Introduction to Machine Learning

Three Day Workshop

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Title Machine Learning and Neural Networks with Mathematical Modelling

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University of Baltistan, Skardu
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Table of Contents

Machine Learning

- Machine learning is programming computers to optimize a performance of learning on data or past experience. Machine learning can automatically detect patterns in data, and then to use the uncovered patterns to predict future.
- In the second half of the 20th century, machine learning evolved as a subfield of artificial intelligence (AI) involving self-learning algorithms that derive knowledge from data in order to make predictions.
- Machine learning is about extracting knowledge from data. It is a research field at the intersection of statistics, artificial intelligence, and computer science and is also known as predictive analytics or statistical learning.

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Human Learning Vs Machine Learning

- Instead of requiring humans to manually derive rules and build models from analyzing large amounts of data, machine learning offers a more efficient alternative for capturing the knowledge in data to gradually improve the performance of predictive models and make data-driven decisions.

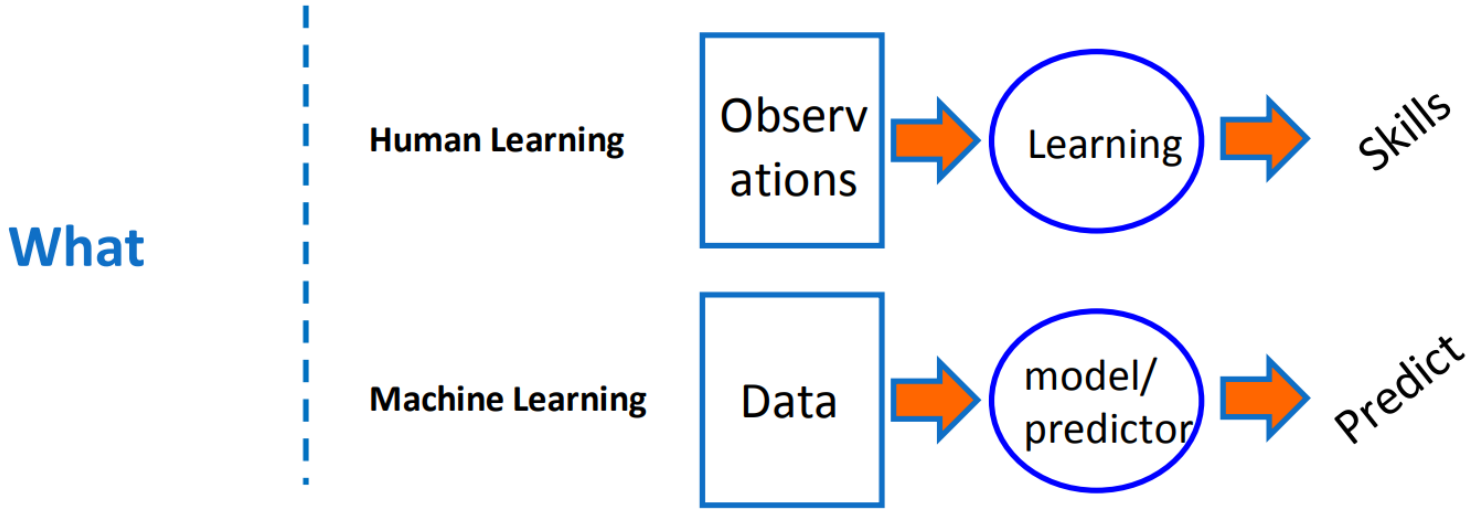

Fig "Take from start-tech"

- Let the data and its pattern example:

Multiplication	Result	Sum
2×1	$= 2$	$= 1 + 1$
2×2	$= 4$	$= 2 + 2$
2×3	$= 6$	$= 3 + 3$
2×4	$= 8$	$= 4 + 4$
2×5	$= 10$	$= 5 + 5$
2×6	$= 12$	$= 6 + 6$
2×7	$= 14$	$= 7 + 7$
2×8	$= 16$	$= 8 + 8$
2×9	$= 18$	$= 9 + 9$
$.. \times ..$	$= ..$	$= .. + ..$
$.. \times ..$	$= ..$	$= .. + ..$
$.. \times ..$	$= ..$	$= .. + ..$
$2 \times x$	$= Y$	$= x + x$

- Generalized the pattern of past information is:

$$2x = Y = x + x \tag{1}$$

- What is values of $x = 0.5$, 1.5, 2.5 and so on?

