U.PORTO

FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

# Robotics

# Introduction to Machine Learning


## Luís Paulo Reis

lpreis@fe.up.pt

**Director of LIACC – Artificial Intelligence and Computer Science Lab.**
**Associate Professor at DEI/FEUP – Informatics Engineering Department,**
**Faculty of Engineering of the University of Porto, Portugal**
**President of APPIA – Portuguese Association for Artificial Intelligence**

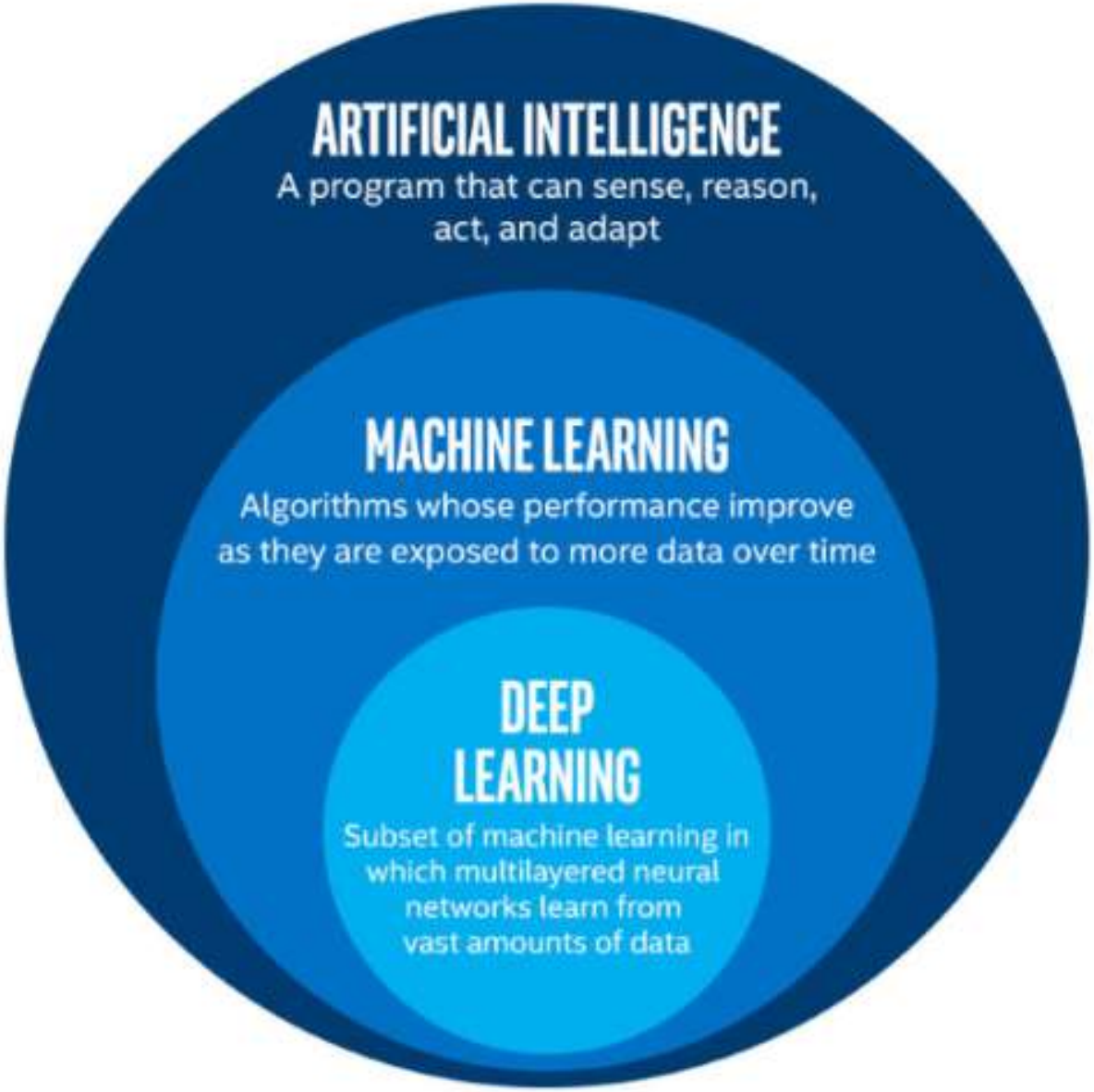

# Artificial Intelligence: Machine Learning

# Machine Learning

"Machine learning enables a machine to automatically learn from data, improve performance from experiences, and predict things without being explicitly programmed."

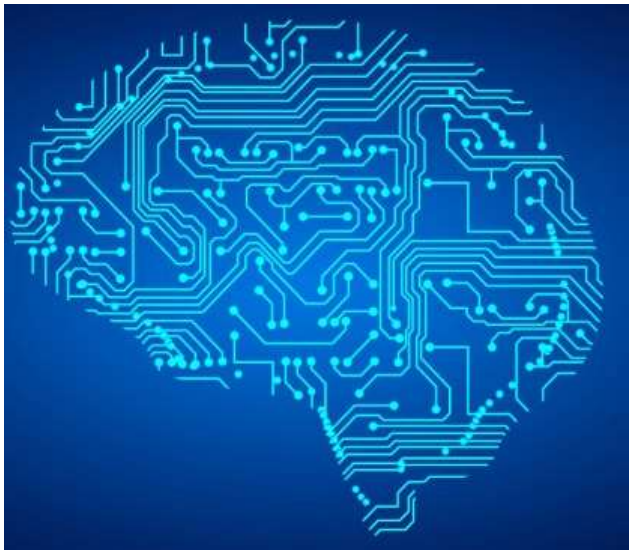
Arthur Samuel, 1959

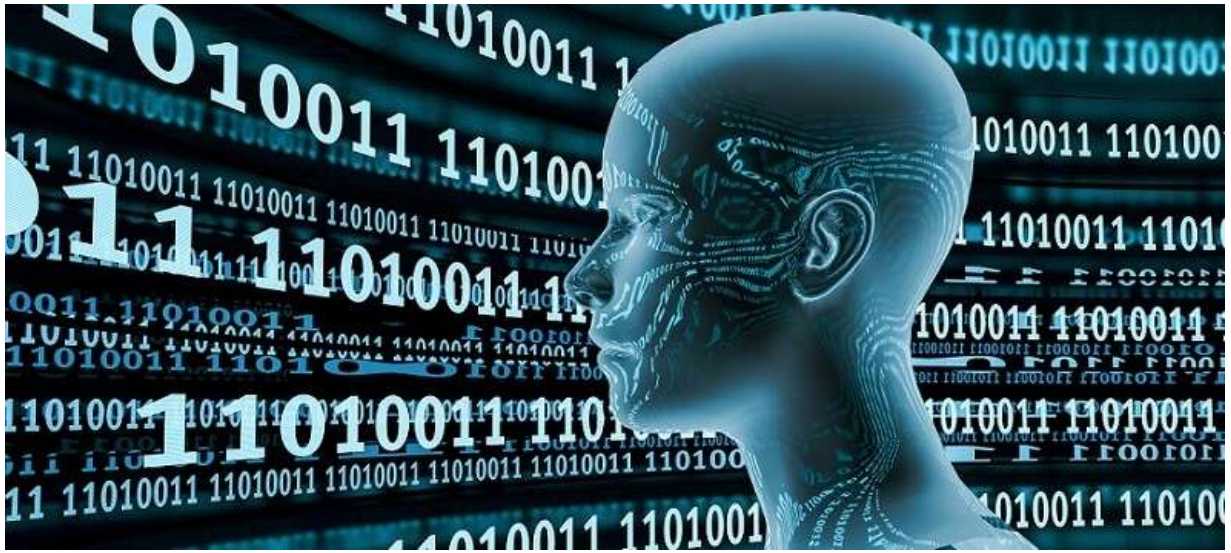
# Machine Learning vs. Artificial Intelligence



# Machine Learning

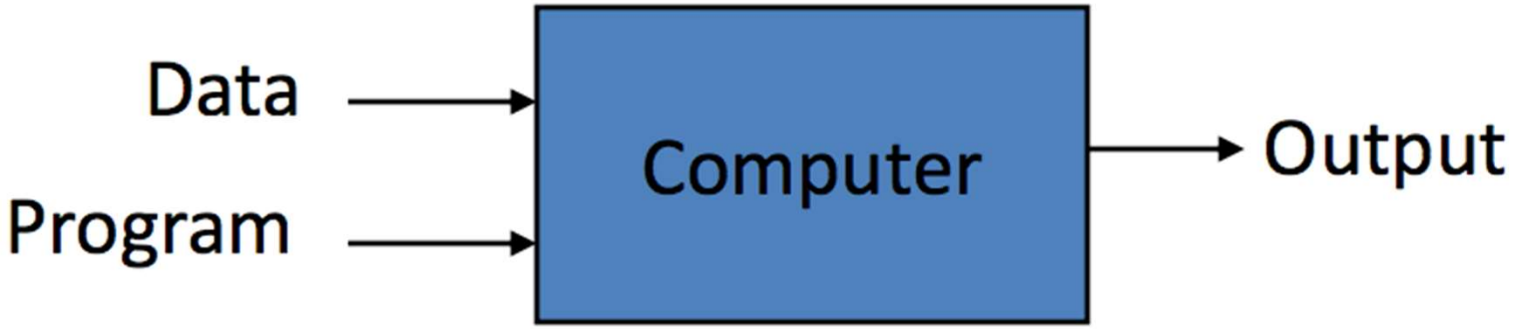
- Machine learning is a field of artificial intelligence that gives computer systems the **ability to "learn"** (e.g., progressively **improve performance** on a specific task) from data/results of their actions, without being explicitly programmed



