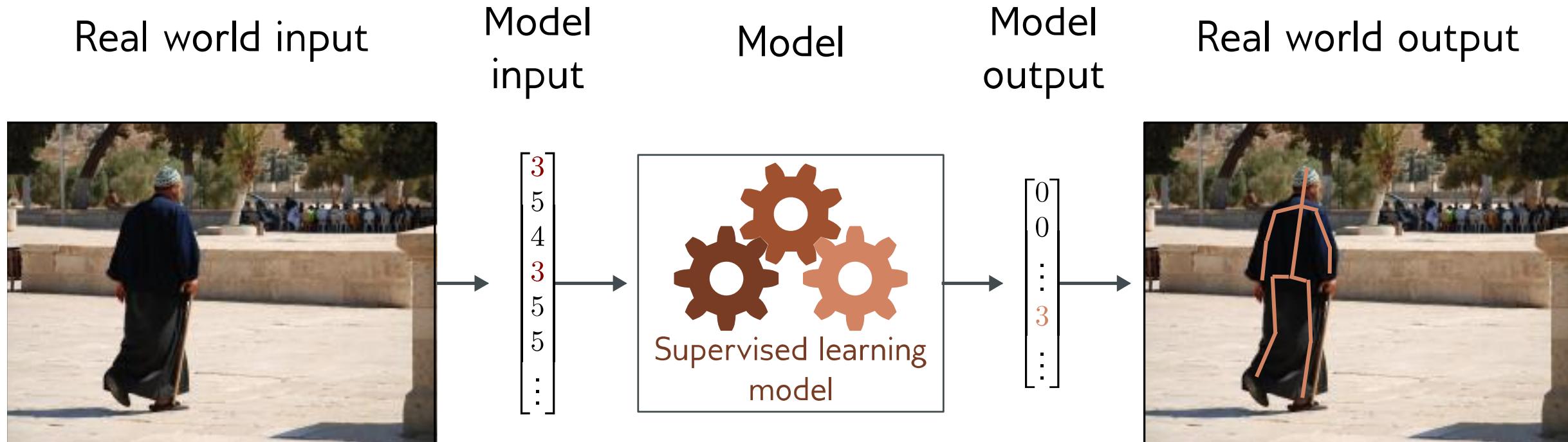
- Supervised ML Applications : Depth Estimation



- Multivariate regression problem (many outputs, continuous)
- Convolutional encoder-decoder network

# Introduction to Machine Learning

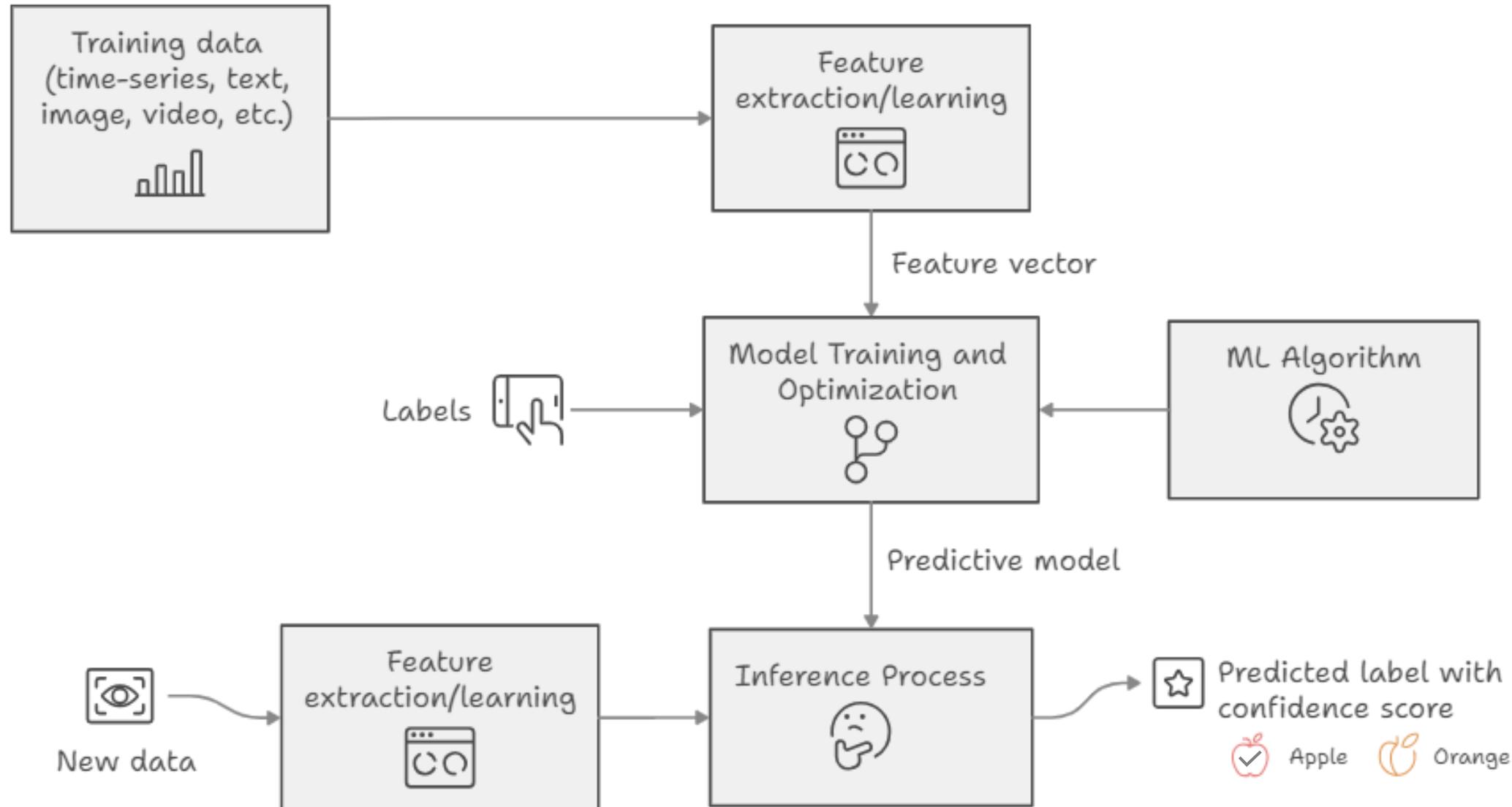
- Supervised ML Applications : Pose Estimation



