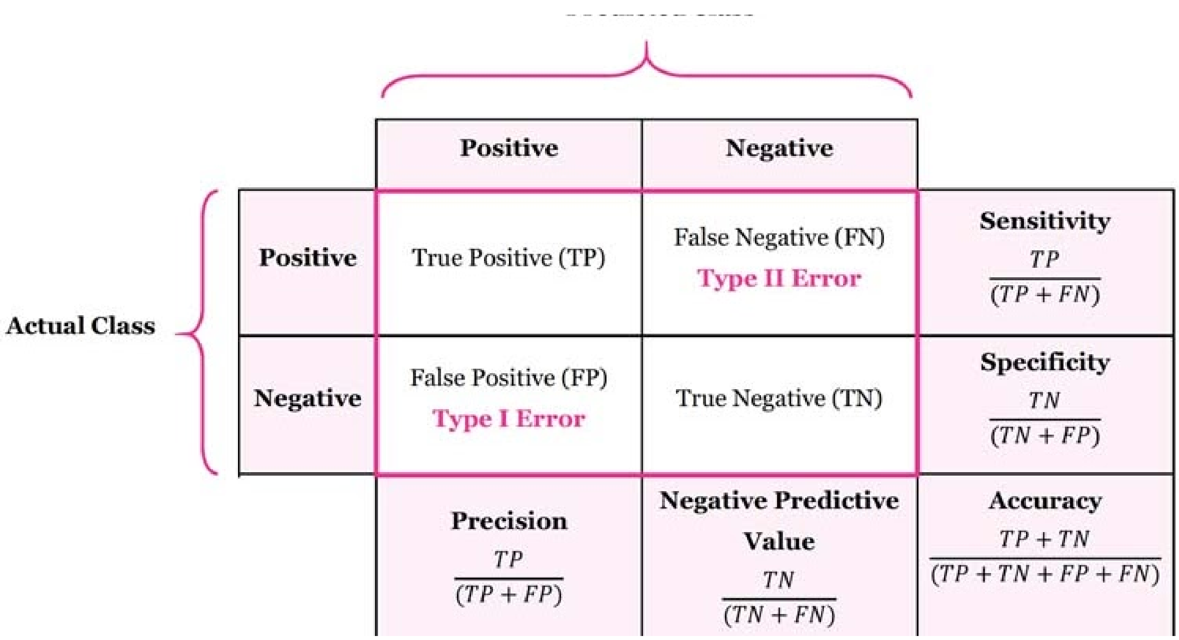
Day 15/100 of Data Science

Model Evaluation Techniques

What is a Confusion Matrix?

- A confusion matrix is a matrix that summarizes the performance of a machine learning model on a set of test data.
- It is a means of displaying the number of accurate and inaccurate instances based on the model's predictions.
- A Confusion matrix is an N x N matrix used for evaluating the performance of a classification model, where N is the number of target classes.
- The matrix compares the actual target values with those predicted by the machine learning model.



The matrix displays the number of instances produced by the model on the test data.

- True positives (TP): occur when the model accurately predicts a positive data point.
- True negatives (TN): occur when the model accurately predicts a negative data point.
- True positives (FP): occur when the model predicts a positive data point incorrectly.

- False negatives (FN): occur when the model mispredicts a negative data point.

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Accuracy

- Accuracy is a metric that measures how often a machine learning model correctly predicts the outcome

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

Precision

- Precision is one indicator of a machine learning model's performance – the quality of a positive prediction made by the model.
- Precision refers to the number of true positives divided by the total number of positive predictions

$$\text{Precision} = \frac{TP}{TP + FP}$$

Recall or Sensitivity

- The recall is the measure of our model correctly identifying True Positives.

$$\text{Recall} = \frac{TP}{TP + FN}$$

F1 score

- F1 score is a measure of the harmonic mean of precision and recall.
- Commonly used as an evaluation metric in binary and multi-class classification

$$\text{F1 Score} = \frac{2}{\frac{1}{\text{Precision}} + \frac{1}{\text{Recall}}} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{F1 Score} = \frac{TP}{TP + \frac{1}{2}(FP + FN)}$$

Specificity

- Specificity itself can be described as the algorithm/model's ability to predict a true negative of each category available.

Specificity Formula

$$Specificity = \frac{TN}{TN + FP}$$

ROC curve

An ROC curve (receiver operating characteristic curve) is a graph showing the performance of a classification model at all classification thresholds. This curve plots two parameters:

- True Positive Rate
- False Positive Rate

True Positive Rate (TPR) is a synonym for recall and is therefore defined as follows:

$$TPR = \frac{TP}{TP + FN}$$

$$FPR = \frac{FP}{FP + TN}$$

False Positive Rate (FPR) is defined as follows:

- An ROC curve plots TPR vs. FPR at different classification thresholds.
- Lowering the classification threshold classifies more items as positive, thus increasing both False Positives and True Positives.
- The following figure shows a typical ROC curve.

