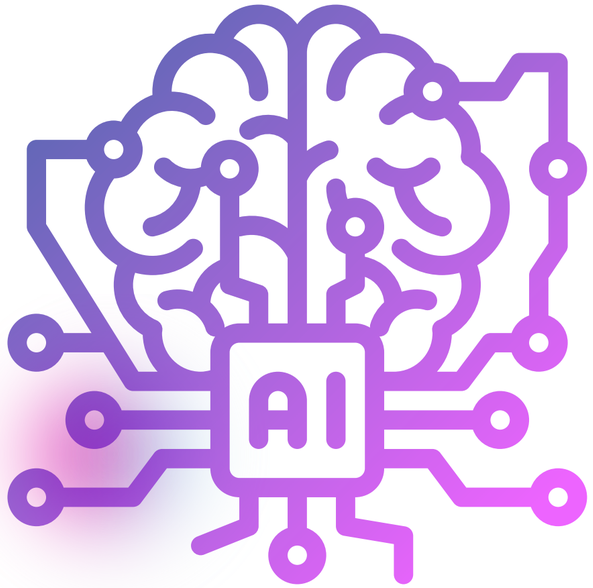
From Fundamentals to Building Your Own Intelligent System

AI & MACHINE LEARNING BOOTCAMP 2025

Dr. Fazlul Hasan Siddiqui
Proferssor, Dept. of CSE, DUET
Chairman, ICT Cell; Director, IICT, DUET

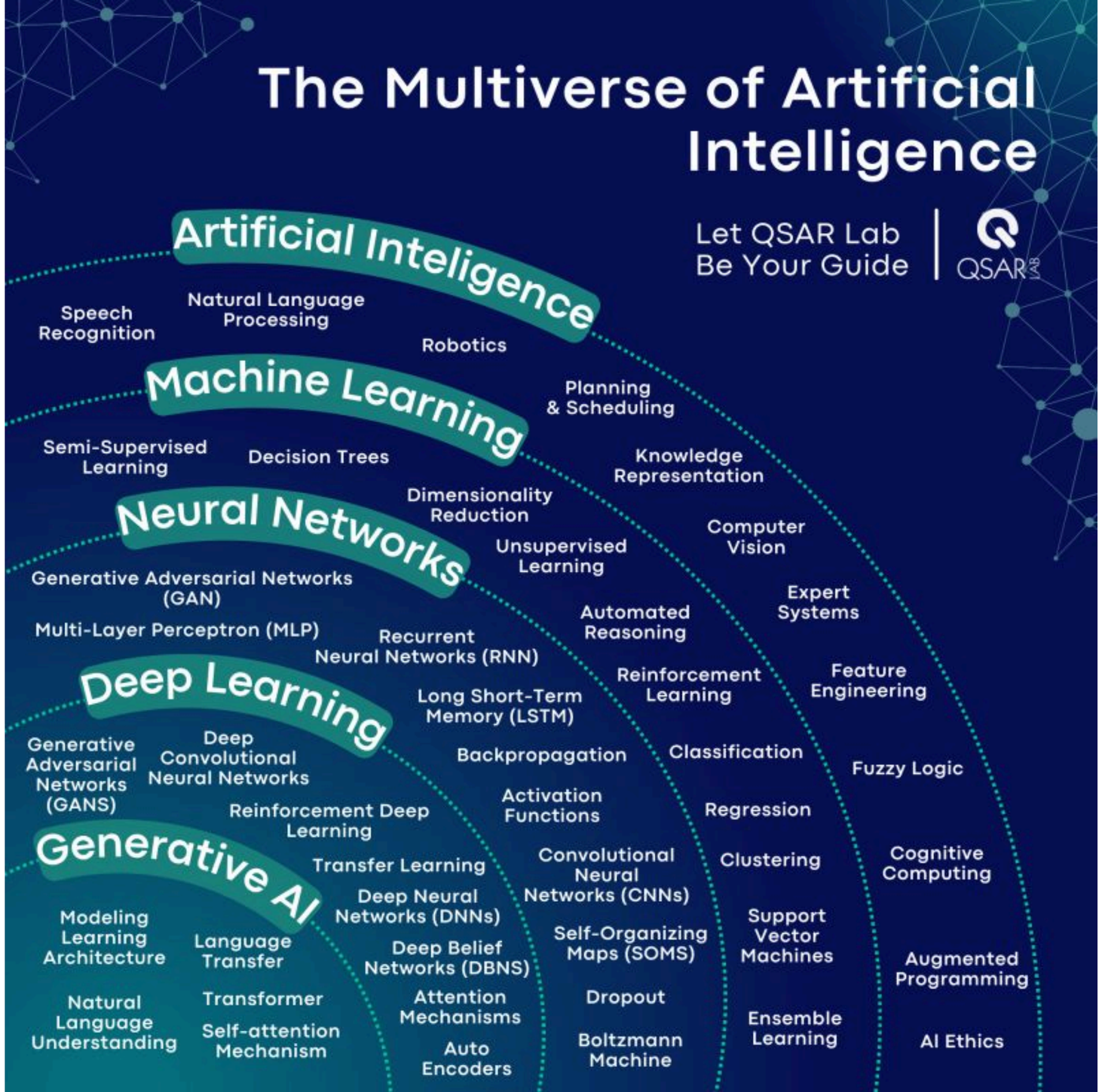
Dr. Sabah Binte Noor
Associate Proferssor,
Dept. of CSE, DUET



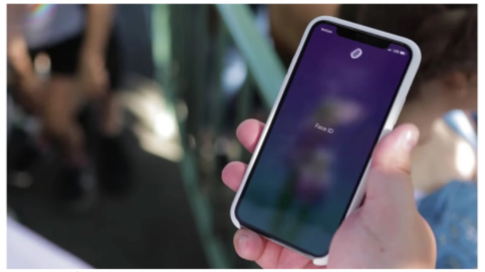
ARTIFICIAL INTELLIGENCE

INTRODUCTION

World of Artificial Intelligence



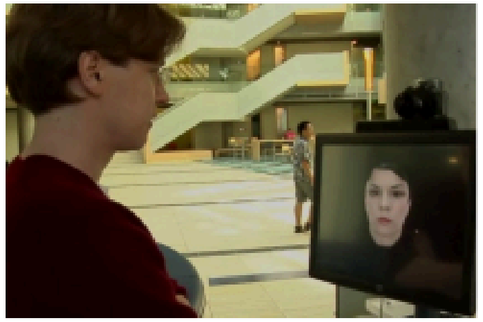
- Machines have far superior computational abilities than humans
  - Square root of 964,324 ?
- Machines can sort through enormous amounts of data.
  - While a doctor makes a diagnosis in ~10 minutes, AI system makes a million.
- Humans, in general, are good at ?



