

CLASSIFICATION

METRICS - 1

Spam / Non Spam filter

Classification model

100 → 70 Non Spam
→ 30 Spam

}

⇒ Logistic Regression
Accuracy.

90% Accurate



Quiz time!

Quiz Ended!

if data1: 20 Cancer Patients and 100 non-Cancer Patients and data2: 80 Cancer Patients 100 non-Cancer Patients, then:

35 users have participated

A	Data1 = Imbalance, Data2 = balance	60%
B	Data1 = balance, Data2 = Imbalance	29%
C	Data1 = balance, Data2 = balance	3%
D	Data1 = Imbalance, Data2 = Imbalance	9%

fraud detection

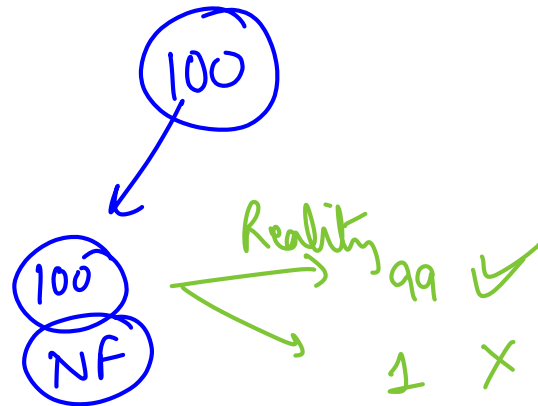
100 → 99 Genuine
1 Not Genuine / fraud.

Actual → 100 → 99 NF
1 F

$$\text{Accuracy} = \frac{99}{99 + 1} = 99\%$$

misleading in this case

dumbest Model



Problems

$$\text{Accuracy} = \frac{\# \text{ Correctly Classified}}{\text{Total \# Classified.}}$$

- ① Does not work with imbalance dataset.
- ② Fails to capture class wise performance.

y \hat{y}
 0 0 ✓

1 1 ✓

0 1 ✗
 1 0 ✗

$$\frac{2}{4} = \underline{\underline{50\%}}$$

Quiz time!

Quiz Ended!

$$\frac{\# \text{ Correctly Classified}}{\# \text{ Total}}$$

In the evaluation of a classification model, what does the accuracy metric represent?

35 users have participated

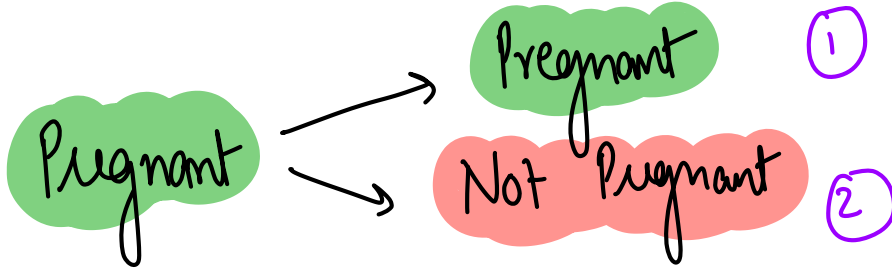
- A The model's ability to handle imbalanced datasets 3%
- B The precision of the model in predicting positive instances 0%
- C The ratio of true positive predictions to the total predictions 60%
- ✓ D The overall correctness of the model's predictions across all classes 37%

Classification Metrics

Pregnant positive
Not pregnant negative

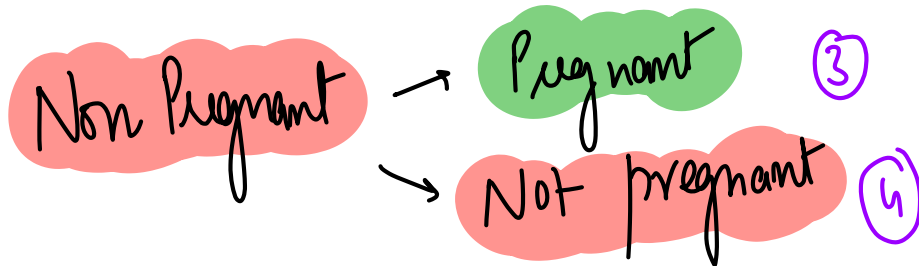
Actual

Prediction



TRUE POSITIVE

FALSE NEGATIVE
Type II error.