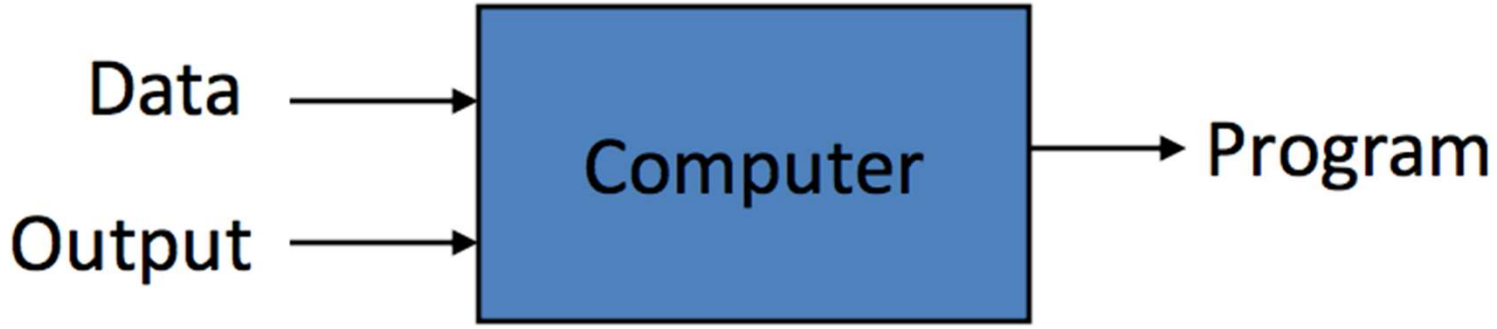


# Programming vs Machine Learning

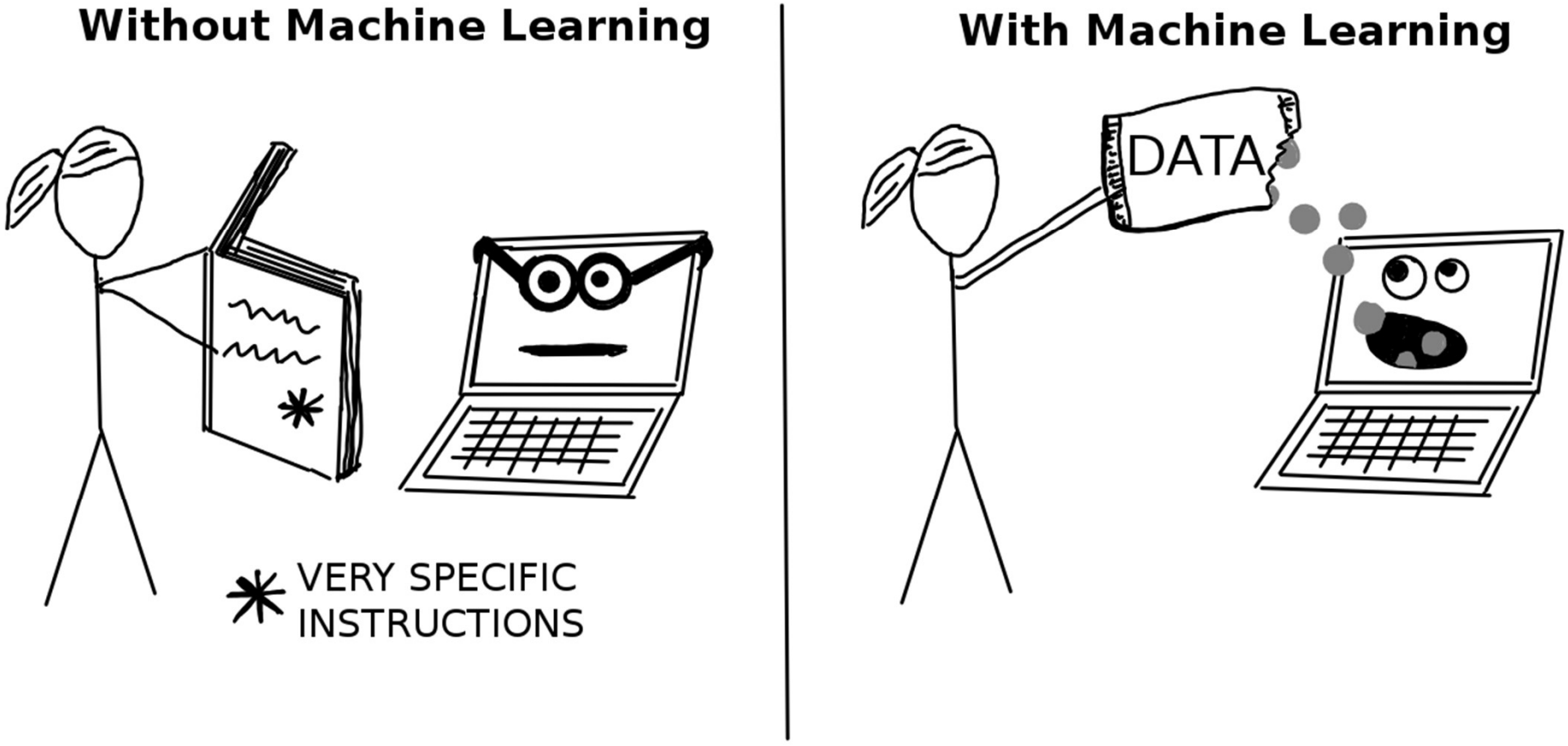
## Traditional Programming



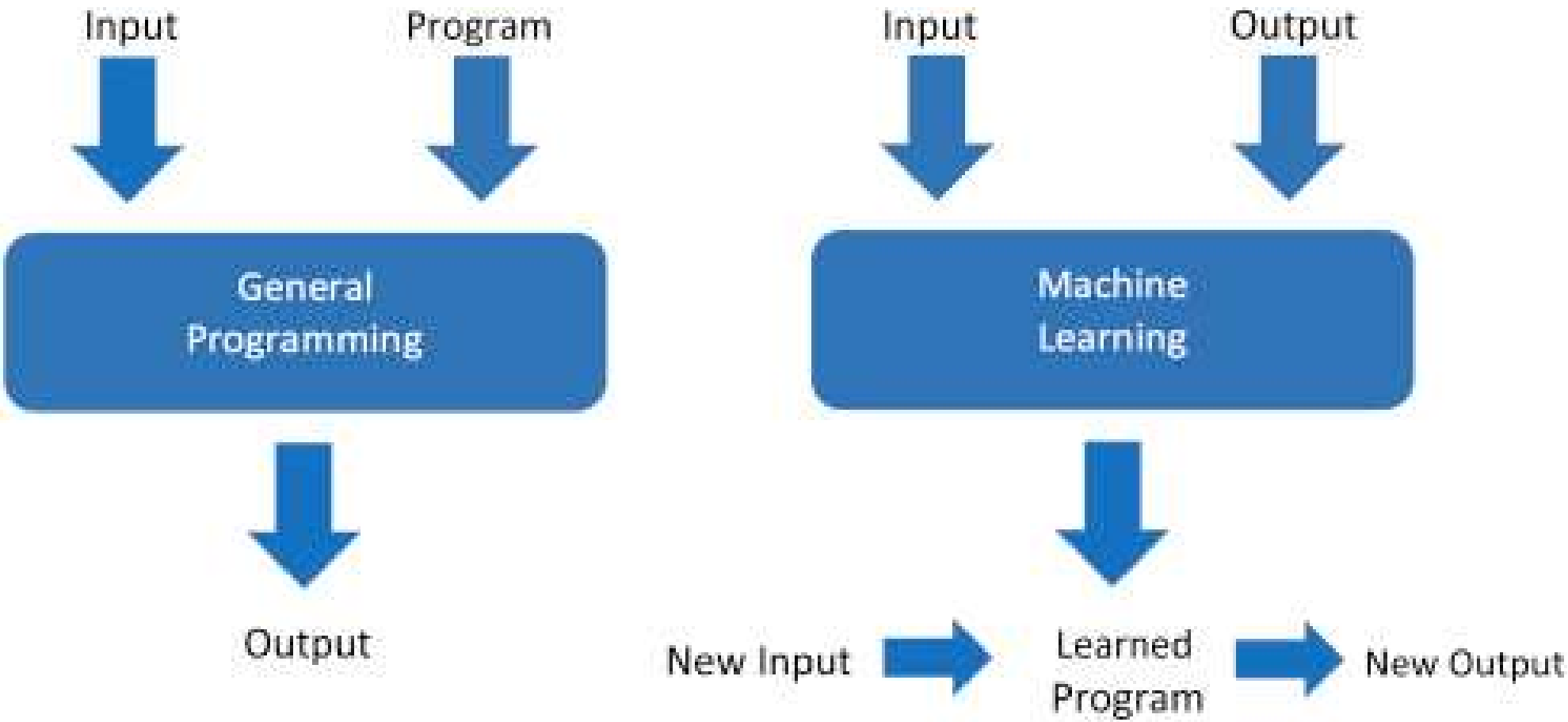

## Machine Learning



# Machine Learning

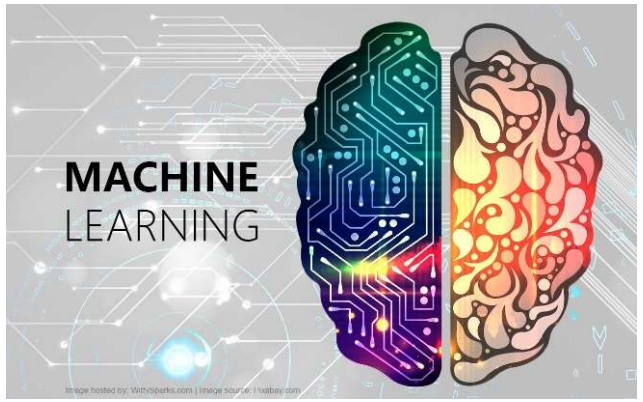


# Machine Learning

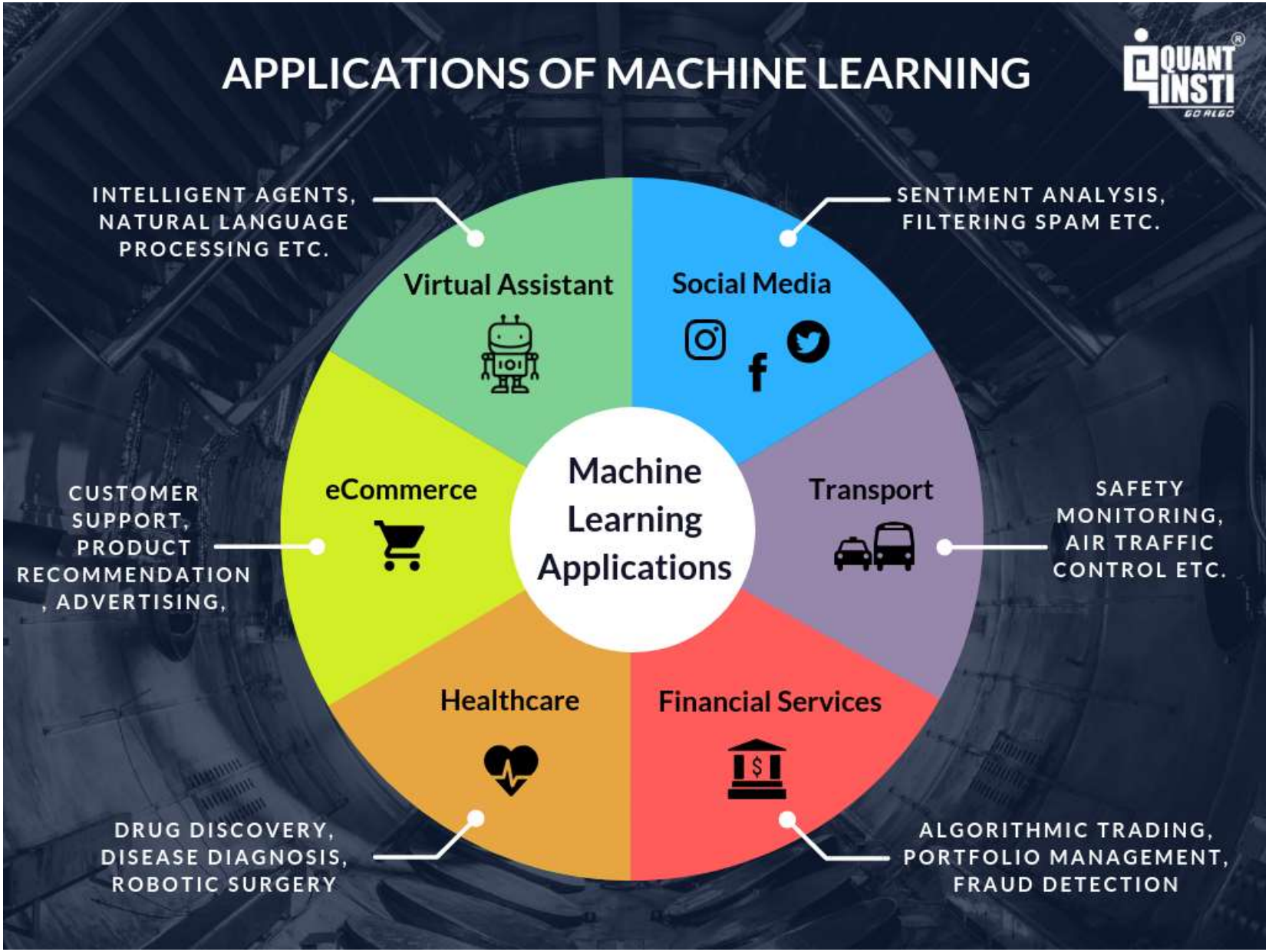


# Machine Learning

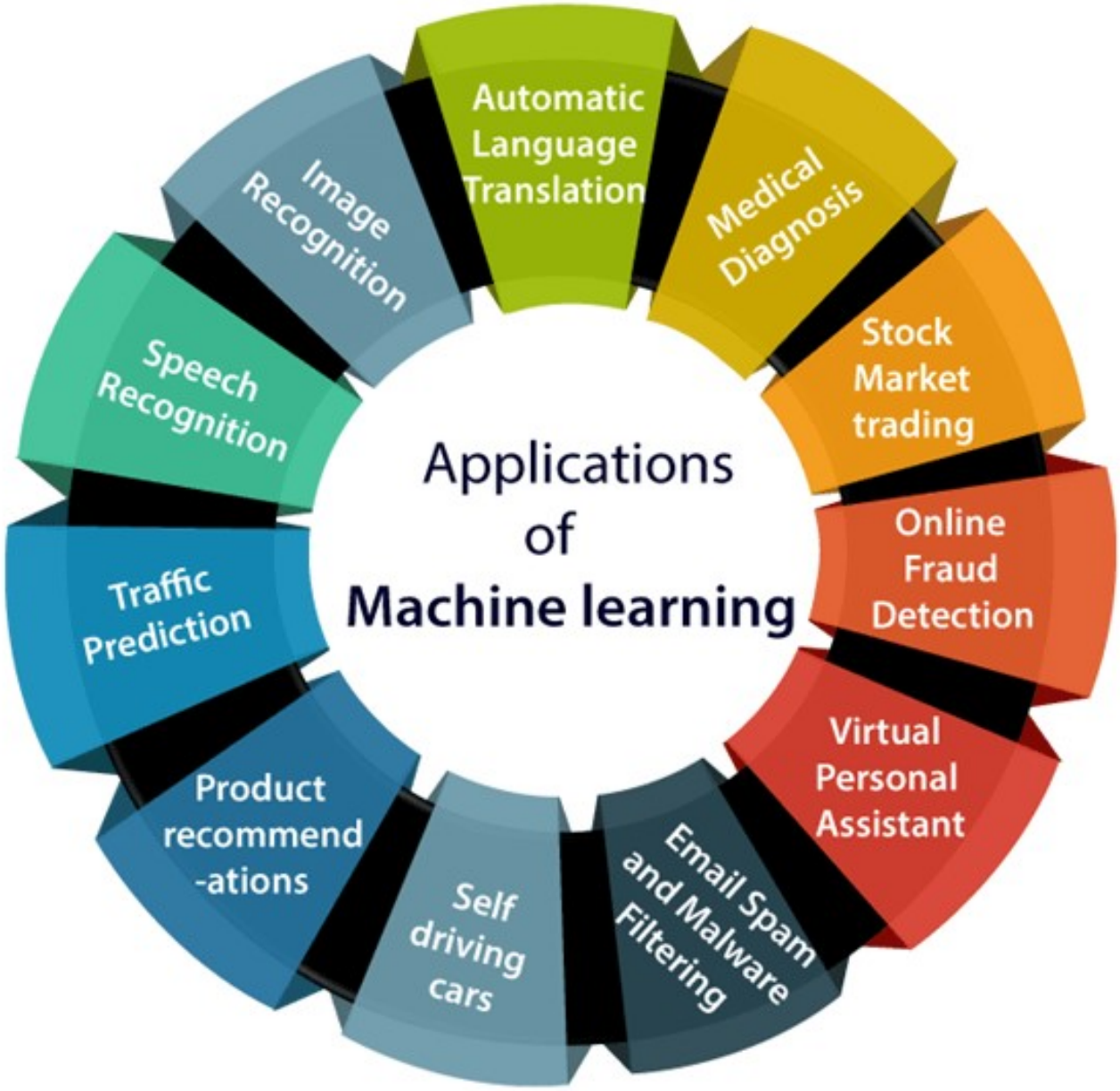
- Machine Learning
- Buzzword for the past few years
- Reason:
  - High amount of data production by applications
  - Increase of computation power in the past few years
  - Development of better algorithms



