Machine Learning

Instructor

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UNIT-1

Review of logic and knowledge system - language, axiom, hypothesis, theorem, logic & types, what is ML, Inductive bias in ML, AI pyramid, Pattern classification pipeline, Linear algebra in ML, Probabilistic logic and statistical inference (Random expt./ variable), CDF, WLLN, Bayes, Markov & Chernoff bound, Hypothesis testing and performance indices - ROC, Estimation - detection, Optimality of Bayes, bias-variance, underfit-overfit, entropy as Information, Cover's packing lemma, Curse of dimensionality, Case study: Wealth – optimal payoffs in portfolios (stock market).

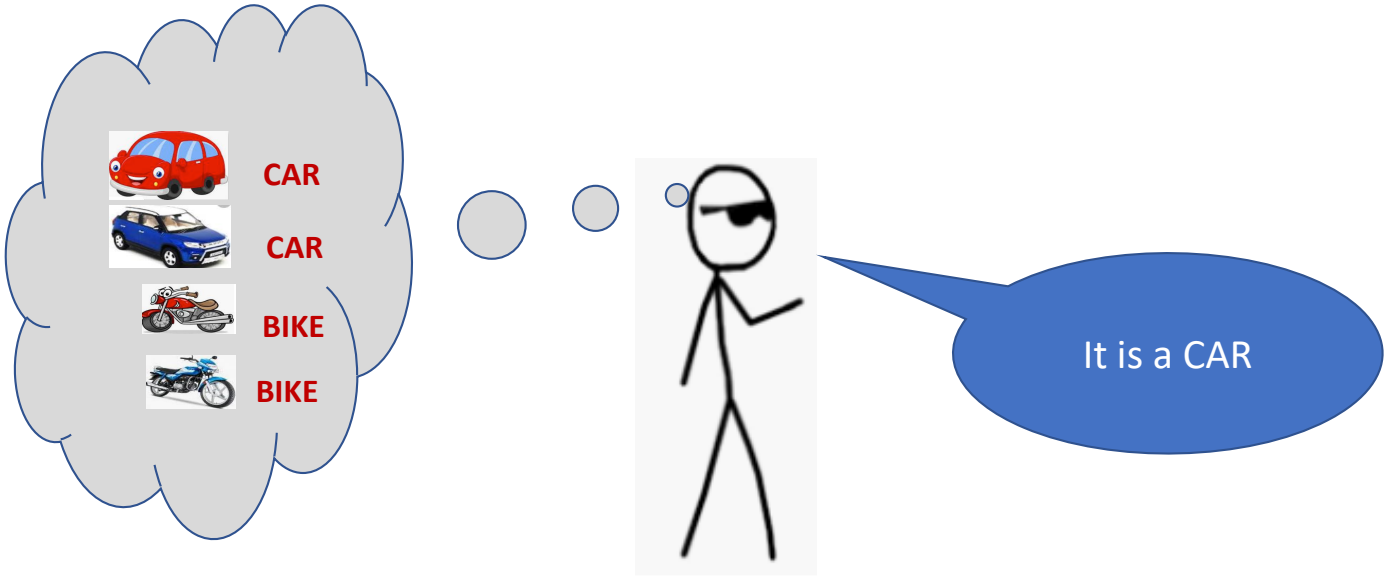
What is Machine Learning?

(Layman’s term)

Human can learn from past experience
and make decision of its own

What is this object?

What is this object?



Let us ask the same question to him

What is this object?

Let us ask the same question to him

What is this object?

[But, he is a human being. He can observe and learn]

Let us make him learn

show him

Let us make him learn

show him

CAR

CAR

BIKE

BIKE

Let us ask the same question now

What is this object?

CAR

CAR

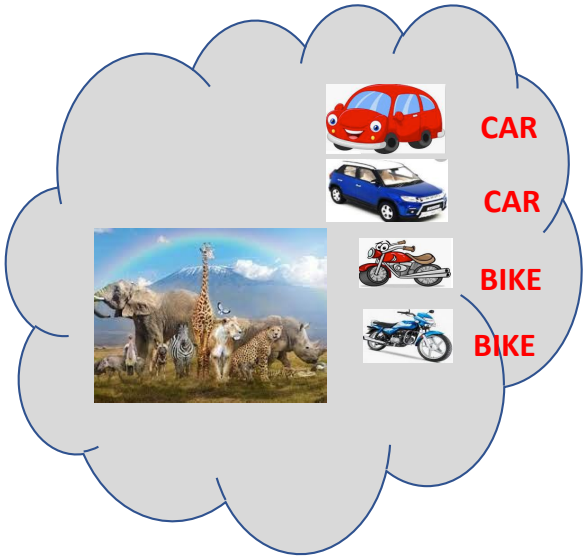
BIKE

BIKE

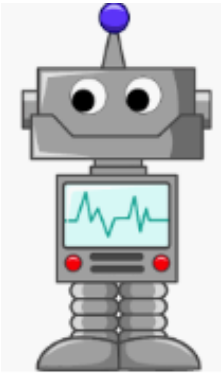
Past experience

Let us ask the same question now

What is this object?



What about a Machine ?



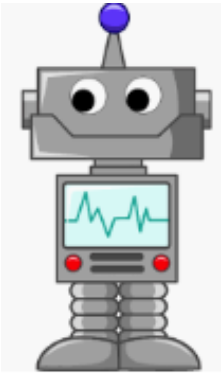
Machines follow instructions

[It can not take decision of its own]

What about a Machine ?

We can ask a machine

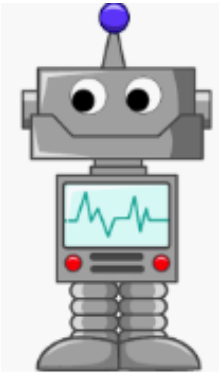
- To perform an arithmetic operations such as
  - Addition
  - Multiplication
  - Division



Machines follow instructions

What about a Machine ?

- Comparison
- Print
- Plotting a chart



Machines follow instructions

What is Machine Learning?

[We want a machine to act like a human]

What is Machine Learning?

[to identify this object.]

What is Machine Learning?

Price in 2025?

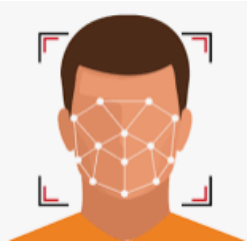
[predict the price in future]

What is Machine Learning?

I ~~made~~ met him yesterday

[Natural Language understand, and correct grammar]

What is Machine Learning?



recognize face

[Recognize Faces]

What is Machine Learning?

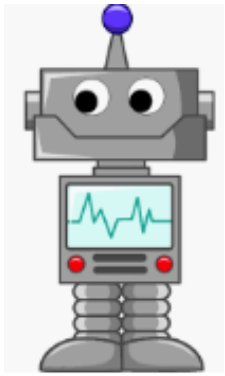
[What do we do?

Just like, what we did to human,

we need to provide experience to the machine.

]

What is Machine Learning?



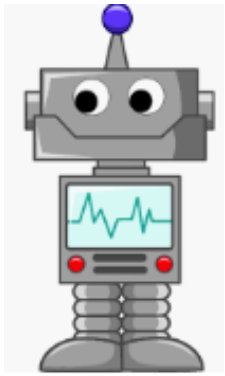
+

Dataset

[
This what we called as Data or Training dataset

So, we first need to provide training dataset to the machine
]

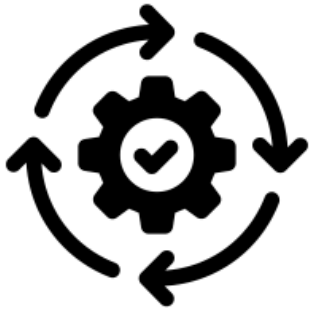
What is Machine Learning?



