# Metodi di Apprendimento Automatico per la Fisica
## Lesson 1

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# General Information

# Learning Outcomes

## Learning Outcomes 1

To acquire knowledge in the domain of artificial intelligence and in the implementation of computer applications based on machine learning methodologies.

## Learning Outcomes 2

To apply the acquired computer techniques in different application domains also belonging to the physics area: physics of matter, nuclear and subnuclear physics, physics of the universe, and astroparticle physics.

# Teaching materials

- Textbook:
  - Raschka, Sebastian. Python machine learning. Packt Publishing Ltd, 2015.
  - Ethem Alpaydin. Introduction to Machine Learning (3rd edition). MIT Press, 2014.

- Other references:
  - https://www.python.org/

- Software: Python (Shell, PyCharm)
- The teaching materials (slides, codes, etc.) will be available on the online platform.

# Assessment Procedure

- Project:
  - Working to a project using python to solve a machine learning problem.

- Oral:
  - Discussion on the project and oral exam

- Possibility of thesis in the area of AI, Machine Learning and Quantum Computing

# Machine Learning: Preliminary Information

# Introduction to the Machine Learning

- In this age of modern technology, there is one resource that we have in abundance: a **large amount of** structured and unstructured **data**.
- In the second half of the twentieth century, **machine learning** evolved as a subfield of artificial intelligence that involved the development of **self-learning algorithms to gain knowledge from that data in order to make predictions**.
- *Machine learning* vs *rules derived by humans*
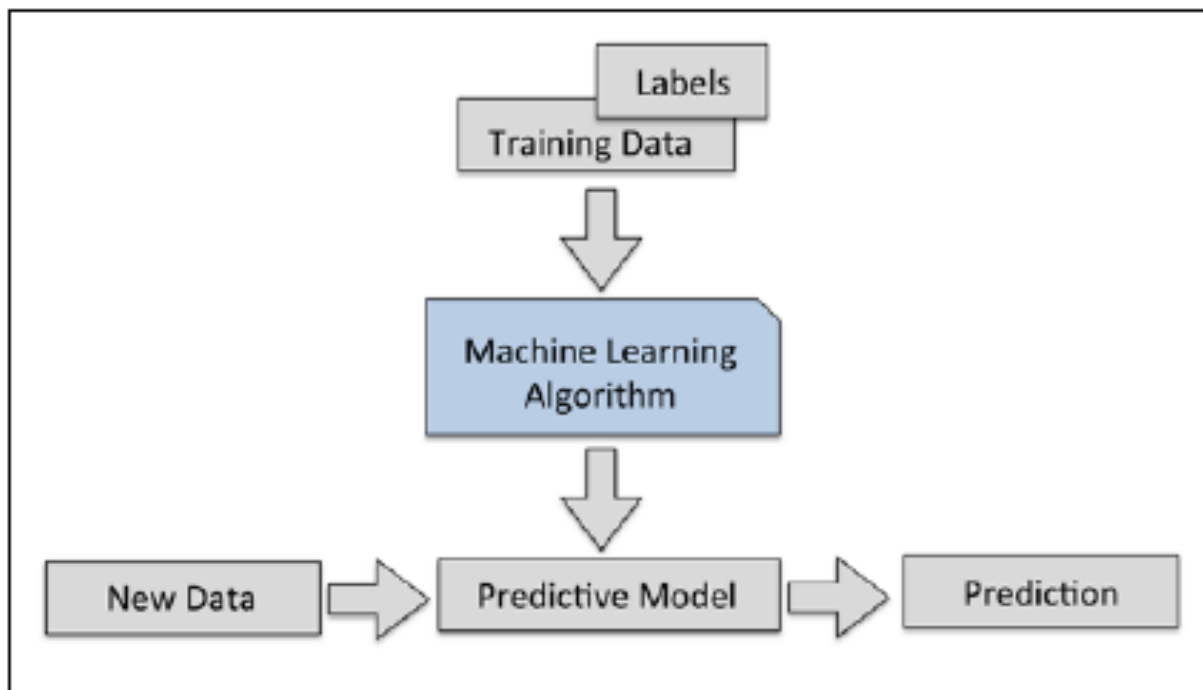- Several everyday life applications
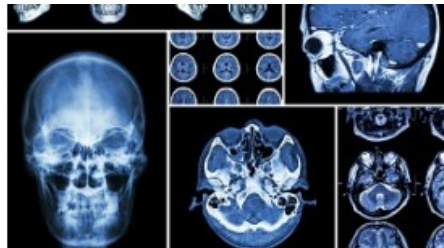
# Introduction to the Machine Learning