# Machine Learning - Applications



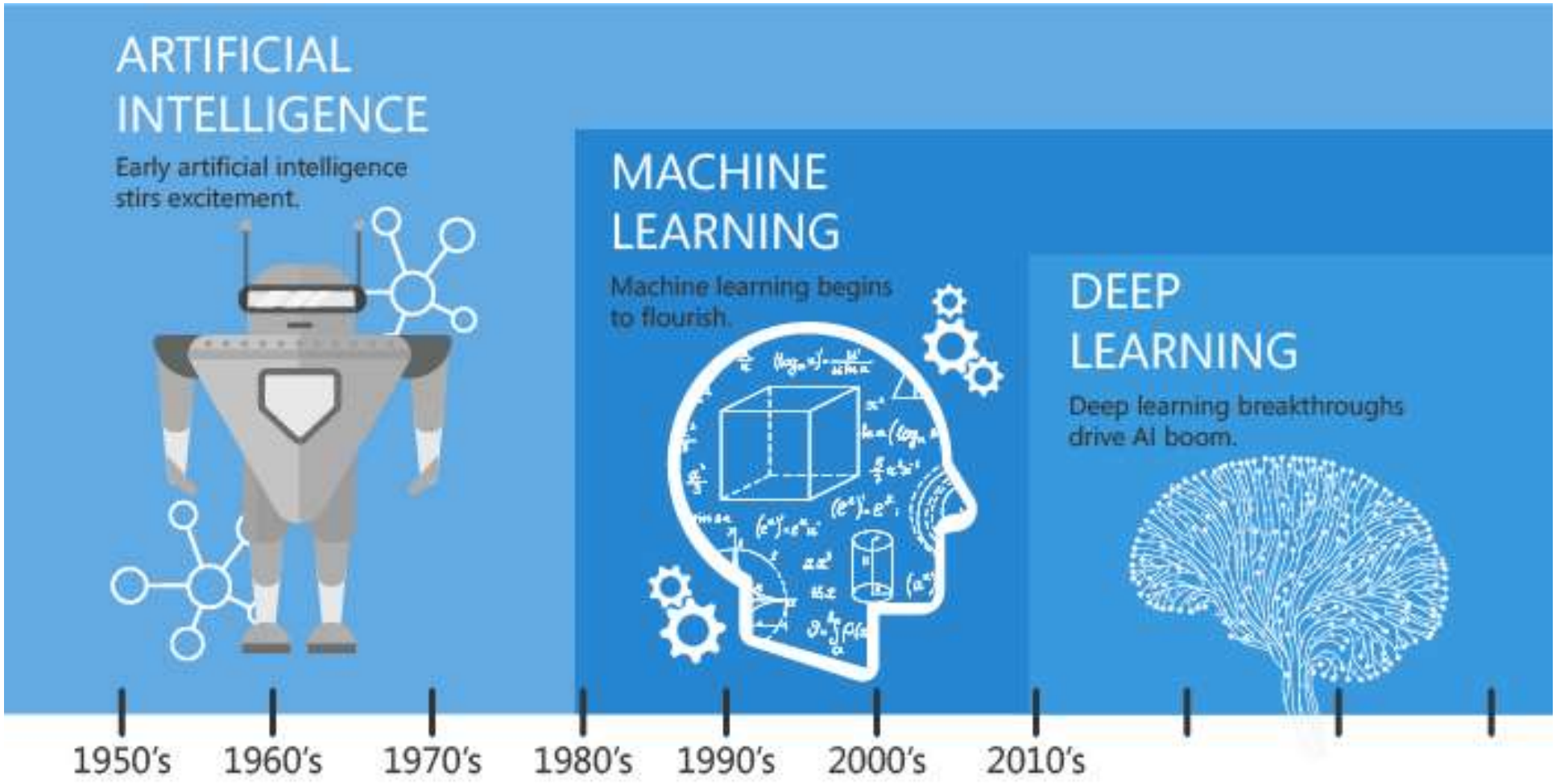
# Machine Learning - Applications



# Machine Learning - Applications

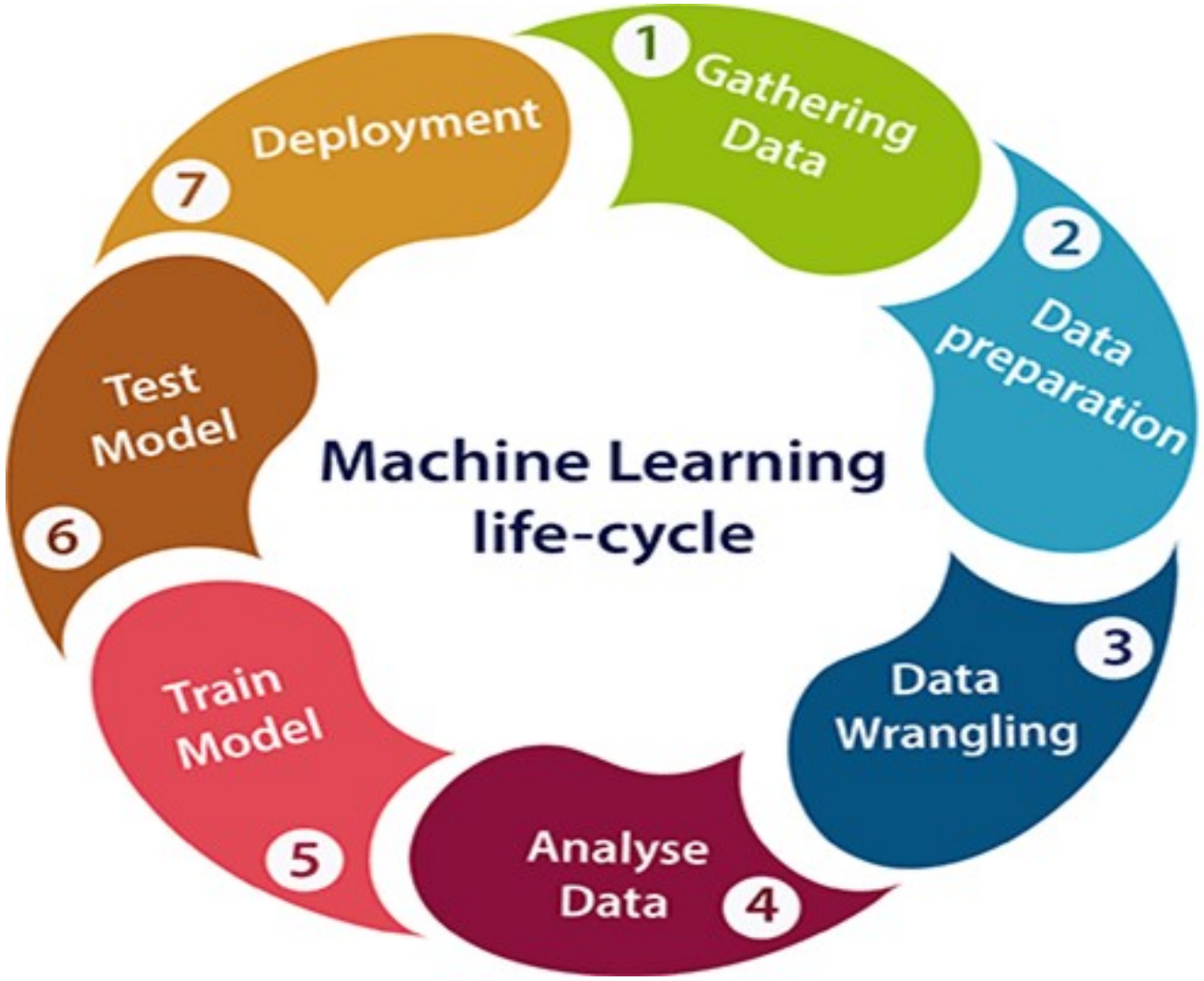
- From automating simple tasks to offering intelligent insights, industries in every sector benefit from it
- We all have devices that use it (wearable fitness tracker, intelligent home assistant, ...).
- Examples of ML in use:
  - **Prediction** — Machine learning can also be used in the prediction systems. Considering the loan example, to compute the probability of a fault, the system will need to classify the available data in groups.
  - **Image recognition** —Face detection in an image as well. There is a separate category for each person in a database of several people.
  - **Speech Recognition** — It is the translation of spoken words into the text. It is used in voice searches and more. Voice user interfaces include voice dialing, call routing, and appliance control. It can also be used a simple data entry and the preparation of structured documents.
  - **Medical diagnoses** — ML is trained to recognize cancerous tissues.
  - **Financial industry and trading** — companies use ML in fraud investigations and credit checks.

# Machine Learning - History

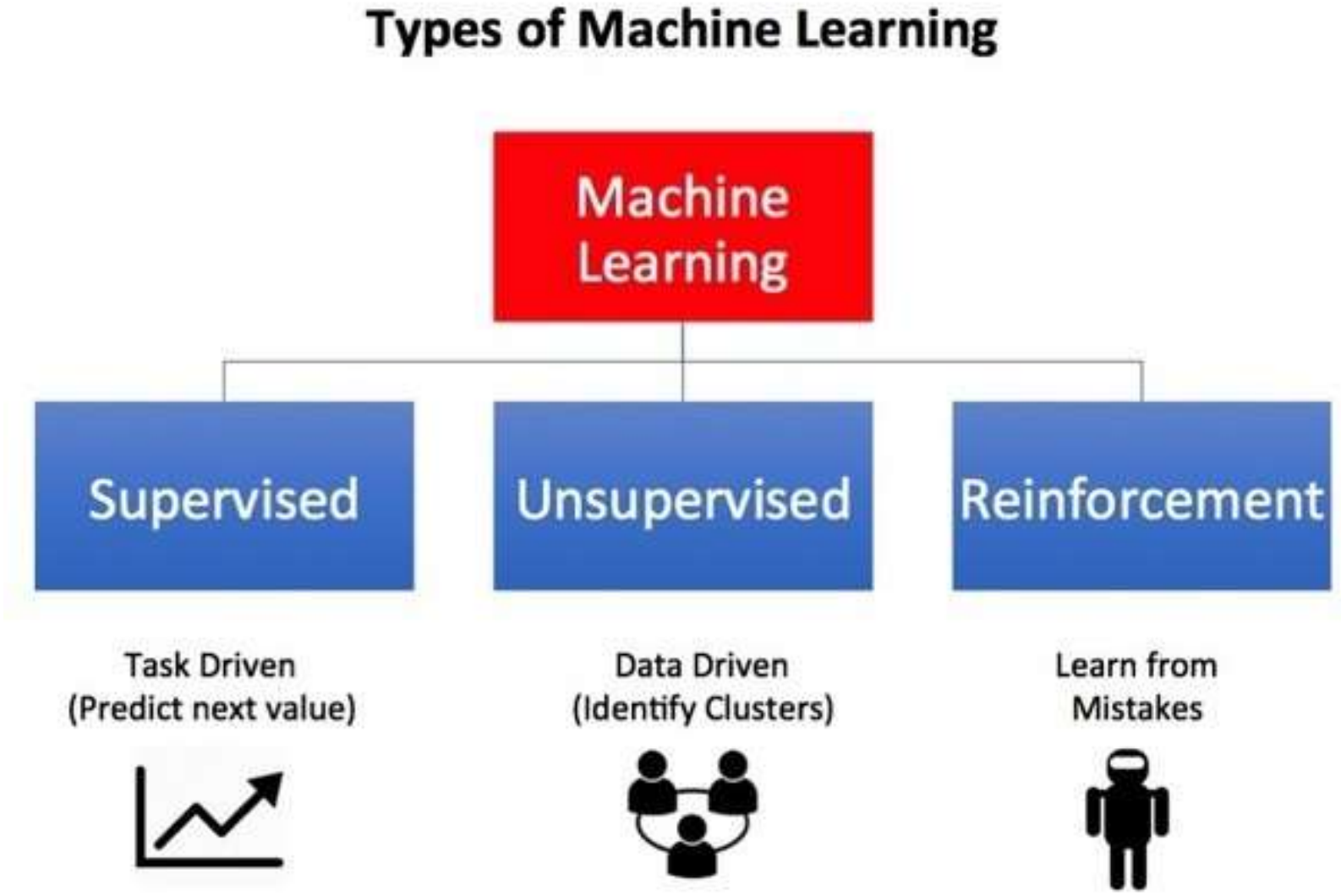



Since an early flush of optimism in the 1950's, smaller subsets of artificial intelligence - first machine learning, then deep learning, a subset of machine learning - have created ever larger disruptions.