+

Dataset

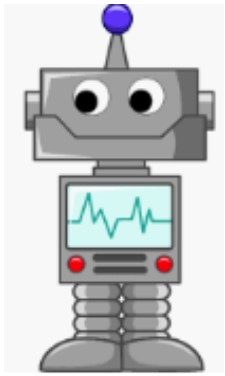
+



[Then, devise algorithms and execute programs on the data

With respect to the underlying target tasks]

What is Machine Learning?



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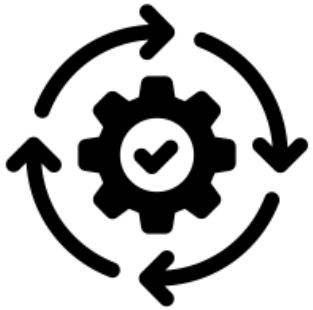
Dataset

+



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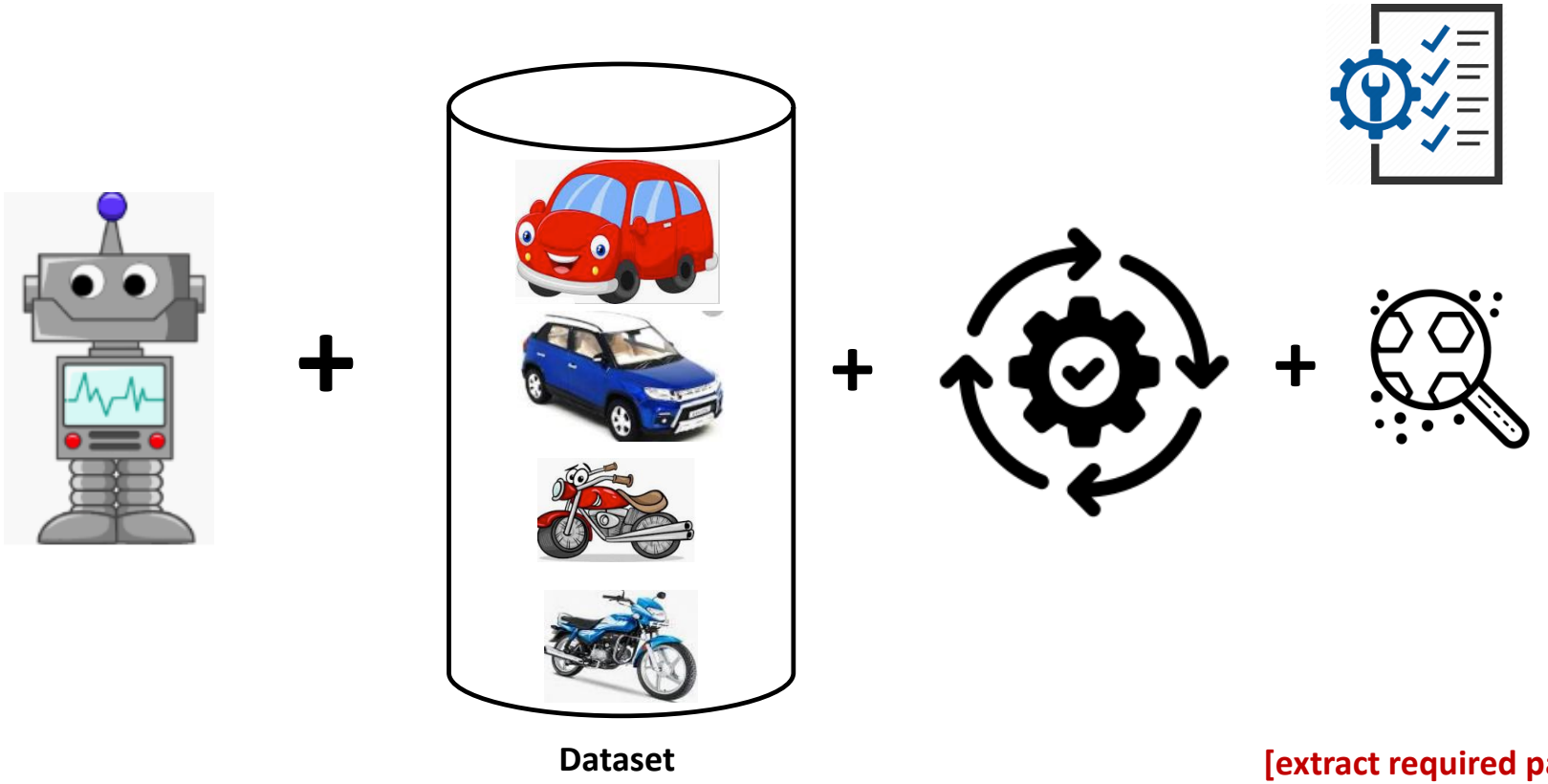
[Then, using the programs, Identify required rules]

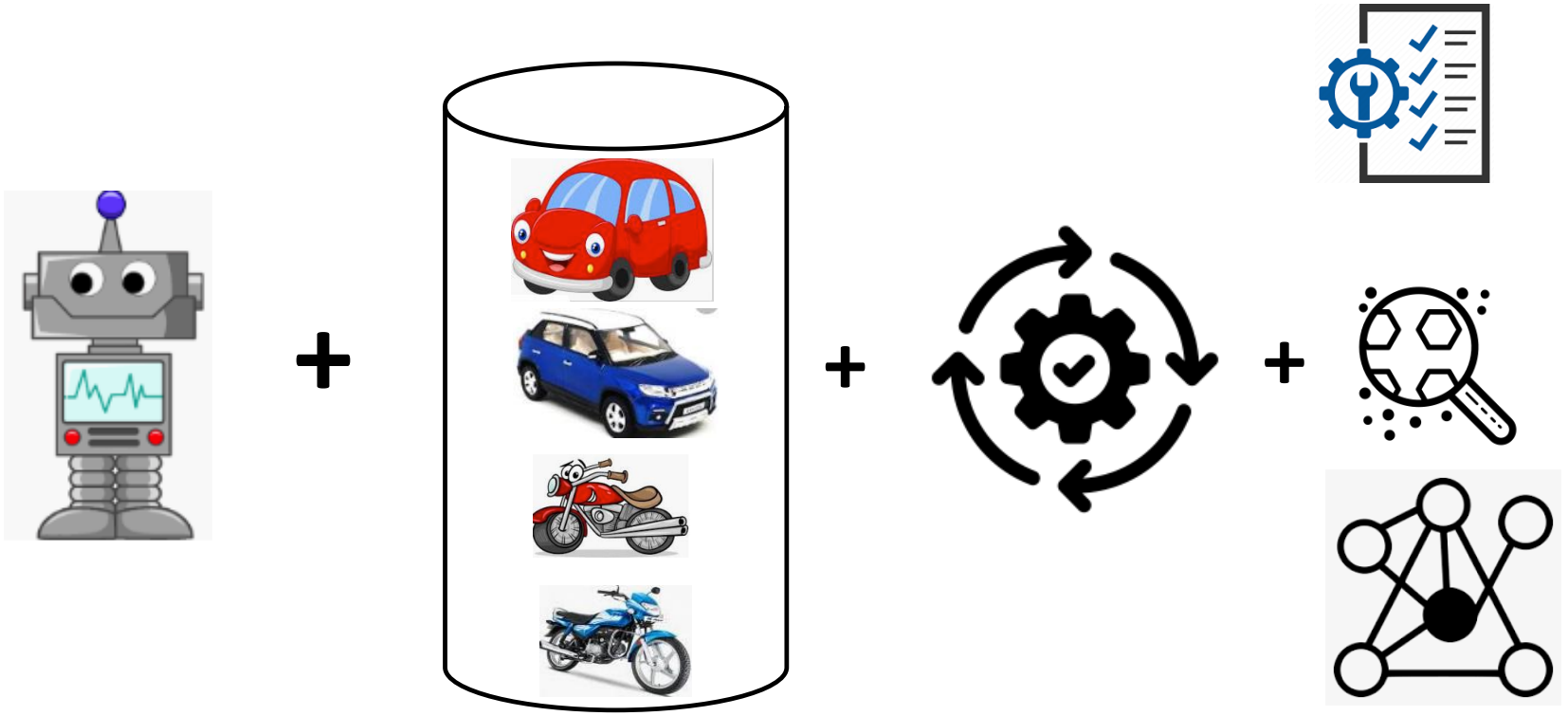
What is Machine Learning?



