Classification

What is Classification in Machine Learning?

Classification is a supervised machine learning method where the model tries to predict the correct label of a given input data. In classification, the model is fully trained using the training data, and then it is evaluated on test data before being used to perform prediction on new unseen data.

For instance, an algorithm can learn to predict whether a given email is spam or no spam.

Machine Learning Classification Vs. Regression

There are four main categories of Machine Learning algorithms: supervised, unsupervised, semi-supervised, and reinforcement learning.

Even though classification and regression are both from the category of supervised learning, they are not the same.

- The prediction task is a ***classification*** when the target variable is discrete. An application is the identification of the underlying sentiment of a piece of text.
- The prediction task is a ***regression*** when the target variable is continuous. An example can be the prediction of the salary of a person given their education degree, previous work experience, geographical location, and level of seniority.

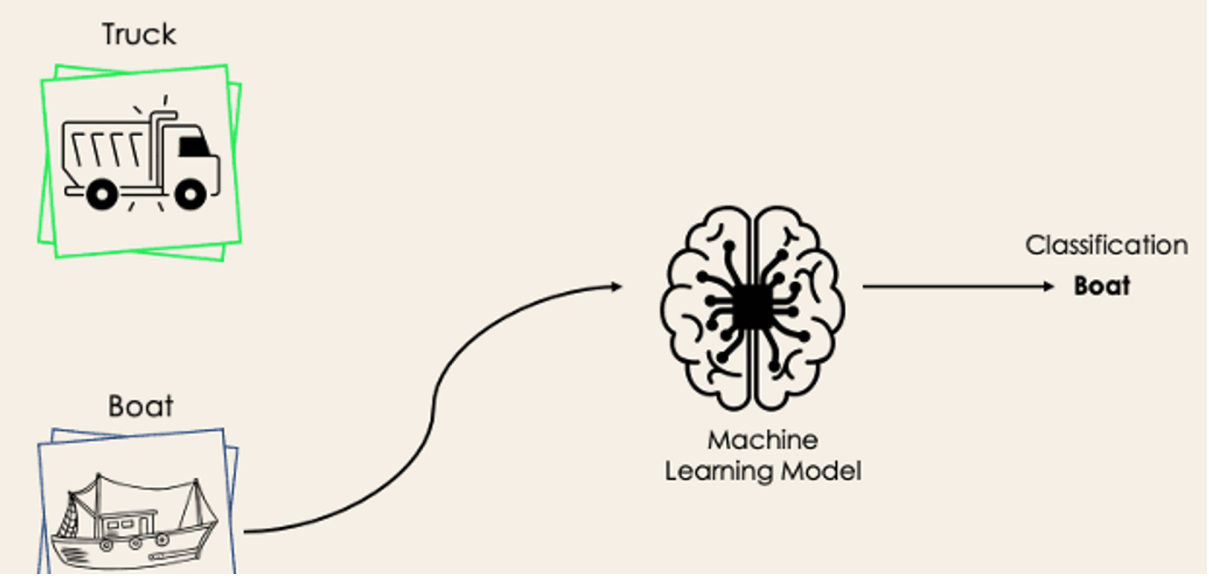
Different Types of Classification Tasks in Machine Learning

There are three main types of classification:

1. ***Binary Classification***
2. ***Multiclass Classification***
3. ***Multi-Label Classification***

1. Binary Classification

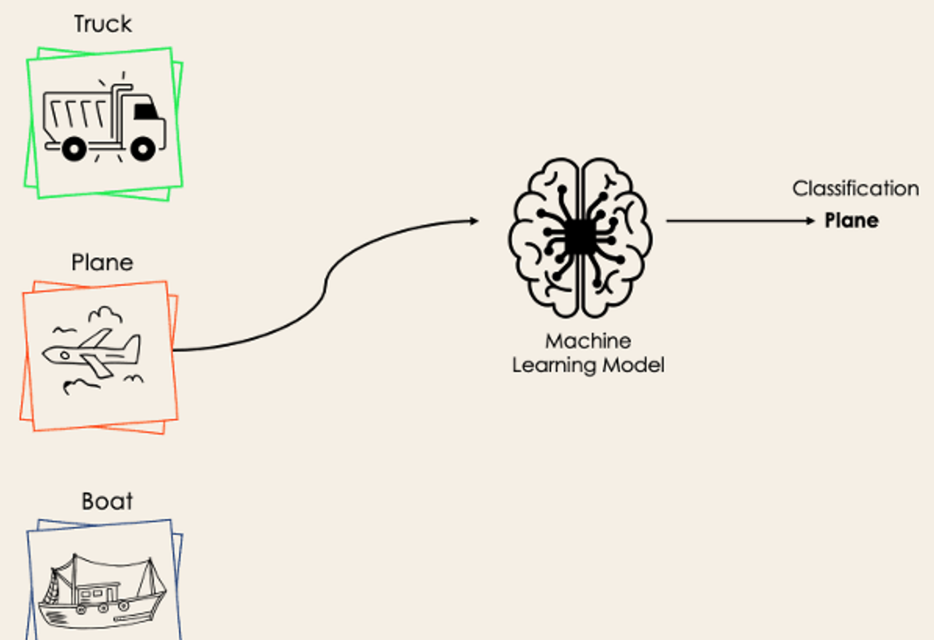
In a binary classification task, the goal is to classify the input data into two mutually exclusive categories. The training data in such a situation is labeled in a binary format: true and false; positive and negative; O and 1; spam and not spam, etc. depending on the problem being tackled. For instance, we might want to detect whether a given image is a truck or a boat.



