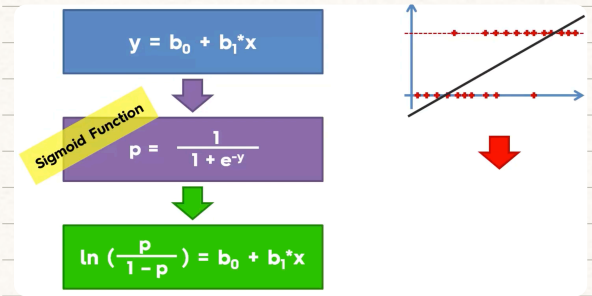
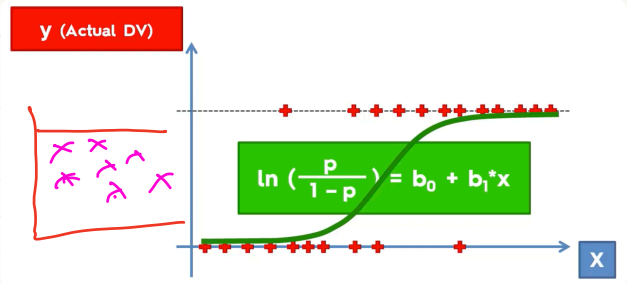
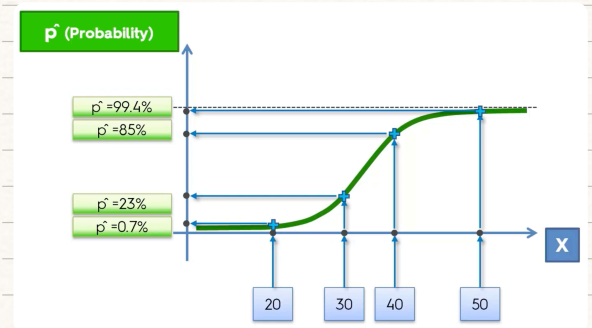
Logistic Regression

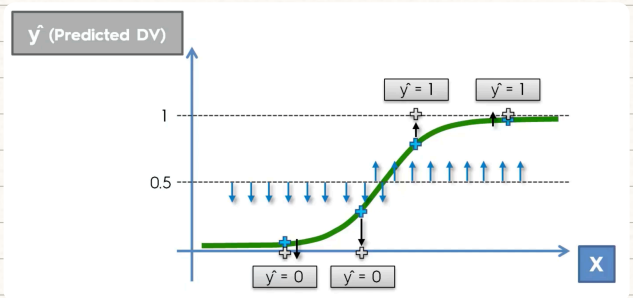
Logistic regression is a classification algorithm used to assign observations to a discrete set of classes. Unlike linear regression which outputs continuous number values, logistic regression transforms its output using the sigmoid function to return the probability value which can then be mapped to two or more discrete classes.

Logistic regression models the probabilities for classification problem with two possible outcomes. Logistic regression is used when dependent variable (target) is categorical.









Instead of fitting a straight line or hyperplane, the logistic regression model uses the logistic function to squeeze the output of a linear equation between 0 & 1.

Sigmoid function $y = \frac{1}{1 + e^{-x}}$

here, x is the independent variable which we want to transform.

e is Euler's constant i.e. 2.71828, and y is output.

Sigmoid function is simply trying to convert the independent variable into a probability that ranges between 0 and 1 with respect to the dependent variable.

A Sigmoid function is a mathematical function which has a characteristic S-shaped curve. There are a number of common sigmoid functions, such as the **logistic function**, the **hyperbolic tangent**, and the **arctangent**

. In machine learning, the term

sigmoid function is normally used to refer specifically to the logistic function, also called the logistic sigmoid function.

All sigmoid functions have the property that they map the entire number line into a small range such as between 0 and 1, or -1 and 1, so one use of a sigmoid function is to convert a real value into one that can be interpreted as a probability.

Sigmoid activation

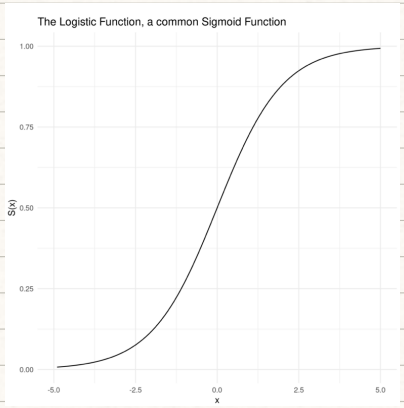
In order to map predicted values to probabilities, we use the sigmoid function. The function maps any real value into another value between 0 and 1. In machine learning, we use sigmoid to map predictions to probabilities.

Math

$$S(z) = \frac{1}{1 + e^{-z}}$$

Note

- $s(z)$ = output between 0 and 1 (probability estimate)
- z = input to the function (your algorithm's prediction e.g. mx + b)
- e = base of natural log

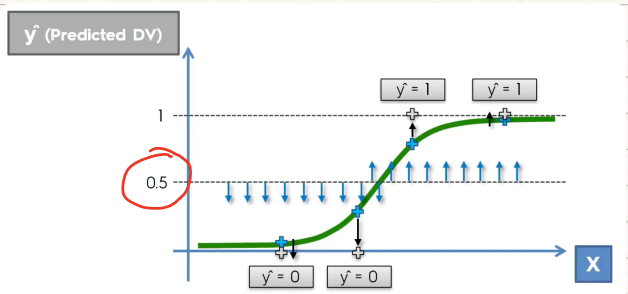


One of the most widely used sigmoid functions is the logistic function, which maps any real value to the range (0, 1). Note the characteristic S-shape which gave sigmoid functions their name (from the Greek letter sigma).

Sigmoid functions have become popular in deep learning because they can be used as an activation function in an artificial neural network. They were inspired by the activation potential in biological neural networks.

Sigmoid functions are also useful for many machine learning applications where a real number needs to be converted to a probability. A sigmoid function placed as the last layer of a machine learning model can serve to convert the model's output into a probability score, which can be easier to work with and interpret.

Sigmoid functions are an important part of a logistic regression model. Logistic regression is a modification of linear regression for two-class classification, and converts one or more real-valued inputs into a probability, such as the probability that a customer will purchase a product. The final stage of a logistic regression model is often set to the logistic function, which allows the model to output a probability.



Q. What about data points which are positioned precisely at 0.5 probability?

Ans. — They will be unclassified. This situation is very rare.

Types of Logistic Regression

1. Binary Logistic Regression

The categorical response has only two 2 possible outcomes. Example: Spam or Not

2. Multinomial Logistic Regression

Three or more categories without ordering. Example: Predicting which food is preferred more (Veg, Non-Veg, Vegan)

3. Ordinal Logistic Regression

Three or more categories with ordering. Example: Movie rating from 1 to 5

Decision Boundary

To predict which class a data belongs, a threshold can be set. Based upon this threshold, the obtained estimated probability is classified into classes.

Say, if predicted_value ≥ 0.5, then classify email as spam else as not spam.

Decision boundary can be linear or non-linear. Polynomial order can be increased to get complex decision boundary.

Fields where Logistic Regression is used :-

- Fraud Detection
- Disease Diagnosis
- Emergency Detection
- Spam / No spam
- True / False

* while working with Logistic Regression, dataset should be free of missing values.