# Machine Learning – Life Cycle

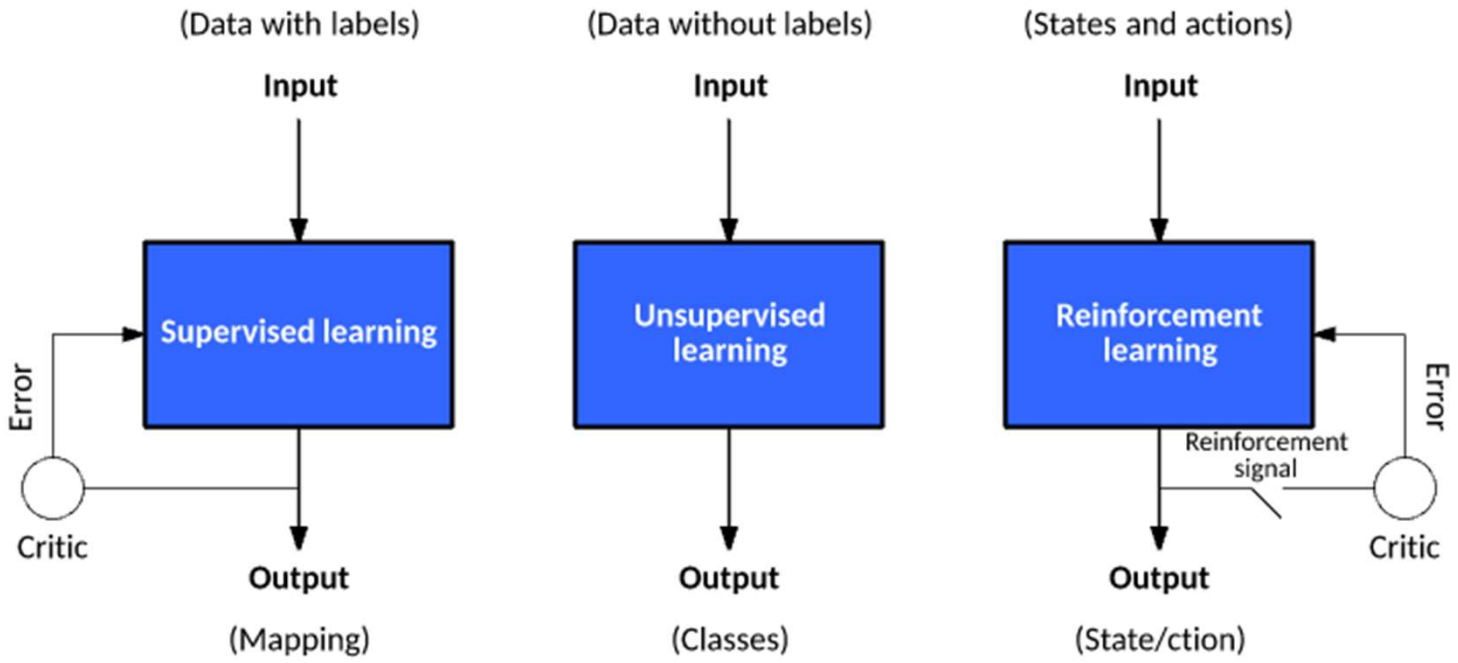


# Machine Learning - Types

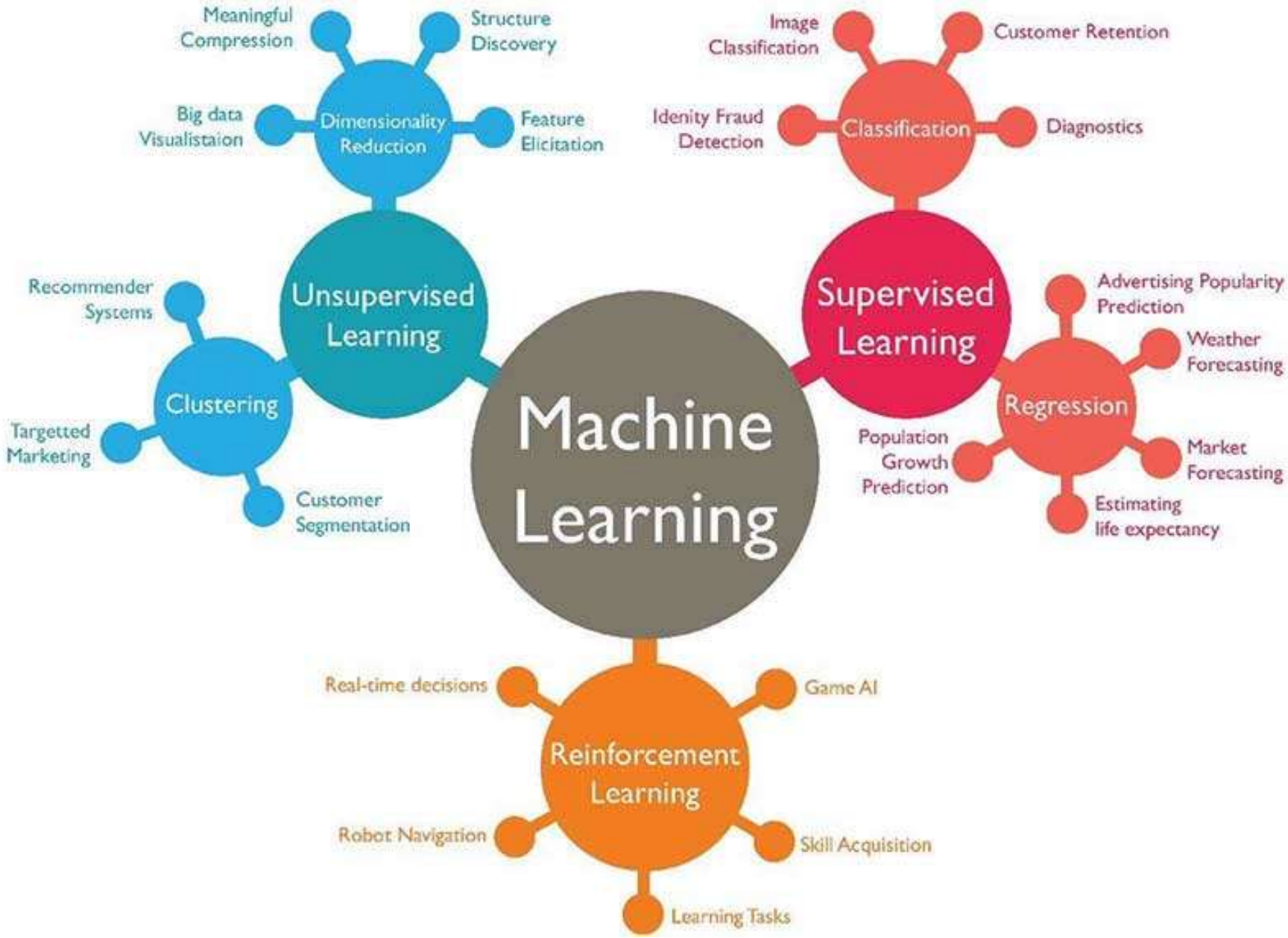


# Machine Learning - Types

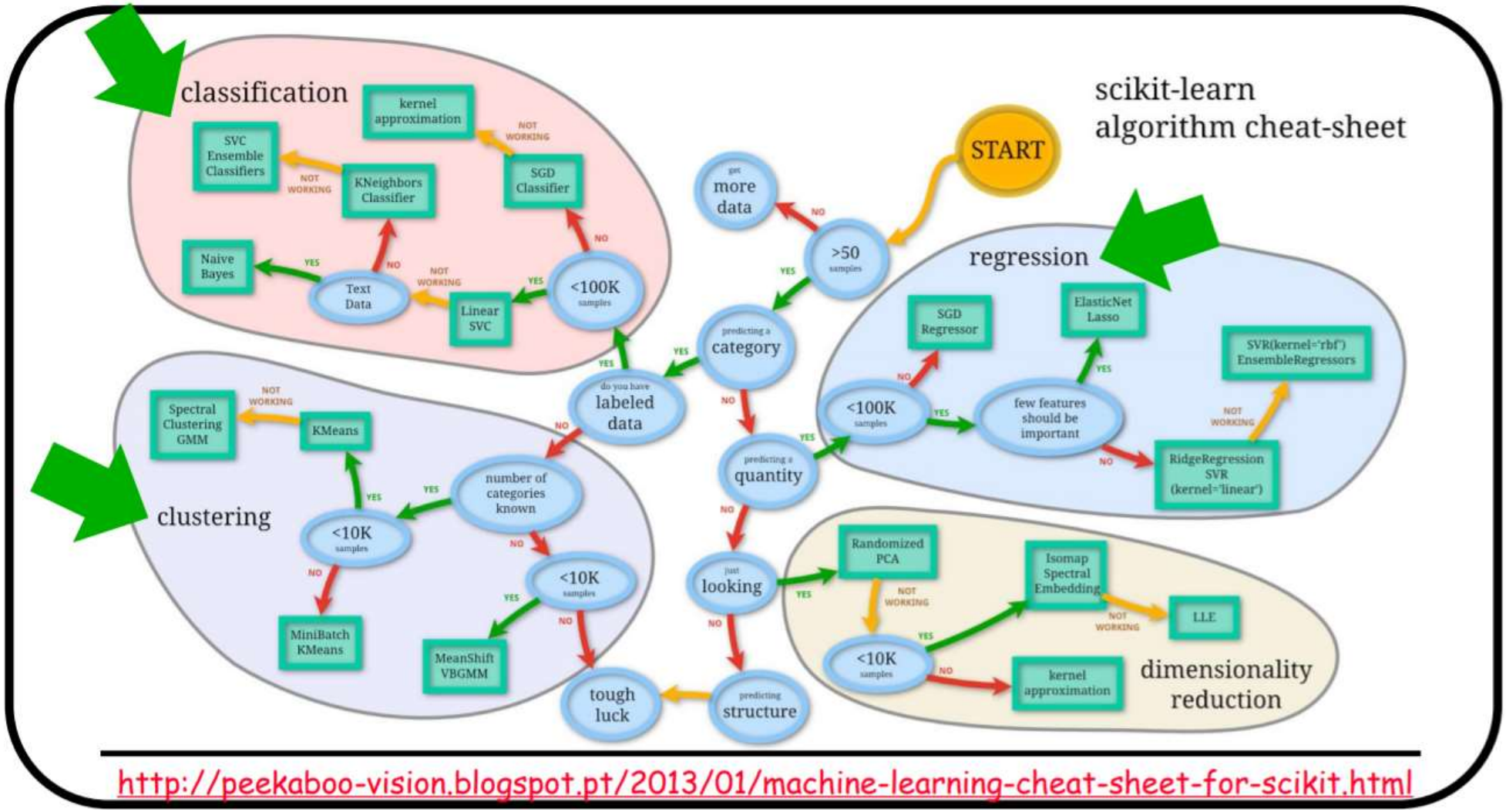
- **Supervised learning:** Example inputs and desired outputs are available/given by a "teacher", and the goal is to learn how to map inputs to outputs (possibility semi-supervised)
- **Unsupervised learning:** No labels/outputs are given to the learning algorithm, leaving it on its own to find structure in its input
- **Reinforcement learning:** Data (in form of rewards and punishments) are given only as feedback to the computer/agent actions in a dynamic environment