FALSE POSITIVE
Type I error

TRUE NEGATIVE

Confusion Matrix

predicted (\hat{y})

-ve
Not SPAM

+ve
SPAM

	0	1
0 NOT SPAM -ve	TN	FP Type I error
1 SPAM +ve	FN Type II error	TP

Actual
(y)

Spam (+ve) (1)

Nonspam (-ve) (0)

TP

$y = 1$

$\hat{y} = 1$

TN

$y = 0$

$\hat{y} = 0$

FP

$y = 0$

$\hat{y} = 1$

FN

$y = 1$

$\hat{y} = 0$

400

Actual (y)

360 NOT SPAM -ve	360 TN	0 FP
SPAM +ve 40	40 FN	0 TP

predicted (\hat{y})

-ve 400 NOT SPAM

+ve 0 SPAM

Actual 400

360 NS

40 S

dumbest model

Predicted

400

400 NS

0 S

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

$$= \frac{360 + 0}{360 + 0 + 40 + 0} = \frac{360}{400} = \underline{\underline{90\%}}$$

Cat dog elephant

+ve predicted -ve
Cat dog elephant .

Actual
Cat +ve
-ve
dog
elephant

	TP	FN	FN
	FP	<u>TN</u>	
	FP		<u>TN</u>

Cat or NonCat
+ve -ve

TP
TN

FP

FN

NC

F C
D C

C D/E

Quiz time!

🕒 Quiz Ended!

if model classifies students into classes A,B and C , then Confusion matrix looks like ?

34 users have participated





A	12 x 12	0%
B	2 x 2	0%
C	4 x 4	3%
✓ D	3 X 3	97%

400 \rightarrow 360 NS \rightarrow 360 TN
 \rightarrow 40 S \rightarrow 40 TP

Quiz time!

⌚ Quiz Ended!

Actual (y)

	predicted (\hat{y})	
	-ve Not SPAM	+ve SPAM
0 NOT SPAM -ve	 TN	 FP
1 SPAM +ve	 FN	 TP

For Ideal Model, which of the following is true?

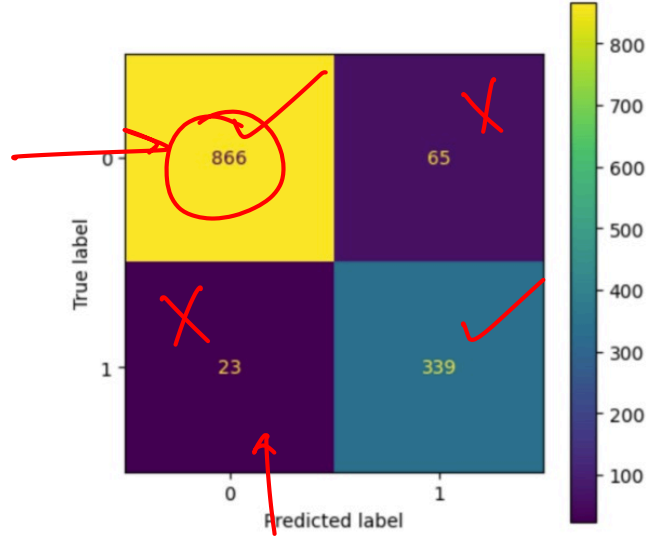
35 users have participated

- ☒ A FP and FN \downarrow , while TP and TN \uparrow 60%
- ☐ B TP and TN \downarrow , while FP and FN \uparrow 20%
- ☐ C TP and FN \downarrow , while FP and TN \uparrow 11%
- ☐ D FP and TN \downarrow , while TP and FN \uparrow 9%

Quiz time!

Quiz Ended!

Based on the Confusion matrix we saw, what is the total number of erroneous points?



