Assignment No. 05

Aim:

Data Analytics II

1. Implement logistic regression using Python/R to perform classification on Social_Network_Ads.csv dataset.
2. Compute Confusion matrix to find TP, FP, TN, FN, Accuracy, Error rate, Precision,

Recall on the given dataset.Prerequisites:

1. Prior knowledge of Python programming.
2. Google Colab / Python IDE
3. Jupyter Notebook

Objectives: to Compute Confusion matrix to find TP, FP, TN, FN, Accuracy, Error rate, Precision,Recall on the given dataset

Theory:

1. Importing Libraries

Social_Network_Ads.csv dataset.

```
import os
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt                      # Importing the required libra
ries
import seaborn as sns
%matplotlib inline
```

Logistic Regression : Logistic regression is a supervised learning algorithm used to predict a dependent categorical target variable. In essence, if you have a large set of data that you want to categorize, logistic regression may be able to help. It is used in statistical software to understand the relationship between the dependent variable and one or more independent variables by estimating probabilities using a logistic regression equation. This type of analysis can help you predict the likelihood of an event happening or a choice being made.

1. **Logistic Regression:** Classification techniques are an essential part of machine learning and data mining applications. Approximately 70% of problems in Data Science are classification problems. There are lots of classification problems

that are available, but logistic regression is common and is a useful regression method for solving the binary classification problem. Another category of classification is Multinomial classification, which handles the issues where multiple classes are present in the target variable. For example, the IRIS dataset is a very famous example of multi-class classification. Other examples are classifying article/blog/document categories. Logistic Regression can be used for various classification problems such as spam detection. Diabetes prediction, if a given customer will purchase a particular product or will they churn another competitor, whether the user will click on a given advertisement link or not, and many more examples are in the bucket. Logistic Regression is one of the most simple and commonly used Machine Learning algorithms for two-class classification. It is easy to implement and can be used as the baseline for any binary classification problem. Its basic fundamental concepts are also constructive in deep learning. Logistic regression describes and estimates the relationship between one dependent binary variable and independent variables

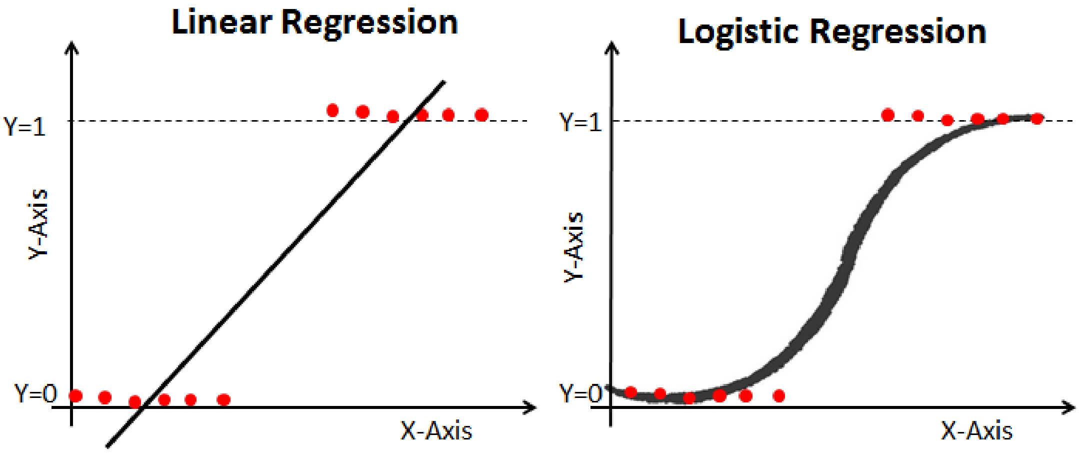
2. Logistic regression is a statistical method for predicting binary classes. The outcome or target variable is dichotomous in nature. Dichotomous means there are only two possible classes. For example, it can be used for cancer detection problems. It computes the probability of an event occurring. It is a special case of linear regression where the target variable is categorical in nature. It uses a log of odds as the dependent variable. Logistic Regression predicts the probability of occurrence of a binary event utilising a logit function.

   Linear Regression Equation: Where, y is a dependent variable and x1, x2 ... and Xn are explanatory variables.

   Sigmoid Function:

Apply Sigmoid function on linear regression:

2. Differentiate between Linear and Logistic Regression Linear regression gives you a continuous output, but logistic regression provides a constant output. An example of the continuous output is house price and stock price. Example's of the discrete output is predicting whether a patient has cancer or not, predicting whether the customer will churn. Linear regression is estimated using Ordinary Least Squares (OLS) while logistic regression is estimated using Maximum Likelihood Estimation (MLE) approach.

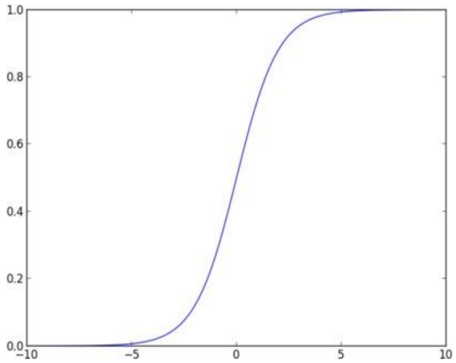


1. Sigmoid Function

The sigmoid function, also called logistic function, gives an 'S' shaped curve that can take any real-valued number and map it into a value between 0 and 1. If the curve goes to positive infinity, y predicted will become 1, and if the curve goes to negative infinity, y predicted will become 0. If the output of the sigmoid function is more than 0.5, we can classify the outcome as 1 or YES, and if it is less than 0.5, we can classify it as 0 or NO. The outputcannotFor example: If the output is 0.75, we can say in terms of probability as: There is a 75 percent chance that a patient will suffer from cancer.

$$f(x) = \frac{1}{1+\mathrm{e}^{-(x)}}$$

1. Types of LogisticRegression



Binary Logistic Regression: The target variable has only two possible outcomes such asSpam or Not Spam, Cancer or No Cancer.