Unlocking Phones

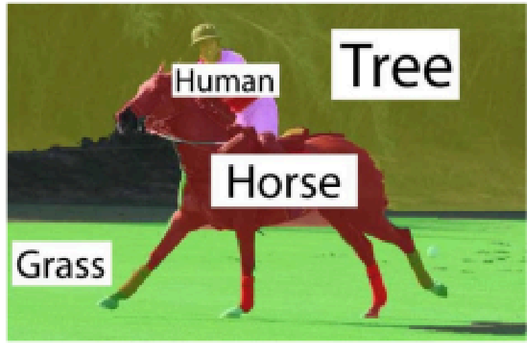
Machine vs Human

Dialogue Processing



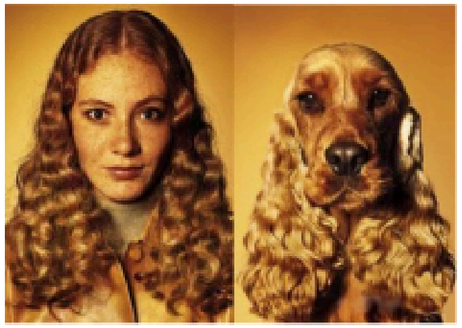
Identify the digits

Scene Understanding

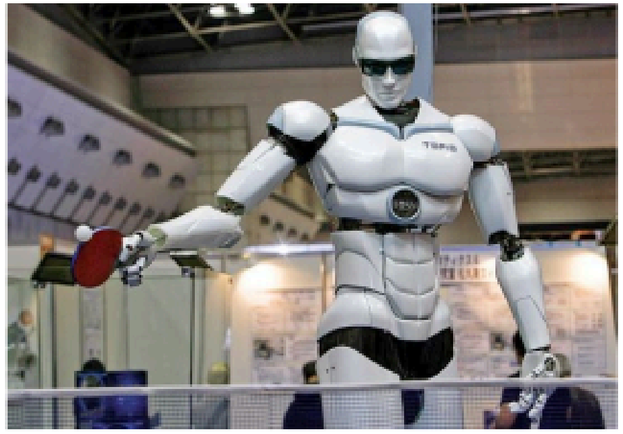


Taxi Driving

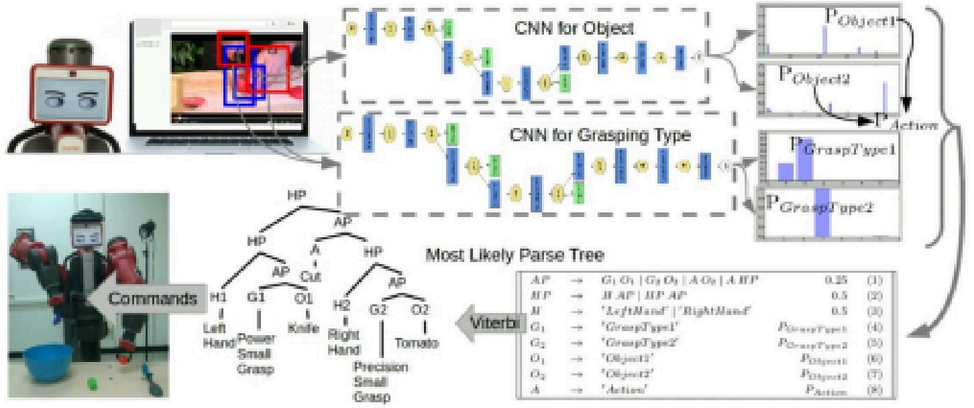
Perform clustering

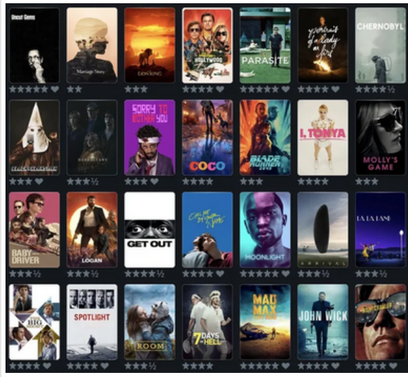


Ping-Pong playing robot

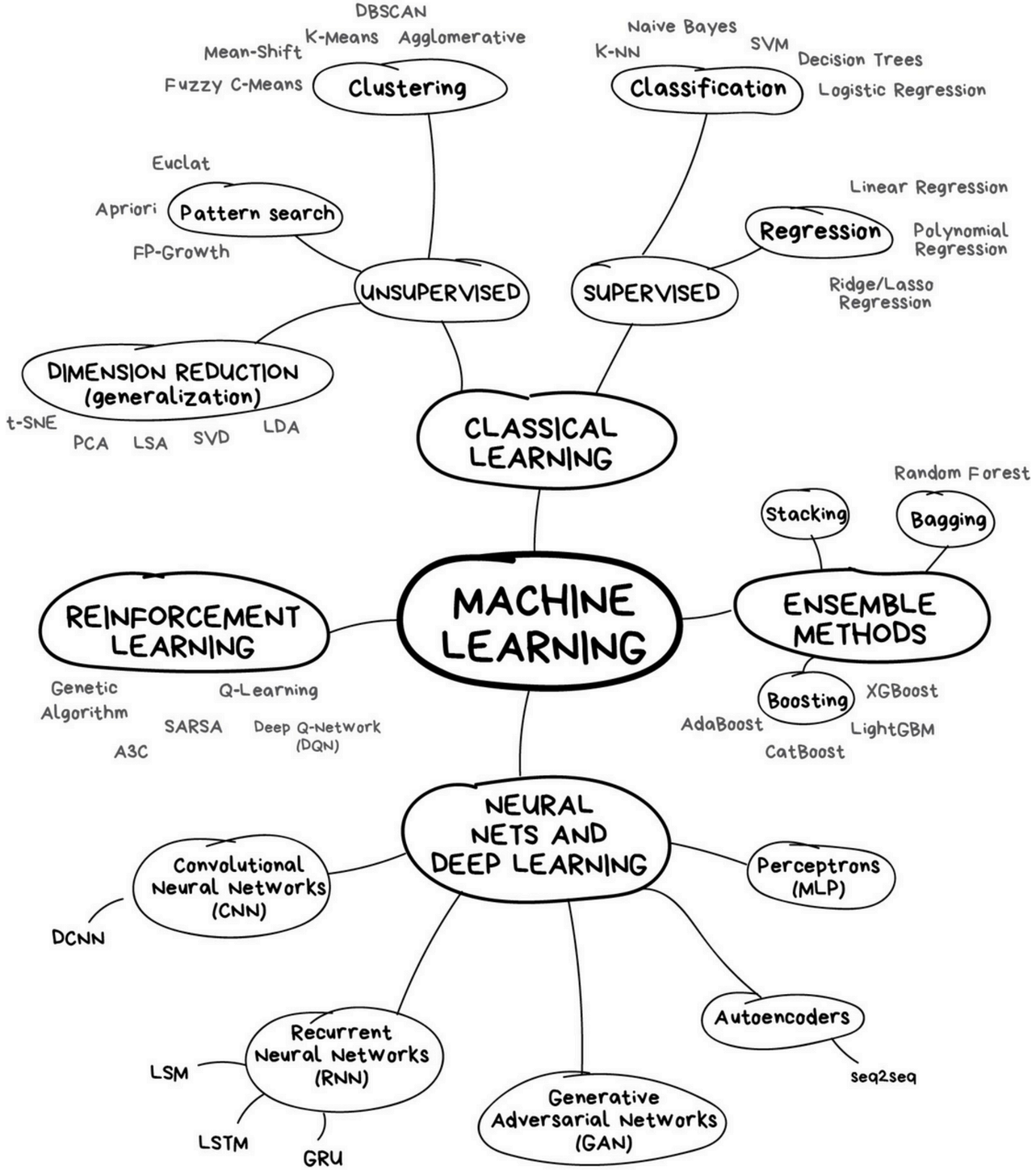


Learn Cook from youtube



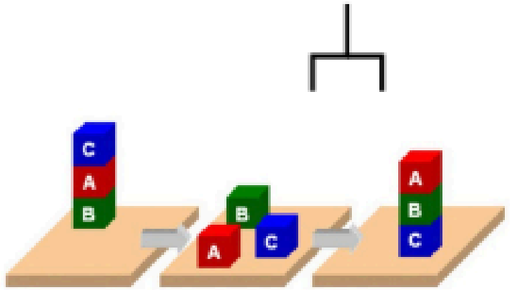


Movie Recommendation



Machine Learning Algorithms

Problems Deep Learning cannot Solve

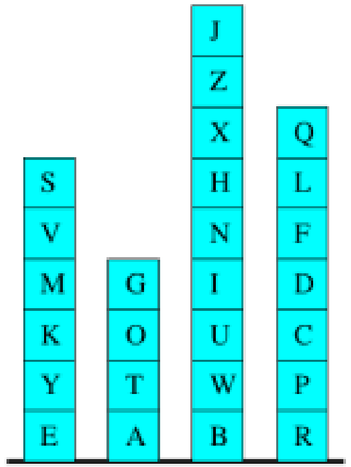


- n blocks, 1 hand.

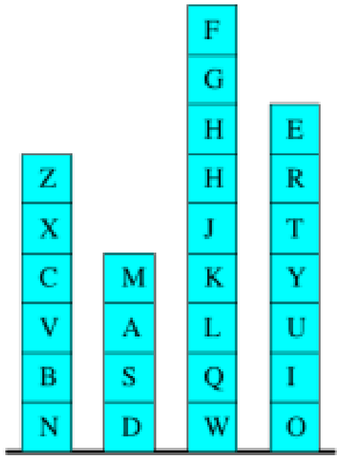
Find the shortest sequence of actions that transforms an **arbitrary** initial configuration of blocks into another **arbitrary** goal configuration

- A single action either takes a block with the hand or puts a block we're holding onto some other block/the table.

blocks	states	blocks	states
1	1	9	4596553
2	3	10	58941091
3	13	11	824073141
4	73	12	12470162233
5	501	13	202976401213
6	4051	14	3535017524403
7	37633	15	65573803186921
8	394353	16	1290434218669921



Initial State



Goal State

→ State spaces typically are huge even for simple problems.

→ In other words: Even solving "simple problems" automatically (without help from a human) requires a form of intelligence. With blind search, even the largest super-computer in the world won't scale beyond 20 blocks!

Example (Agricultural experiment design)

	plot1	plot2	plot3	plot4	plot5	plot6	plot7
barley	✓	✓	✓	–	–	–	–
corn	✓	–	–	✓	✓	–	–
millet	✓	–	–	–	–	✓	✓
oats	–	✓	–	✓	–	✓	–
rye	–	✓	–	–	✓	–	✓
spelt	–	–	✓	✓	–	–	✓
wheat	–	–	✓	–	✓	✓	–

Constraints to be **satisfied**:

1. Equal growth load: Every plot grows 3 grains.
2. Equal sample size: Every grain is grown in 3 plots.
3. Balance: Every grain pair is grown in 1 common plot.

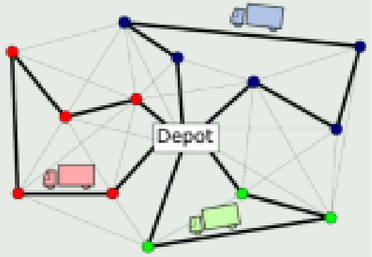
Instance: 7 plots, 7 grains, 3 grains/plot, 3 plots/grain, balance 1.

Example (Vehicle routing: parcel delivery)

Given a depot with parcels for clients and a vehicle fleet, **find** which vehicle visits which client when.

Constraints to be **satisfied**:

1. All parcels are delivered on time.
2. No vehicle is overloaded.
3. Driver regulations are respected.
4. ...



Objective function to be **minimised**:

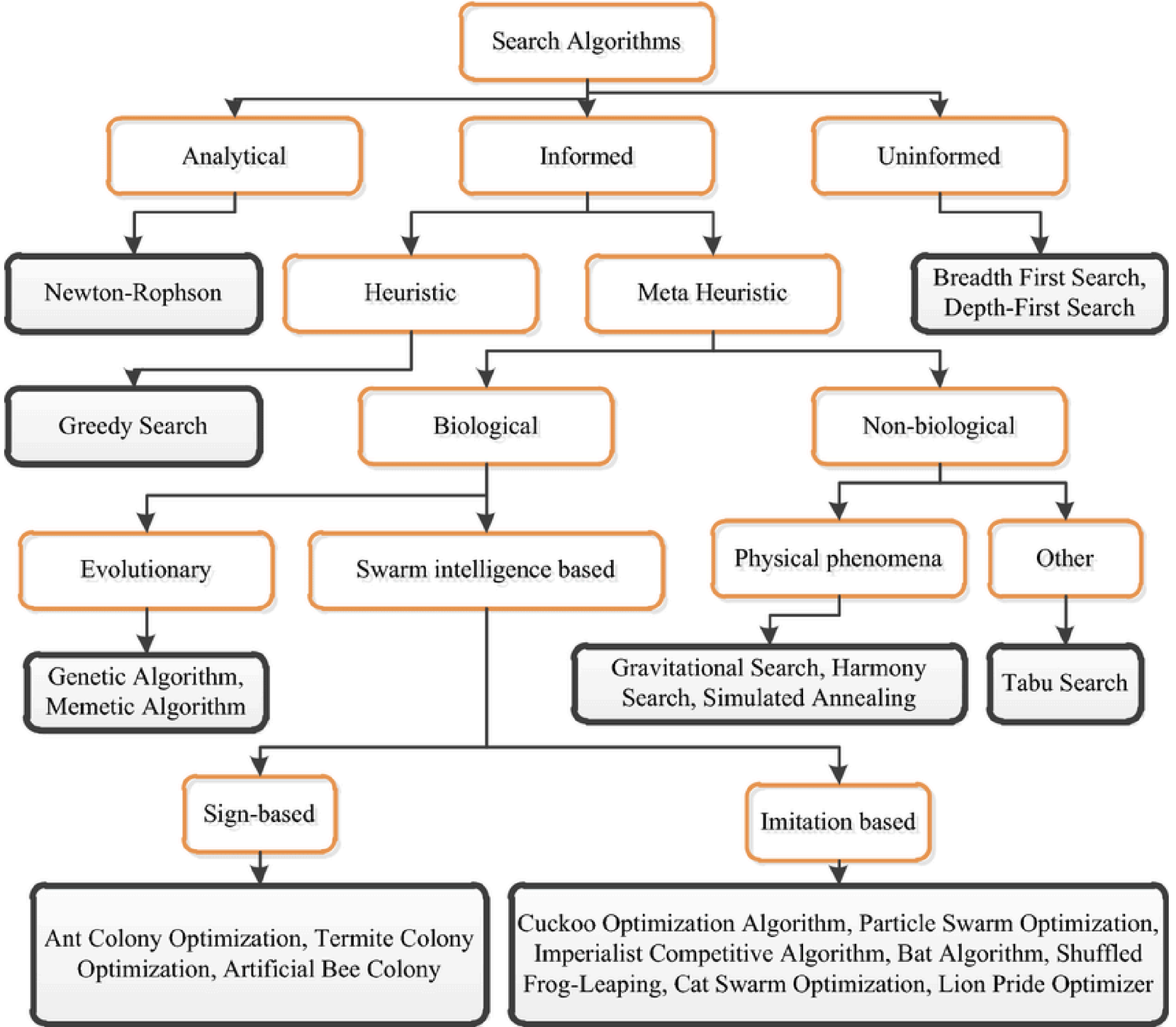
- Cost: the total fuel consumption and driver salary.

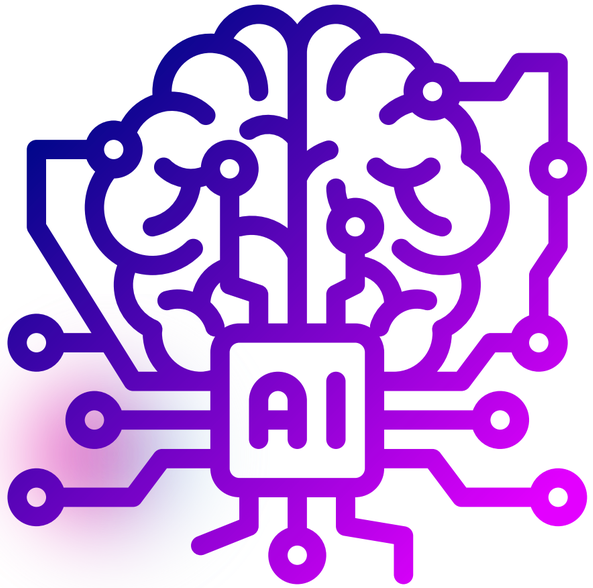
Construction Scheduling and Resource Allocation (Planning)

Task	Description	Duration	Predecessor
a	Erecting Walls	7	none
b	Carpentry for Roof	3	a
c	Roof	1	b
d	Installations	8	a
e	Facade Painting	2	c, d
f	Windows	1	c, d
g	Garden	1	c, d
h	Ceilings	3	a
i	Painting	2	f, h
j	Moving in	1	i

Problems Deep Learning cannot Solve

Problems Deep Learning cannot Solve





MACHINE LEARNING

INTRODUCTION

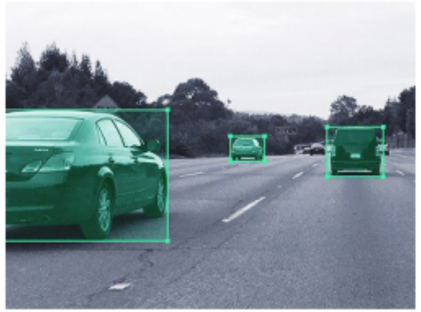
Credit: Sebastian Raschka

Common Application Areas - 1. Making Predictions

Is this email spam or not?

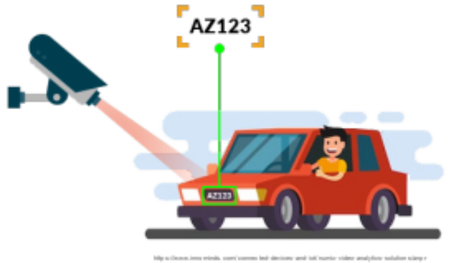
A label prediction task

Where are the cars located?



Predicting the bounding boxes

What is the license plate code?