- Multivariate regression problem (many outputs, continuous)
- Convolutional encoder-decoder network

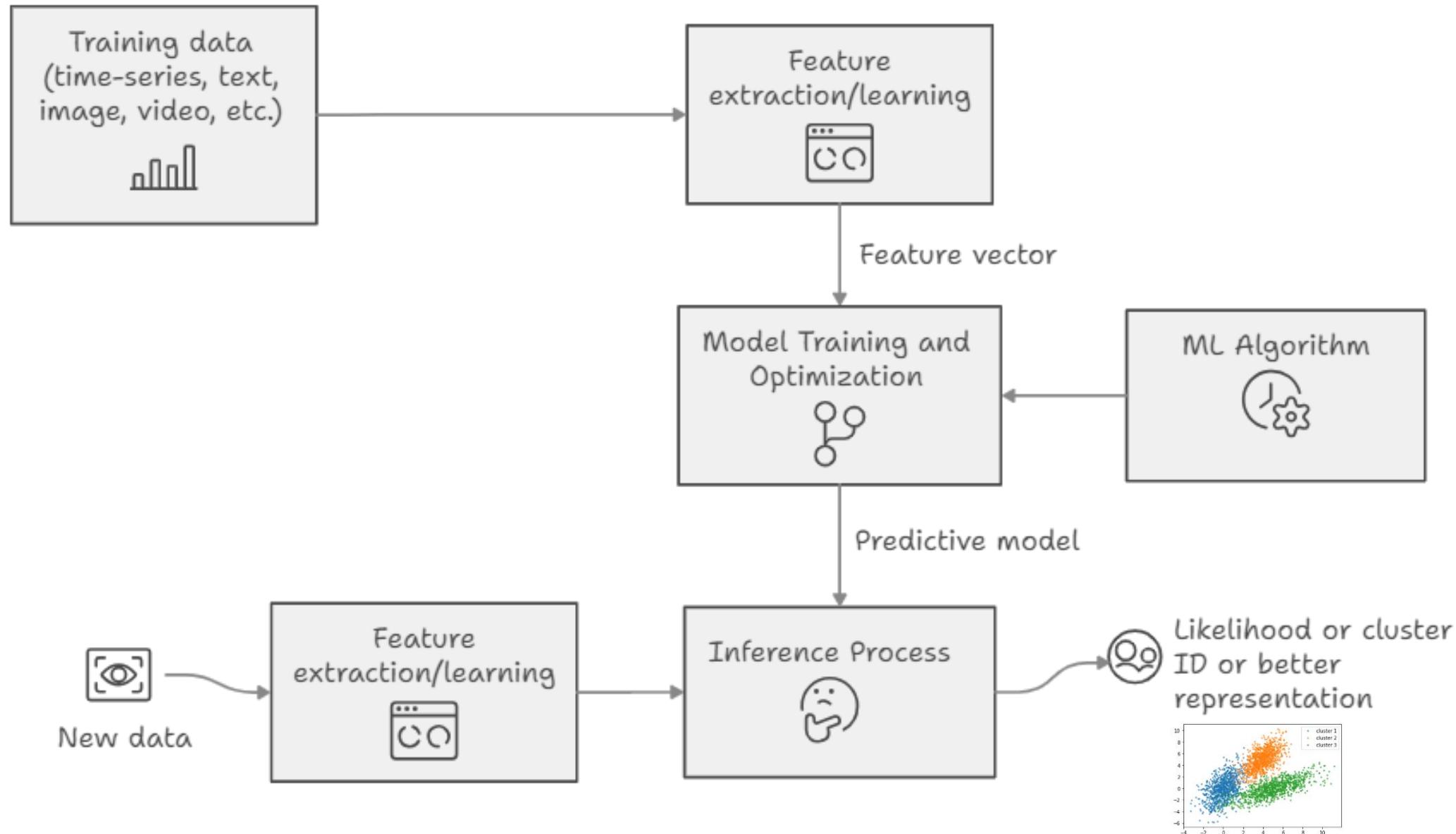
# Introduction to Machine Learning

- Supervised Learning



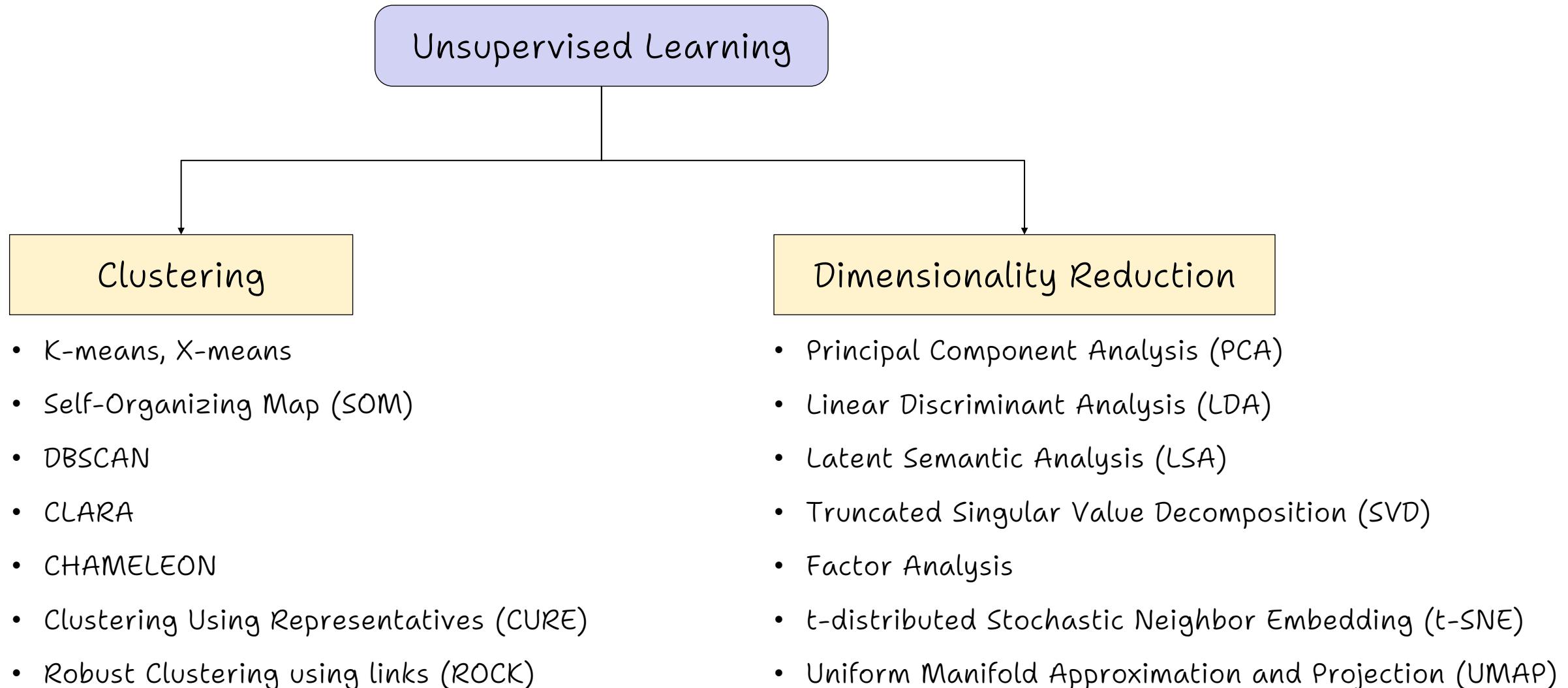
# Introduction to Machine Learning

- Unsupervised Learning



# Introduction to Machine Learning

- Unsupervised Learning

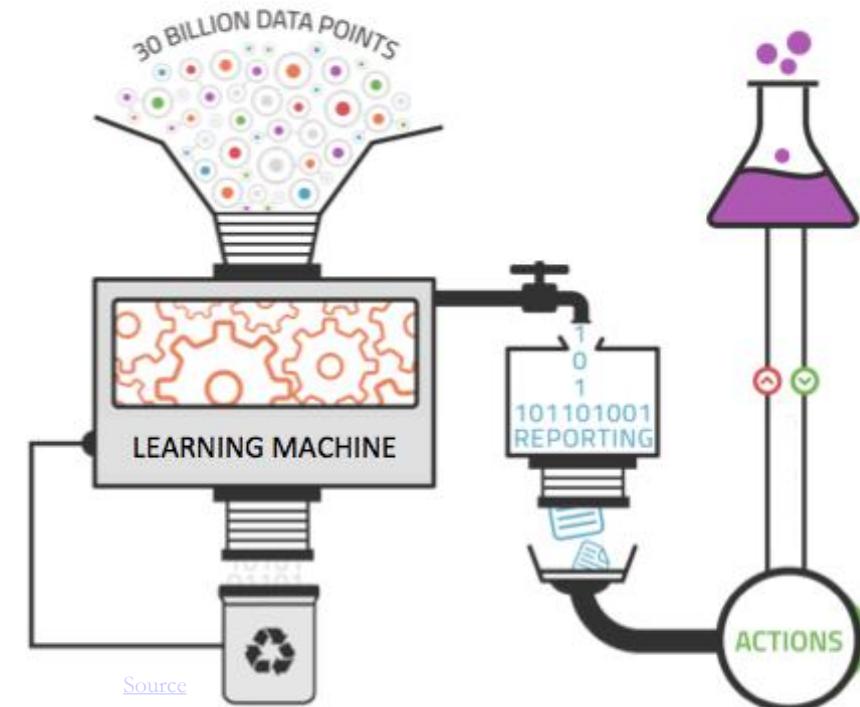


# Introduction to Machine Learning

## • Statistical ML Requirements

Three main requirements to apply data-driven ML:

- Pattern exists;
- Pattern cannot pin out mathematically using attainable and mathematically tractable models and
- Data is available



# Introduction to Machine Learning

- Machine Learning versus Curve Fitting

The learning algorithm seeks a mapping function  $f: X \times y \rightarrow \mathbb{R}$

*where X represents feature vector and y represents the output*

The learned state returns  $y$  that gives a minimum cost/loss function  $L(y, f(X))$  over the joint distribution of all  $(y, X)$  of  $f$ :

$$f^* = \arg \min_f E_{y,X} L(y, f(X)) = \arg \min_f E_X [E_y(L(y, f(X))) | X]$$



Model	Input	Output
Image classification	Image	Category
Speech recognition	Acoustic utterances	Spoken word as text
Machine translation	English sentence	Spanish sentence
Gaming	Current board state	Next move
Prognostic	Vehicle data	Vehicle condition
...	...	...



# Introduction to Machine Learning

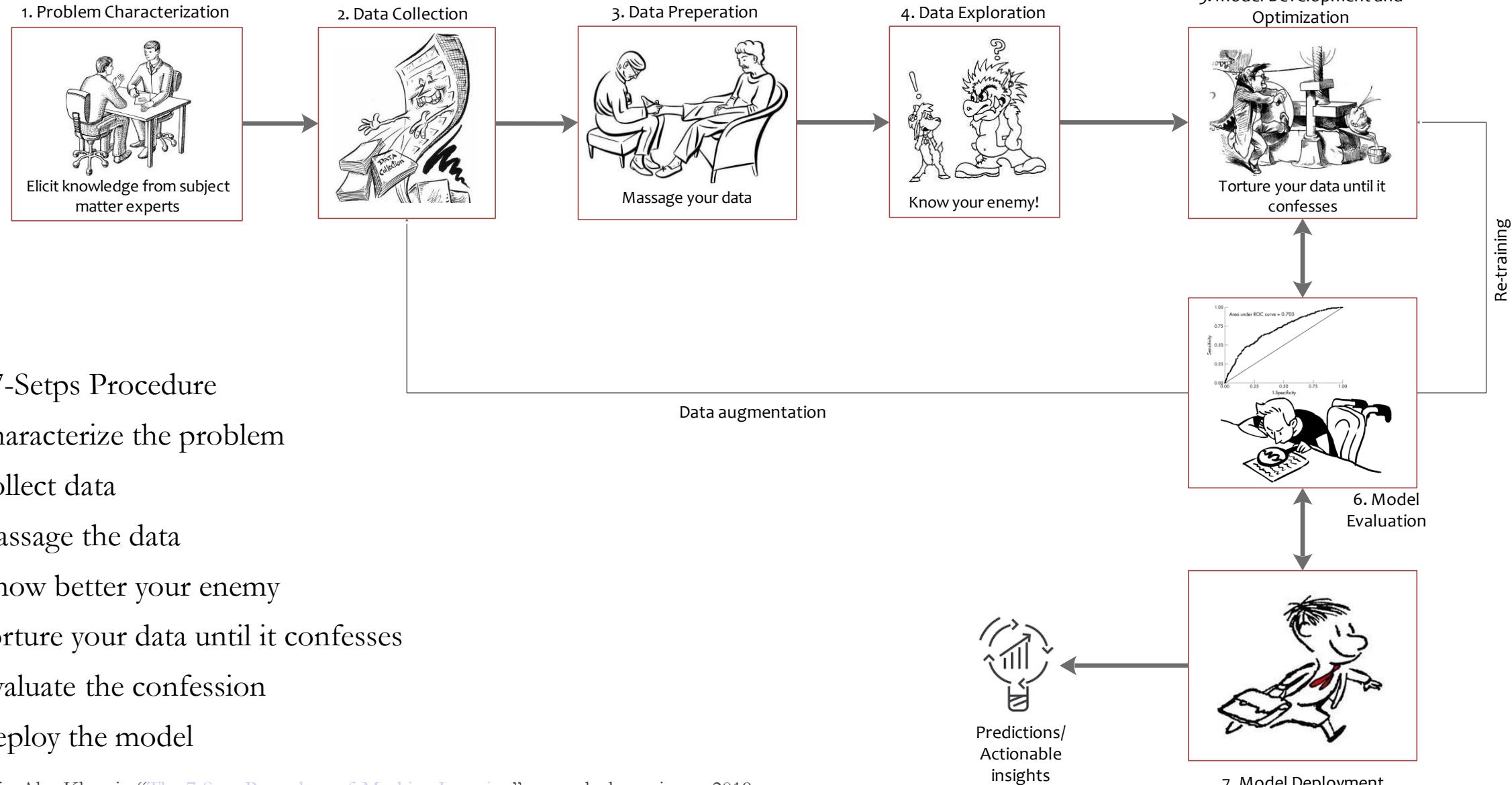
## • Machine Learning versus Curve Fitting

