Machine Learning with R: Logistic Regression

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- □ Choosing which software package to use, including free and open-source software
- □ Troubleshooting problems related to file formats, data retrieval, and download
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Machine Learning with R: Logistic Regression

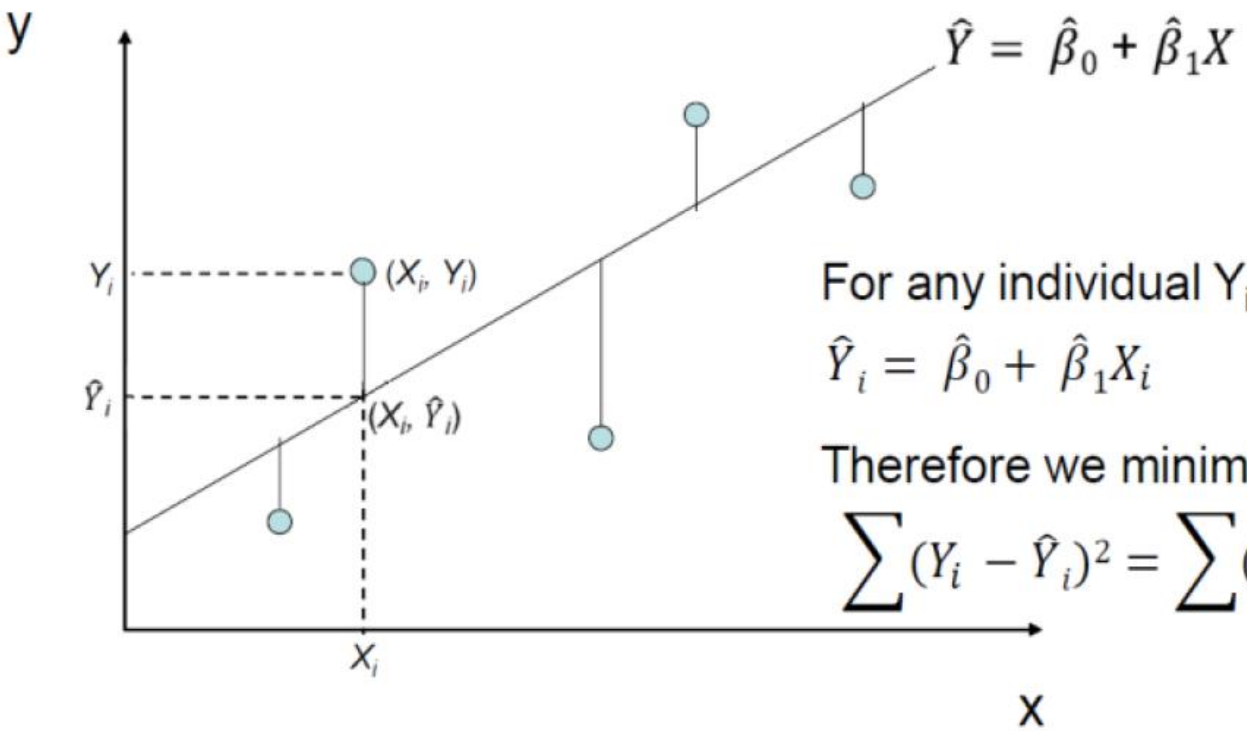
Objective

LEARNING THE BASICS OF LOGISTIC REGRESSION

MACHINE LEARNING CODE WITH R

Linear regression

Geometry of Least Square



For any individual Y_i,

$$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 X_i$$

Therefore we minimize:

$$\sum (Y_i - \hat{Y}_i)^2 = \sum (Y_i - (\hat{\beta}_0 + \hat{\beta}_1 X_i))^2$$

Source: Dr. Shofiqul Islam, McMaster University

What is Logistic Regression?

- Many situations where the dependent variable is binary or categorical.

✓ Dead vs. Aliv

✓ CVD vs No CVD

✓ Employed vs. Unemployed

✓ Guilty vs. Not guilty

- Requires to consider a special type of model called logistic regression

Source: Dr. Shofiqul Islam, McMaster University

A new Regression Model

- Need to modify our regression equation so that:
  1. Predictions lie between 0 and 1
  2. Effects of covariates can be interpreted on a relative (multiplicative) scale.