Recognizing or predicting letters and digits

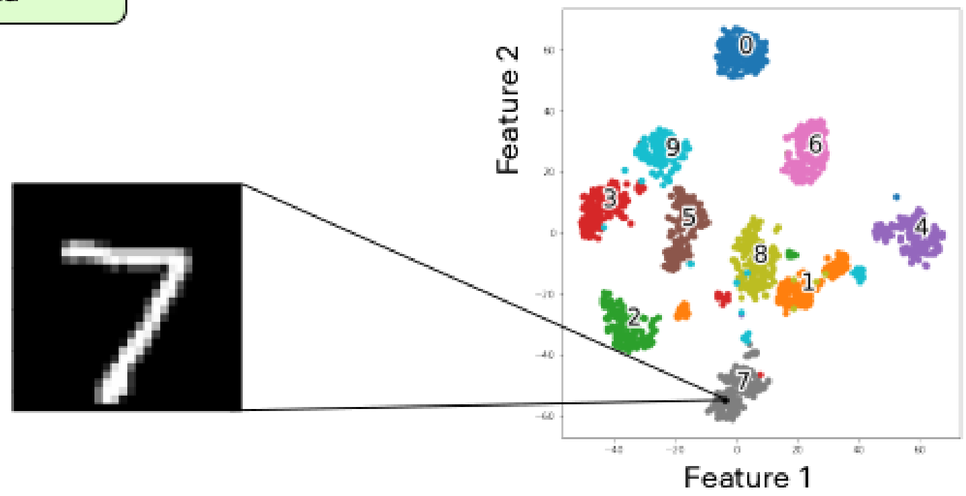
Common Application Areas - 2. Compressing dataset