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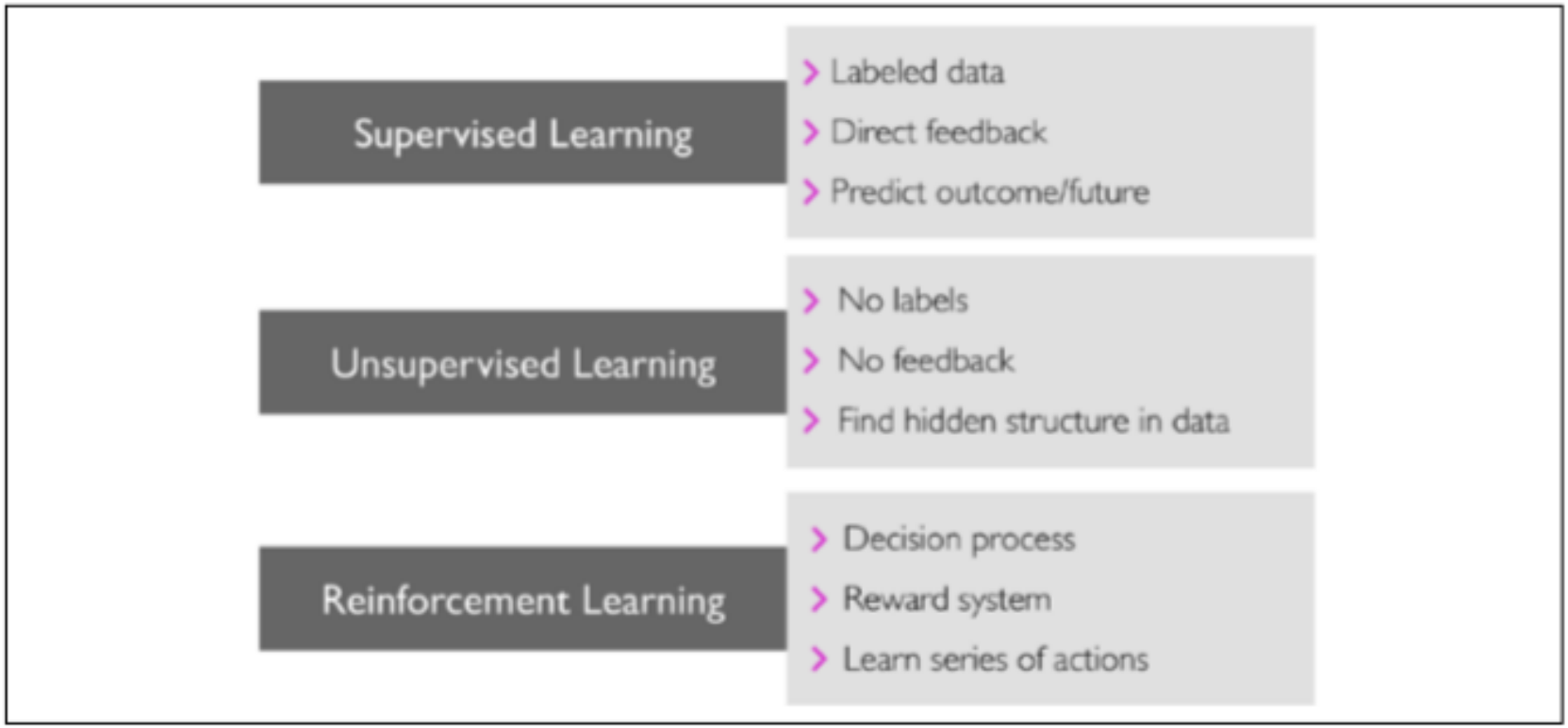
Types of Machine Learning

There are three common types of machine learning;



Supervised Learning Method

Definition

Supervised learning involves training a model on a labeled dataset, where each input data point is paired with an output label. The model learns to predict the output from the input data.