Dataset

[extract required patterns]

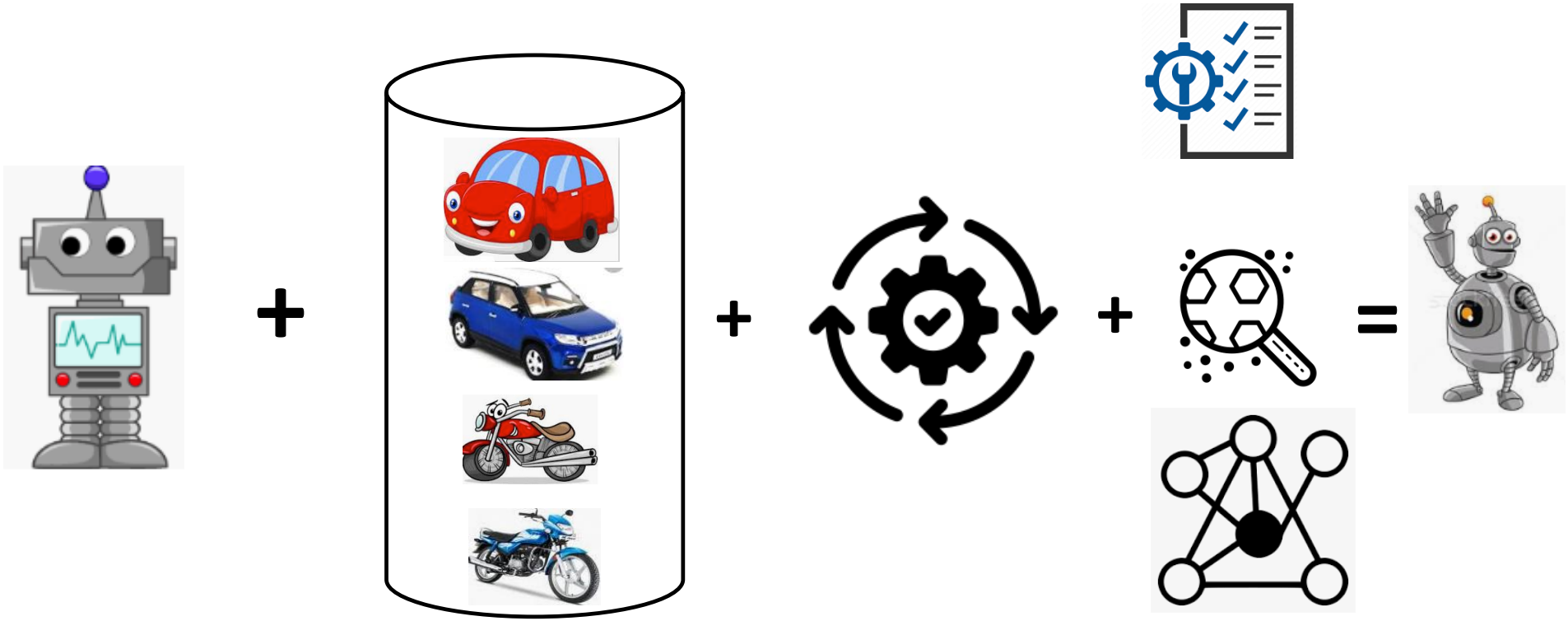
What is Machine Learning?



Dataset

[Identify relations]

What is Machine Learning?



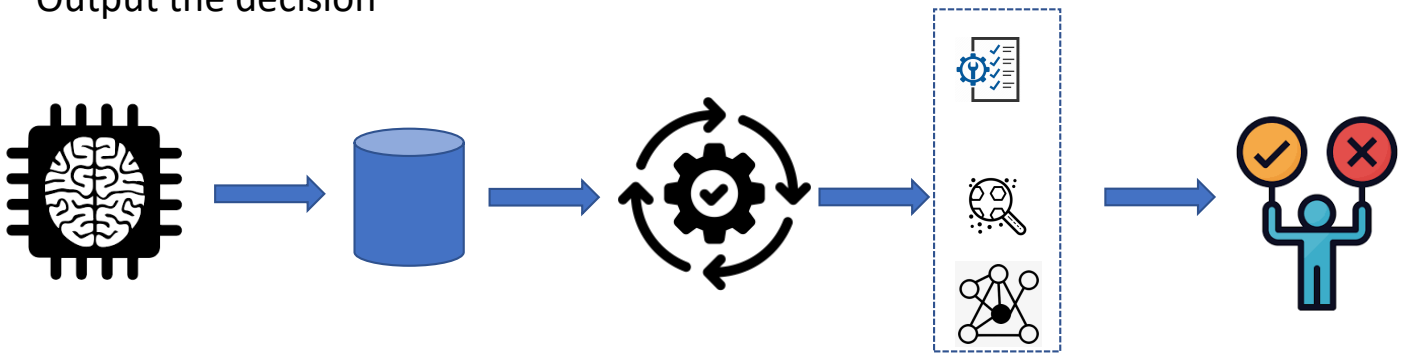
Dataset

[So that machine can derive inferences from the data]

In summary, what is machine learning?

Given a machine learning problem

- Identify and create the appropriate dataset
- Perform computation to learn
  - Required rules, pattern and relations
- Output the decision

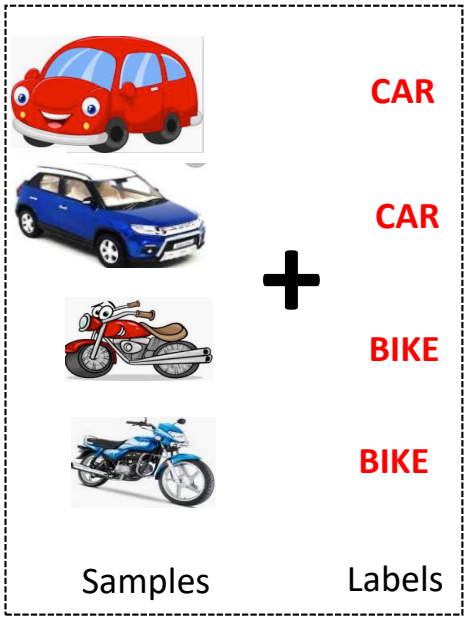


Machine Learning Paradigms

- Supervised
- Unsupervised Learning
- Reinforcement learning

[We as human being solve various types of problem in our day-to-day life, <pause> Various decisions need to be taken.
Depending on the nature of the problem, machine learning tasks can be broadly divided in]

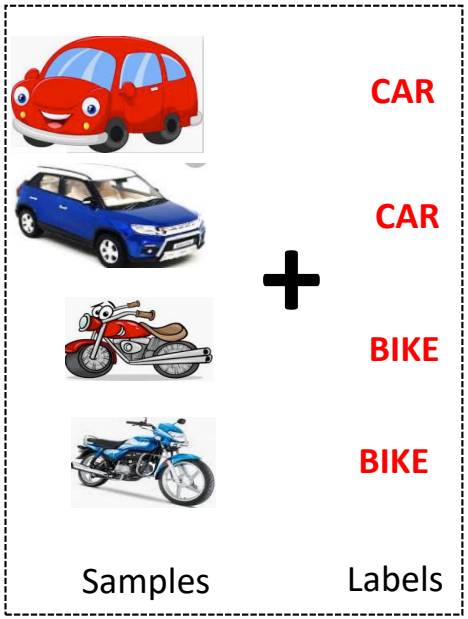
What is Supervised Learning?



