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Performance measurement of Models

1) **Accuracy Score:** It's a measure or a matrix to check the accuracy of the classification model

$$Accuracy\ Score = \frac{Total\ no\ of\ correctly\ classified\ points}{Total\ number\ of\ points}$$

Problem with Accuracy Score

i) Imbalance Dataset
   a. Where we have one class in majority (If the transaction is fraudulent or not, there will be roughly 5-10% transactions as fraudulent but rest will be non-fraudulent)
   b. We are giving more non-fraudulent transactions to machine for learning, the chances will be high your machine will predict a fraudulent transaction as a non-fraudulent.
   c. 90% - non-Fraudulent / 10% - Fraudulent – 100% Non-Fraudulent
   d. There will be a high chance that the model will be a dumb model and the accuracy will come as 90% which is wrong.

ii) Model Comparison: In the model comparison accuracy score will not help us to understand which model is the best as it does not consider probability.

X	Y	M1	M2	$\widehat{Y_1}$	$\widehat{Y_2}$
1	1	0.9	0.6	1	1
2	1	0.8	0.55	1	1
3	0	0.1	0.45	0	0
4	0	0.15	0.48	0	0

2) **Confusion Matrix**

	0 (Prediction)	**1 (Prediction)**	
0 (Actual)	A (TN)	B (FP)	**TN+FP = N**
1 (Actual)	C (FN)	D (TP)	**FN+TP = P**

A+B+C+D = Total number of records

A+B = Total no of negative records in the actual data

C+D = Total no of positive records in the actual data

A+C = Total no of negative records in the prediction

B+D = Total no of positive records in the prediction

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A+D/A+B+C+D = Accuracy score

A = TN = True Negatives

D = TP = True Positives

C = FN = False Negatives

B = FP = False Positives

TN + TP = Total number of correct classification

FN + FP = Total number of wrong classification

FN + TP = Total number of Positives in the dataset

FP + TN = Total number of negatives in the dataset

- **TPR (True positive rate) = TP/P (TP/TP+FN)**
  Total number of correctly classified Positive points upon total number of positive points in the dataset
- **TNR (True negative rate) = TN/N (TN/TN+FP)**
  Total number of correctly classified negative points upon total number of negative points in the dataset
- **FPR (False positive rate) = FP/N (FP/TN+FP)**
  Total number of incorrectly classified as Positive points upon total number of negative points in the dataset
- **FNR (False negative rate) = FN/P (FN/TP+FN)**
  Total number of incorrectly classified as negative points upon total number of positive points in the dataset

When TPR and TNR is high my model is good it's a sensible model

When FNR and FPR is high my model is not good

Problem with these 4 ratios

	(NF) 0 (Prediction)	(F) 1 (Prediction)
(NF) 0 (Actual)	900	0
(F) 1 (Actual)	100	0

TPR = 0

TNR = 1

FPR = 0

FNR = 1

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Dumb model

Cancer patients:

Patient is having a cancer as per the model but actually he is not having the cancer – Better

The further tests will happen

Patient is not having the cancer as per the model but actually he is having the cancer – Not good

	(NC) 0 (Prediction)	(C) 1 (Prediction)
(NC) 0 (Actual)	A	B (High – OK)
(C) 1 (Actual)	C (Low - Good)	D (High – Good)

B = Patient is having a cancer as per the model but actually he is not having the cancer – Better

C = Patient is not having the cancer as per the model but actually he is having the cancer – Problem

We are looking for High TPR and very low FNR

If FPR is high its ok as we can go with more powerful tests

3) **Precision and Recall**

	0 (Prediction)	1 (Prediction)	
0 (Actual)	A (TN)	B (FP)	TN+FP = N
1 (Actual)	C (FN)	D (TP)	FN+TP = P

Precision: TP/TP+FP

Out of total number of points predicted as positive what %age of points is actually positive

Recall: True positive rate (TPR) = TP/TP+FN

Total number of correctly classified Positive points upon total number of positive points in the dataset