- Supervised learning is where you have input variables (x) and an output variable (Y) and you use an algorithm to learn the mapping function from the input to the output.
- The goal is to approximate the mapping function so well that when you have new input data (x) that you can predict the output variables (Y) for that data.
- It can be further categorized into:
- **Classification:** Predicting categorical target variables, such as classifying emails as spam or not spam.
- **Regression:** Predicting continuous target variables, such as forecasting product sales or predicting house prices.

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Supervised Learning: Example

- Categorical target labels

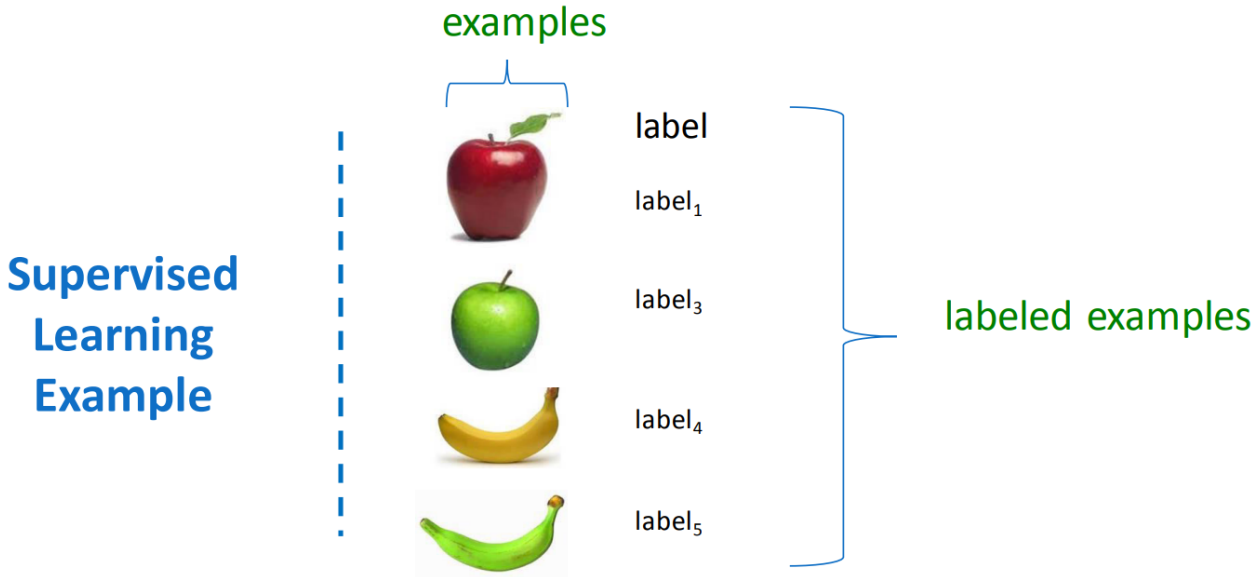
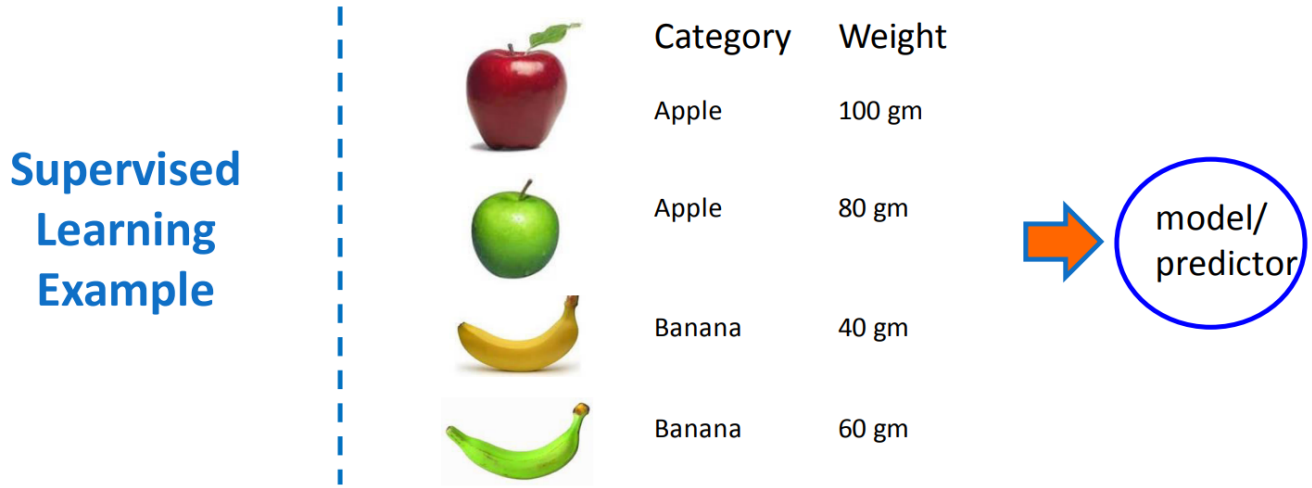