Compressing large datasets

Extracting interesting data for storage

2 Compressing data

Exploring datasets



Compressing 28x28 (=784) dimensional images to 2 dimensions

Common Application Areas - 3. Generating New Data

AI-GENERATED IMAGES

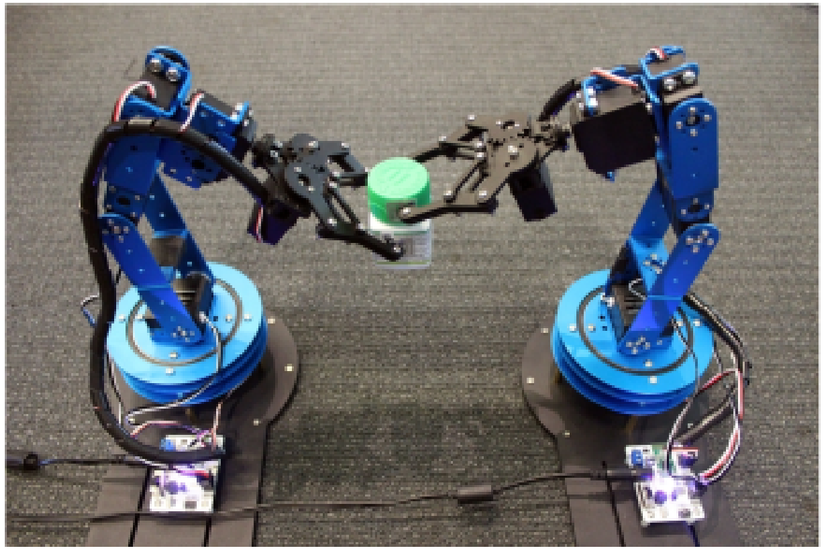
Edit prompt or view more images↓

Source: https://openai.com/blog/dall-e/

Common Application Areas - 4. Learning a series of actions

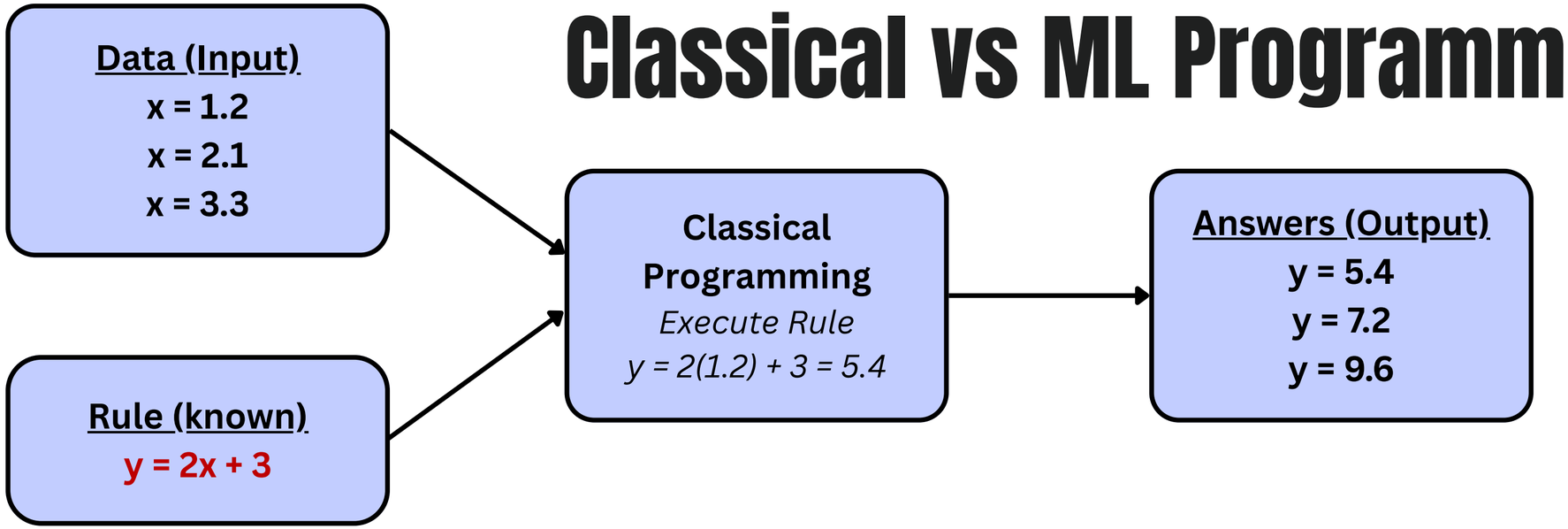
Performing moves to win a game

Moving a robot

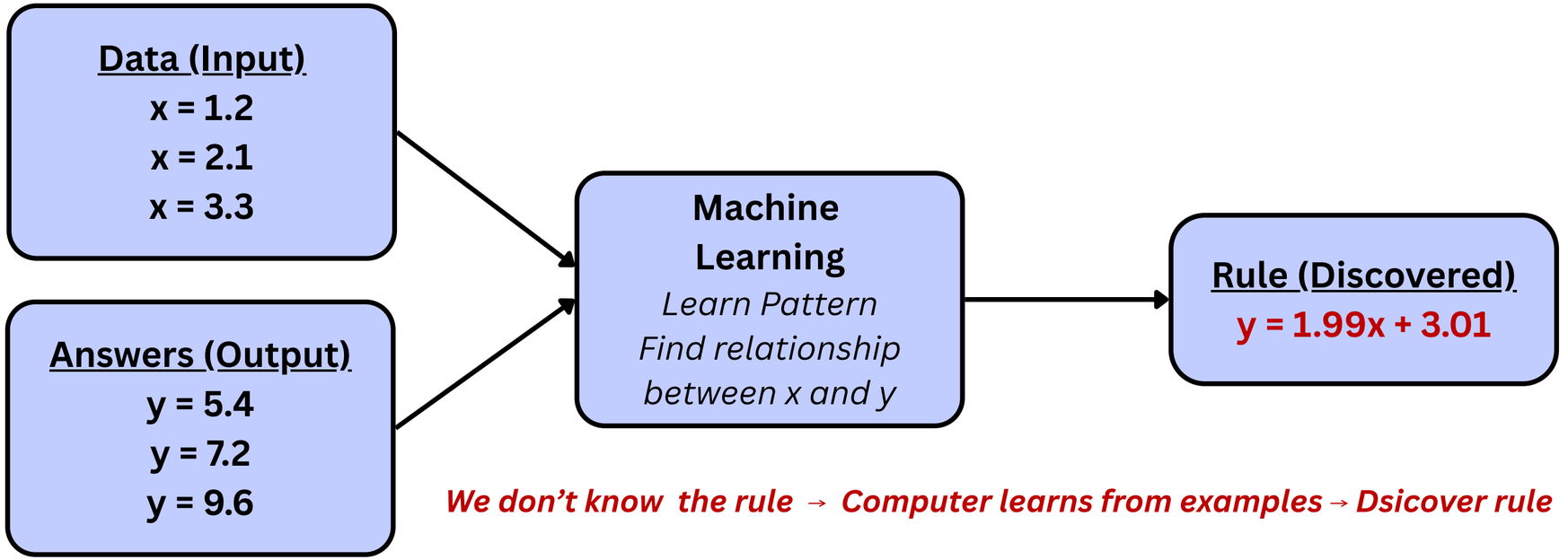


https://news.mit.edu/2019/robots-track-moving-objects-unprecedented-precision-0219