- Solution
  - Use the log odds or logit of p to represent the
  - Outcome: $\text{logit } p = \ln\left(\frac{p}{1-p}\right)$
- Where p is the probability of having the outcome
  - When $p \rightarrow 0$, $\text{logit } p \rightarrow -\infty$
  - When $p \rightarrow 1$, $\text{logit } p \rightarrow \infty$

Source: Dr. Shofiqul Islam, McMaster University

A new Regression Model

- Logit transformation of the binary Outcome leads to Logistic Regression
- The logistic function: $\frac{1}{1+e^{-x}}$
- Inverse is called the logit: $\ln(\frac{x}{1-x})$
- Logistic regression models:
  - The log-odds (or logit) of a binary outcome as a straight-line function of covariates:

$$\mathrm{E}[\ln(\frac{p}{1-p})|\mathrm{X}] = \beta_0 + \beta_1 * \mathrm{X}_1 + \; ... + \beta_k * \mathrm{X}_k$$

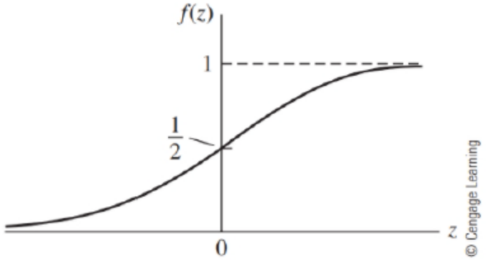


FIGURE 22.1 The logistic function $f(z) = \frac{1}{1+e^{-z}}$

Source: Dr. Shofiqul Islam, McMaster University

Logistic Function

- How do we transform the logit back to p ?

$$\text{Logit(p)} = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X$$

$$e^{ln\left(\frac{p}{1-p}\right)} = e^{(\beta_0+\beta_1 X)}$$

$$\frac{p}{1-p} = e^{(\beta_0+\beta_1 X)}$$

$$p = (1-p)\, e^{(\beta_0+\beta_1 X)}$$

$$p = e^{(\beta_0+\beta_1 X)} - pe^{(\beta_0+\beta_1 X)}$$

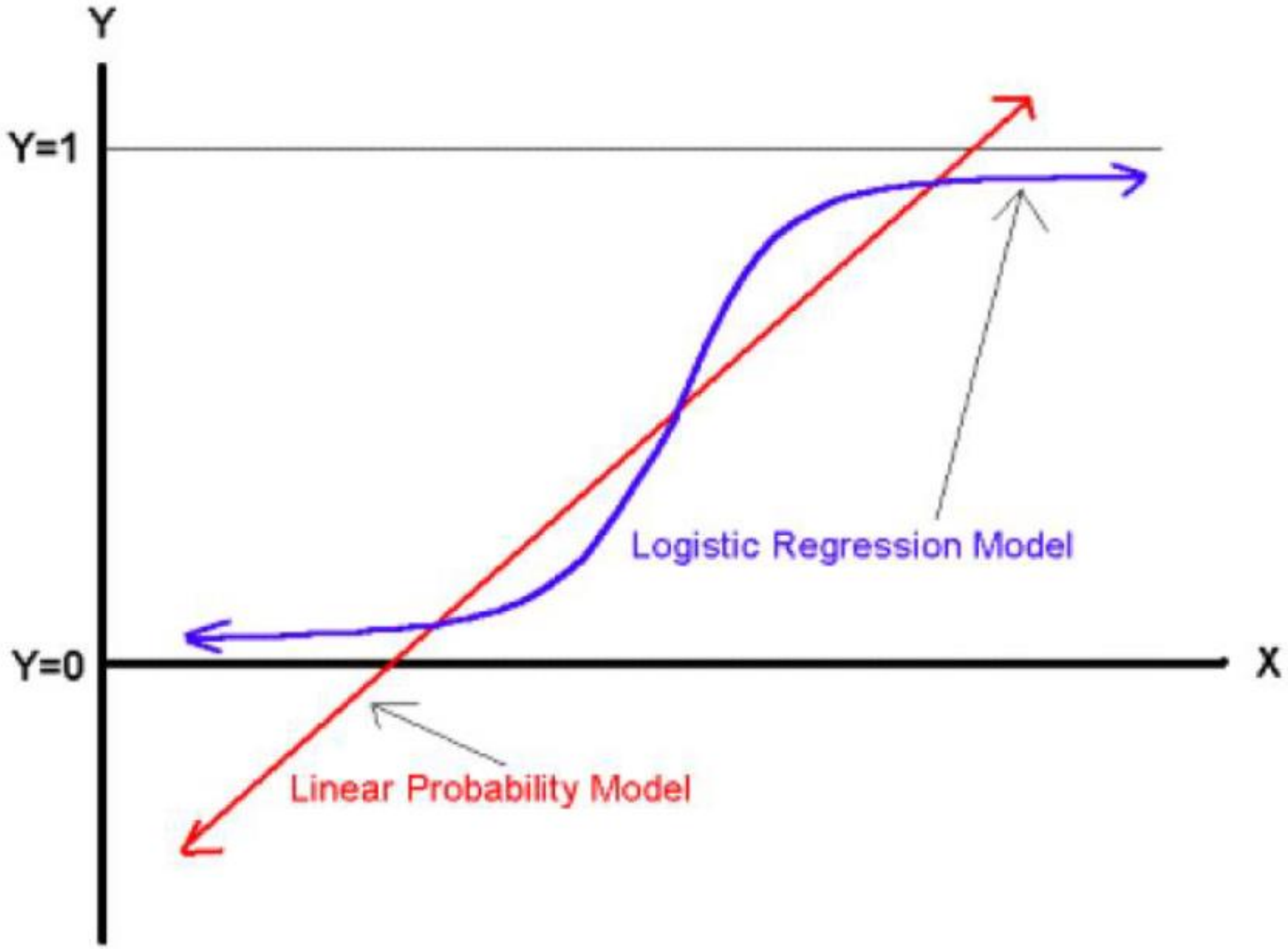
$$p + pe^{(\beta_0+\beta_1 X)} = e^{(\beta_0+\beta_1 X)}$$