Logistic Regression and Support Vector Machines algorithms are natively designed for binary classifications. However, other algorithms such as K-Nearest Neighbors and Decision Trees can also be used for binary classification.

2. Multi-Class Classification

The multi-class classification, on the other hand, has at least two mutually exclusive class labels, where the goal is to predict to which class a given input example belongs to. In the following case, the model correctly classified the image to be a plane.



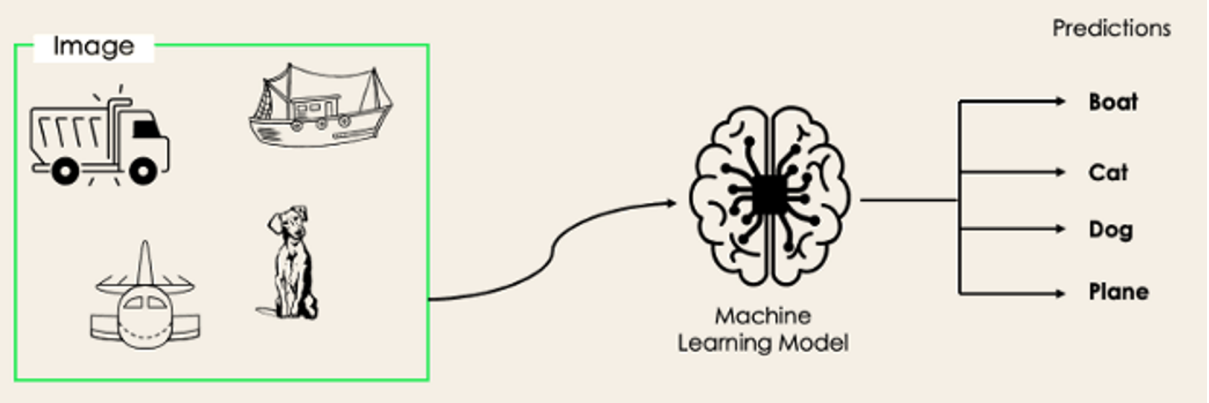
Most of the binary classification algorithms can be also used for multi-class classification. These algorithms include but are not limited to:

- Random Forest
- Naive Bayes
- K-Nearest Neighbors
- Gradient Boosting
- SVM
- Logistic Regression.

Multi-Label Classification

In multi-label classification tasks, we try to predict 0 or more classes for each input example. In this case, there is no mutual exclusion because the input example can have more than one label.

Such a scenario can be observed in different domains, such as auto-tagging in Natural Language Processing, where a given text can contain multiple topics. Similarly to computer vision, an image can contain multiple objects, as illustrated below: the model predicted that the image contains: a plane, a boat, a truck, and a dog.



It is not possible to use multi-class or binary classification models to perform multi-label classification. However, most algorithms used for those standard classification tasks have their specialized versions for multi-label classification. We can cite:

- *Multi-label Decision Trees*
- *Multi-label Gradient Boosting*
- *Multi-label Random Forests*

Lazy Learners Vs. Eager Learners

In the classification problems, there are two types of learners:

1. ***Lazy Learners***
2. ***Eager Learners***

1. Lazy Learners

Lazy Learner firstly stores the training dataset and wait until it receives the test dataset. In Lazy learner case, classification is done on the basis of the most related data stored in the training dataset.

Lazy learners or instance-based learners do not create any model immediately from the training data, and this is where the lazy aspect comes from. They just memorize the training data, and each time there is a need to make a prediction, they search for the nearest neighbor from the whole training data, which makes them very slow during prediction. Some examples of this kind are:

- K-Nearest Neighbor.
- Case-based reasoning.

However, some algorithms, such as **Ball Trees** and **KD Trees**, can be used to improve the prediction latency.

2. Eager Learners

Eager learners are machine learning algorithms that first build a model from the training dataset before making any prediction on future datasets. They spend more time during the training process because of their eagerness to have a better generalization during the training from learning the weights, but they require less time to make predictions.

Most machine learning algorithms are eager learners, and below are some examples:

- Logistic Regression.
- Support Vector Machine.
- Decision Trees.
- Artificial Neural Networks.