Classical vs ML Programming - 1D

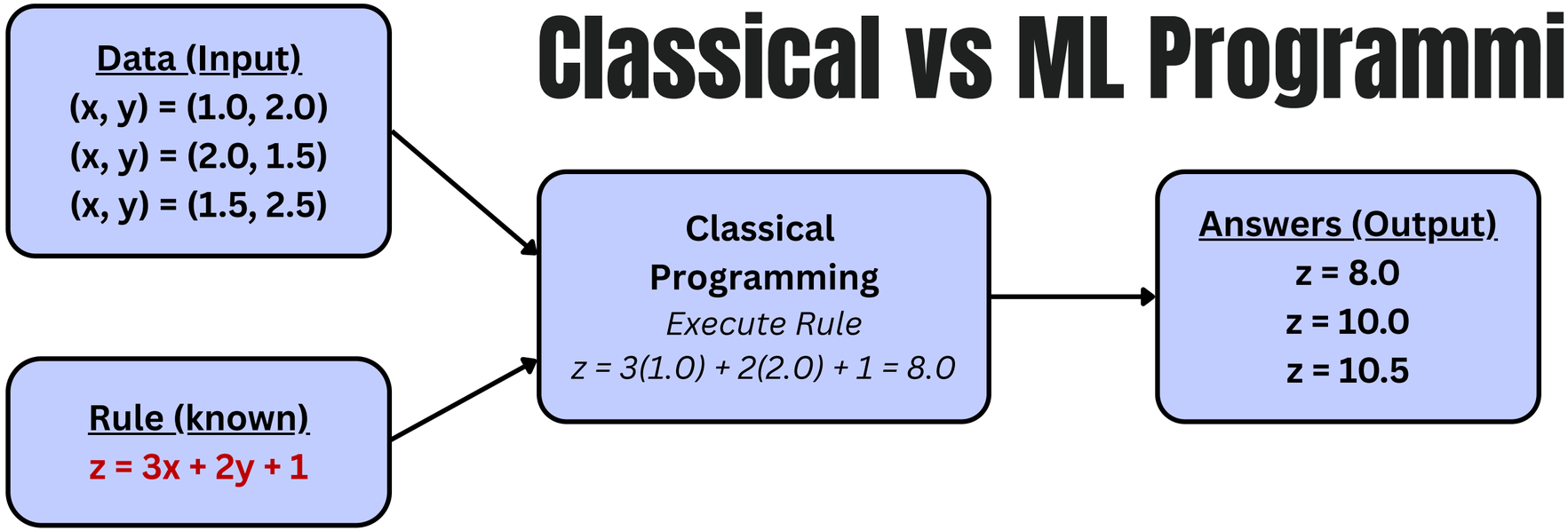


We know the rule → Computer applies it → Get Answers

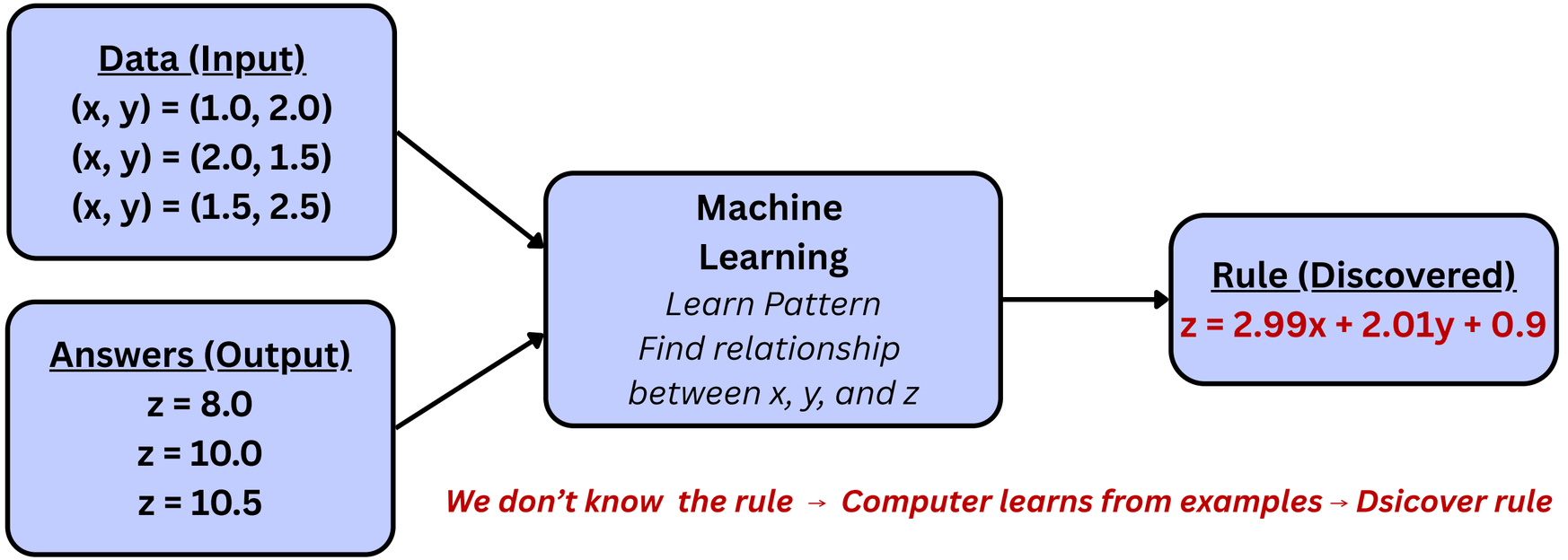


We don't know the rule → Computer learns from examples → Dsicover rule

Classical vs ML Programming - 2D