$$p\left(1 + e^{(\beta_0+\beta_1 X)}\right) = e^{(\beta_0+\beta_1 X)}$$

$$p = \frac{e^{(\beta_0+\beta_1 X)}}{1 + e^{(\beta_0+\beta_1 X)}}$$

Source: Dr. Shofiqul Islam, McMaster University

Comparing the Linear vs Logistic fit



Source: Dr. Shofiqul Islam, McMaster University

Assumptions of Logistic Regression

- The logistic regression model assumes:
  - Outcome is a binary or dichotomous variable
  - There is a linear relationship between the logit of the outcome and each predictor variables
  - There is no influential values (extreme values or outliers) in the continuous predictors
  - There are no high correlations (multi-collinearity) among the predictors

Source: Dr. Shofiqul Islam, McMaster University

Logistic Regression

- Goodness of fit is examined using
  - Measures of predictive ability:
    - Pseudo R^2 by McFadden (1974)
    - Generalized R^2 by Cox-Snell (1989)
    - Tjur (2009) coefficient of discrimination
    - Diagnostic test criteria - sensitivity/specificity, area under the ROC curve
- Goodness of fit statistics –
  - Deviance and Pearson chi-squared statistics
  - Hosmer-Lemeshow (1980) test
- Information criteria – Akaike (AIC) & Bayesian (BIC)

Source: Dr. Shofiqul Islam, McMaster University

Machine learning

Machine learning involves showing a large volume of data to a machine/model so that it can learn and make predictions, find patterns, or classify data.

Source: coursera.org

Types of machine learning

Basically, machine learning are three types.

Supervised

Unsupervised

Reinforcement learning.

Source: coursera.org

Supervised learning

Machine learning ***feeds historical input and output data*** *in machine learning algorithms, with processing in between each input/output pair that allows the algorithm to shift the model* ***to create outputs as closely aligned with the desired result as possible****.*

Common algorithms used during supervised learning include linear regression, neural networks, decision trees, and support vector machines.

Source: coursera.org

Unsupervised learning

While supervised learning requires users to help the machine learn, unsupervised ***learning algorithms do not use the same labeled training sets and data****. Instead, the machine looks for less obvious patterns in the data.*

Unsupervised machine learning is very helpful when you need ***to identify patterns*** *and use data to make decisions.*

Common algorithms used in unsupervised learning include k-means clustering, and Gaussian mixture models.