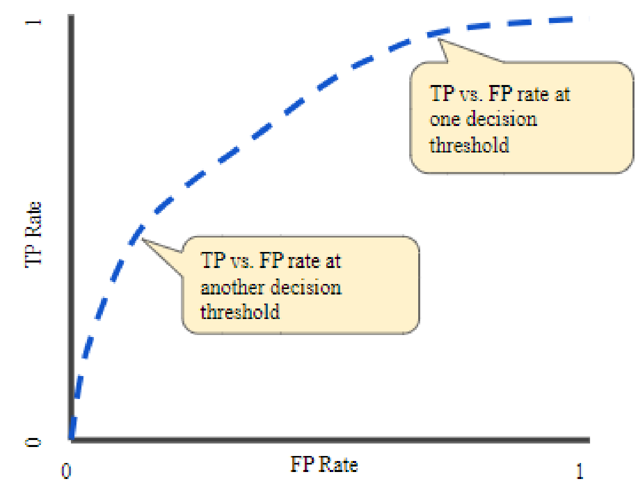

Figure 4. TP vs. FP rate at different classification thresholds.

AUC: Area Under the ROC Curve

- AUC stands for "Area under the ROC Curve."
- That is, AUC measures the entire two-dimensional area underneath the entire ROC curve (think integral calculus) from (0,0) to (1,1).

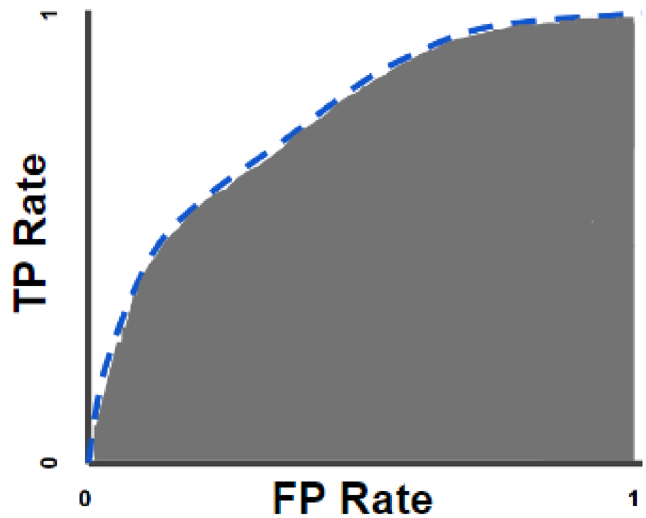

Figure 5. AUC (Area under the ROC Curve).

Mean Squared Error

- In Statistics, Mean Squared Error (MSE) is defined as Mean or Average of the square of the difference between actual and estimated values.

MSE Formula

The formula for MSE is the following.

$$MSE = \frac{\sum(y_i - \hat{y}_i)^2}{n}$$

Where:

- yi is the ith observed value.
- ŷi is the corresponding predicted value.
- n = the number of observations.

The Root Mean Squared Error (RMSE)

- The Root Mean Squared Error (RMSE) is one of the two main performance indicators for a regression model.

- It measures the average difference between values predicted by a model and the actual values.
- It provides an estimation of how well the model is able to predict the target value (accuracy).

$$\mathrm{RMSD} = \sqrt{\frac{\sum_{i=1}^{N}\left(x_i - \hat{x}_i\right)^2}{N}}$$

RMSD	= root-mean-square deviation
i	= variable i
N	= number of non-missing data points
x_i	= actual observations time series
$\hat{x}_i$	= estimated time series

R squared (R2)

- R squared (R2) is a regression error metric that justifies the performance of the model.
- It represents the value of how much the independent variables are able to describe the value for the response/target variable.

$$R^2 = 1 - \frac{SS_{RES}}{SS_{TOT}} = 1 - \frac{\sum_i (y_i - \hat{y}_i)^2}{\sum_i (y_i - \overline{y})^2}$$

Where:

- **$SS_{regression}$** is the sum of squares due to regression (explained sum of squares)
- **SS_{total}** is the total sum of squares

Mean Absolute Error (MAE)

- It is the arithmetic average of the absolute difference between predicted and actual values

$$\mathrm{MAE} = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n}$$

MAE = mean absolute error

y_i = prediction

x_i = true value

n = total number of data points

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Github: https://github.com/Vamsi-2203

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