Figure: An example for label understanding using visual of fruits.

Supervised Learning: Example

- Categorical and numerical target labels



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Supervised Learning: Classification

- Algorithm's result will be Categorical target labels

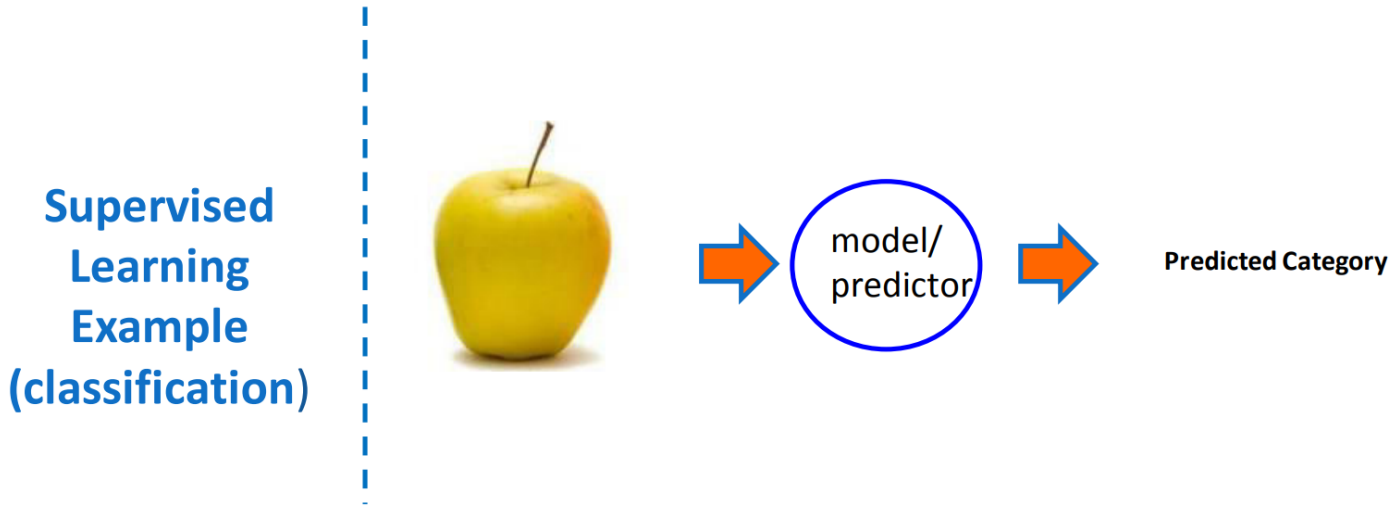

Figure: An example of classification algorithms.

