

| Write-up | Correctness of Program | Documentation of Program | Viva | Timely Completion | Total | Dated Sign of Subject Teacher |
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Expected Date of Completion:..... Actual Date of Completion:.....

Group A

Assignment No: 6

Title of the Assignment:

1. Implement Simple Naïve Bayes classification algorithm using Python/R on iris.csv dataset.
2. Compute Confusion matrix to find TP, FP, TN, FN, Accuracy, Error rate, Precision, Recall on the given dataset.

Objective of the Assignment: Students should be able to data analysis using Naïve Bayes classification algorithm using Python for any open source dataset

Prerequisite:

1. Basic of Python Programming
2. Concept of Join and Marginal Probability.

Contents for Theory:

1. Concepts used in Naïve Bayes classifier
2. Naïve Bayes Example
3. Confusion Matrix Evaluation Metrics

1. Concepts used in Naïve Bayes classifier

- Naïve Bayes Classifier can be used for Classification of categorical data.
 - Let there be a 'j' number of classes. $C=\{1,2,\dots,j\}$
 - Let, input observation is specified by 'P' features. Therefore input observation x is given , $x = \{F1,F2,\dots,Fp\}$
 - The Naïve Bayes classifier depends on Bayes' rule from probability theory.
- Prior probabilities: Probabilities which are calculated for some event based on no other information are called Prior probabilities.

For example, $P(A)$, $P(B)$, $P(C)$ are prior probabilities because while calculating $P(A)$, occurrences of event B or C are not concerned i.e. no information about occurrence of any other event is used.

Conditional Probabilities:

$$P\left(\frac{A}{B}\right) = \frac{P(A \cap B)}{P(B)} \quad \text{if } P(B) \neq 0 \quad \dots \dots (1)$$

$$P\left(\frac{B}{A}\right) = \frac{P(B \cap A)}{P(A)} \quad \dots \dots (2)$$

From equation (1) and (2) ,

$$P(A \cap B) = P\left(\frac{A}{B}\right) \cdot P(B) = P\left(\frac{B}{A}\right) \cdot P(A)$$

$$\therefore P\left(\frac{A}{B}\right) = \frac{P\left(\frac{B}{A}\right) \cdot P(A)}{P(B)}$$

Is called the Bayes Rule.

2. Example of Naive Bayes

We have a dataset with some features Outlook, Temp, Humidity, and Windy, and the target here is to predict whether a person or team will play tennis or not.

| Outlook | Temp | Humidity | Windy | Play |
|----------|------|----------|-------|------|
| sunny | hot | high | FALSE | no |
| sunny | hot | high | TRUE | no |
| overcast | hot | high | FALSE | yes |
| rainy | mild | high | FALSE | yes |
| rainy | cool | normal | FALSE | yes |
| rainy | cool | normal | TRUE | no |
| overcast | cool | normal | TRUE | yes |
| sunny | mild | high | FALSE | no |
| sunny | cool | normal | FALSE | yes |
| rainy | mild | normal | FALSE | yes |
| sunny | mild | normal | TRUE | yes |
| overcast | mild | high | TRUE | yes |
| overcast | hot | normal | FALSE | yes |
| rainy | mild | high | TRUE | no |

$$X = [\text{Outlook}, \text{Temp}, \text{Humidity}, \text{Windy}]$$

$$\begin{array}{cccc} \underbrace{\hspace{1.5cm}} & \underbrace{\hspace{1.5cm}} & \underbrace{\hspace{1.5cm}} & \underbrace{\hspace{1.5cm}} \\ x_1 & x_2 & x_3 & x_4 \end{array}$$

$$C_k = [\text{Yes}, \text{No}]$$

$$\begin{array}{cc} \underbrace{\hspace{1.5cm}} & \underbrace{\hspace{1.5cm}} \\ C_1 & C_2 \end{array}$$

Conditional Probability

Here, we are predicting the probability of class1 and class2 based on the given condition. If I try to write the same formula in terms of classes and features, we will get the following equation

$$P(C_k | X) = \frac{P(X | C_k) * P(C_k)}{P(X)}$$

Now we have two classes and four features, so if we write this formula for class C1, it will be something like this.

$$P(C_1 | x_1 \cap x_2 \cap x_3 \cap x_4) = \frac{P(x_1 \cap x_2 \cap x_3 \cap x_4 | C_1) * P(C_1)}{P(x_1 \cap x_2 \cap x_3 \cap x_4)}$$

Here, we replaced Ck with C1 and X with the intersection of X1, X2, X3, X4. You might have a question, It's because we are taking the situation when all these features are present at the same time.