Component	Curve Fitting	Machine Learning
Model (Hypothesis class)	$f(x) \in \mathcal{F}$	<ul style="list-style-type: none"> <li>Linear (Perceptron, SVM, Logistic regression, etc.)</li> <li>Directed graphical model</li> <li>Undirected graphical model</li> <li>Matrices</li> <li>Deep structure (Feedforward deep networks, RBM, RNN, CNN, CapsNets, GANs, GNNs)</li> </ul>
Scoring Criterion	Population: $S(f) = E_{x,y} L(y, f(x))$ Sample: $\frac{1}{n} \sum_{i=1}^n L(y_i, f(x_i))$	Loss function, log loss, etc.
Search Strategy	$\hat{f} = \arg \min_{f \in \mathcal{F}} S(f)$	Gradient decent, Stochastic gradient descent (SGD)

Name	Type	Description	Advantages	Disadvantages
Linear Regression		-The best fit line through all data points	-Easy to understand -you can clearly see what the biggest drivers off the model are.	-sometimes to simple to capture complex relationships between variables, -Tendency for the model to overfit.
Logistic Regression		-The adoption for linear regression to problems of classification	-Easy to understand	-sometimes to simple to capture complex relationships between variables, -Tendency for the model to overfit.
Decision Tree		-A graph that uses branching method to match all possible outcomes of a decision	-Easy to understand and implement.	-Not often use of its own for prediction because it's also often too simple and not powerful enough for complex data.
Random Forest		-Takes the average of many decision trees. Each tree is weaker than the full decision tree, but combining them we get better overall performance.	-A sort of „wisdom of the crowd“, Tend to result in very high quality results. -Fast to train	-Can be slow to output predictions relative to other algorithms. -Not easy to understand predictions.
Gradient Boosting		-Uses even weaker decision trees that increasingly focused on „hard examples“	-High-performing	-A small change in the future set or training set can create radical changes in the model. -Not easy to understand predictions.
Neural Networks		-Mimics the behaviour of the brain. NNs are interconnected Neurons that pass messages to each other. Deep Learning uses several layers of NNs to put one after the other.	-Can handle extremely complex tasks. No other algorithm comes close in image recognition.	-very very slow to train. Because they have so many layers. Require a lot of power. -Almost impossible to understand predictions.

# Introduction to Machine Learning

## • The 7-Step Procedure



# Introduction to Machine Learning

## • Machine learning Challenges

1. Problem Characterization (ill-structured problems, unknown unknowns or edge cases)
2. Data Collection (noise, control factors and adversarial cases)
3. Data Preprocessing (data imperfection, cleaning, fusion, feature extraction, etc.)
4. Modeling (No free lunch theorem)
5. Optimization (Many parameters to be tuned)
6. Evaluation (Metrics tradeoff)
7. Validation (Robustness test and mass validation)
8. Deployment (Operational AI, data mismatch)
9. Learning over time (model updates, domain adaptation, OTA, Edge, Fog, Cloud)
10. Model interpretability

# Outline

- Introduction to Artificial Intelligence
- Introduction to Machine Learning
- **Responsible AI**
- Data Analytics

# Responsible AI

- AI: Benefits or Risks?