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F1-Score = $(2 * \frac{PRECISION * RECALL}{PRECISION + RECALL})$

The value of F1 score – 0 to 1 (More towards 1 better the model is , more towards 0 worst the model is)

Cancer patients:

We want high recall if we are looking for the cancerous patients prediction

We are allowed to have a low precision as we can go with further tests

	(NC) 0 (Prediction)	(C) 1 (Prediction)
(NC) 0 (Actual)	A	B (High – OK)
(C) 1 (Actual)	C (Low - Good)	D (High – Good)

4) ROC (Receiver operating characteristics curve) / AUC (Area under the curve)

Electronics and Radio engineers – 2nd world war – They wanted to predict how well your missile working

X	Y	$\widehat{Y_p}$
1	1	0.95
2	1	0.92
3	0	0.80
4	1	0.76
5	1	0.71

Step1: Take the data and sort $\widehat{Y_p}$ Predicted in descending order

Step2: Take the first predicted value as a threshold = 0.95

X	Y	$\widehat{Y_p}$	$\widehat{Y_{T1}}$	TPR @ T1	FPR @ T1
1	1	0.95	1		
2	1	0.92	0		
3	0	0.80	0		
4	1	0.76	0		
5	1	0.71	0		

X	Y	$\widehat{Y_p}$	$\widehat{Y_{T2}}$	TPR @ T2	FPR @ T2
1	1	0.95	1		
2	1	0.92	1		

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3	0	0.80	0		
4	1	0.76	0		
5	1	0.71	0		

X	Y	$\widehat{Y_p}$	$\widehat{Y_{T3}}$	TPR @ T3	FPR @ T3
1	1	0.95	1		
2	1	0.92	1		
3	0	0.80	1		
4	1	0.76	0		
5	1	0.71	0		

X	Y	$\widehat{Y_p}$	$\widehat{Y_{T4}}$	TPR @ T4	FPR @ T4
1	1	0.95	1		
2	1	0.92	1		
3	0	0.80	1		
4	1	0.76	1		
5	1	0.71	0		

X	Y	$\widehat{Y_p}$	$\widehat{Y_{T5}}$	TPR @ T5	FPR @ T5
1	1	0.95	1		
2	1	0.92	1		
3	0	0.80	1		
4	1	0.76	1		
5	1	0.71	1		

TPR (Y)	FPR (X)
TPR@T1	FPR@T1
TPR@T2	FPR@T2
TPR@T3	FPR@T3
TPR@T4	FPR@T4
TPR@T5	FPR@T5

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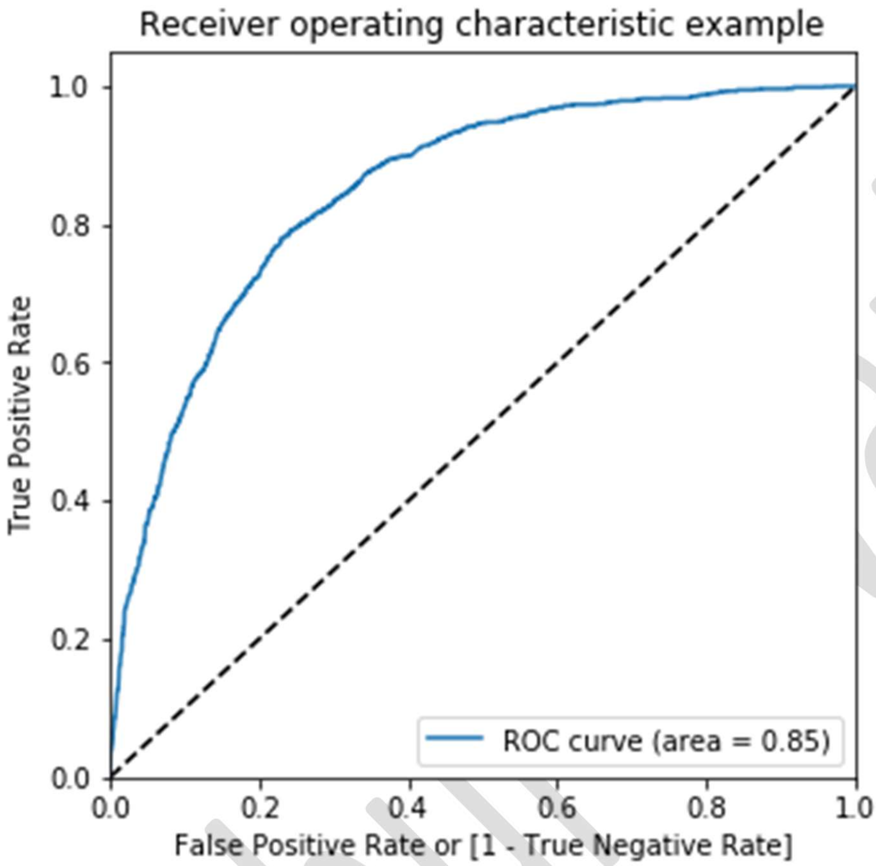
Plot the chart