Supervised Learning: Regression

- Algorithm's result will be numerical target labels

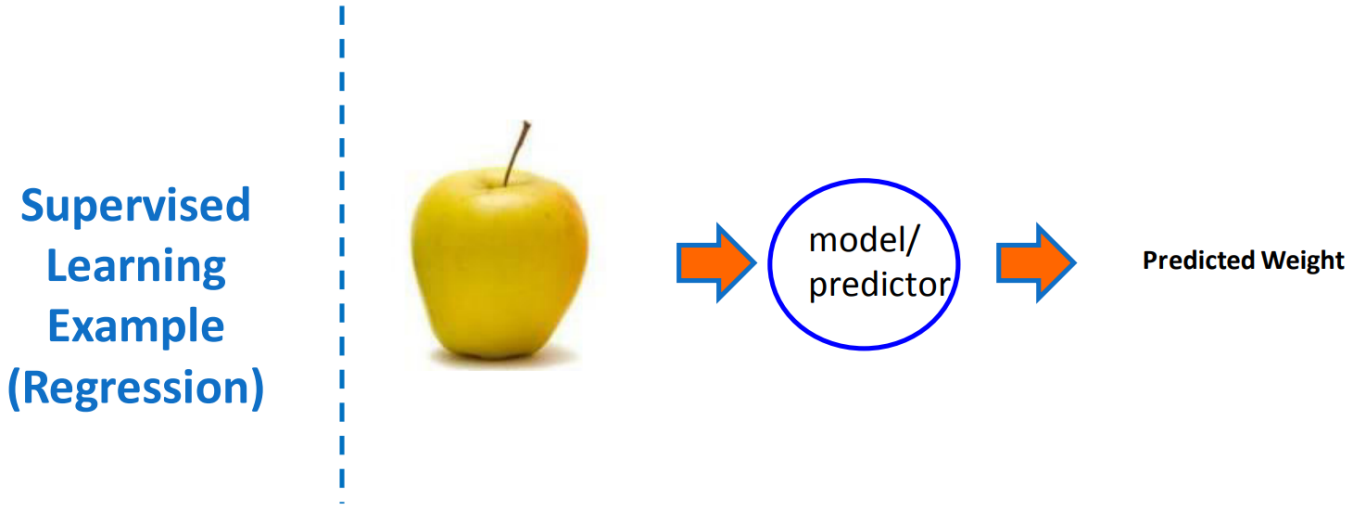

Figure: An example of regression algorithm.

Unsupervised Learning

Definition

Unsupervised learning uses datasets without labeled outcomes. The model learns the inherent structure from the input data alone, identifying patterns such as clusters or data distributions.

- The unsupervised algorithms are includes:
- Clustering: Grouping similar data points together.
- Dimensionality Reduction: Reducing the number of variables under consideration by obtaining a set of principal variables.
- The goal for unsupervised learning is to model the underlying structure or distribution in the data in order to learn more about the data.

Note

Unsupervised learning is where you only have input data (x) and no corresponding output variables.

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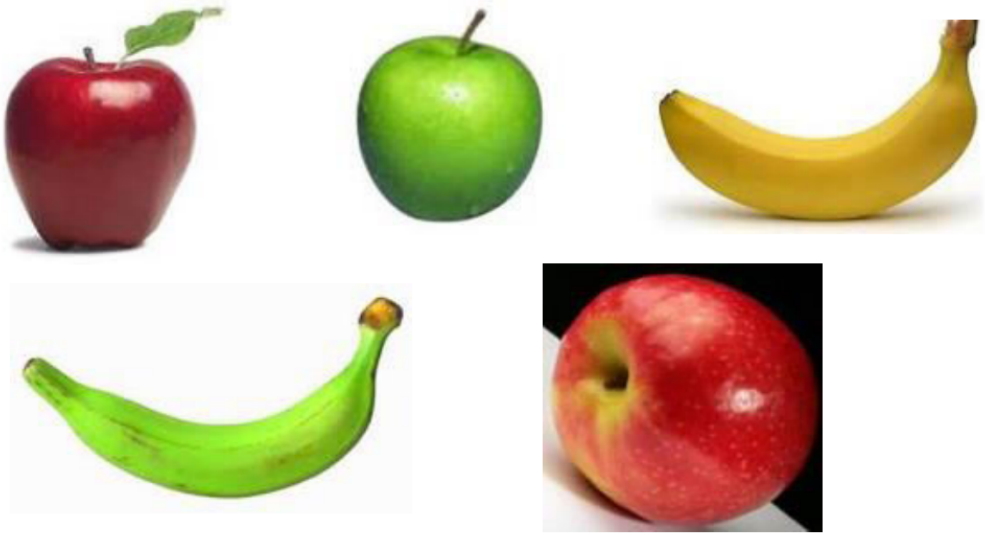
Unsupervised Learning: Example

- No target labels

Unsupervised Learning Example



Unupervised learning: given data, i.e. examples, but no labels

Figure: An example for no label understanding using visual of fruits.