Andrew Ng

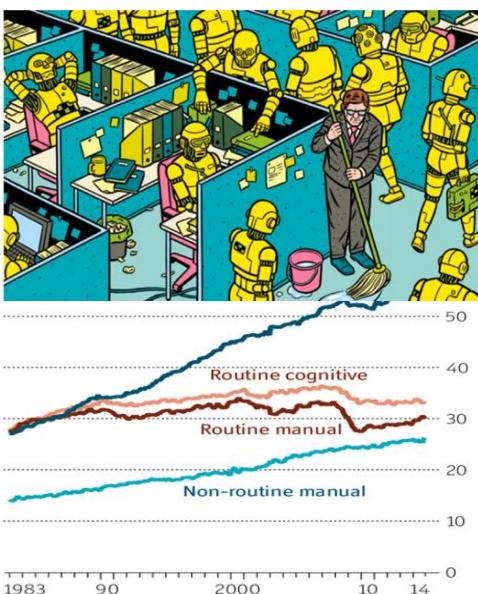


Sebastian Thrun



Ray Kurzweil

Benefits to the humanity →



← Significant existential risk ||



Stephen Hawking



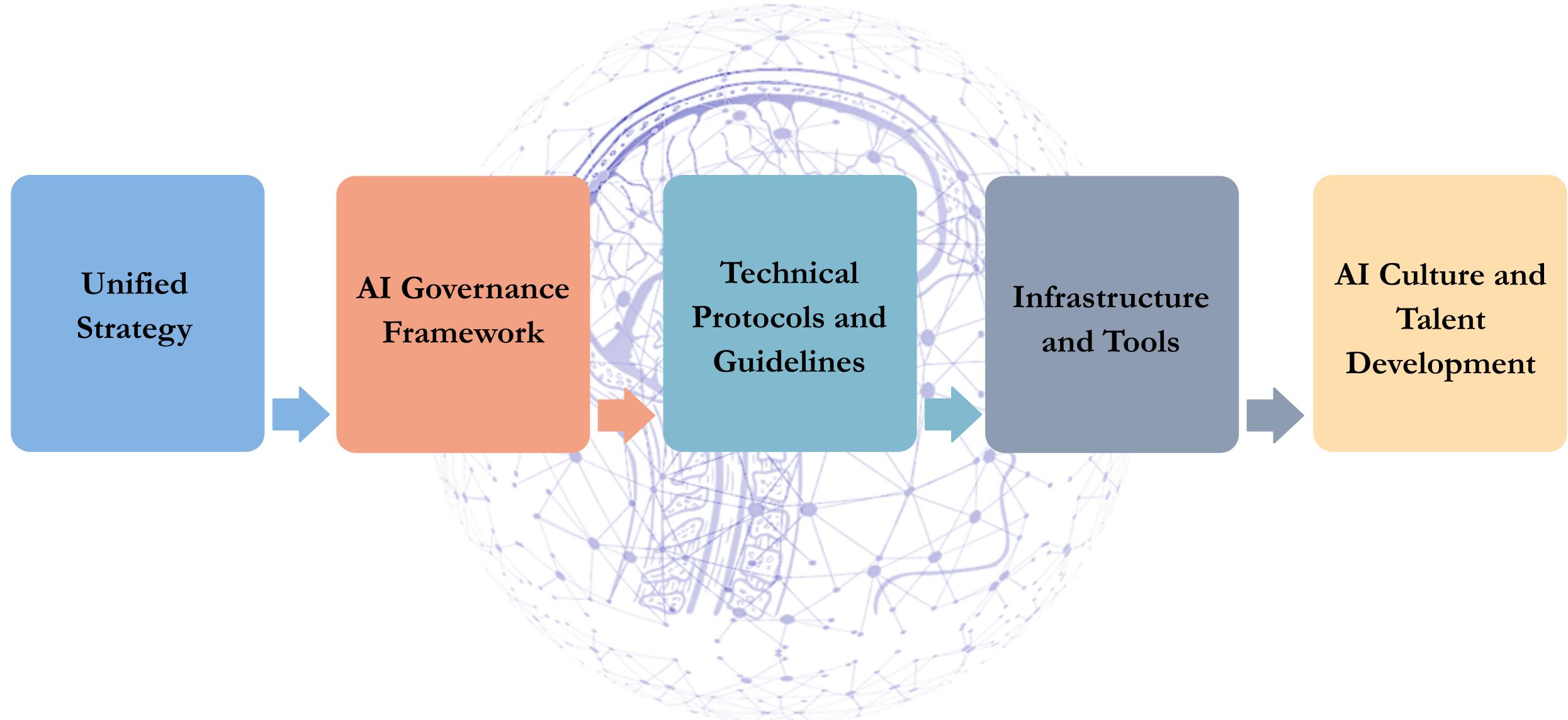
Bill Gates

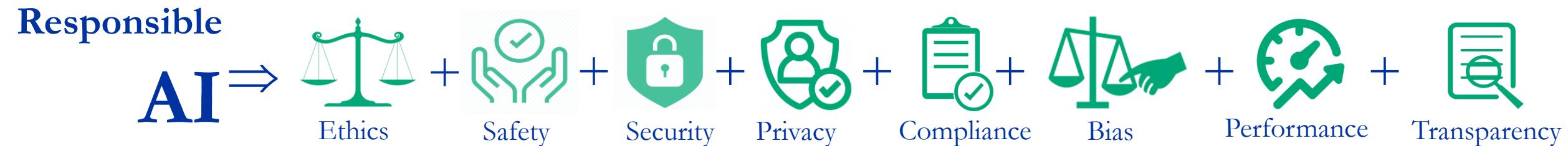


Elon Musk

# Responsible AI

- Keys for successful adoption of Responsible AI



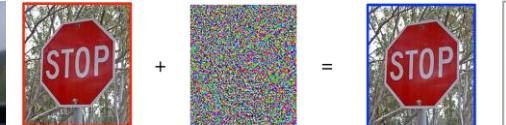
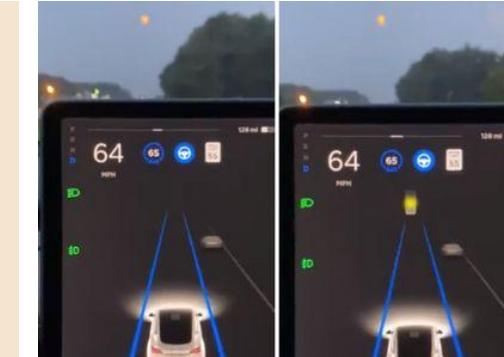


**TECHNOLOGY**

## The Future of Artificial Intelligence Depends on Trust

If it is to drive business success, AI cannot hide in a black box. For more insight, see "[3 Steps to Building Trust in AI](#)."

by Anand Rao and Euan Cameron



classified as Stop Sign + = classified as Max Speed 100