The Naive Bayes algorithm assumes that all the features are independent of each other or in other words all the features are unrelated. With that assumption, we can further simplify the above formula and write it in this form

$$P(C_1 | x_1 \cap x_2 \cap x_3 \cap x_4) = \frac{P(x_1 | C_1) * P(x_2 | C_1) * P(x_3 | C_1) * P(x_4 | C_1) * P(C_1)}{P(x_1) * P(x_2) * P(x_3) * P(x_4)}$$

This is the final equation of the Naive Bayes and we have to calculate the probability of both C1 and C2. For this particular example.

| Outlook | Temp | Humidity | Windy | Play |
|---------|------|----------|-------|------|
| Rainy | Cool | High | True | ? |

$$P(Yes | X) = P(Rainy | Yes) \times P(Cool | Yes) \times P(High | Yes) \times P(True | Yes) \times P(Yes)$$

$$P(Yes | X) = 2/9 \times 3/9 \times 3/9 \times 3/9 \times 9/14 = 0.00529 \rightarrow 0.2 = \frac{0.00529}{0.02057 + 0.00529}$$

$$P(No | X) = P(Rainy | No) \times P(Cool | No) \times P(High | No) \times P(True | No) \times P(No)$$

$$P(No | X) = 3/5 \times 1/5 \times 4/5 \times 3/5 \times 5/14 = 0.02057 \rightarrow 0.8 = \frac{0.02057}{0.02057 + 0.00529}$$

$P(No | Today) > P(Yes | Today)$ So, the prediction that golf would be played is 'No'.

Algorithm (Iris Dataset):

Step 1: Import libraries and create alias for Pandas, Numpy and Matplotlib

Step 2: Import the Iris dataset by calling URL.

Step 3: Initialize the data frame

Step 4: Perform Data Preprocessing

- Convert Categorical to Numerical Values if applicable
- Check for Null Value

- Divide the dataset into Independent (X) and Dependent (Y) variables.
- Split the dataset into training and testing datasets
- Scale the Features if necessary.

Step 5: Use Naive Bayes algorithm(Train the Machine) to Create Model

```
# import the class
from sklearn.naive_bayes import GaussianNB
gaussian = GaussianNB()
gaussian.fit(X_train, y_train)
```

Step 6: Predict the y_pred for all values of train_x and test_x

```
Y_pred = gaussian.predict(X_test)
```

Step 7: Evaluate the performance of Model for train_y and test_y

```
accuracy = accuracy_score(y_test, Y_pred)
precision = precision_score(y_test, Y_pred, average='micro')
recall = recall_score(y_test, Y_pred, average='micro')
```

Step 8: Calculate the required evaluation parameters

```
from sklearn.metrics import
precision_score, confusion_matrix, accuracy_score, recall_score
cm = confusion_matrix(y_test, Y_pred)
```

Conclusion:

In this way we have done data analysis using Naive Bayes Algorithm for Iris dataset and evaluated the performance of the model.

Value Addition: Visualising Confusion Matrix using Heatmap**Assignment Question:**

- 1) Consider the observation for the car theft scenario having 3 attributes colour, Type and origin.

| Example No. | Color | Type | Origin | Stolen? |
|-------------|--------|--------|----------|---------|
| 1 | Red | Sports | Domestic | Yes |
| 2 | Red | Sports | Domestic | No |
| 3 | Red | Sports | Domestic | Yes |
| 4 | Yellow | Sports | Domestic | No |
| 5 | Yellow | Sports | Imported | Yes |
| 6 | Yellow | SUV | Imported | No |
| 7 | Yellow | SUV | Imported | Yes |
| 8 | Yellow | SUV | Domestic | No |
| 9 | Red | SUV | Imported | No |
| 10 | Red | Sports | Imported | Yes |

Find the probability of car theft having scenarios Red SUV and Domestic.

- 2) Write python code for the preprocessing mentioned in step 4. and Explain every step in detail.