Reinforcement Learning

Definition

Reinforcement learning is based on an agent taking actions in an environment to maximize a reward. The agent learns by trial-and-error interactions with the dynamic environment

- Each algorithm has specific characteristics and applications, contributing to the advancement of reinforcement learning in various fields like robotics, gaming, and industrial automation.

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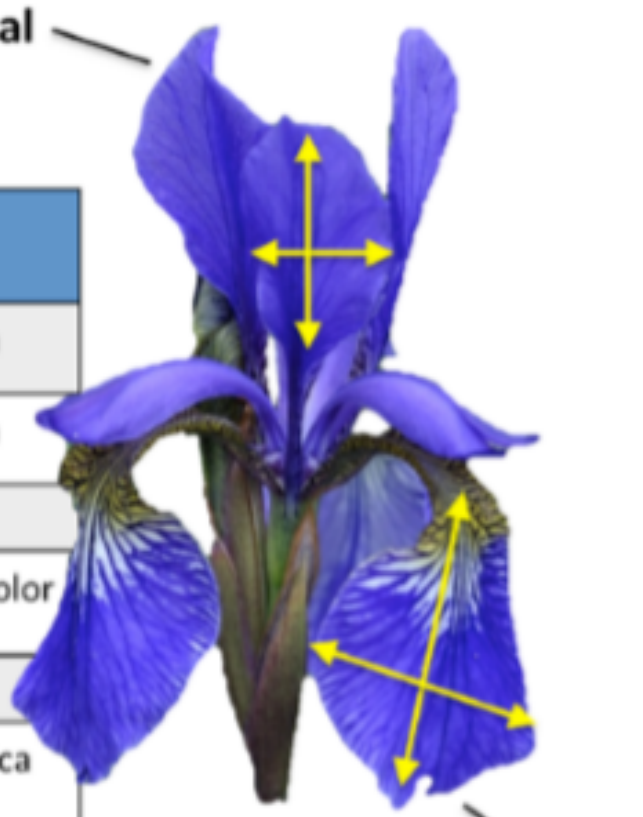
Basic Terminology and Notations

We will be using when referring to different aspects of a dataset, as well as the mathematical notation to communicate more precisely and efficiently. The following table depicts an excerpt of the Iris dataset, which is a classic example in the field of machine learning. The Iris dataset contains the measurements of 150 Iris flowers from three different species—Setosa, Versicolor, and Virginica. Here, each flower example represents one row in our dataset, and the flower measurements in centimeters are stored as columns, which we also call the features of the dataset: To keep the notation and implementation simple yet efficient, we will make use of some of the basics of linear algebra. we will use a matrix and vector notation to refer to our data. We will follow the common convention to represent each example as a separate row in a feature matrix, X, where each feature is stored as a separate column.

Basic Terminology and Notations

Samples
(instances, observations)

	Sepal length	Sepal width	Petal length	Petal width	Class label
1	5.1	3.5	1.4	0.2	Setosa
2	4.9	3.0	1.4	0.2	Setosa
...					
50	6.4	3.5	4.5	1.2	Versicolor
...					
150	5.9	3.0	5.0	1.8	Virginica



Features
(attributes, measurements, dimensions)

Class labels
(targets)

Basic Terminology and Notations

The Iris dataset, consisting of 150 examples and four features, can then be written as a 150×4 matrix, $\boldsymbol{X} \in \mathbb{R}^{150 \times 4}$:

$$\begin{bmatrix} x_1^{(1)} & x_2^{(1)} & x_3^{(1)} & x_4^{(1)} \\ x_1^{(2)} & x_2^{(2)} & x_3^{(2)} & x_4^{(2)} \\ \vdots & \vdots & \vdots & \vdots \\ x_1^{(150)} & x_2^{(150)} & x_3^{(150)} & x_4^{(150)} \end{bmatrix}$$

- Subscript, show that the features, column vectors, independent variables and denote as x_i.
- Superscript, show that the observation, row vectors, data points and denote as x^i.
- It can be written as a matrix notation like $x \in \mathbb{R}^{x^i \times x_i}$