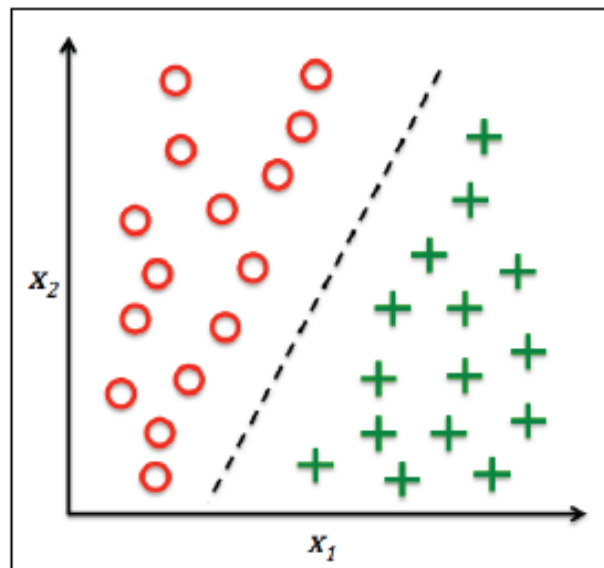There exist three types of machine learning tasks
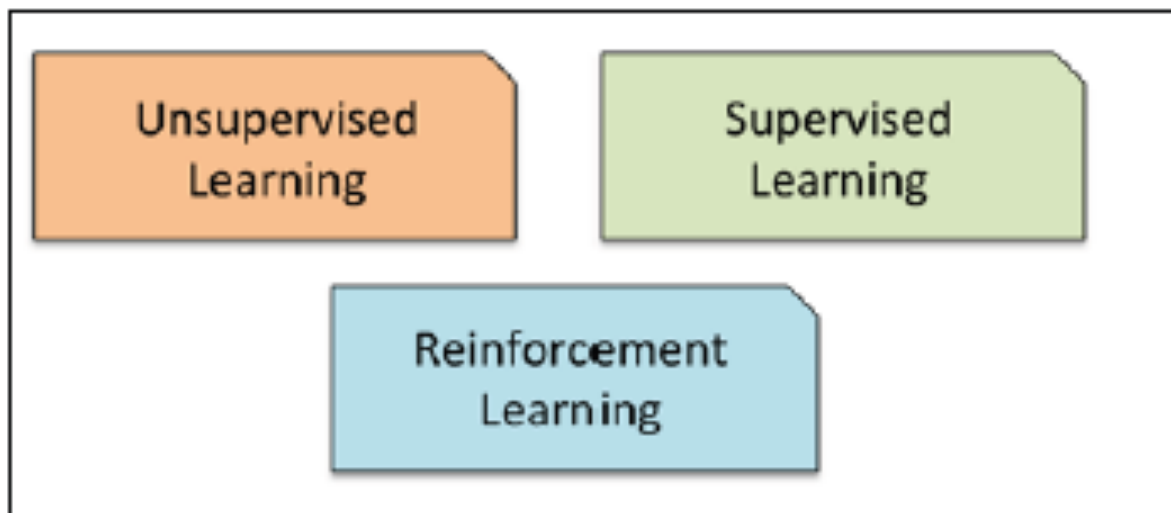
# Supervised Learning

The main goal in supervised learning is to learn a model from labeled training data that allows us to make predictions about unseen or future data.