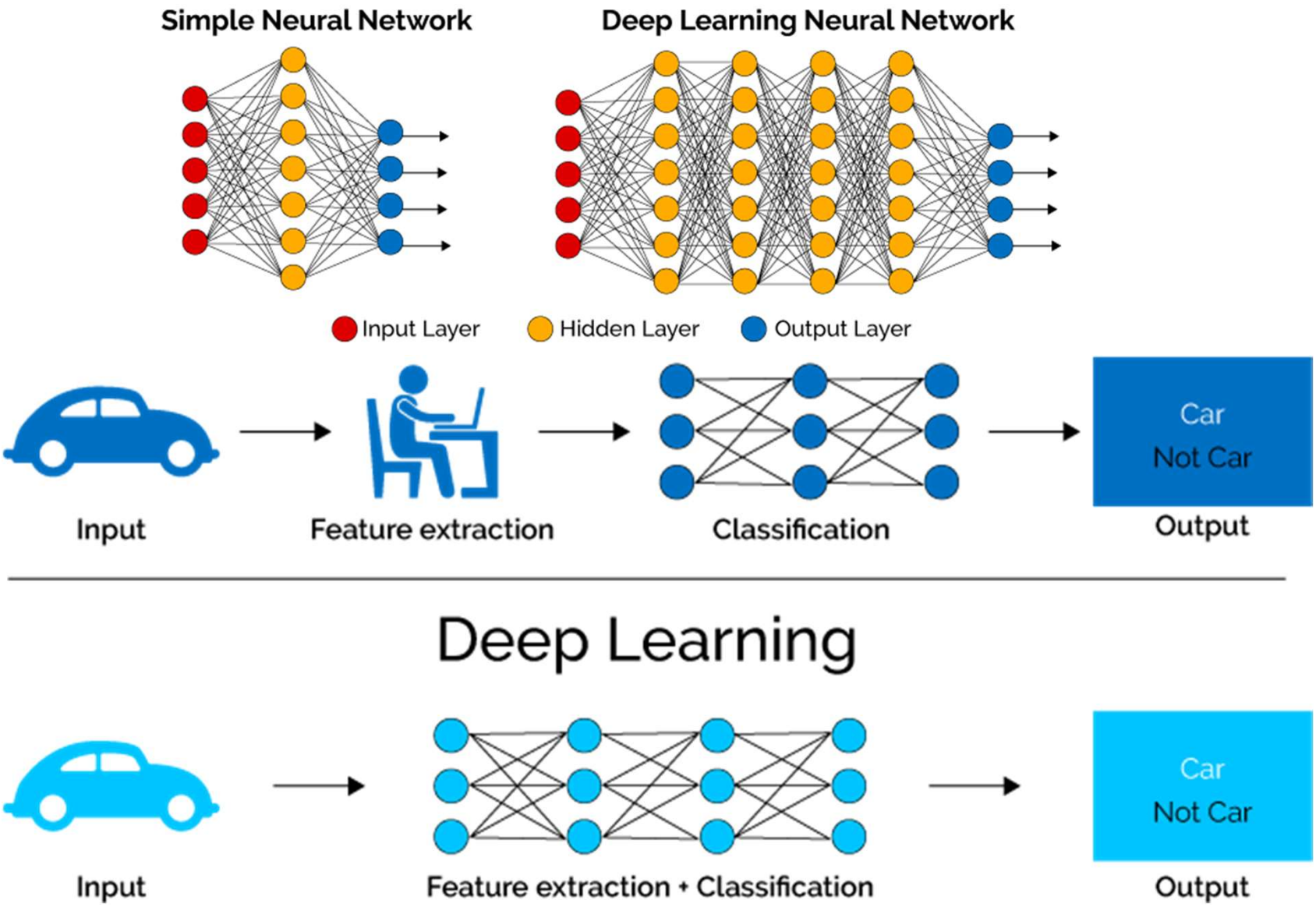
# Machine Learning



# Machine Learning

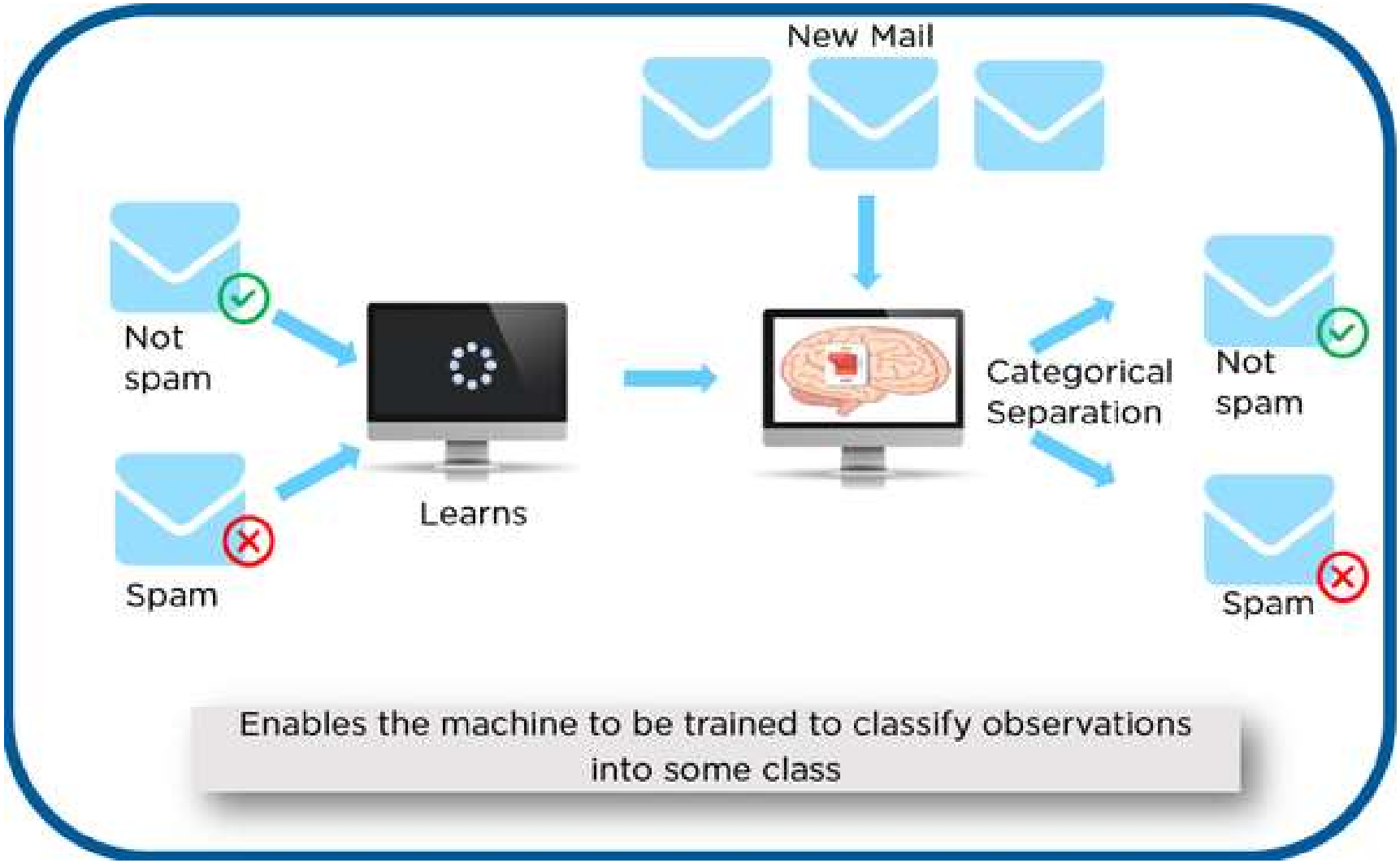


# Machine Learning - Deep Learning



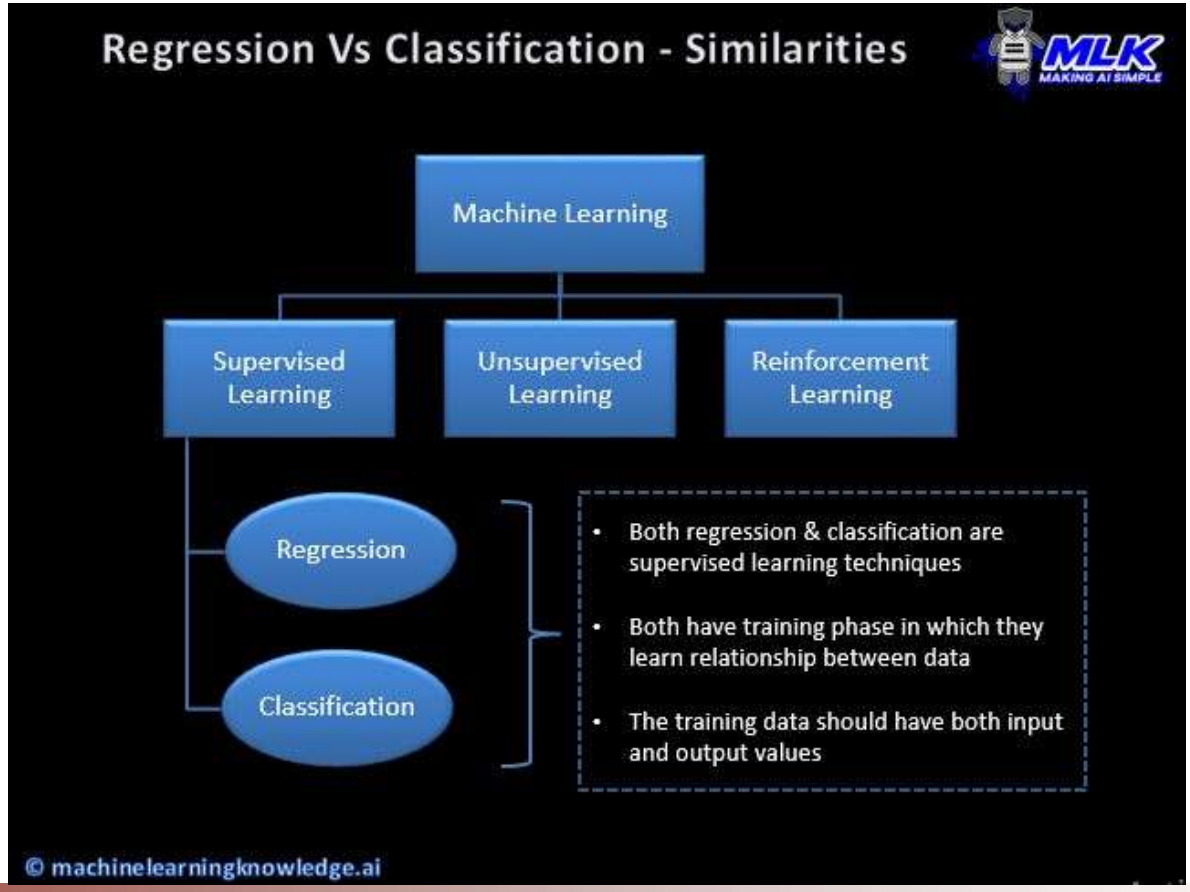

*https://www.xenonstack.com/blog/static/public/uploads/media/machine-learning-vs-deep-learning.png*

# Supervised Learning

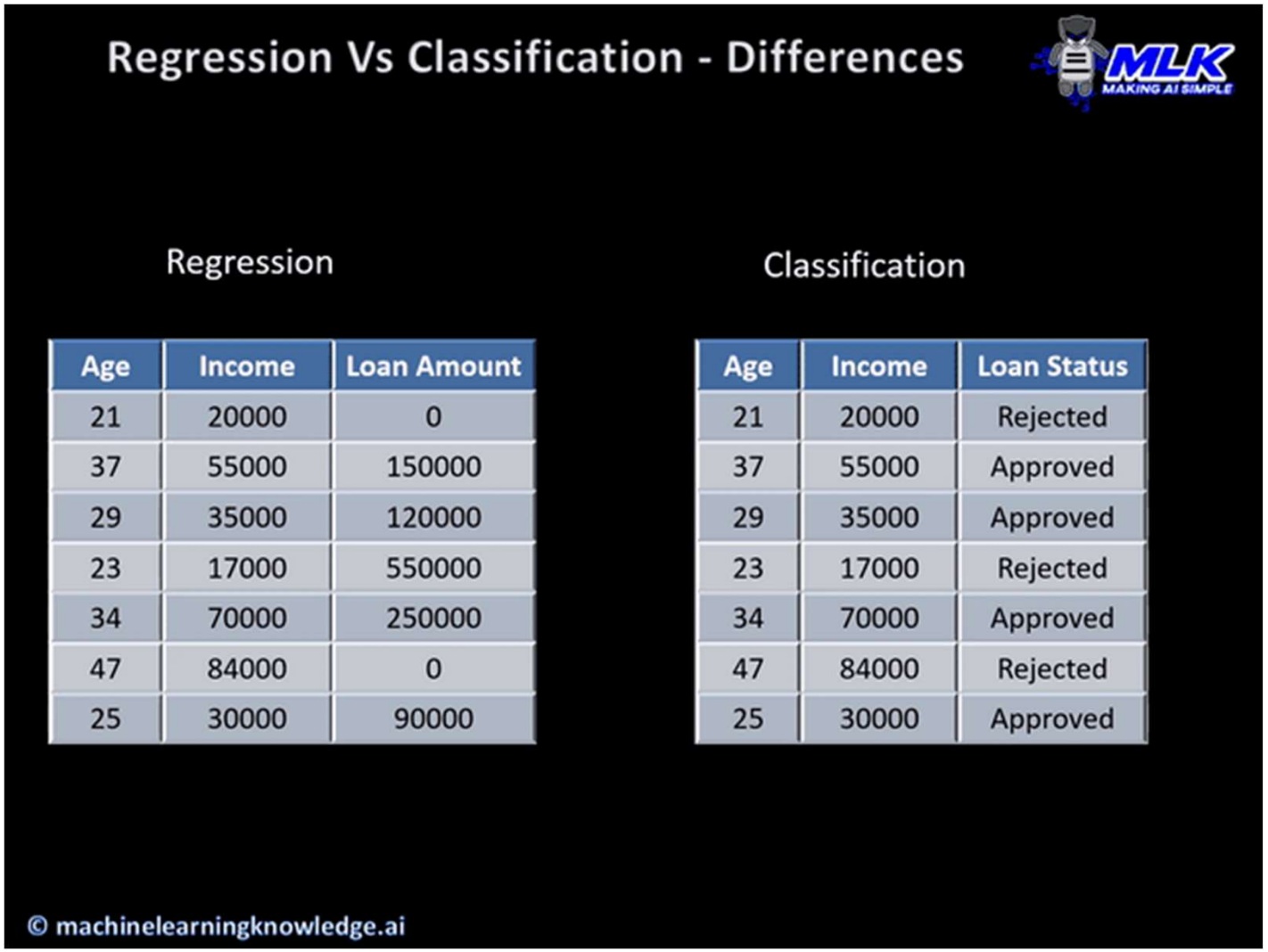


# Types of Supervised Learning

- **Types of Supervised learning**
  - **Classification**: A classification problem is when the output variable is a category, such as “red” / “blue” / “yellow” or “disease” / “no disease”.
  - **Regression**: A regression problem is when the output variable is a real value, such as “distance”, “euros” or “weight”.

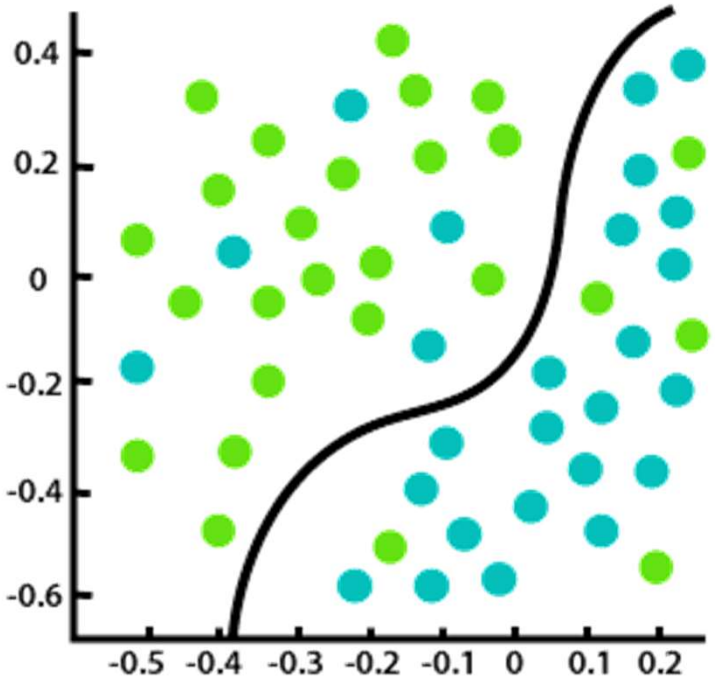


# Types of Supervised Learning

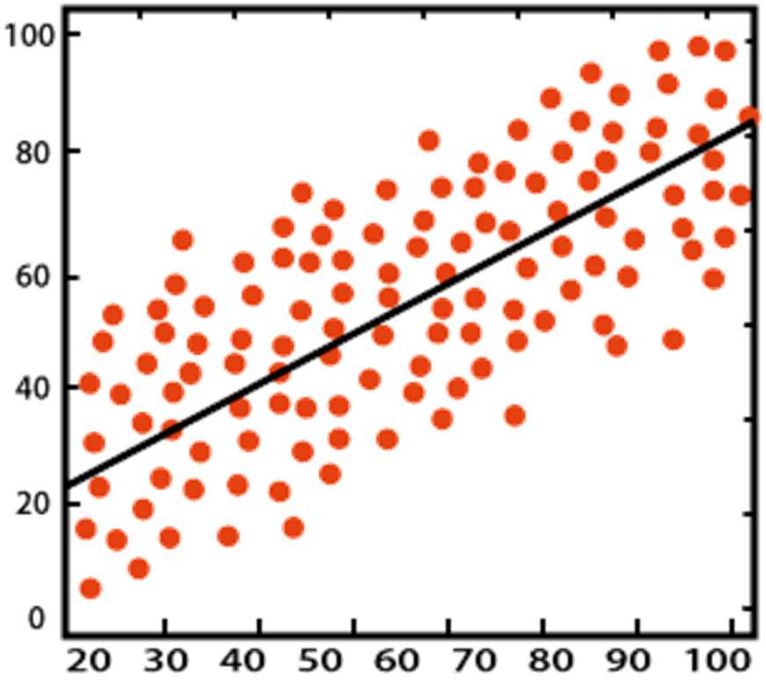


# Classification vs. Regression in ML

Regression algorithms are used to **predict the continuous** values such as price, salary, age, etc. while Classification algorithms are used to **predict/Classify the discrete values** such as Male / Female, True / False, Spam / Not Spam, etc.