= Training Dataset

[In supervised learning, we need some thing called a Labelled Training Dataset]

What is Supervised Learning?

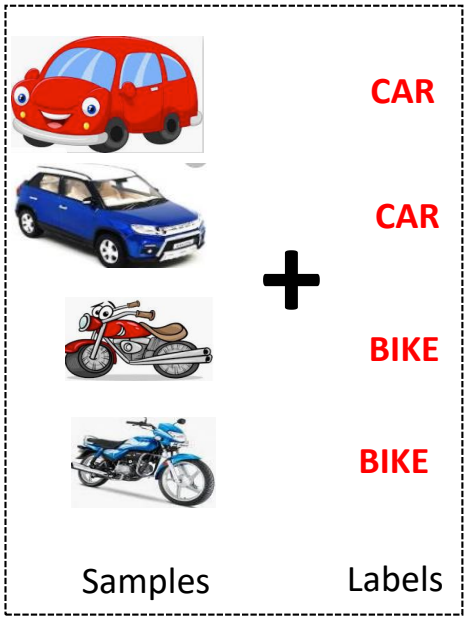


= Training Dataset

$f($  $,\quad\quad)=$

[Given a labelled dataset, the task is to devise a function which takes the dataset, and a new sample, and produces an output value.]

What is Supervised Learning?

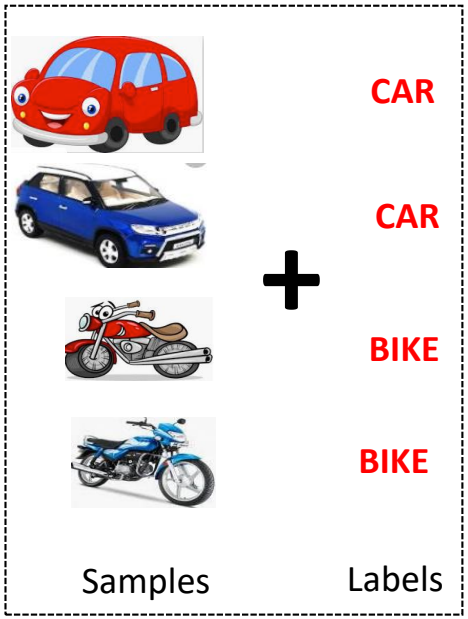


= Training Dataset

$f($  $)=$

[Given a labelled dataset, the task is to devise a function which takes the dataset, and a new sample, and produces an output value.]

What is Supervised Learning?

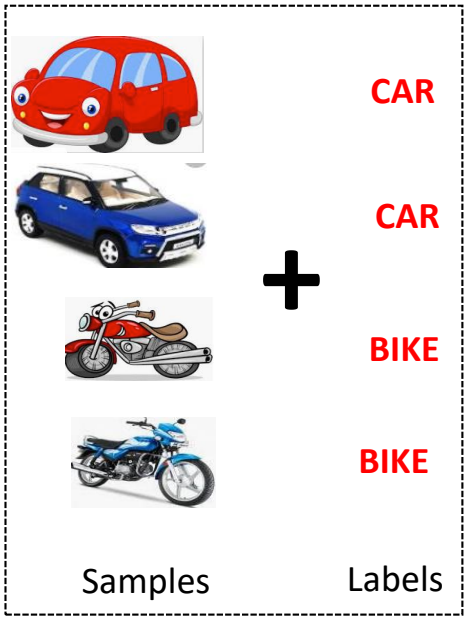


= Training Dataset

$f($  $)=$ CAR

[Given a labelled dataset, the task is to devise a function which takes the dataset, and a new sample, and produces an output value.]

What is Supervised Learning?



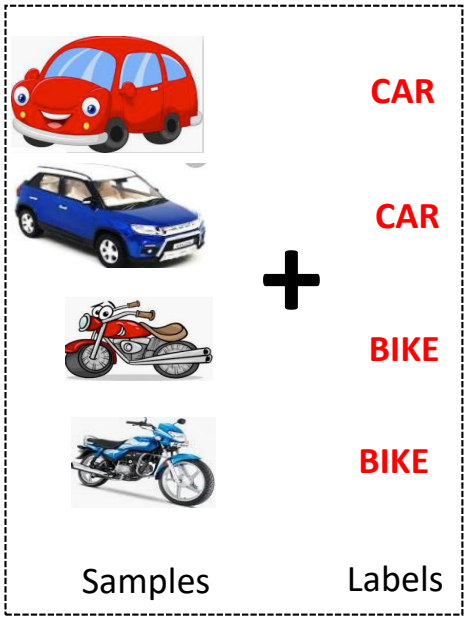
= Training Dataset

Classification

$f($  $)=$ CAR

[If the possible output values of the function are predefined and discrete/categorical, it is called Classification

What is Supervised Learning?



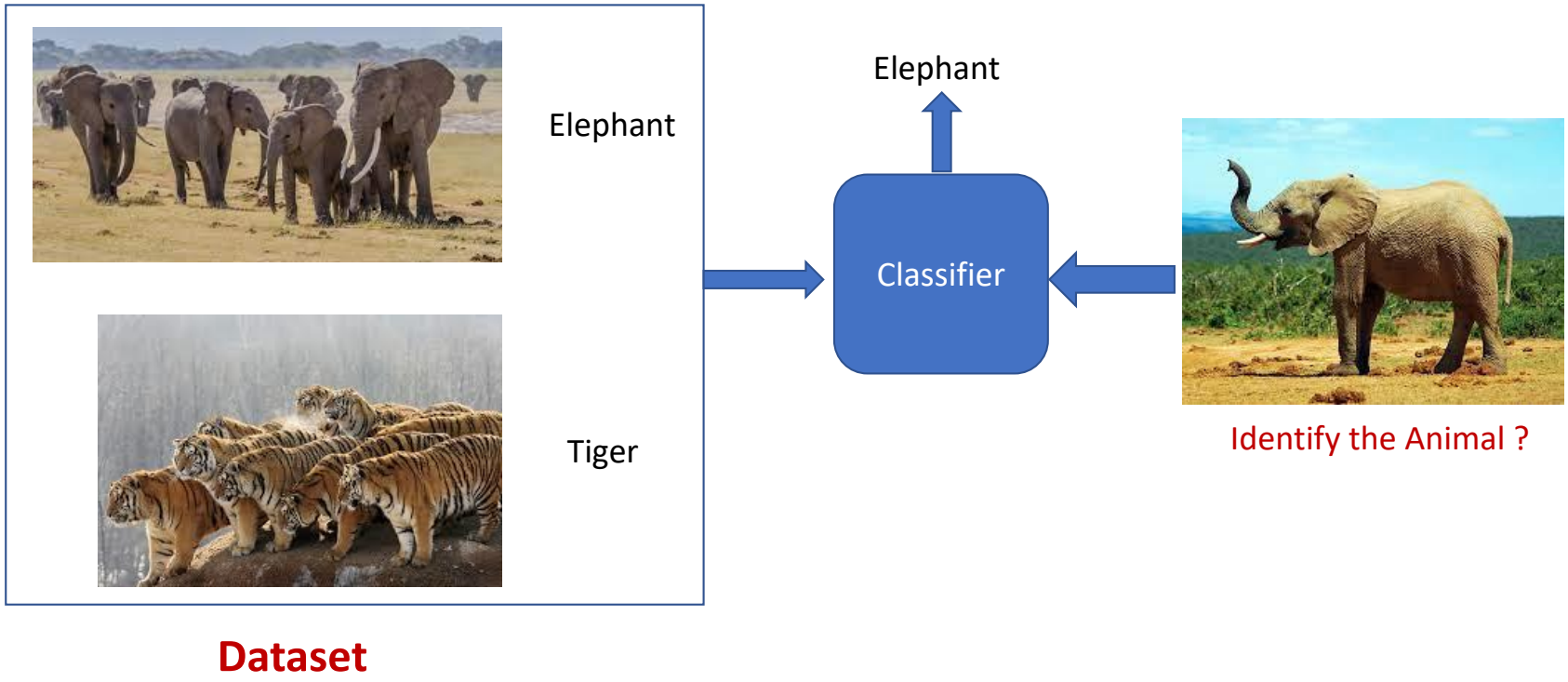
= Training Dataset

Classification

$f($  $)=$ CAR

[Predefined classes means, it will produce output only from the labels defined in the dataset. For example, even if we input a bus, it will produce either CAR or BIKE]

