Confusion Matrix

Agenda :
1. Accuracy
2. Confusion Matrix
3. Precision / Recall
4. F1 Score
5. ROC - AUC

* Accuracy

Spam (+) "Positive" (1.0)

Non-Spam (-) "negative class" (0.0)

→ 50% (by 4)

O.P. (real spam → Spam)

Dumb Model : always predicting "0" (non-Spam)

"not Spam" (real non-Spam) → 10 Spam, 90 non-Spam

∴ $\frac{90}{100} = 0.9$

Problem Accuracy

→ 90% Total Accuracy

∴ "Accuracy is a bad metric"

(Imp) → Pre. does not use Probabilities.

0.99	0.01	→ 1
0.51	0.49	→ 1

* Confusion Matrix.

Spam/non-Spam

Spam Non-Spam

→ Binary classification / multi-class classification

→ (K×K) ie. K classes

Target

Predicted

	0	1
0	TN	FP
1	FN	TP

Target

Predicted

	0	1
0	TN	FP
1	FN	TP

Class → 0 Positive

Class → 1 negative

T N

T P

Actual negative → TN + FP

Actual Positive → FN + TP

TP : actual = 1 ; Pred = 1 → Correct Prediction ↑↑

TN : actual = 0 ; Pred = 0

FP : actual = 0 ; Pred = 1 → Target Target → Target Target → Errors (Type I, Type II) ↓↓

FN : Actual = 1 ; pred = 0

Q. Dumb Model :→ Plot C.M ?

Test data : 100 records

90 negative, 10 Spam

Dumb Predictor (Non-Spam)

Spam, Non-Spam

Pred → 0, 1

Actual → 0, 1

	0	1
0	90	0
1	10	0

TN ↑ FP ↓ ⇒ v. good.

FN ↑↑ ; TP ↓ ⇒ very "bad"

Q. C.M → Tweet / Non Tweet !!

Actual (Non Tweet) → 100 (NT), 0 (Tweet)

Predicted (Tweet / Non Tweet) → 100 (NT), 0 (Tweet)

	0	1
0	100	0
1	0	0

{ Predicted negative (N̂) = TN + FN
Predicted Positive (P̂) = FP + TP }

Accuracy ⇒ $\frac{TP + TN}{TN + TP + FN + FP}$ → correct Pred.

→ Total Pred.

* Precision.

① Binary → Spam email in mailbox → FN

② Missing "information retrieval" from your search → FP

"Pure Spam" are more always

Pred

	0	1
0	TN	FN
1	FP	TP

→ FN

→ FP

note ↓FP & ↑TP

⇒ out of all the positive predictions you have made, how many actual positive were there

Precision → $\frac{TP}{TP + FP}$

$\frac{97}{100}$

$\hat{P}$ ⇒ 1

$\hat{P}$ ⇒ 1

↑ C

F P ↓

Precision ∈ [0, 1]

* Recall

1. MIS-classify a healthy person as "cancer" (F P)

MIS-classify a person with cancer as "healthy" (F N)

note FN ↓↓ & TP ↑↑

Recall → $\frac{\text{How many cancer have detected correctly}}{\text{How 100 are actual cancer patient}}$

Pred

	0	1
0	TN	FN
1	FP	TP

→ FN

→ FP

Recall ⇒ $\frac{TP}{P}$

⇒ $\frac{TP}{TP + FN}$

$\frac{90}{100}$

$\frac{90}{100}$ ⇒ ↓

* Other metrics C.M.

Pred

	0	1
0	TN	FP
1	FN	TP

True Negative

↑ TNR (True Negative Rate) ⇒ $\frac{TN}{N}$ ⇒ $\frac{TN}{TN + FP}$

True Positive

↑ TPR (True positive Rate) ⇒ $\frac{TP}{P}$ ⇒ $\frac{TP}{TP + FN}$

↓ FPR (False Positive Rate) ⇒ $\frac{FP}{N}$ ⇒ $\frac{FP}{TN + FP}$

↓ FNR (False negative Rate) ⇒ $\frac{FN}{P}$ ⇒ $\frac{FN}{TP + FN}$

FP → Bad debt → loss

FN → opportunity loss → loss

} Both are Imp.

	Precision	Recall
M1	0.54	0.89 →
M2	0.85	0.40 →
M3	0.78	0.60 →

Simple Avg → $\frac{P + R}{2}$

	P	R	Avg Mean $\left(\frac{P+R}{2}\right)$
M1	0.3	0.7	0.3
M2	0.9	0.5	0.7
M3	1	0.1	0.55

Harmonic mean $HM(5, 3) = \frac{2}{\frac{1}{5} + \frac{1}{3}}$

$HM(P, R) \Rightarrow \frac{2}{\frac{1}{P} + \frac{1}{R}} \Rightarrow \frac{2}{\frac{R+P}{PR}} \Rightarrow \boxed{\frac{2 \cdot PR}{P+R}}$

$F_1 \text{ Score} \Rightarrow \frac{2 \cdot P \cdot R}{P + R}$

	P	R	Avg Mean $\left(\frac{P+R}{2}\right)$	F1 Score
M1	0.3	0.7	0.3	0.7
M2	0.9	0.5	0.3	0.64
M3	1	0.1	0.55	0.18

F1 - Score ⇒ [0, 1] Best

when P, R = 1

F1 Score ⇒ $\frac{2 \times 1 \times 1}{1 + 1}$ ⇒ 1

when F1 = 0

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

Doubt!

R + Score → classification ✗

Precision → Regression ✗

Yours	Your
0.3	0.2
0.2	0.1
0.1	0.3
0.0	0.0

0.3 ⇒ 0.2

0.2 ⇒ 0.1

0.1 ⇒ 0.3 ⇒ 0.0 ⇒ 0.2 ⇒ 0.1 ⇒ 0.3 ⇒ 0.0 ✗