Source: coursera.org

Reinforcement learning

Reinforcement learning is the closest machine learning type to how humans learn.

*The algorithm used **learns by interacting with its environment and getting a positive or negative reward**.*

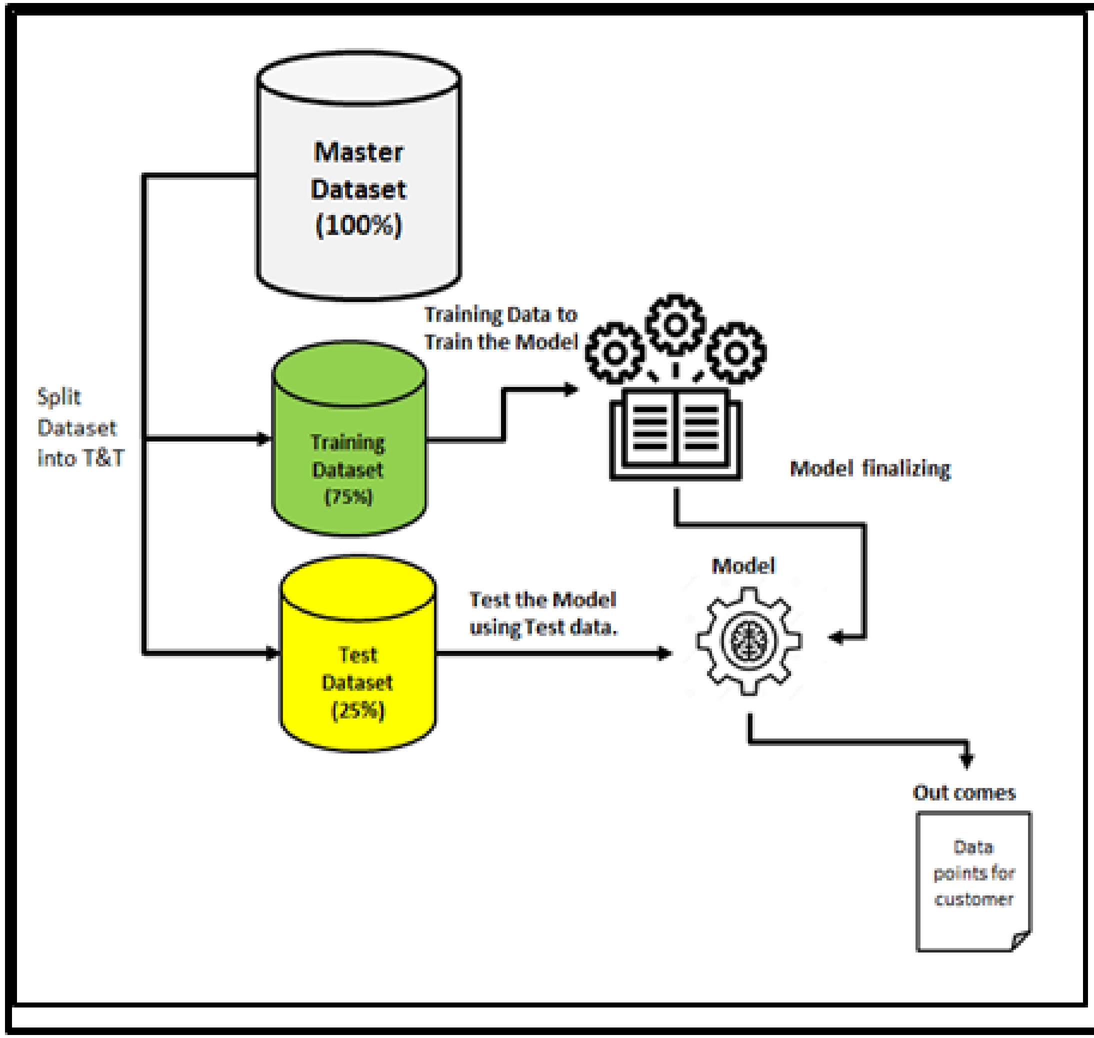
Common algorithms include temporal difference, and Q-learning.