$$65 + 23 = \underline{\underline{88}}$$

24 users have participated

- A 31 0%
- ✓ B 88 79% ✓
- C 106 8% ✓
- D 1187 13%

⇒ 2 Scenario

Spam +ve

NonSpam -ve

① Receiving spam email in your inbox → FN

② Receiving appraisal letter in spam folder. → FP

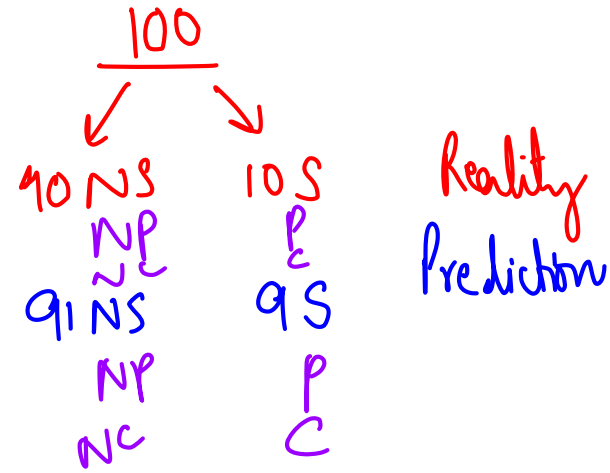
Conclusion

FP is more dangerous
→ Minimise FP

Precision :
$$\frac{\# \text{ of actual spam emails}}{\text{Out of all predictions as spam}}$$

Actual (y)

		predicted (\hat{y})	
		-ve	+ve
Actual (y)	0	90 TN	0 FP
	1	1 FN	9 TP
		Not SPAM	SPAM
		-ve	+ve



$$\text{Precision} = \frac{TP}{TP + FP} = \frac{9}{9} = 100\%$$

Actual (y)

predicted (\hat{y})

-ve NOT SPAM

+ve SPAM

NOT SPAM -ve

SPAM +ve

	0	1
0	88 TN	2 FP
1	3 FN	7 TP

The figure is a handwritten confusion matrix for a binary classification task. The vertical axis is labeled 'Actual (y)' and the horizontal axis is labeled 'predicted (\hat{y})'. The matrix is divided into four quadrants by a diagonal line from the top-left to the bottom-right. The top-left quadrant (Actual=0, Predicted=0) is labeled 'NOT SPAM -ve' and contains the value 88, with 'TN' (True Negative) written below it. The top-right quadrant (Actual=0, Predicted=1) is labeled 'SPAM +ve' and contains the value 2, with 'FP' (False Positive) written below it. The bottom-left quadrant (Actual=1, Predicted=0) contains the value 3, with 'FN' (False Negative) written below it. The bottom-right quadrant (Actual=1, Predicted=1) contains the value 7, with 'TP' (True Positive) written below it. A blue box highlights the top-right quadrant, and a red box highlights the bottom-right quadrant.

fortis → 1000 →

$$\text{precision} = \frac{7}{9}$$

Accuracy → All classes

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

2nd Scenario

Cancer +ve

NC -ve

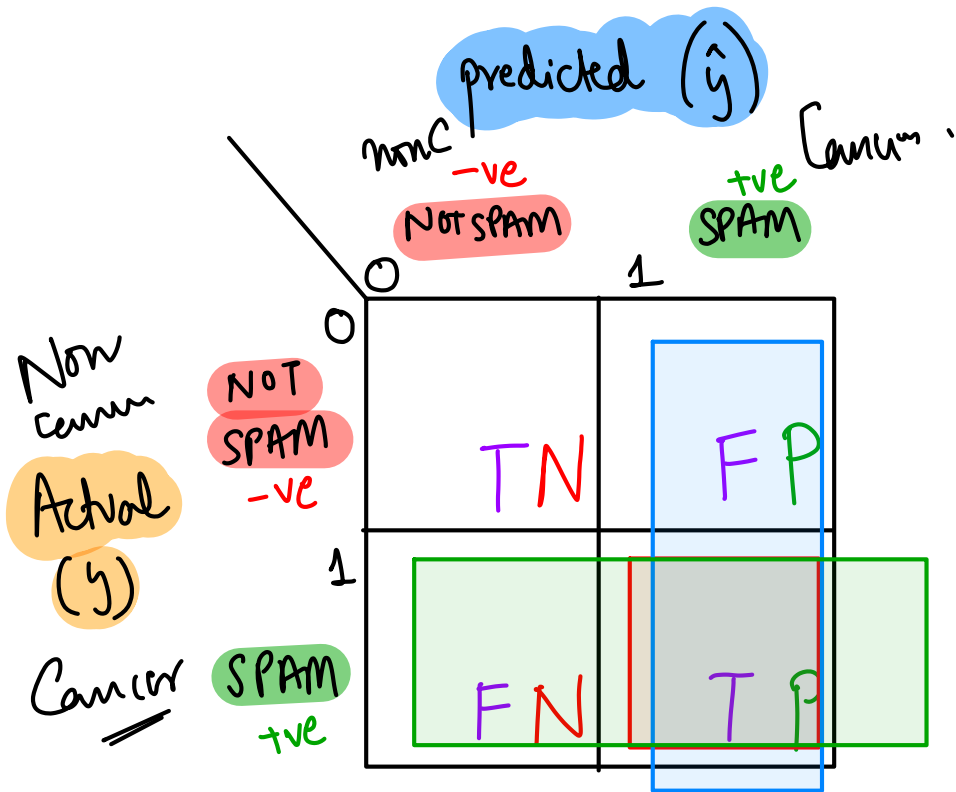
- ① healthy person is identified as Cancerous
- ② Cancerous patient identified as healthy.