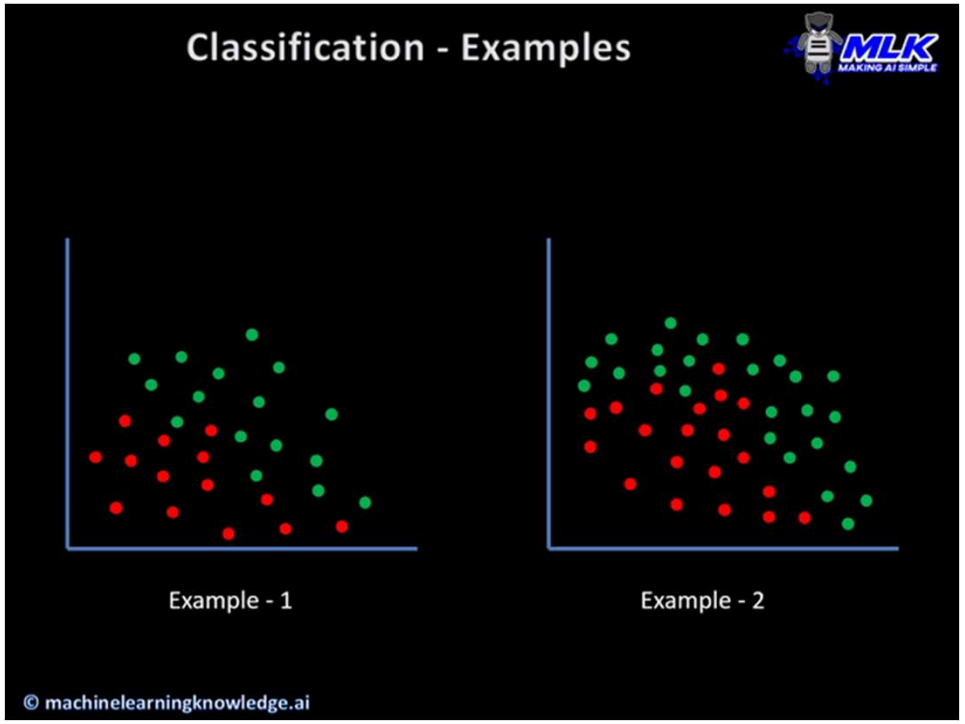


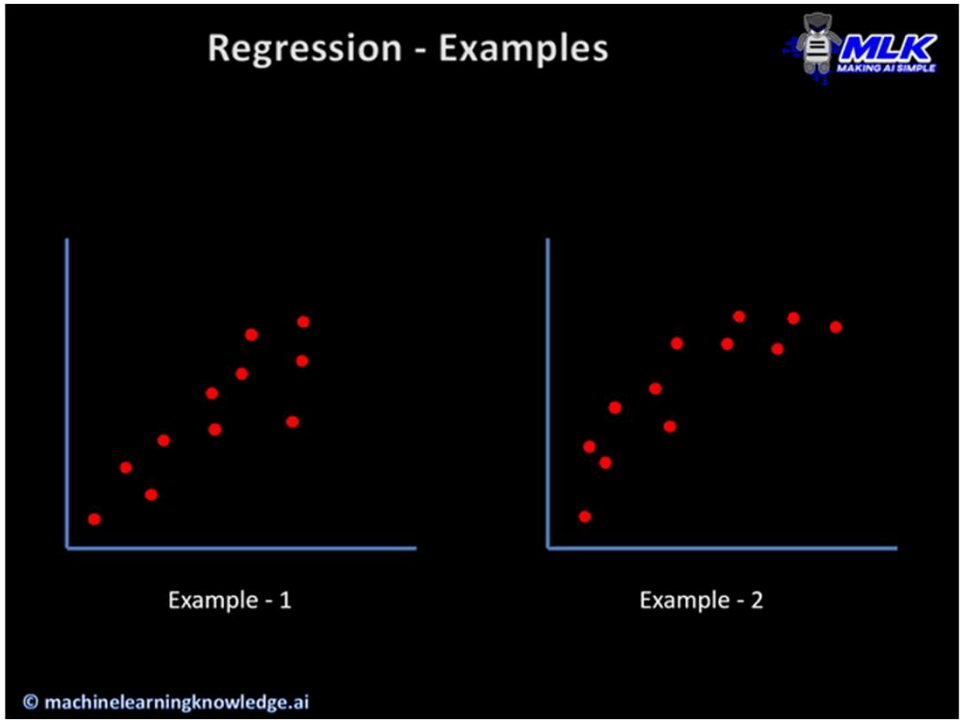

Classification




Regression

# Classification vs. Regression in ML

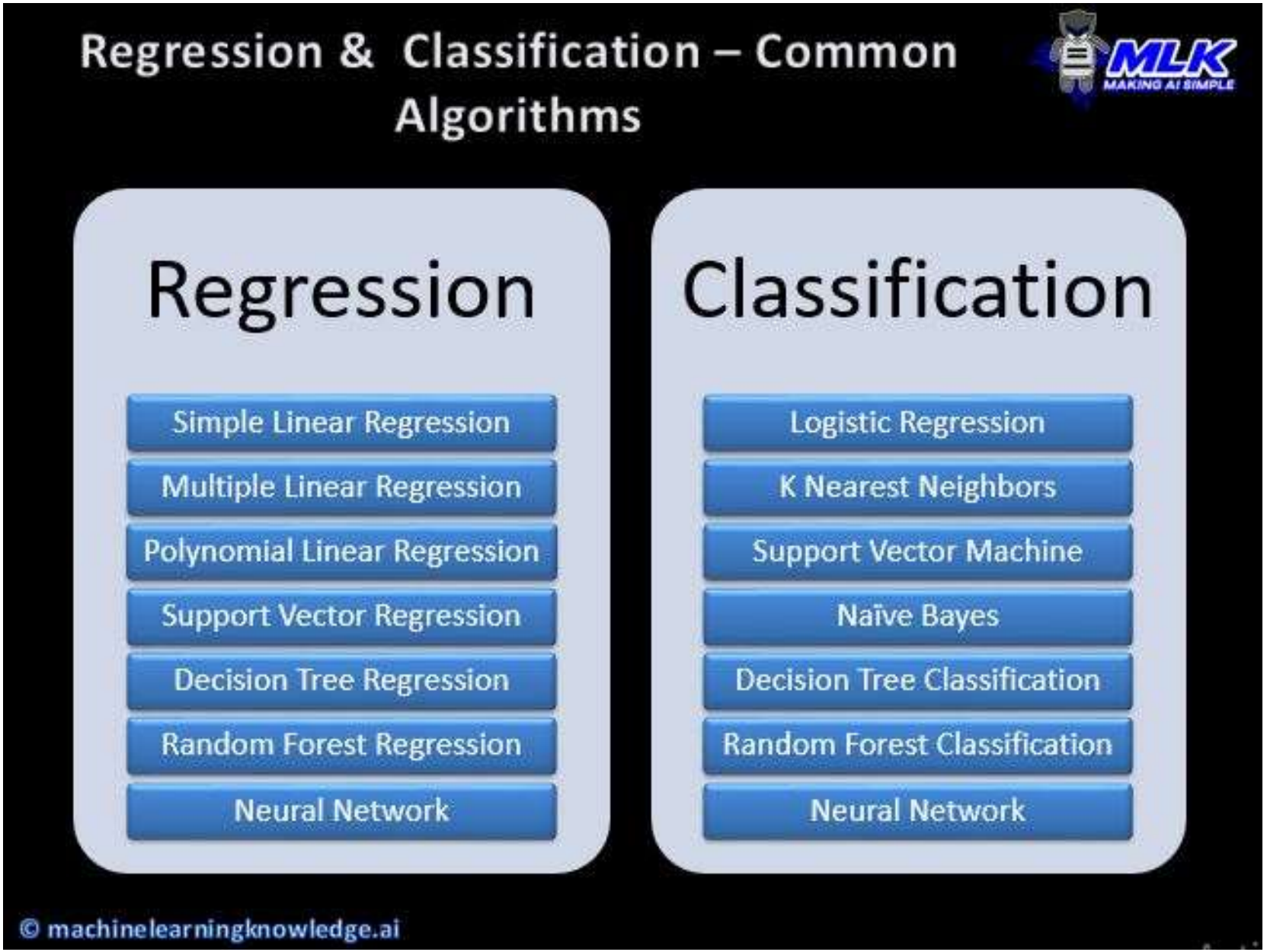


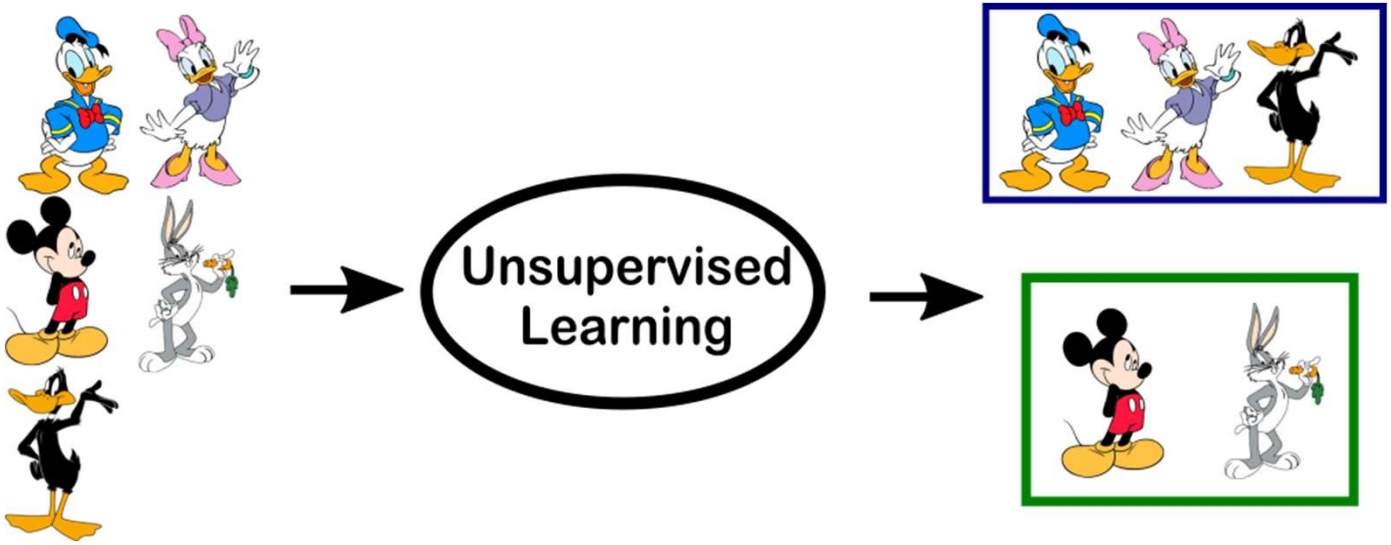
# Classification vs. Regression in ML

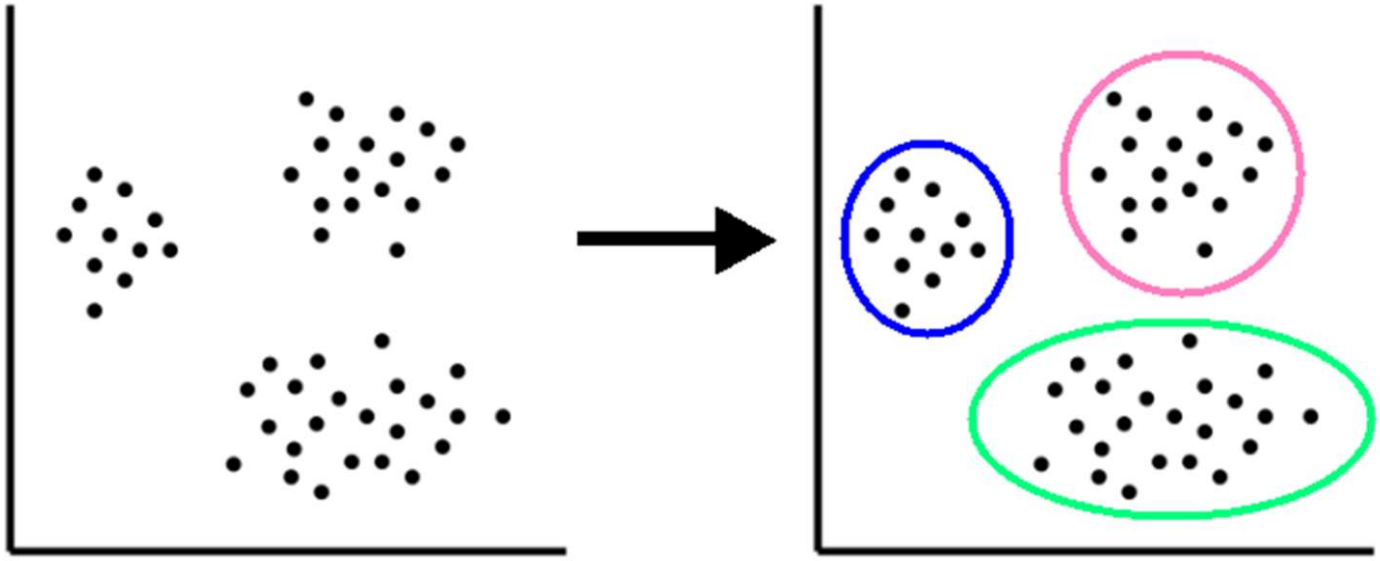
| Regression Algorithm | Classification Algorithm |
|---|---|
| The output variable must be of **continuous** nature or real value | The output variable must be a discrete value |
| The task of the regression algorithm is to map the input values (x) to the continuous output variable(y). | The task of the classification algorithm is to map the input values (x) to the discrete output variable(y). |
| Regression Algorithms are typically used with continuous data | Classification Algorithms are typically used with discrete data |
| In Regression, we try to find the **best fit line**, which can predict the output more accurately | In Classification, we try to **find the decision boundary**, which can divide the dataset into different classes |
| Regression algorithms can be used to solve the regression problems such as Weather Prediction, House price prediction, etc. | Classification algorithms can be used to solve classification problems such as Identification of spam emails, identification of tumors, etc. |
| The regression Algorithm can be further divided into Linear and Non-linear Regression | The Classification algorithms can be divided into Binary and Multi-class Classifier |