We know the rule → Computer applies it → Get Answers



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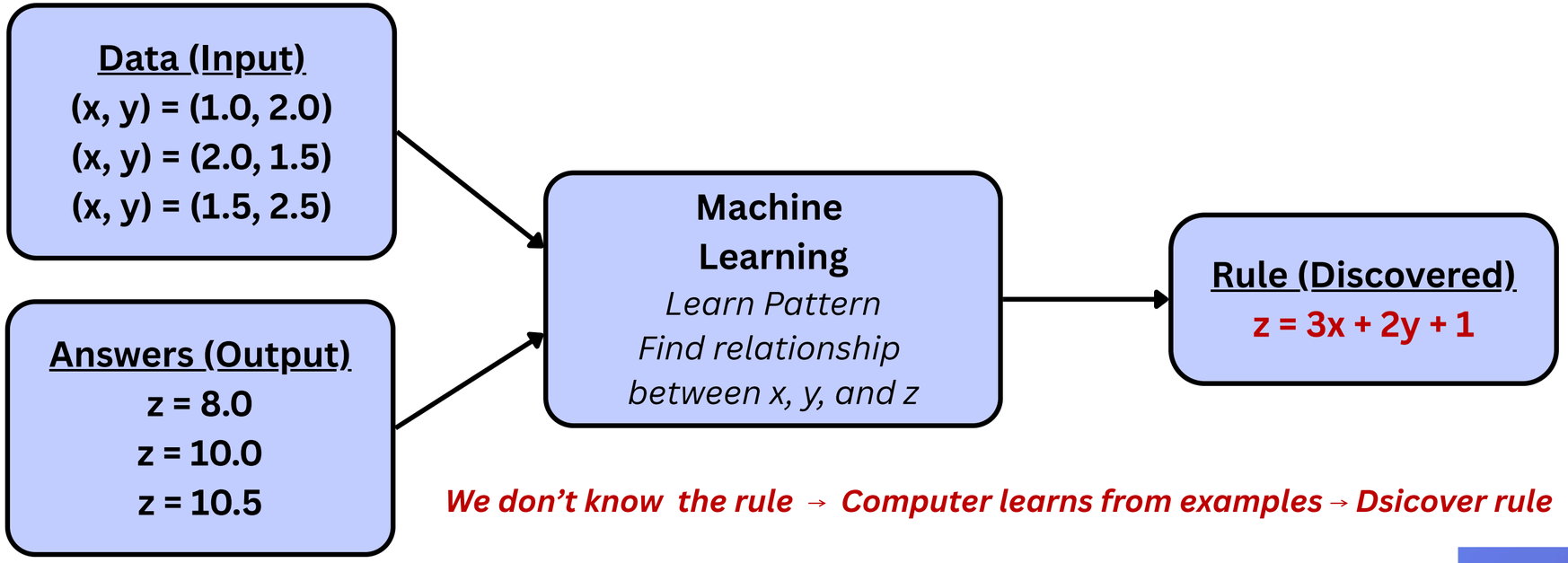


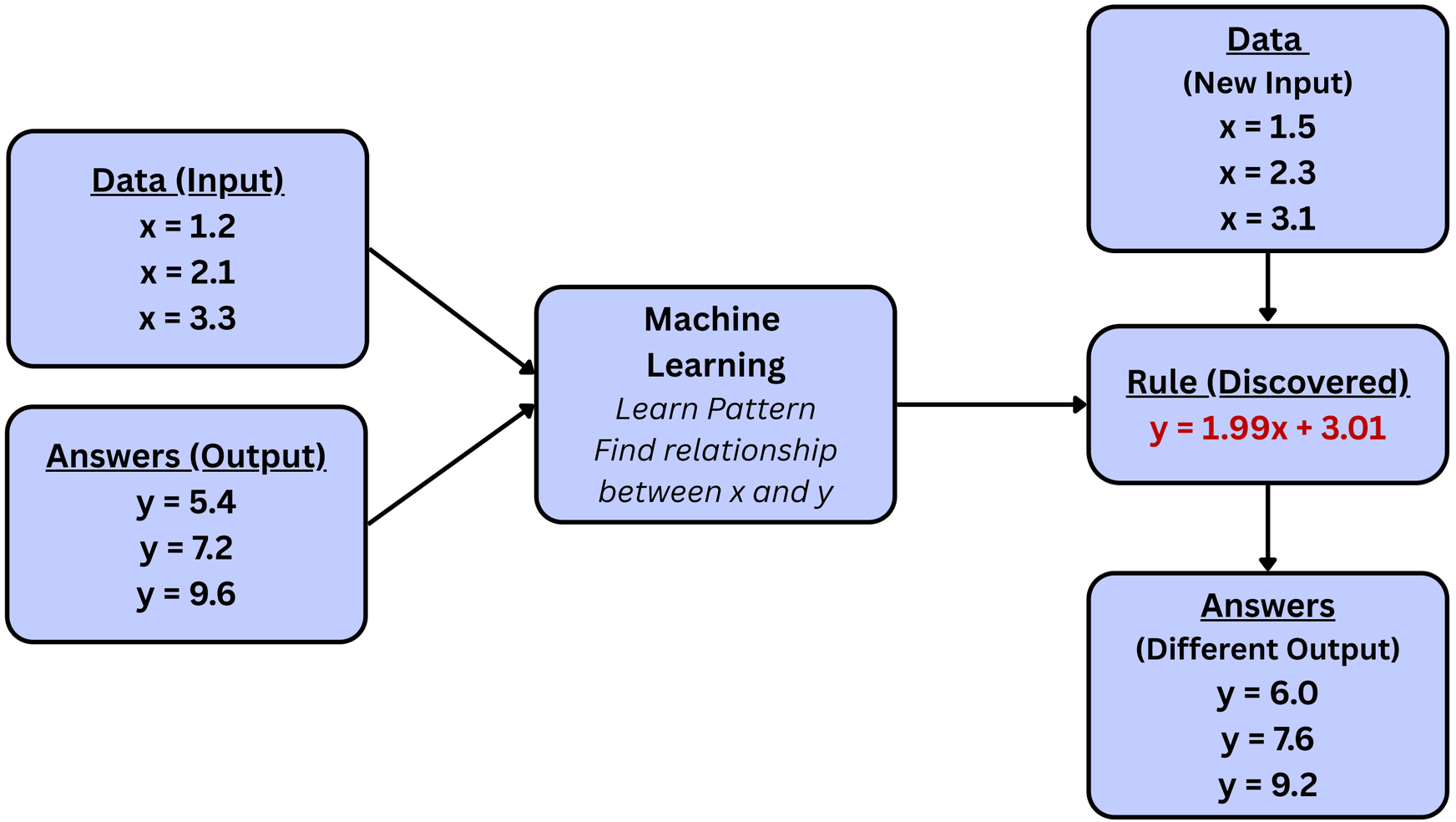
We don't know the rule → Computer learns from examples → Dsicover rule