FP

FN

Minimise FN

$$\Rightarrow \frac{\text{How many of them were identified by my hospital.}}{\text{Out of all Cancerous patients that arrive at hospital}} = \underline{\underline{\text{Recall}}}$$



Recall: $\frac{\text{How many were predicted as cancer}}{\text{All Cancers Patient Reality}}$

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

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

Quiz time!

Quiz Ended!

For spam email filtering, what would you prioritize more in this case?

24 users have participated



A

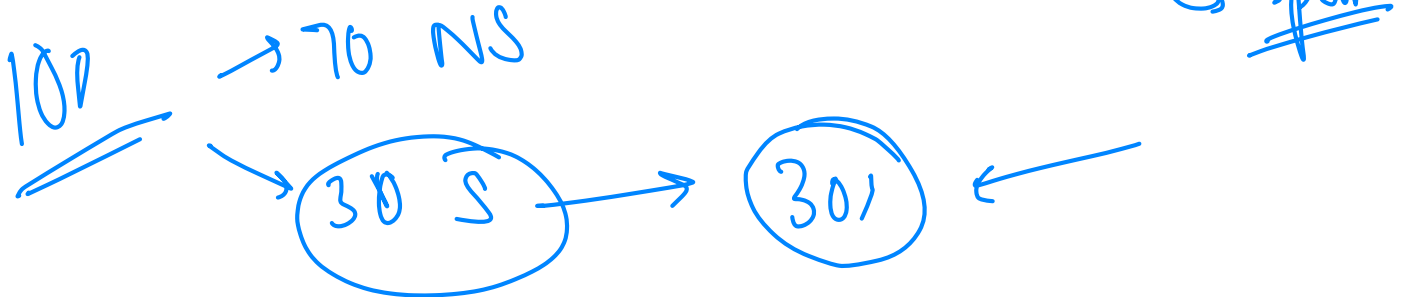
recall

8%

B

precision

92%



$$P = \frac{TP}{TP + FP}$$

of \downarrow spam I predicted

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

1 predicted spam
 All actual spam emails

3 models

	Precision	Recall	<u>Acc</u>	
M1	0.3	0.8	0.55	0.24
M2	0.2	0.9	0.55	0.18
M3	0.7	0.4	0.55	0.28

Harmonic Mean

$$HM(P, R) =$$

$$\frac{1}{\frac{1}{2} \left(\frac{1}{P} + \frac{1}{R} \right)}$$

\Rightarrow

$$\frac{2PR}{P+R}$$

f1 Score

$$0.2 \times 0.9$$

$$0.18$$

$$0.4 \times 0.6$$

$$0.24$$


$$0.5 \times 0.5$$

$$0.25$$

$$0.9 \times 0.9$$


$$0.81$$

Quiz time!


 Quiz Ended!

Why does the F-1 score use Harmonic Mean (HM) instead of Arithmetic Mean (AM) ?

22 users have participated

- | | | |
|---|--|-----|
| A | AM penalizes models the most when even Precision and Recall are low. | 14% |
|  | B HM penalizes models the most when even Precision and Recall are low. | 64% |
| C | HM penalizes models the most when even Precision and Recall are high. | 23% |
| D | AM penalizes models the most when even Precision and Recall are high. | 0% |

$$\underline{\text{Wout mod}} = P \& R \Rightarrow 0$$

$$F1 = \frac{2 \& R}{P + R} = \frac{2 \times 0 \times 0}{0 + 0} = \frac{\overline{0}}{0}$$


$$= \frac{2 \times 0 \times 0}{0 + 0 + 10^{-6}}$$

BEST

$$P \& R = 2$$

$$\underline{\underline{F1}} = \frac{2 \times 1 \times 1}{1+1} = 1$$

$$\text{Range of } F1 = [0, 1]$$