## Logistic Regression (Binary Classifier):

Logistic Regression is a regression model where the dependent variable is categorical. In our project, the dependent variable is binary, hence indicating a Binary Classifier form of logistic regression. In binary classification, the dependent variable can take up only two values, ‘0’ or ‘1’. Such a representation is indicative of tackling problems such as pass/fail, accepted/rejected and so on.

Sigmoid function-
The output vector will only be 0 or 1 i.e. $y \in \{0,1\}$**.** The hypothesis function h(x) must satisfy $0<h(x)<1$. In order to map h(x) to the interval (0,1) we use the sigmoid function, also known as the logistic function.

$$h_\theta(x) = g(\theta^T x)$$

$$z = \theta^T x$$
$$g(z) = \frac{1}{1+e^{-z}}$$

The function g(z) known as the sigmoid function, maps any real number to the (0,1) interval. We use sigmoid function to determine the probability of the output given a particular input.

Cost Function-

The cost function for the logistic regression is as follows-

$$J(\theta) = \frac{1}{m}\sum_{i=1}^{m} \text{Cost}(h_\theta(x^{(i)}), y^{(i)})$$
$$\text{Cost}(h_\theta(x), y) = -\log(h_\theta(x)) \qquad \text{if y} = 1$$
$$\text{Cost}(h_\theta(x), y) = -\log(1 - h_\theta(x)) \qquad \text{if y} = 0$$

The above two forms of the cost function can be clubbed into one single equation as shown below,

$$\text{Cost}(h_\theta(x), y) = -y \ \log(h_\theta(x)) - (1-y)\log(1-h_\theta(x))$$

Vectorized implementation is as shown below,

$$h = g(X\theta)$$
$$J(\theta) = \frac{1}{m} \cdot \left(-y^T \log(h) - (1-y)^T \log(1-h)\right)$$

Gradient Descent-

General form of gradient descent,

$$
\begin{aligned}
&Repeat\ \{ \\
&\theta_j := \theta_j - \alpha \frac{\partial}{\partial \theta_j} J(\theta) \\
&\}
\end{aligned}
$$

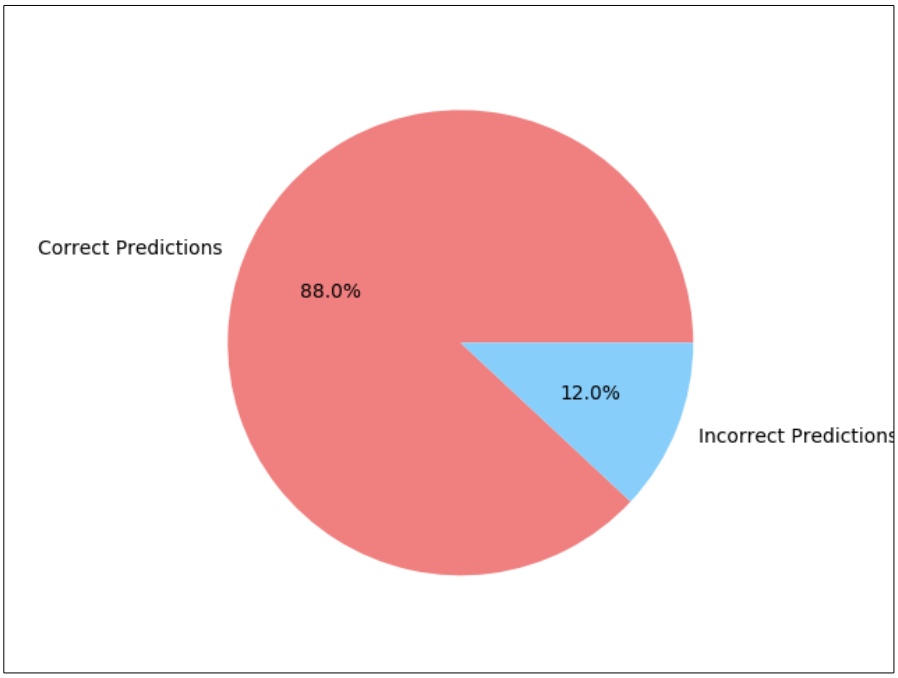
Vectorized implementation,

$$\theta := \theta - \frac{\alpha}{m} X^T (g(X\theta) - \vec{y})$$

Features used for Banking Dataset:

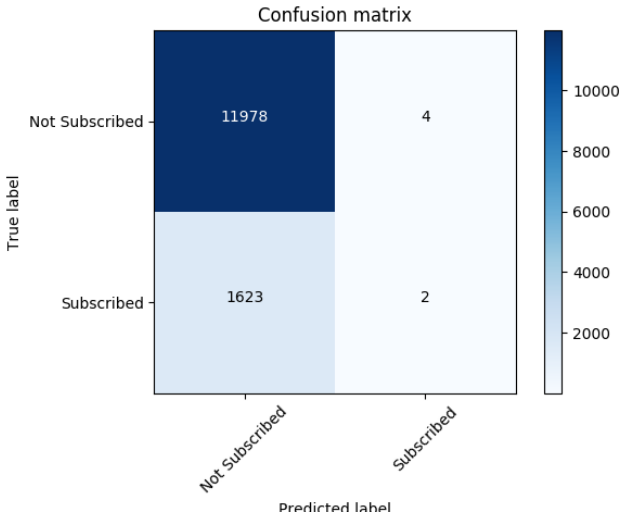
| | |
|---|---|
| Age | (numeric) |
| Job | type of job (categorical: 'admin.','blue-collar','entrepreneur','housemaid','management','retired','self-employed','services','student','technician','unemployed','unknown') |
| Marital | marital status (categorical: 'divorced','married','single','unknown'; note: 'divorced' means divorced or widowed) |
| Education | (categorical: 'basic.4y','basic.6y','basic.9y','high.school','illiterate','professional.course','university.degree','unknown') |
| Defaulter | has credit in default? (categorical: 'no','yes','unknown') |
| Housing | has housing loan? (categorical: 'no','yes','unknown') |
| Loan | has personal loan? (categorical: 'no','yes','unknown') |
| Contact | contact communication type (categorical: 'cellular','telephone') |
| Duration | last contact duration, in seconds (numeric). |
| Campaign | number of contacts performed during this campaign and for this client (numeric, includes last contact) |
| Pdays | number of days that passed by after the client was last contacted from a previous campaign |
| Previous | number of contacts performed before this campaign and for this client (numeric) |
| Poutcome | outcome of the previous marketing campaign (categorical: 'failure','nonexistent','success') |

Logistic Regression Accuracy-

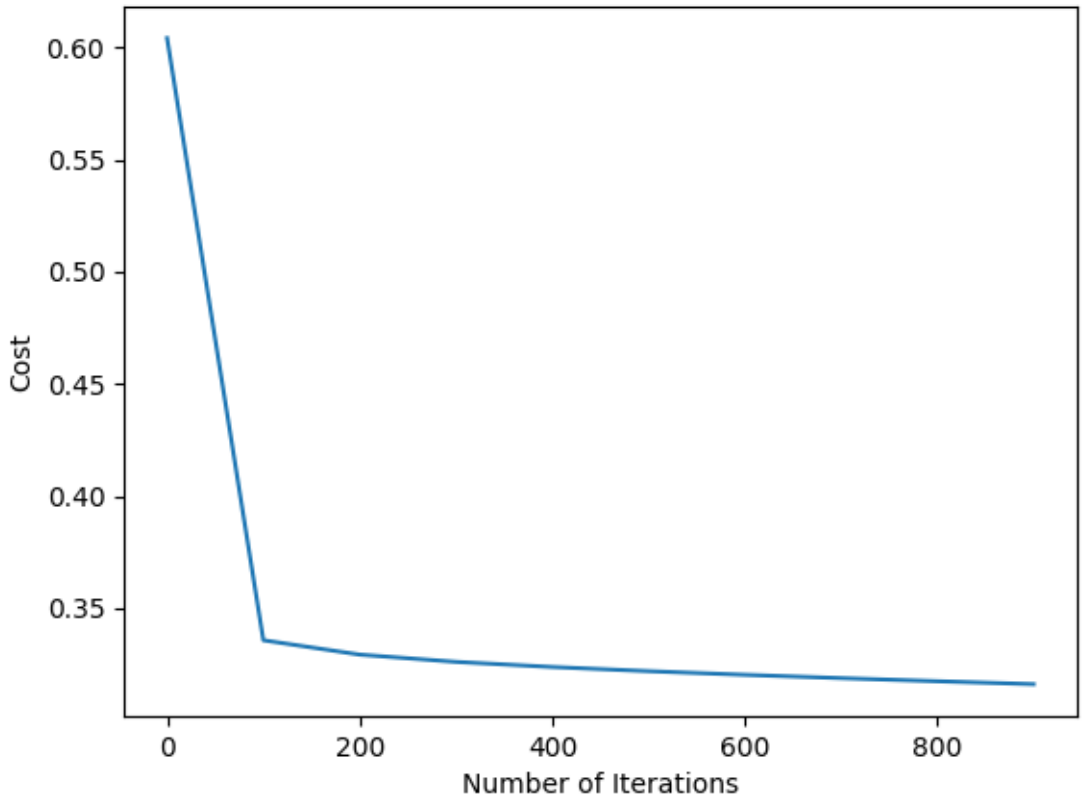



Performing One-Hot encoding on categorical features increases the accuracy by 3%. This is because in Label encoding the categorical classes are encoded into numeric values. In such a case higher the numerical value of the categorical class, higher is its impact on the outcome. Hence using One-Hot encoding will eliminate such a case by binarizing the categorical values.

Confusion Matrix-



Cost vs Number of Iterations -




Execution Instructions -

Run the following commands,

spark-submit LogisticRegression.py

Note: Ensure the dataset .csv file is in the same directory as that of Logisticregression.py