• Data set: 67% of people cooking are women  
• Algorithm predicts: 84% of people cooking are women



By Alaa Khamis based on 1940 Walt Disney "Fantasia"



The Magic of AI

[[Video](#)]

# Outline

- Introduction to Artificial Intelligence
- Introduction to Machine Learning
- Responsible AI
- **Data Analytics**

# Data Analytics

Data Analytics is the process of **examining raw data to discover patterns, trends, and insights** that can support decision-making.

**Data Analytics in maintenance and reliability** is the process of **collecting, cleaning, and analyzing equipment and operational data** to uncover patterns, predict failures, and support better maintenance decisions.

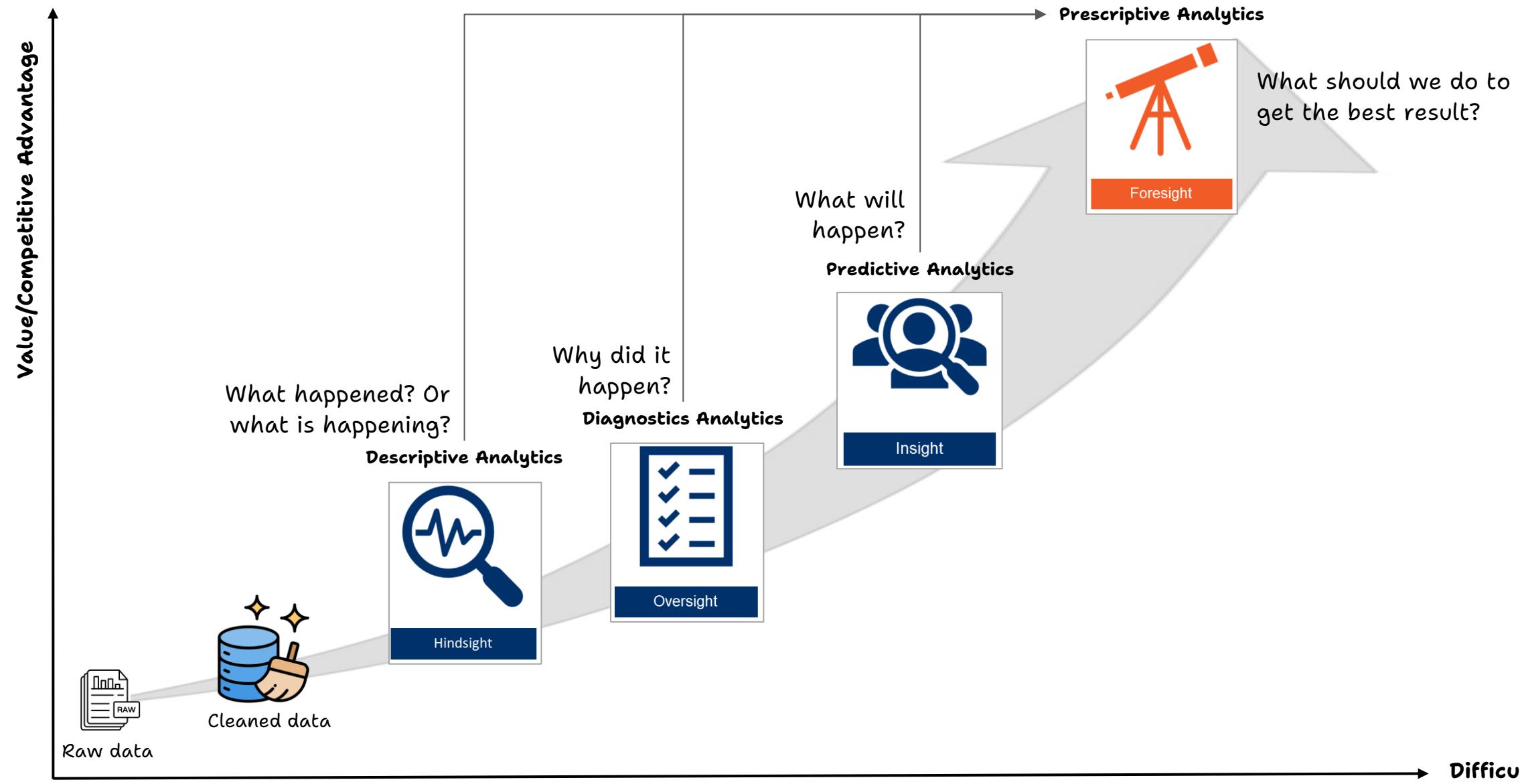
## It helps organizations:

- Understand past events (why failures happened).
- Monitor current conditions (detect anomalies).
- Predict future outcomes (estimate remaining useful life)
- Optimize actions (decide the best time for maintenance)

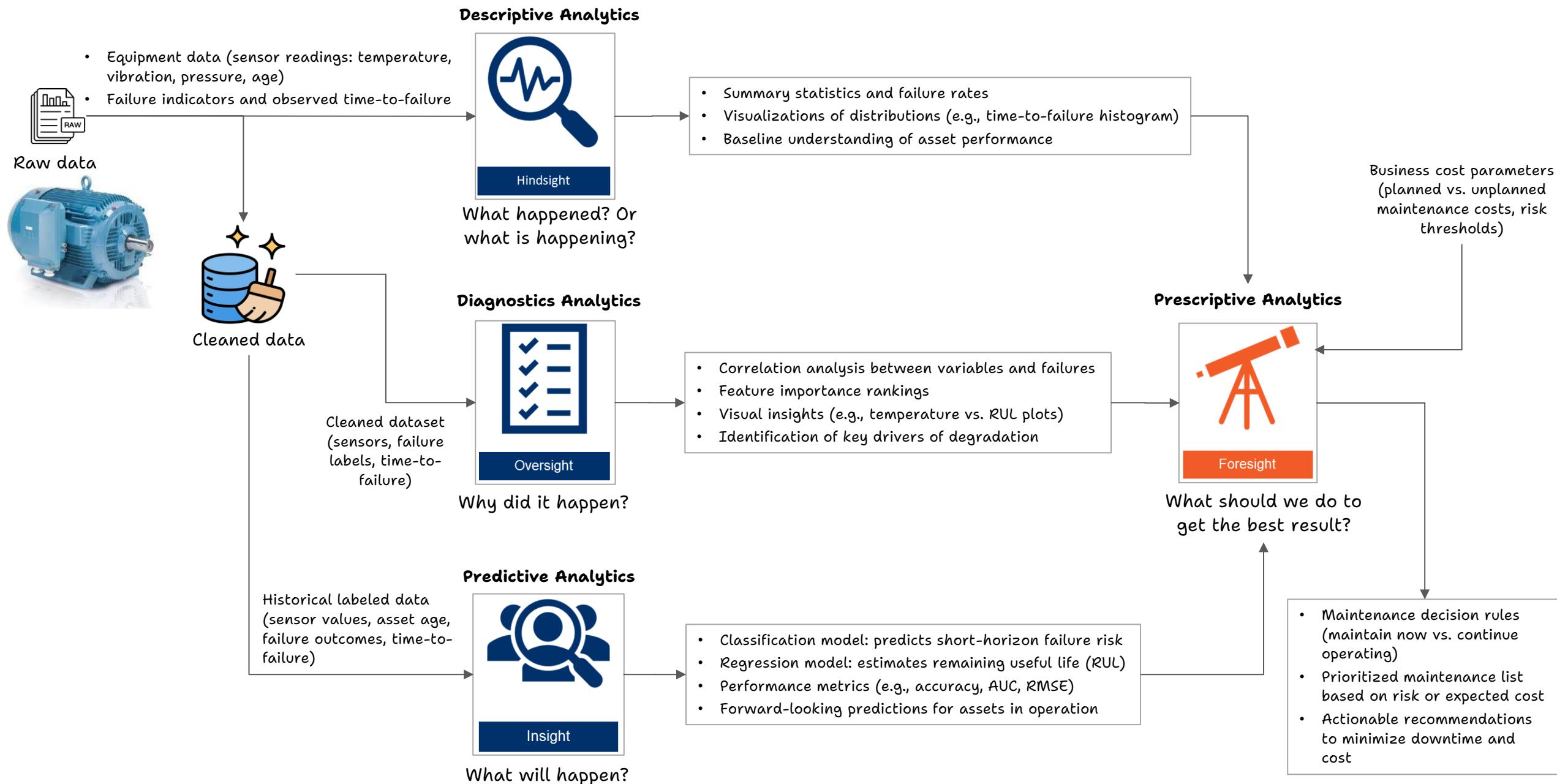


# Data Analytics

## • The 4 Lines of Sight



# Data Analytics



## • Hands-on Example