# Classification vs. Regression in ML



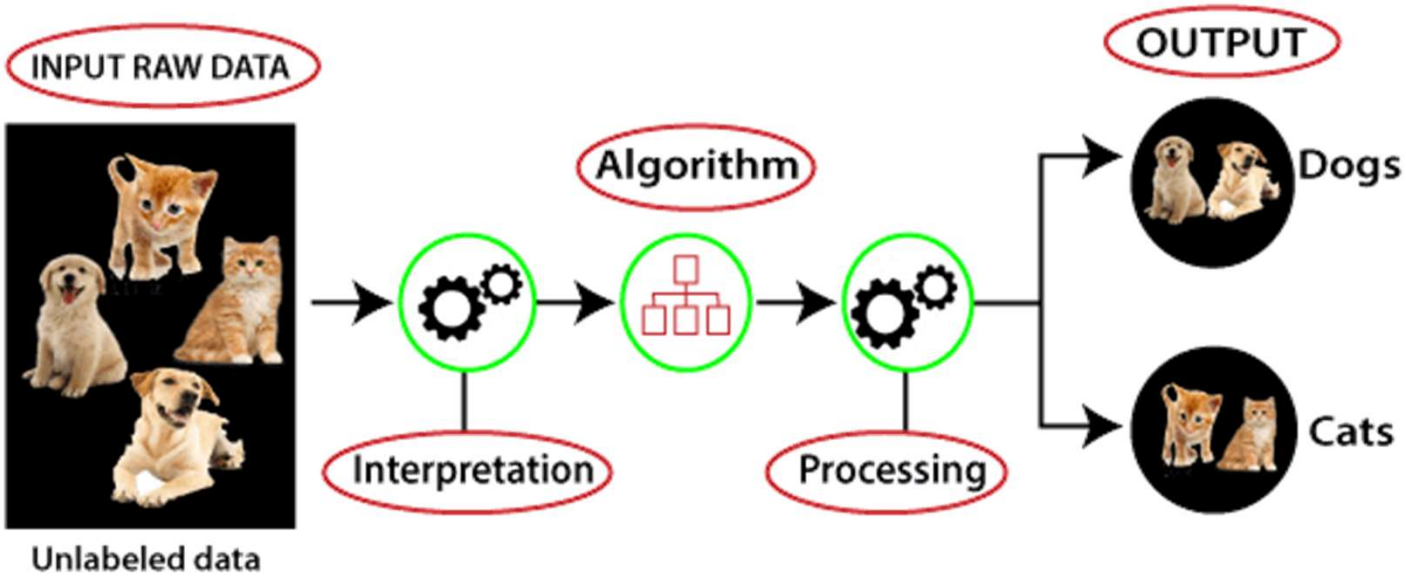
# Unsupervised Learning



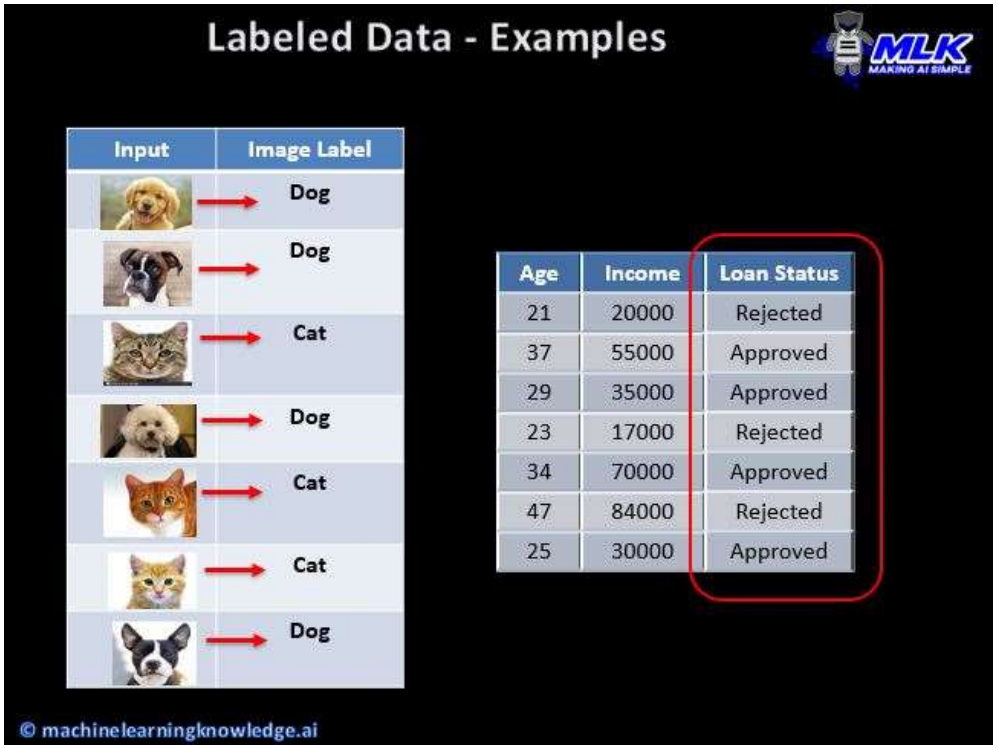



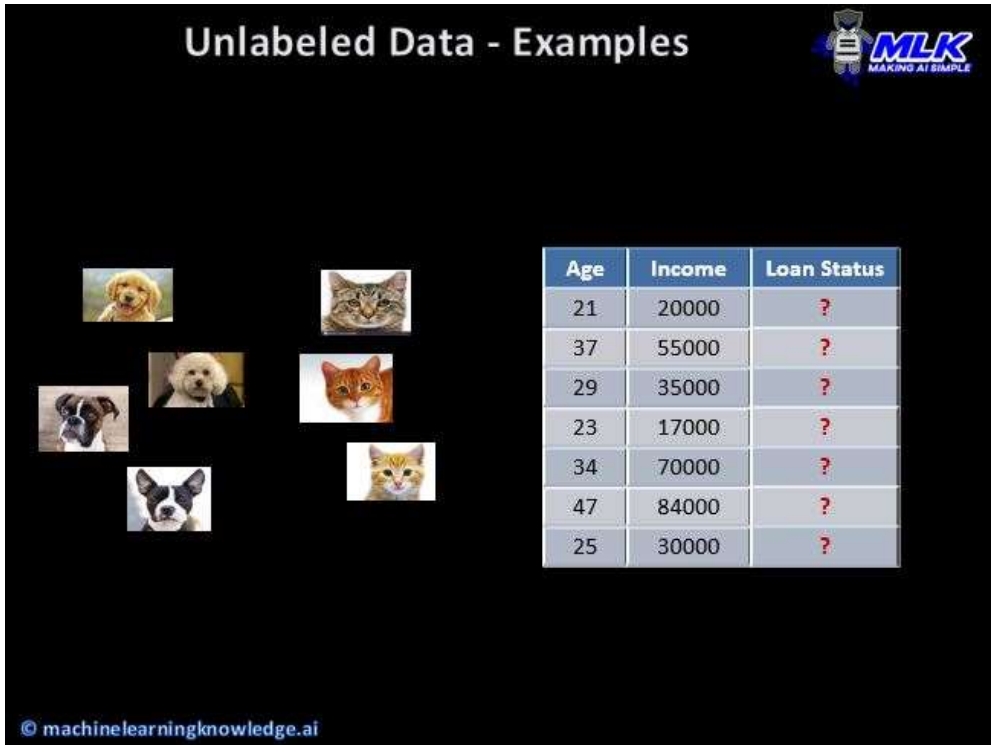
# Unsupervised Learning

*Unsupervised learning is a type of machine learning in which models are trained using unlabeled dataset and are allowed to act on that data without any supervision*



# Labelled vs Unlabelled Data

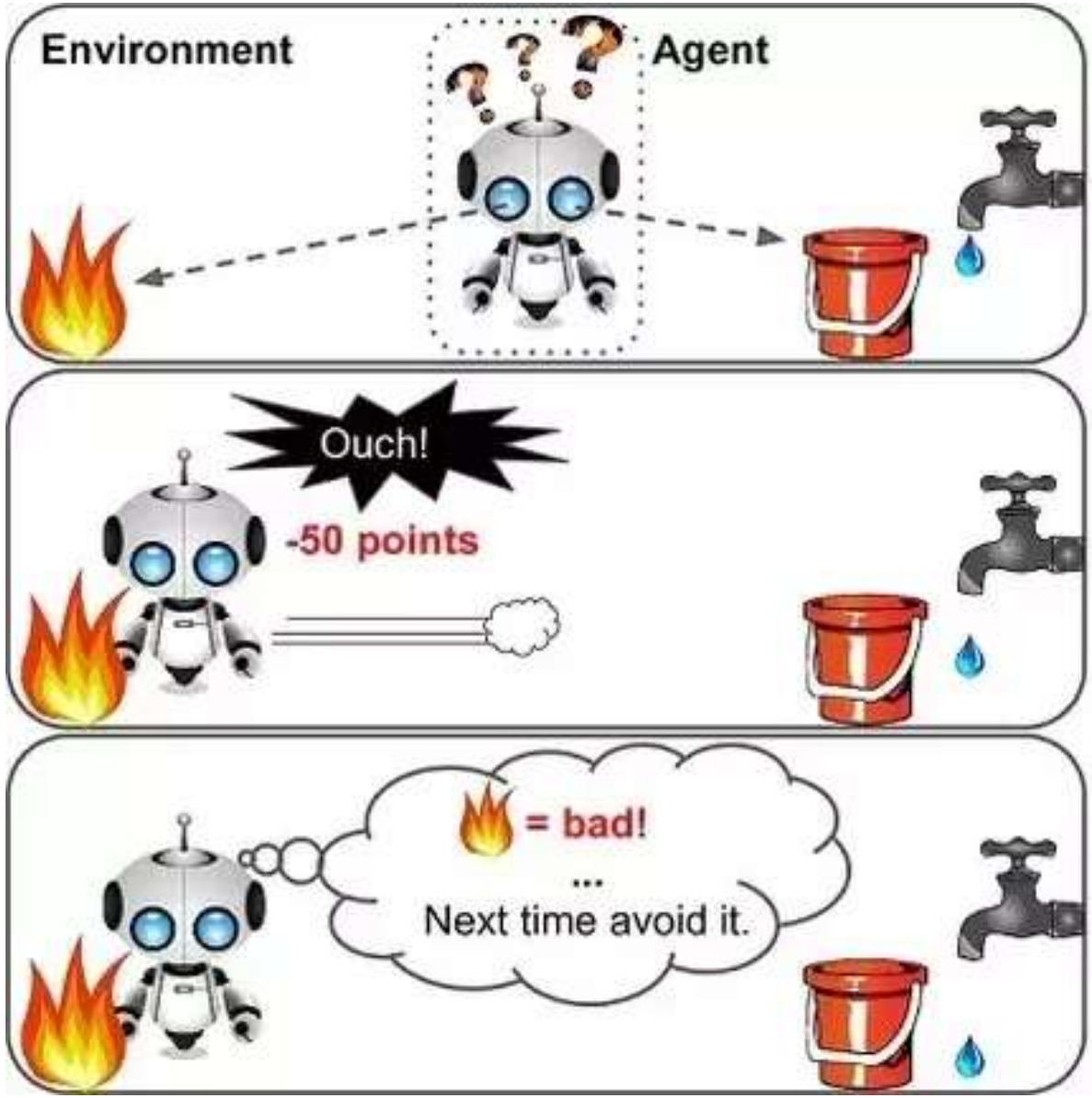


# Unsupervised vs Supervised Learning

| Supervised Learning | Unsupervised Learning |
|---|---|
| Algorithms are trained using labeled data. | Algorithms are trained using unlabeled data. |
| Supervised learning model takes direct feedback to check if it is predicting correct output or not. | Unsupervised learning model does not take any feedback. |
| Supervised learning model predicts the output. | Unsupervised learning model finds the hidden patterns in data. |
| In supervised learning, input data is provided to the model along with the output. | In unsupervised learning, only input data is provided to the model. |
| The goal of supervised learning is to train the model so that it can predict the output when it is given new data. | The goal of unsupervised learning is to find the hidden patterns and useful insights from the unknown dataset. |
| Supervised learning needs supervision to train the model. | Does not need any supervision to train the model. |
| Supervised learning can be categorized in Classification and Regression problems. | Unsupervised Learning can be classified in Clustering and Associations problems. |
| Supervised learning can be used for those cases where we know the input as well as corresponding outputs. | Unsupervised learning can be used for those cases where we have only input data and no corresponding output data. |
| Supervised learning model produces an accurate result. | Less accurate result as compared to supervised learning. |
| Supervised learning is not close to true Artificial intelligence as in this, we first train the model for each data, and then only it can predict the correct output. | Unsupervised learning is more close to the true Artificial Intelligence as it learns similarly as a child learns daily routine things by his experiences. |
| It includes various algorithms such as Linear Regression, Logistic Regression, SVMs, Decision tree, Bayesian Logic, etc. | It includes various algorithms such as Clustering, KNN, and Apriori algorithm. |

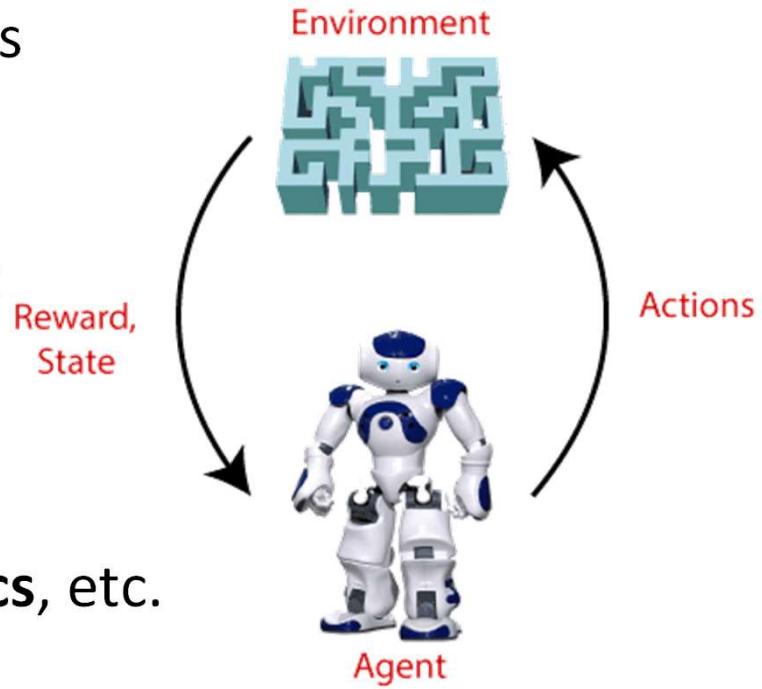
# Reinforcement Learning




1. Observe
2. Select action using policy
3. Action!
4. Get reward or penalty
5. Update policy (learning step)
6. Iterate until an optimal policy is found

# Reinforcement Learning

- Reinforcement Learning is a feedback-based Machine learning technique in which an agent learns to behave in an environment by performing the actions and seeing the results of actions.
- For each good action, the agent gets positive feedback, and for each bad action, the agent gets negative feedback or penalty.
- In Reinforcement Learning, the agent learns automatically using feedbacks without any labeled data
- Since there is no labeled data, so the agent is bound to learn by its experience only.
- RL solves a specific type of problem where decision making is sequential, and the goal is long-term, such as **game-playing, robotics**, etc.



# Reinforcement Learning

- The agent interacts with the environment and explores it by itself
- The primary goal of an agent in reinforcement learning is to improve the performance by getting the maximum positive rewards
- The agent learns with the process of hit and trial, and based on the experience, it learns to perform the task in a better way
- ***"Reinforcement learning is a type of machine learning method where an intelligent agent (computer program) interacts with the environment and learns to act within that."***
- We do not need to pre-program the agent, as it learns from its own experience without any human intervention
- The agent learns that what actions lead to positive feedback or rewards and what actions lead to negative feedback penalty.
- As a positive reward, the agent gets a positive point, and as a penalty, it gets a negative point

# Reinforcement vs. Supervised Learning

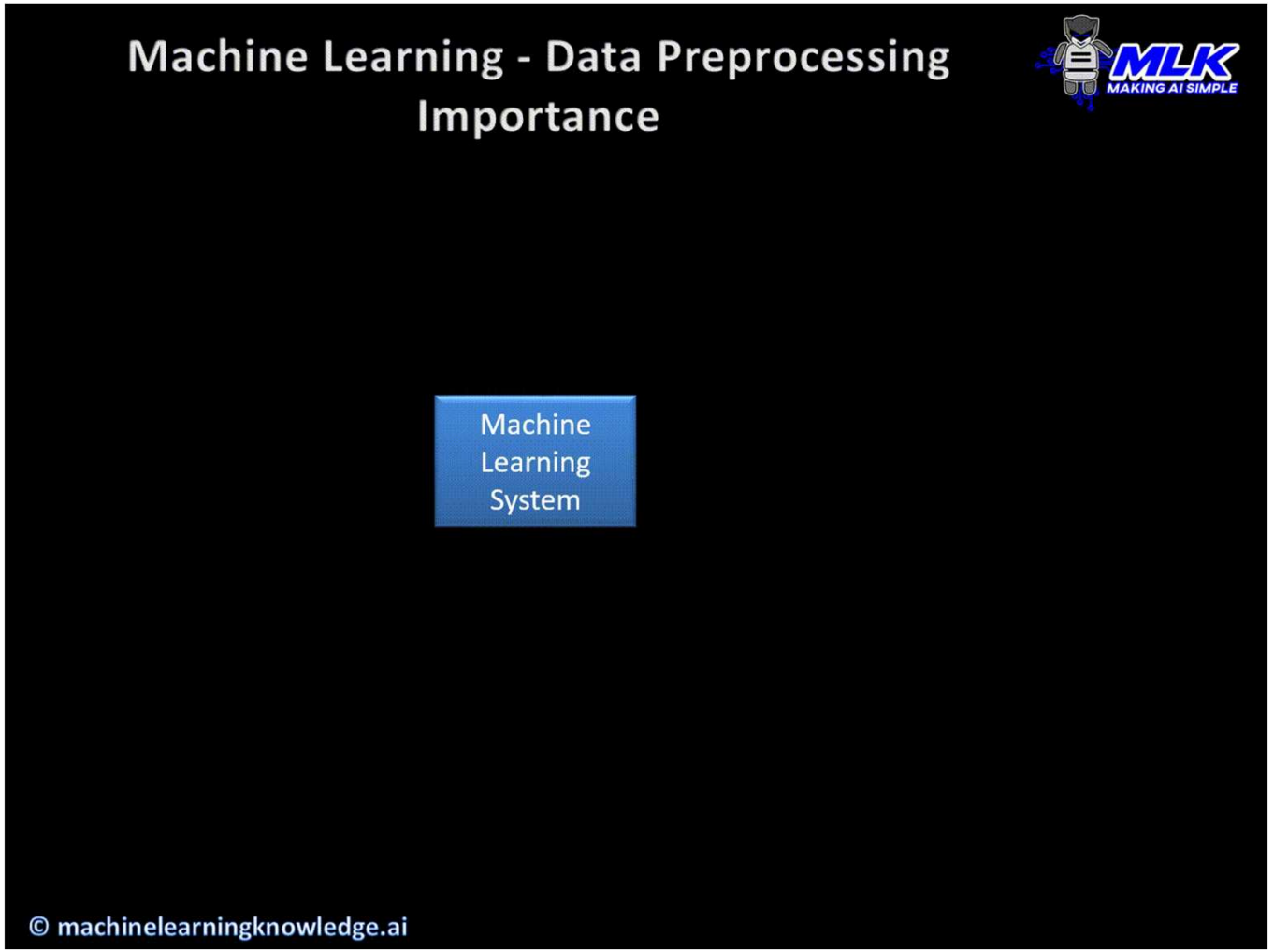
| Reinforcement Learning | Supervised Learning |
|---|---|
| RL works by interacting with the environment | Supervised learning works on the existing dataset |
| The RL algorithm works like the human brain works when making some decisions | Supervised Learning works as when a human learns things in the supervision of a guide |
| There is no labeled dataset is present | The labeled dataset is present |
| No previous training is provided to the learning agent | Training is provided to the algorithm so that it can predict the output |
| RL helps to take decisions sequentially | In Supervised learning, decisions are made when input is given |