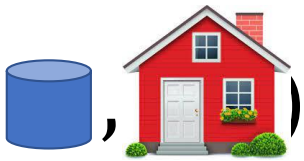
Classifier


Elephant
Tiger
Classifier
Elephant
Identify the Animal ?
Dataset

Regression

Dataset

Regression

$f($  $)= 20500.50$

[If the possible output values of the function are continuous real values, then it is called Regression

[
The classification and Regression problems are supervised, because the decision depends on the characteristics of the ground truth labels or values present in the dataset, which we define as experience
]

What is Unsupervised Learning


~~CAR~~


~~CAR~~


~~BIKE~~


~~BIKE~~

Dataset

[In the unsupervised learning, we do not need to know the labels or Ground truth values]

What is Unsupervised Learning

Dataset

Clustering

[The task is to identify the patterns like group the similar objects together]

What is Unsupervised Learning

Dataset

Association Rules Mining

[Association rules like]

More Example Unsupervised Learning

Dataset

More Example Unsupervised Learning

Dataset

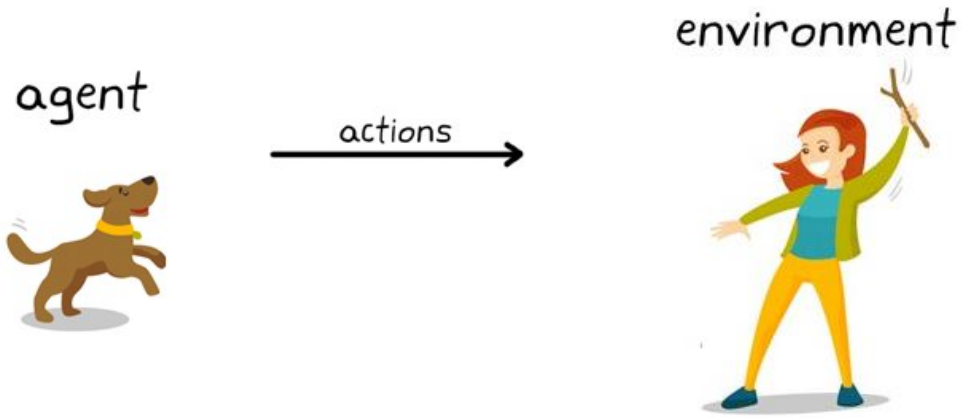
More Example Unsupervised Learning

What is Reinforcement Learning

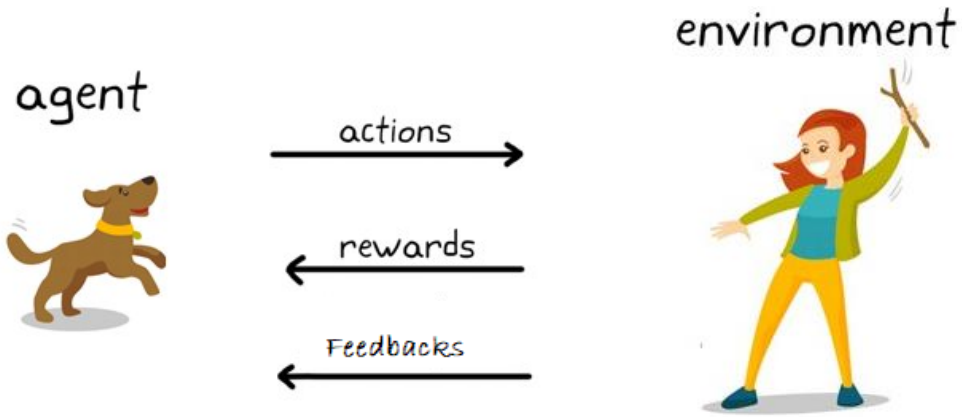
[It is also known as learning from trials and errors]

What is Reinforcement Learning

What is Reinforcement Learning



What is Reinforcement Learning



Another Example

Agent

Task

Environment

Reinforcement Learning

Punishment

Reinforcement Learning

Reward

Reinforcement Learning

Reward

Baby Learn from the Trials and Errors

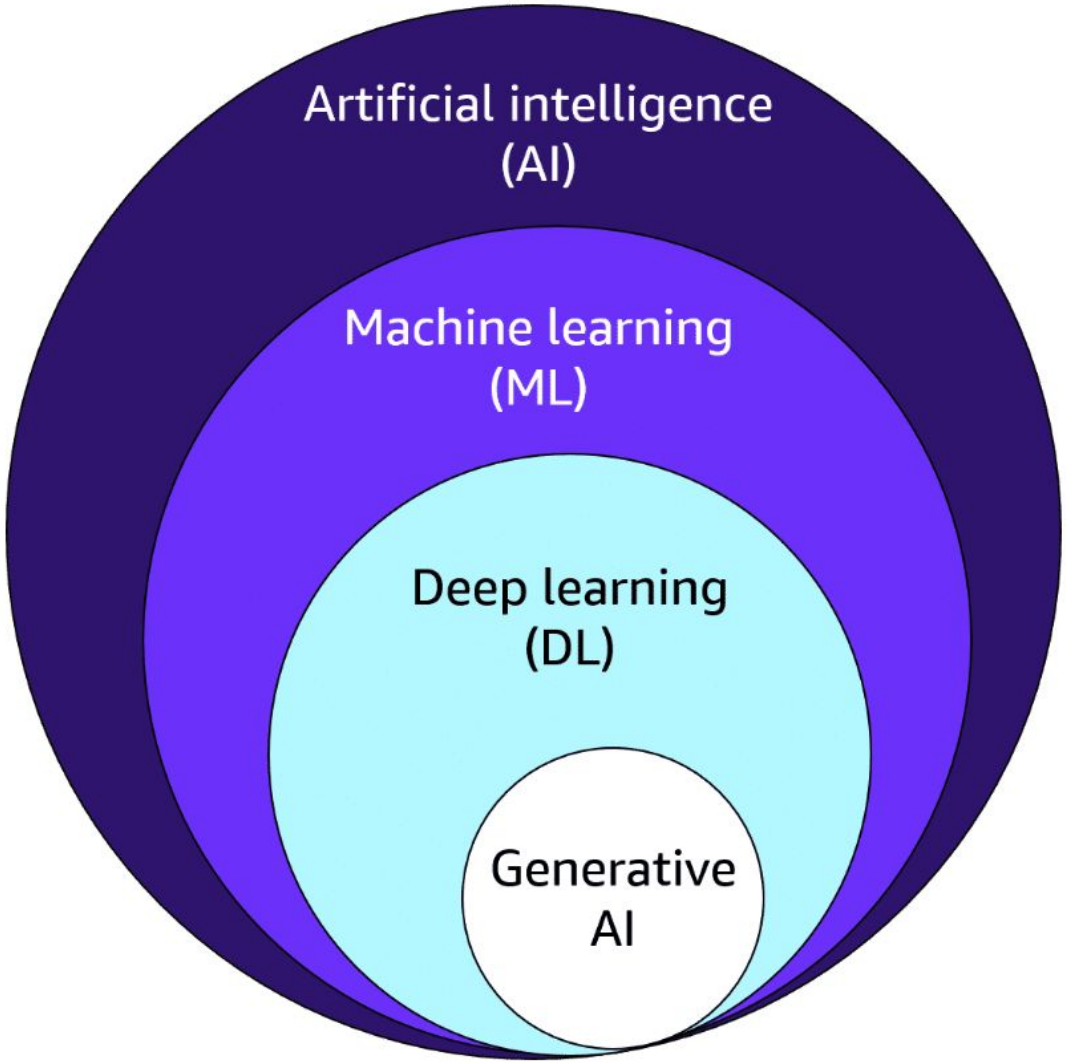
Reinforcement Learning

Machine Learning:

Study of algorithms that

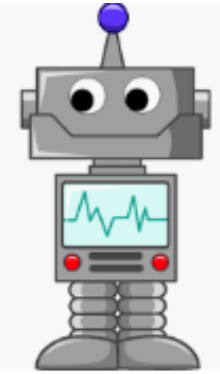
- improve their performance P
- at some task T
- with experience E

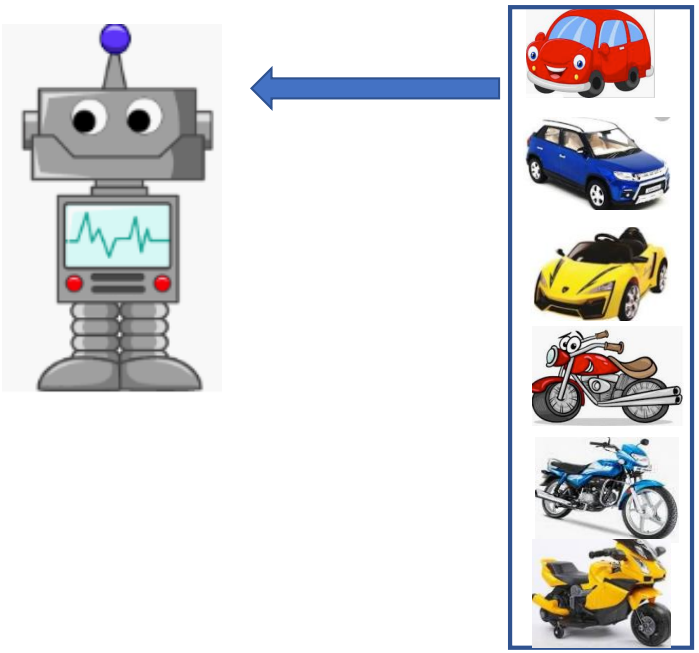
well-defined learning task: <P,T,E>


Artificial intelligence
(AI)
Machine learning
(ML)
Deep learning
(DL)
Generative
AI

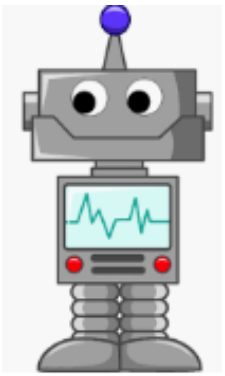
First machine learning model from Scratch

Teach a machine to identify vehicle types



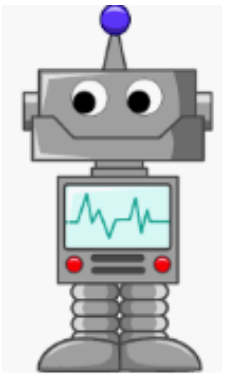


Represent the sample



#Wheel Height Weight Color

Represent the sample



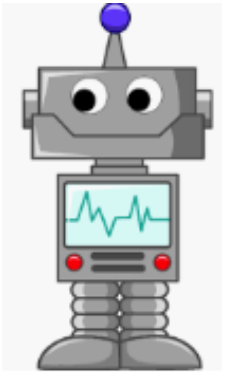
#Wheel Height Weight Color

Identify the features which can represent the objects

$$F = \{f_1 f_2 f_3 \dots f_k\}$$

Feature set={ #Wheel Height Weight Color }

Represent the sample



#Wheel Height Weight Color

Identify the features which can represent the objects

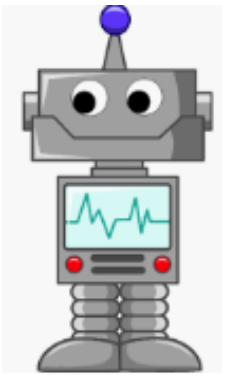
$$F = \{f_1 f_2 f_3 \dots f_k\}$$

For every sample, assign value to corresponding feature

$$v_i = \{w_{i1} w_{i2} w_{i3} \dots w_{ik}\}$$

where w_{ij} is the value assigned for the feature f_j

Represent the sample



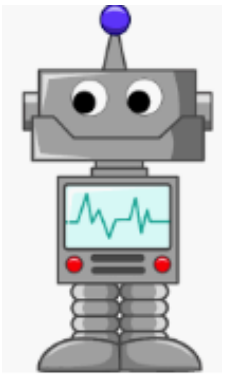
#Wheel	Height	Weight	Color
4	6	500	Red
4	5.5	600	Blue
4	5	550	Yellow
2	3	200	Red
2	3.5	150	blue
2	4	250	Yellow

For every object, assign value to corresponding feature

$$v_i = \{w_{i1} w_{i2} w_{i3} \dots w_{ik}\}$$

where w_{ij} is the value assigned for the feature f_j

Vector Space Model



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4	6	500	Red
4	5.5	600	Blue
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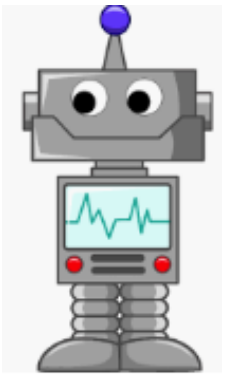
2	3	200	Red
2	3.5	150	blue
2	4	250	Yellow

Features Vectors

This form of representation is called Vector Space Model

Are all features useful?



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4	5	550	Yellow
2	3	200	Red
2	3.5	150	blue
2	4	250	Yellow

Features

Features Vectors

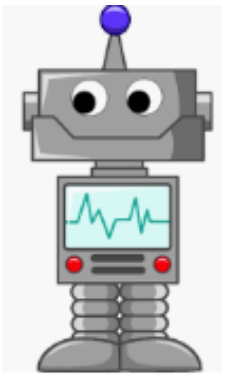
Good Features

- #Wheel
- Height
- Weight

Bad Feature

- Colour

Let us consider single feature

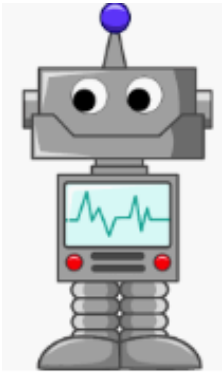


#Wheel	Class Label
4	CAR
4	CAR
4	CAR
2	BIKE
2	BIKE
2	BIKE

Training Dataset

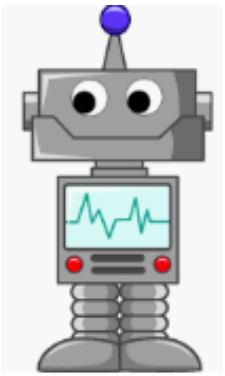
Feature vector with Class label

Given the #Wheel, identify the vehicle



#Wheel	Class Label
4	CAR
4	CAR
4	CAR
2	BIKE
2	BIKE
2	BIKE
2	?

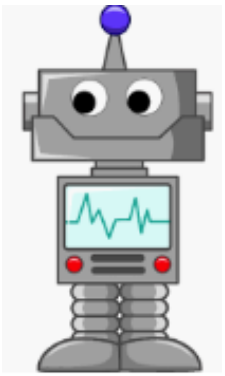
Let us estimate



#Wheel	Class Label
4	CAR
4	CAR
4	CAR
2	BIKE
2	BIKE
2	BIKE

Pr(Vehicle type| #Wheel) = ?