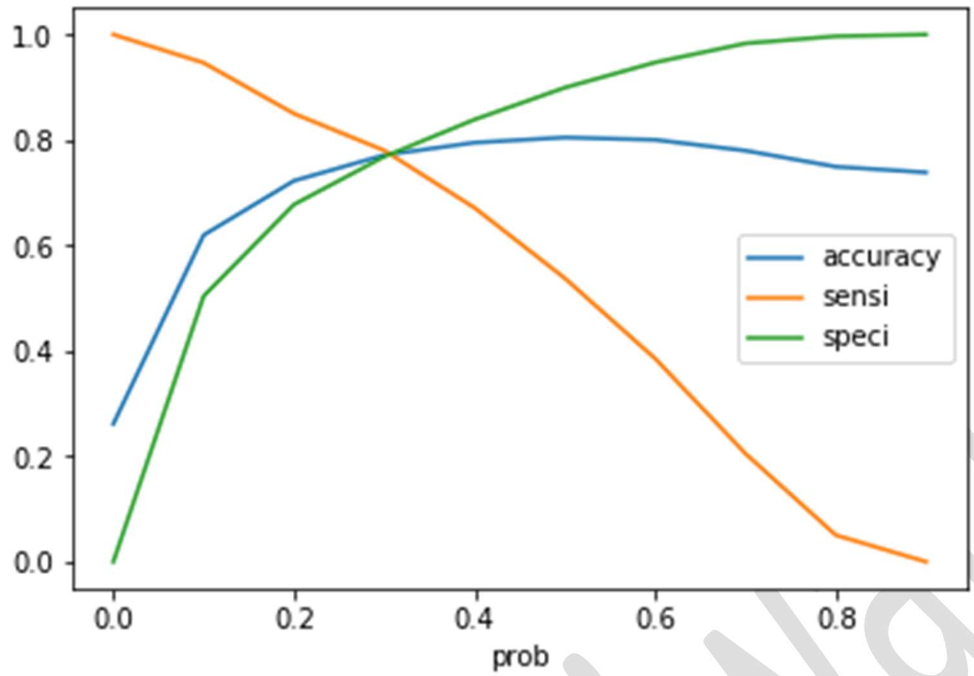
Sensitivity and Specificity

$$Sensitivity = \frac{No\ of\ actual\ yes\ correctly\ predicted\ (TP)}{No\ of\ actual\ Yes\ (FN + TP)}$$

Sensitivity is nothing but TPR

$$Specificity = \frac{No\ of\ actual\ Nos\ correctly\ predicted\ (TN)}{No\ of\ actual\ Nos\ (TN + FP)}$$

Specificity is nothing but TNR



From the above chart anything which is greater than the probability of 0.3 are positives and anything which is lesser than 0.3 are negatives