# Supervised Learning: Classification

- The goal of the classification is to predict the categorical class labels of new instances based on past observations.
- *E-mail-spam detection* is an example of binary classification.
- *Handwritten character recognition* is an example of multi-class classification.
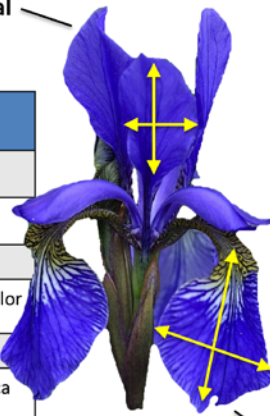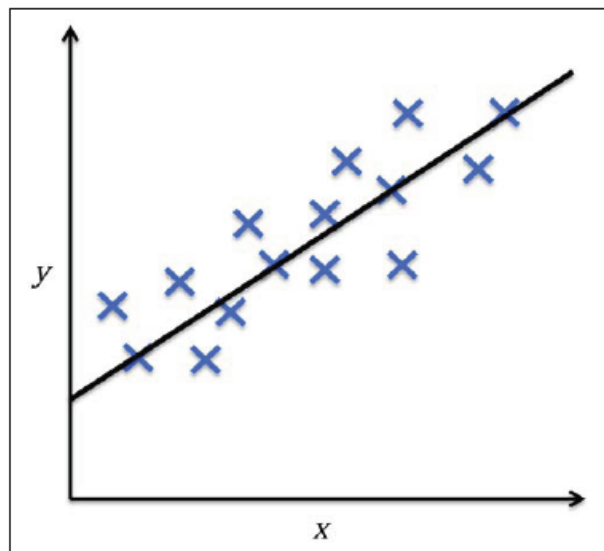
# Supervised Learning: Training data



$$\begin{bmatrix} x_1^{(1)} & x_2^{(1)} & x_3^{(1)} & x_4^{(1)} \\ x_1^{(2)} & x_2^{(2)} & x_3^{(2)} & x_4^{(2)} \\ \vdots & \vdots & \vdots & \vdots \\ x_1^{(150)} & x_2^{(150)} & x_3^{(150)} & x_4^{(150)} \end{bmatrix}$$
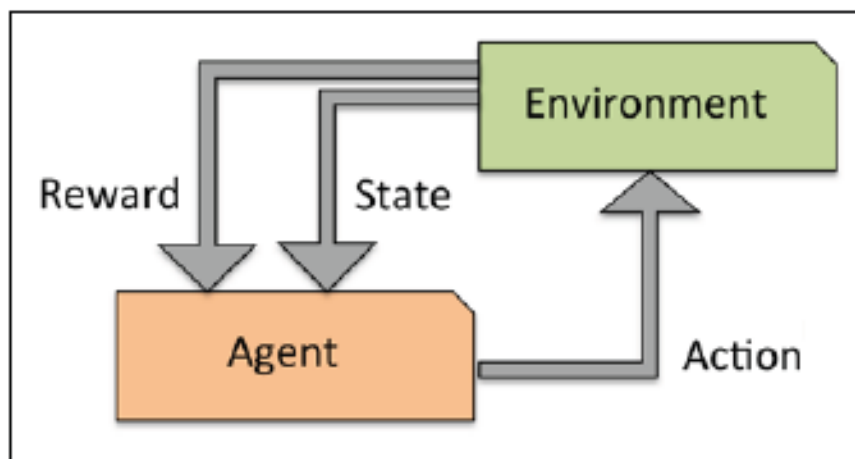
# Supervised Learning: Regression

- The goal of the regression is the prediction of continuous outcomes.
- *Score prediction* is an example of regression.

# Reinforcement Learning

- The main goal of the reinforcement learning is to develop a system that improves its performance based on interactions with the environment.



- PacMan game is an example of reinforcement learning.

# Unsupervised Learning

- The main goal of the unsupervised learning is to explore the structure of data to extract meaningful information without the guidance of a known outcome variable or reward function.
- Clustering allows us to organize a pile of information into meaningful subgroups (clusters) without having any prior knowledge of their group memberships.
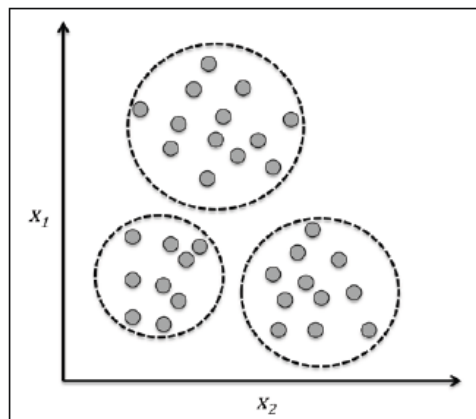


- Another subfield of unsupervised learning is dimensionality reduction.

# A roadmap for building machine learning systems