# Machine Learning vs Data Science

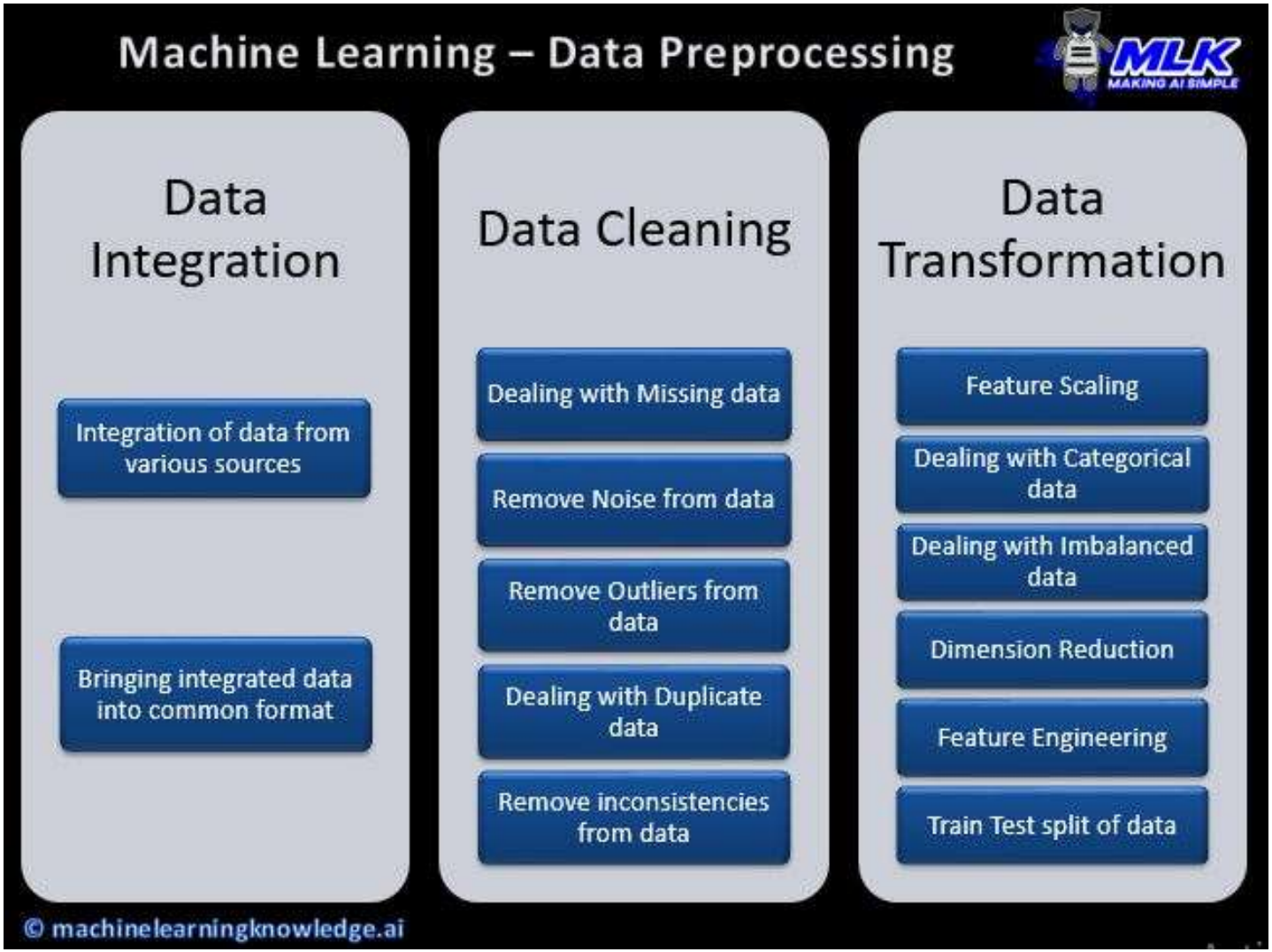
- Data Science is a “concept to unify statistics, data analysis, machine learning and their related methods” in order to “understand and analyse actual phenomena” with data.
- Data Science is the field of study to solve business, industry and even society problem with the help of data.
- Both machine learning and data science encompasses:
  - Regression and classification algorithms of supervised learning for creating predictive models.
  - Unsupervised learning algorithms for finding hidden patterns, association, outliers in the data.

# Data Preprocessing Importance

- 80% Data Preprocessing and 20% Building Machine Learning Models?

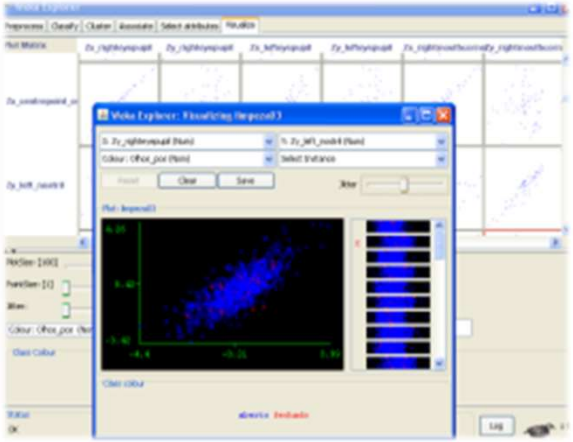
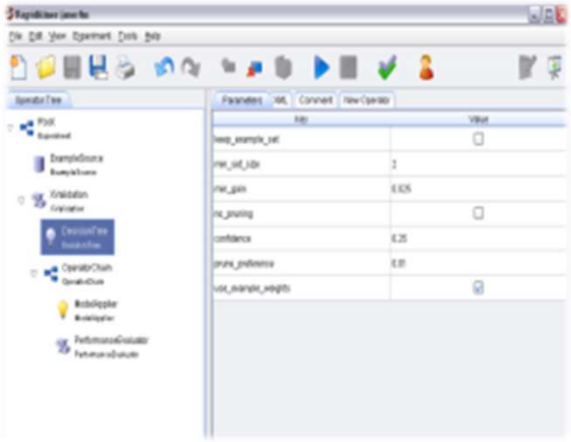
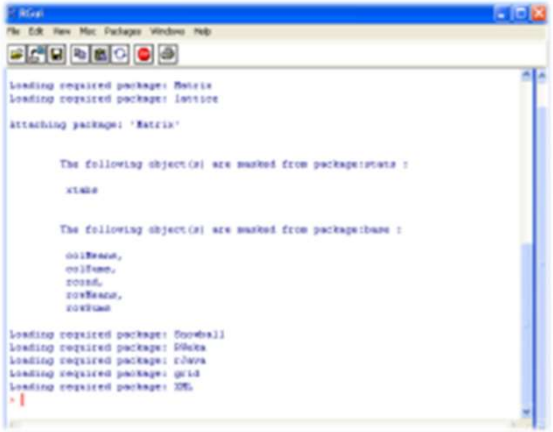
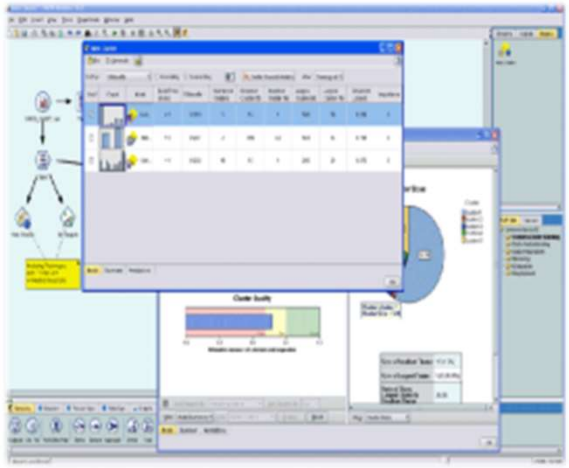
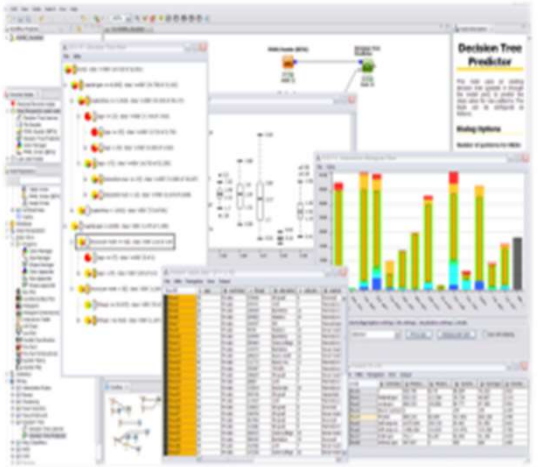


# Data Preprocessing



# Interesting Machine Learning Tools/Libraries/Software Packages

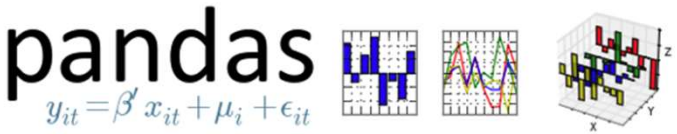
- RapidMiner; WEKA; R; Python Libraries; SPSS; KNIME; SAS Enterprise Miner; Insightful Miner

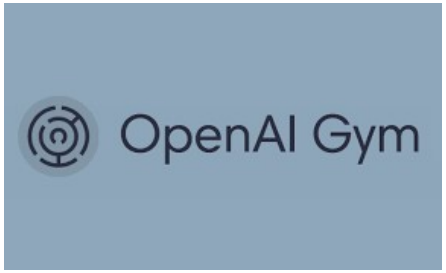
# Interesting Machine Learning Tools

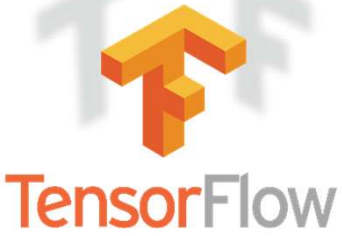








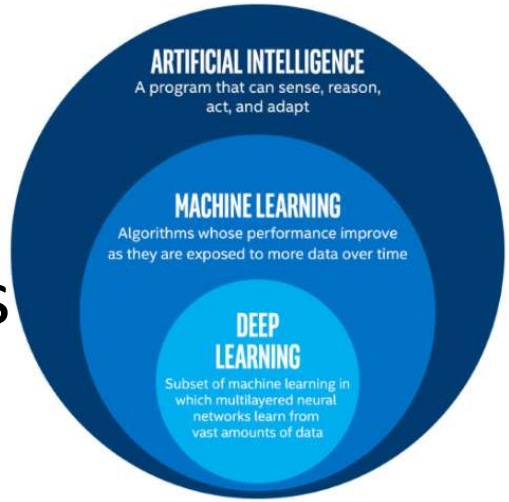


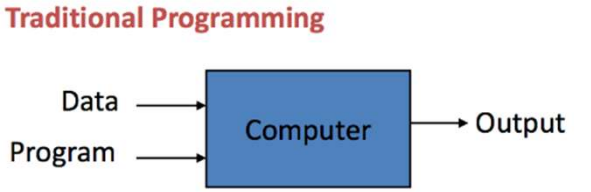



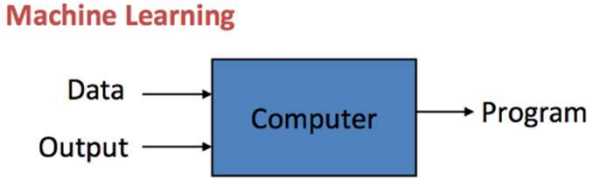


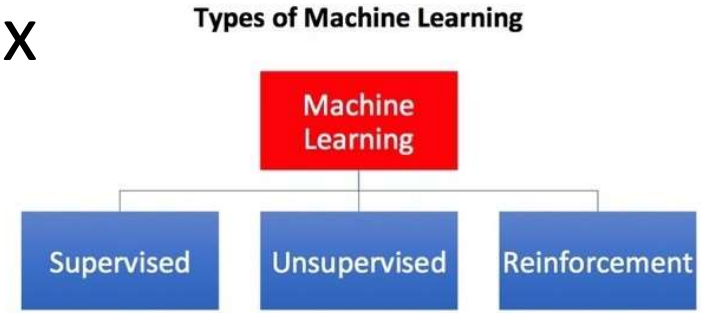
# Conclusions

- Machine Learning is a subarea of AI
- New way of building computer programs
- Powered by huge amount of data, computer power and new algorithms
- Supervised, Unsupervised and Reinforcement Learning
- Using ML machines can beat human champions in games such as Chess, Go and learn to solve very complex problems



U.PORTO

FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

# Robotics

# Introduction to Machine Learning


## Luís Paulo Reis

lpreis@fe.up.pt

**Director of LIACC – Artificial Intelligence and Computer Science Lab.**
**Associate Professor at DEI/FEUP – Informatics Engineering Department,**
**Faculty of Engineering of the University of Porto, Portugal**
**President of APPIA – Portuguese Association for Artificial Intelligence**