📊 Student Exam Performance Data

STUDENT	STUDY HOURS (X)	PREP EXAMS (Y)	FINAL EXAM SCORE (Z)
Student 1	5	2	76
Student 2	7	6	88
Student 3	16	5	96
Student 4	14	2	90
Student 5	12	7	98
Student 6	7	4	80
Student 7	4	4	86
Student 8	19	2	89
Student 9	4	8	68
Student 10	8	4	75
Student 11	8	1	72
Student 12	3	3	76

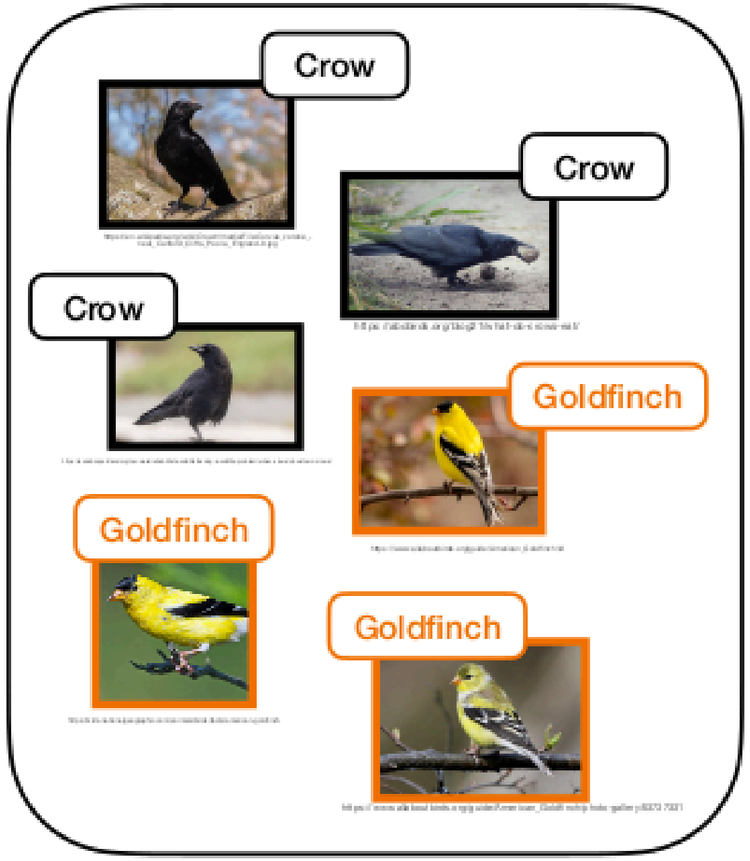
AVG STUDY HOURS	AVG PREP EXAMS	AVG FINAL SCORE	HIGHEST SCORE
8.9	4.2	82.8	98

Deployed ML Model

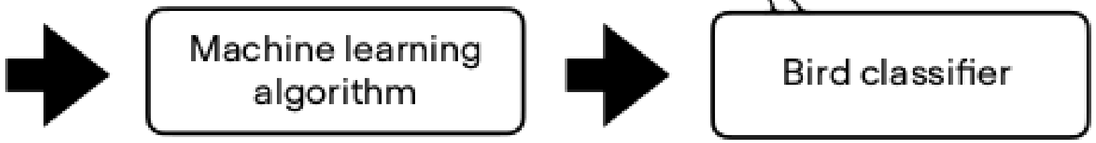


We input new data → Computer applies the discovered rule → Get new answer

Machine learning lets computers learn from data

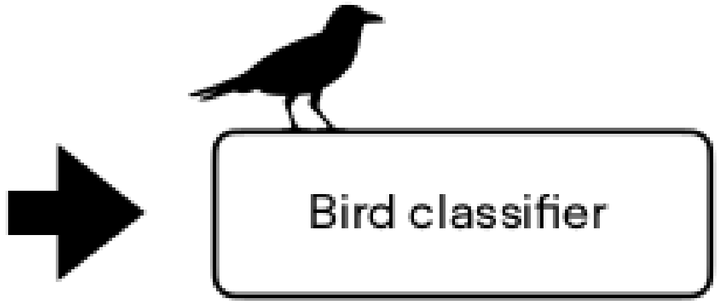


Labeled examples



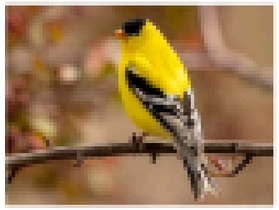
Goal

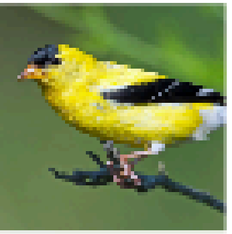
New bird picture

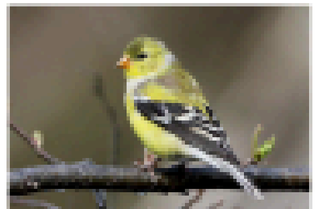


Deep Learning

large datasets
in "unstructured" form
(e.g., images and text)







Manual feature extraction

Classical Machine Learning

Datasets in "structured"
form like tables

	Beak length	Wing span	Primary color	...
Bird 1	3 cm	43 cm	black	...
Bird 2	0.5 cm	19 cm	yellow	...
Bird 3	5 cm	48 cm	black	...
Bird 4	4 cm	45 cm	black	...
...	...	...	...	...