Multinomial Logistic Regression: The target variable has three or more nominal categories such as predicting the type of Wine.

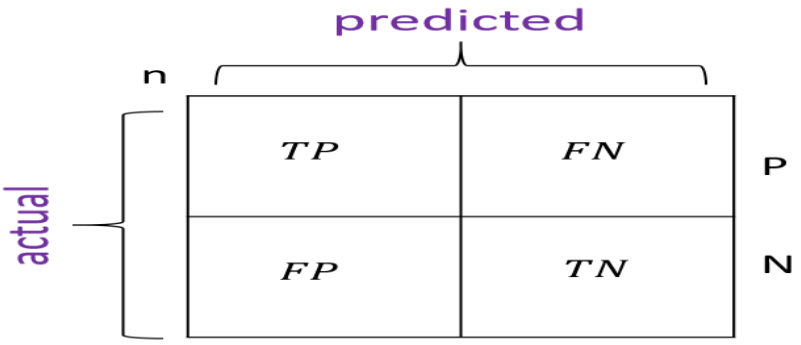
Ordinal Logistic Regression: the target variable has three or more ordinal categoriessuch as restaurant or product rating from 1 to 5.

Steps:

```
1. #To check if the data is equally balanced between the target classes
2. #Defining features and target variable
3. #Splitting the data into train and test set
4. #Predicting using Logistic Regression for Binary classification
5. #Evaluation of Model - Confusion Matrix Plot
6. # Plot non-normalized confusion matrix
7. #extracting true_positives, false_positives, true_negatives, false_negatives
8. #Accuracy #Precision #Recall #F1 Score
```

Confusion Matrix Definition

A confusion matrix is used to judge the performance of a classifier on the test dataset for which we already know the actual values. Confusion matrix is also termed as Error matrix. It consists of a count of correct and incorrect values broken down by each class. It not only tells us the error made by classifier but also tells us what type of error the classifier made. So, we can say that a confusion matrix is a performance measurement technique of a classifier model where output can be two classes or more. It is a table with four different groups of true and predicted values.



Confusion matrix

Terminologies in Confusion Matrix

The confusion matrix shows us how our classifier gets confused while predicting. In a confusion matrix we have four important terms which are:

1. **True Positive (TP)**
2. **True Negative (TN)**
3. **False Positive (FP)**
4. **False Negative (FN)**

True Positive (TP)

Both actual and predicted values are Positive.

True Negative (TN)

Both actual and predicted values are Negative.

False Positive (FP)

The actual value is negative but we predicted it as positive.

False Negative (FN)

The actual value is positive but we predicted it as negative.

Performance Metrics

Confusion matrix not only used for finding the errors in prediction but is also useful to find some important performance metrics like Accuracy, Recall, Precision, F-measure. We will discuss these terms one by one.

Accuracy

As the name suggests, the value of this metric suggests the accuracy of our classifier in predicting results.

It is defined as:

Accuracy = (TP + TN) / (TP + TN + FP + FN)

A 99% accuracy can be good, average, poor or dreadful depending upon the problem.

Precision

Precision is the measure of all actual positives out of all predicted positive values.

It is defined as:

Precision = TP / (TP + FP)

Recall

Recall is the measure of positive values that are predicted correctly out of all actual positive values.

It is defined as:

Recall = TP / (TP + FN)

High Value of Recall specifies that the class is correctly known (because of a small number of False Negative).

F-measure

It is hard to compare classification models which have low precision and high recall or vice versa. So, for comparing the two classifier models we use F-measure. F-score helps to find the metrics of Recall and Precision in the same interval. Harmonic Mean is used instead of Arithmetic Mean.

F-measure is defined as:

F-measure = 2 * Recall * Precision / (Recall + Precision)

The F-Measure is always closer to the Precision or Recall, whichever has a smaller value.

Calculation of 2-class confusion matrix

Let us derive a confusion matrix and interpret the result using simple mathematics.

Let us consider the actual and predicted values of y as given below:

Actual y	Y predicted	Predicted y with threshold 0.5
1	0.7	1
0	0.1	0
0	0.6	1
1	0.4	0
0	0.2	0

Now, if we make a confusion matrix from this, it would look like:

N=5	Predicted 1	Predicted 0
Actual: 1	1 (TP)	1 (FN)
Actual: 0	1 (FP)	2 (TN)

This is our derived confusion matrix. Now we can also see all the four terms used in the above confusion matrix. Now we will find all the above-defined performance metrics from this confusion matrix.

Accuracy

Accuracy = (TP + TN) / (TP + TN + FP + FN)

So, Accuracy = (1+2) / (1+2+1+1)

= 3/5 which is 60%.

So, the accuracy from the above confusion matrix is 60%.

Precision

Precision = TP / (TP + FP)

= 1 / (1+1)

=1 / 2 which is 50%.

So, the precision is 50%.

Recall

Recall = TP / (TP + FN)

= 1 / (1+1)

= ½ which is 50%

So, the Recall is 50%.

F-measure

F-measure = 2 * Recall * Precision / (Recall + Precision)

= 2*0.5*0.5 / (0.5+0.5)

= 0.5

So, the F-measure is 50%.

Conclusion:

Thus we have computed Confusion matrix to find TP, FP, TN, FN, Accuracy, Error rate, Precision,Recall on the given dataset(Social_Network_Ads.csv)