Summary

Summerization of these lecture

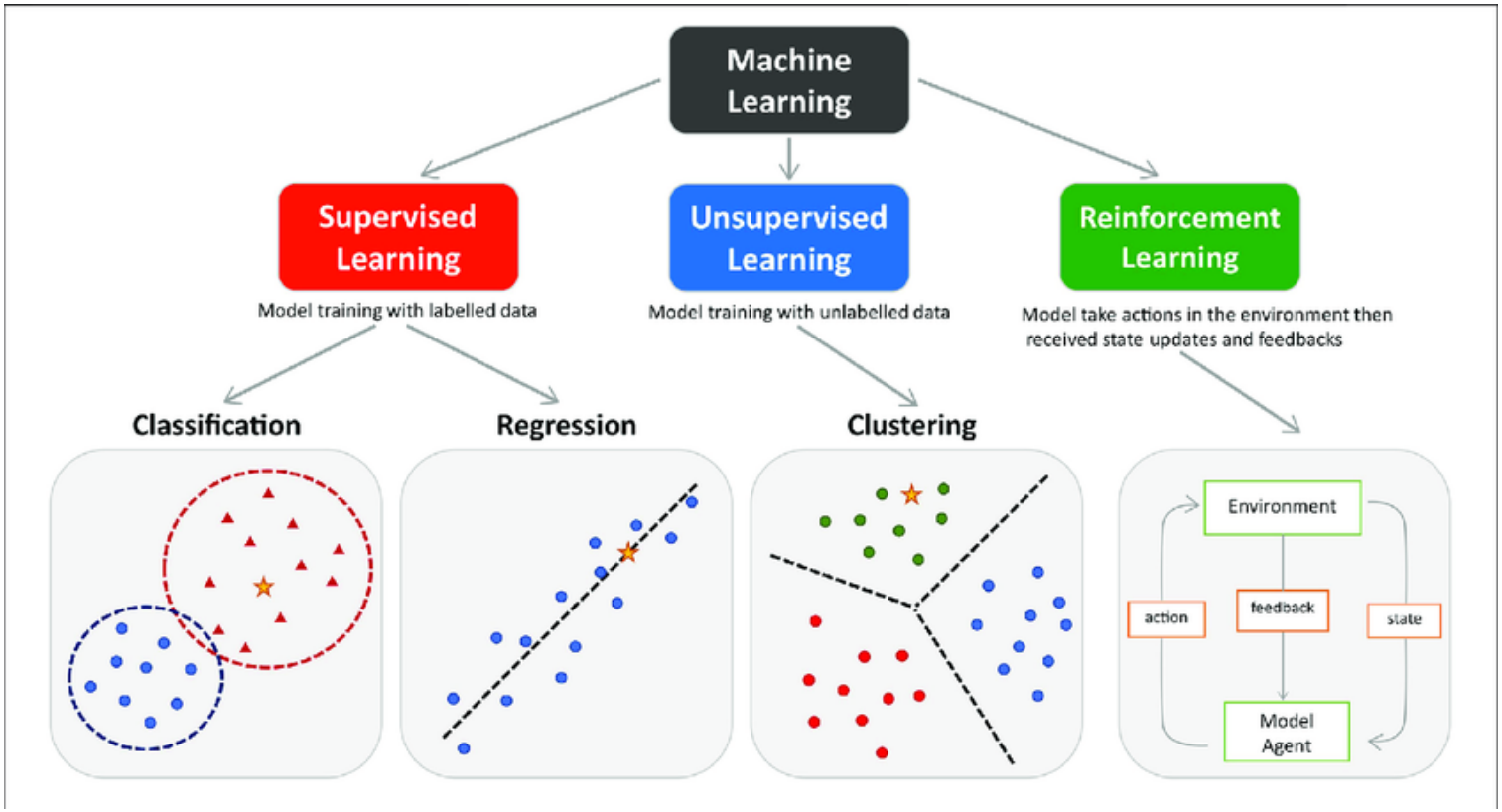


Figure: Visual Summary.

Questions and Answers

Search for Resource of Workshop