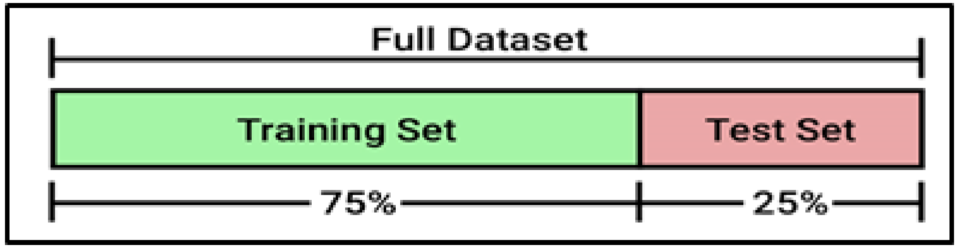
Source: coursera.org

Logistic regression

- A supervised machine learning
- Learns from labeled data
- Make predictions on unseen data

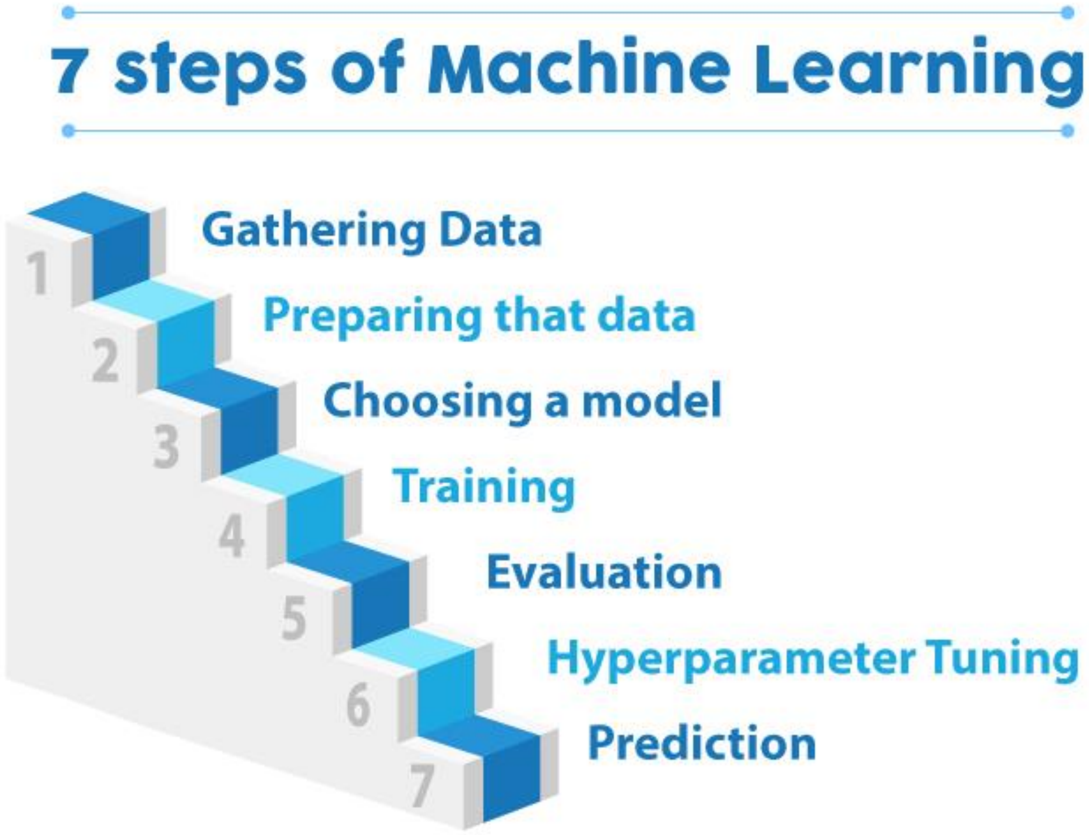
Steps of ML





https://www.analyticsvidhya.com/

Steps of ML including tuning



7 steps of Machine Learning

1. Gathering Data
2. Preparing that data
3. Choosing a model
4. Training
5. Evaluation
6. Hyperparameter Tuning
7. Prediction

www.mygreatlearning.com

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Contact DASH: Data Analysis Support Hub: libdash@mcmaster.ca

Let move to the coding part

https://colab.research.google.com/drive/1iOvC52mkSdQ-EkNQZFSi-O9y05YSRSMs#scrollTo=yi7vfdCrHQaU