Let us estimate the probability (type|#wheel)



#Wheel	Class Label
4	CAR
4	CAR
4	CAR
2	BIKE
2	BIKE
2	BIKE

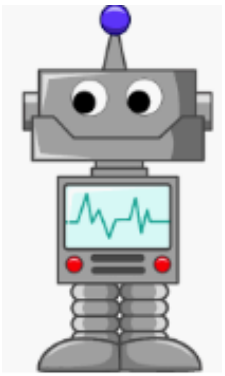
Pr(CAR| 4) = 100%

Pr(BIKE| 4) = 0%

Pr(CAR| 2) = 0%

Pr(BIKE| 2) = 100%

Ask the question now



#Wheel	Class Label
4	CAR
4	CAR
4	CAR
2	BIKE
2	BIKE
2	BIKE

Pr(CAR| 4) = 100%

Pr(BIKE| 4) = 0%

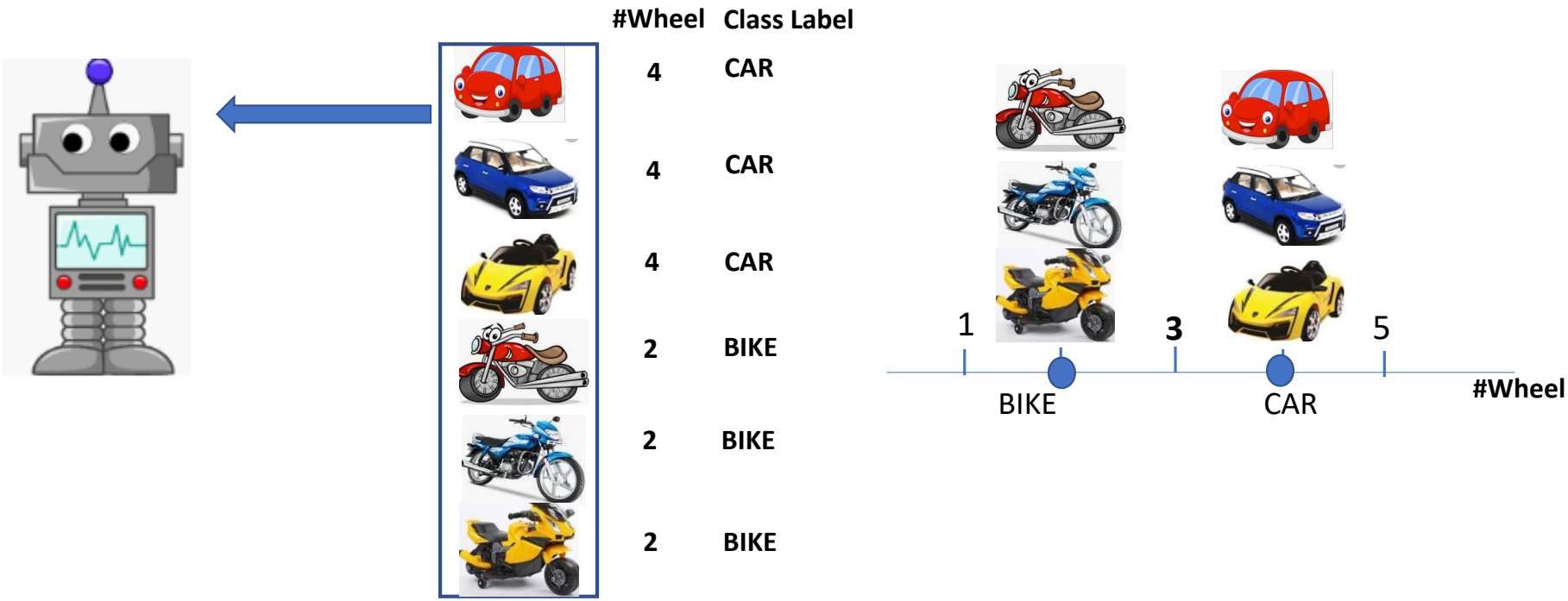
Pr(CAR| 2) = 0%

Pr(BIKE| 2) = 100%

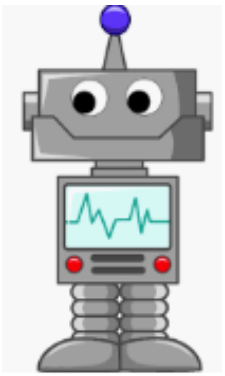
{2} ?

2 → **Classifier**
Pr(BIKE|2) > Pr(CAR|2) => BIKE → **BIKE**

There are multiple ways

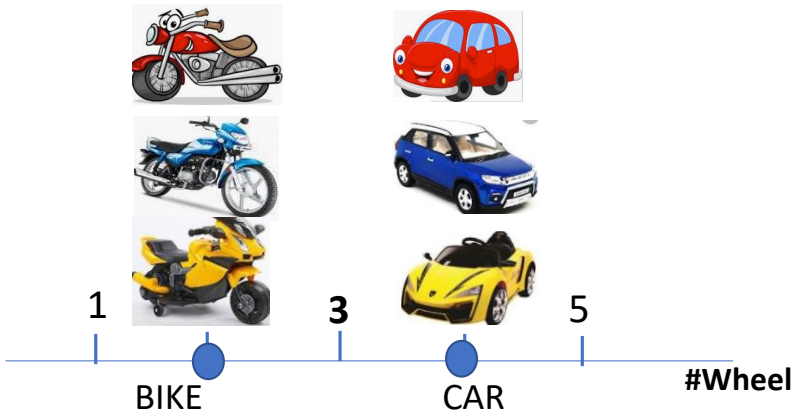


There are multiple ways

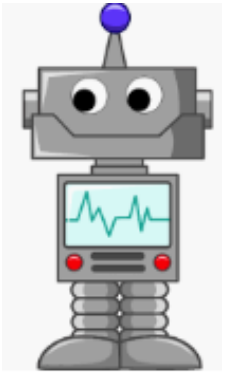


#Wheel	Class Label
4	CAR
4	CAR
4	CAR
2	BIKE
2	BIKE
2	BIKE

2 → **Classifier**
If #Wheel < 3, then it is BIKE → **BIKE**



If selected feature is not sufficient



	#Wheel	Class Label
	4	CAR
	4	CAR
	4	CAR
	2	BIKE
	2	BIKE
	2	BIKE
	4	BIKE
	2	CAR

Pr(CAR| 4) = 75%

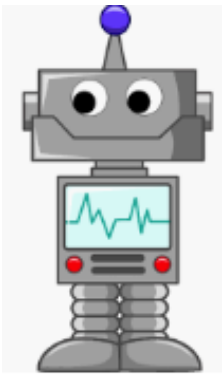
Pr(BIKE| 4) = 25%

Pr(CAR| 2) = 25%

Pr(BIKE| 2) = 75%

 2 ?

If selected feature is not sufficient



#Wheel	Class Label
4	CAR
4	CAR
4	CAR
2	BIKE
2	BIKE
2	BIKE
4	BIKE
2	CAR

Pr(CAR| 4) = 75%

Pr(BIKE| 4) = 25%

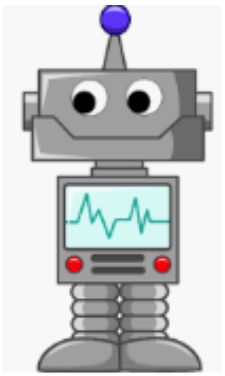
Pr(CAR| 2) = 25%

Pr(BIKE| 2) = 75%

2 **BIKE**

Pr(BIKE|2) > Pr(CAR|2) => BIKE

More Features

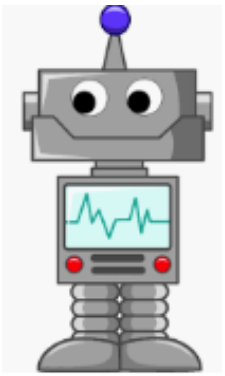


#Wheel	Height	Class Label
4	H	CAR
4	H	CAR
4	H	CAR
2	L	BIKE
2	L	BIKE
2	L	BIKE
4	L	BIKE
2	H	CAR

H: High, height >= 5

L: Low, height < 5

Estimate the probabilities, and ask the same question



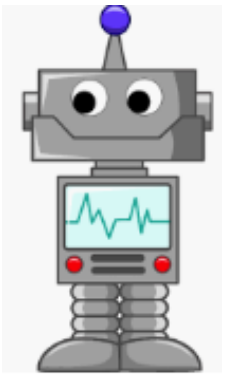
#Wheel	Height	Class Label
4	H	CAR
4	H	CAR
4	H	CAR
2	L	BIKE
2	L	BIKE
2	L	BIKE
4	L	BIKE
2	H	CAR

Pr(CAR| 4,H) = 100%
Pr(BIKE| 4,L) = 100%
Pr(CAR| 2,H) = 100%
Pr(BIKE| 2,L) = 100%
Pr(CAR| 4,L) = 0%
Pr(BIKE|4,H) = 0%
Pr(CAR| 2,L) = 0%
Pr(BIKE| 2,H) = 0%

{2 H}

?

Estimate the probabilities, and ask the same question



#Wheel	Height	Class Label
4	H	CAR
4	H	CAR
4	H	CAR
2	L	BIKE
2	L	BIKE
2	L	BIKE
4	L	BIKE
2	H	CAR

Pr(CAR| 4,H) = 100%

Pr(BIKE| 4,L) = 100%

Pr(CAR| 2,H) = 100%

Pr(BIKE| 2,L) = 100%

Pr(CAR| 4,L) = 0%

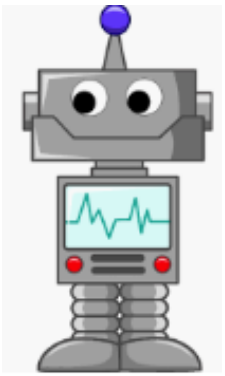
Pr(BIKE|4,H) = 0%

Pr(CAR| 2,L) = 0%

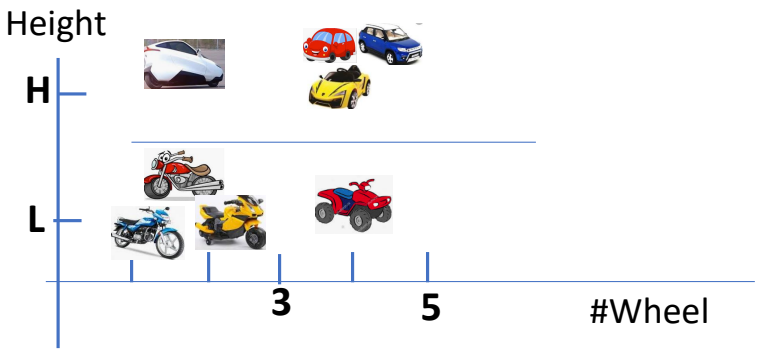
Pr(BIKE| 2,H) = 0%

{2 H} **CAR**

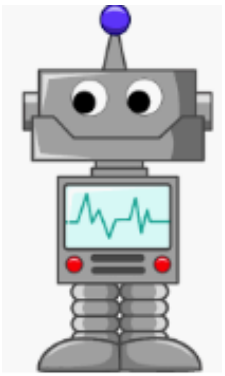
Multiple ways



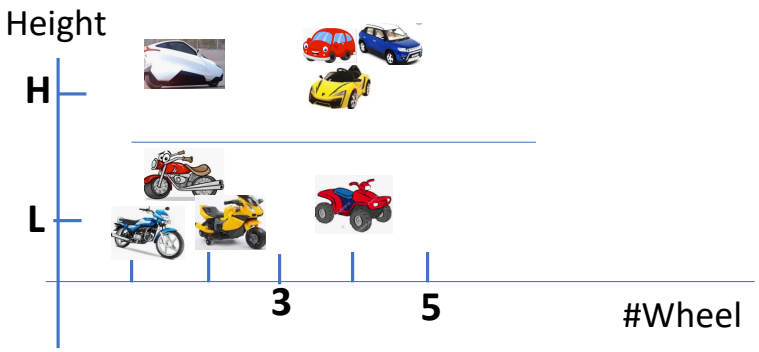
#Wheel	Height	Class Label
4	H	CAR
4	H	CAR
4	H	CAR
2	L	BIKE
2	L	BIKE
2	L	BIKE
4	L	BIKE
2	H	CAR

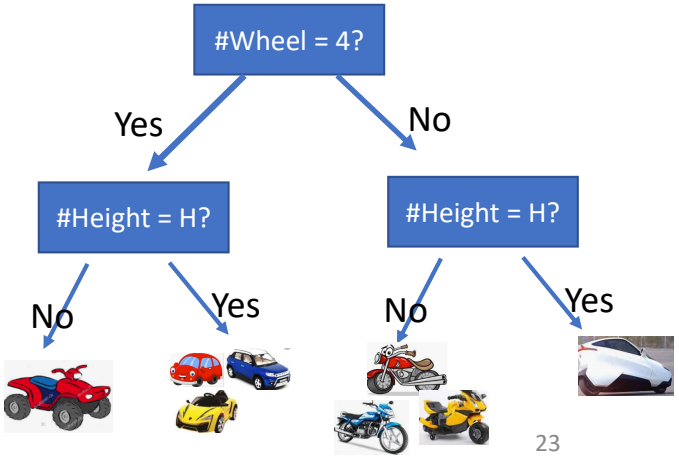


Multiple ways



#Wheel	Height	Class Label
4	H	CAR
4	H	CAR
4	H	CAR
2	L	BIKE
2	L	BIKE
2	L	BIKE
4	L	BIKE
2	H	CAR





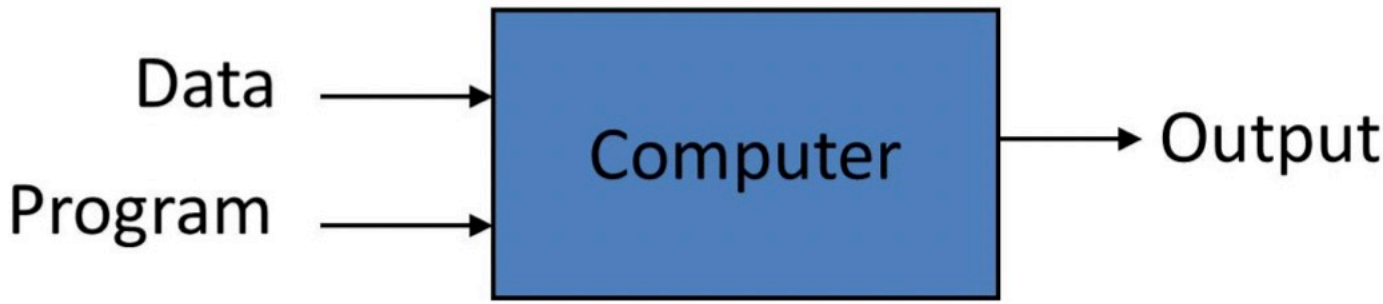
Summary

- **Identify the features**
- **Represent the vehicles by the features**
- **Remove non-informative features**
- **Build the classification model from the data**
- **Perform the classification task**

Machine Learning vs Programming

Traditional Programming

- Automating automation
- Getting computers to program themselves



Machine Learning