Classification-Metrics

Friday, 29 August 2025 9:24 AM

Cute Pic Credit:

Confusion Matrix

Agenda:

1. Accuracy : Problems
2. Confusion Matrix
3. Precision, Recall
4. F1 Score
5. ROC - AUC
6. Precision Recall Curve (Show) → Imp

Accuracy

Email → Spam / Not Spam

Binary classification

Spam (1) (+ve) / Not Spam (0) (-ve)

Mail → Spam / Not Spam → 0 bad

Dummy Model : Always predicts 0 (Non-Spam)

Total (100 mails)

96	Non-spam
4	Spam

Predictions (Dummy Model)

100 Non-spam.

Acc (Dummy Model) ⇒ $\frac{96}{100} \Rightarrow$ 96% → Baseline no

Problem: Accuracy.

→ Imbalanced data: accuracy is v. bad model.

(96) → Acc. does not use Probability.

Confusion Matrix

Binary classification / multi-class.

use for medium

Predictions → (Row)

Actual → (Column)

Positive

Actual Negative: $\frac{TN+FP}{}$

Actual Positive: $\frac{TP+FN}{}$

TP : actual = 0, pred = 0

TN : actual = 1, pred = 1

FP : actual = 0, pred = 1

FN : actual = 1, pred = 0

TP, TN, FP, FN

Spam → 1

Not Spam → 0

Positive

Negative

TP ? → your prediction ?

true per Column ?

→ Correct Pred. ↑↑

→ Error (Bound) = 0

Q: Dumb Model : Confusion Matrix ?

Total 100 Emails.

96 (Non-Spam)

4 (Spam)

Dumb Predictor

Total Non-Spam

	Pred 0	Pred 1
Actual 0	96 TN	0 FP
Actual 1	4 FN	0 TP

Q: Confusion Matrix : Total Mail ?

500 → 1000 Mail.

Actual

400 (Non-Spam)

100 (Spam)

Predicts

→ 1 : 40

→ 0 : 460

Pred

	Pred 0	Pred 1
Actual 0	360 TN	40 FP
Actual 1	60 FN	40 TP

Actual Negative

Actual Positive

Predicted Positive $(\hat{P}) \Rightarrow \frac{TP+FP}{}$

Predicted Negative $(\hat{N}) \Rightarrow \frac{TN+FN}{}$

Accuracy formula (CM) : $\frac{TP+TN}{TP+TN+FP+FN}$ → correct pred / total pred.

Precision

1. Accuracy → your model is performing bad. → FN
2. Mining → expensive cost, time you arrange → FP

Precision → $\frac{TP}{TP+FP}$

Pred

	0	1
Actual 0	TN	FP
Actual 1	FN	TP

Pred: 0 → $\hat{N}$, 1 → $\hat{P}$

Actual: 0 → N, 1 → P

$\hat{P}$ → TP, FP

$\hat{N}$ → TN, FN

False Positive is dangerous

Write FP.

FP ↓ , TP ↑↑

Precision → $\frac{TP}{\hat{P}}$

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

How precise your model is when mining your data.

100 emails spam.

TP = 100

100 / 100 = 1

$\hat{P}$ = 100

TP = 0

Precision = [0, 1]

$\frac{0}{0+100} = 0$

Recall

1. Accuracy → healthy patient as Cancerous. (FP)
2. Mis-classify → patient having Cancer as healthy. (FN)

P: Cancer

N: Not Cancer

min FN ↓↓

TP ↑

Recall → $\frac{TP}{P}$

Pred

	0	1
Actual 0	TN	FP
Actual 1	FN	TP

P

Recall → $\frac{TP}{TP+FN}$

Range Recall ∈ [0, 1]

Fraud Transac.

1 : Fraud

0 : Not Fraud

(→ FP : actual from Model as fraud.

X FN : actual fraud trans. predicted as Non-fraud

Recall

Confusion Matrix C-M

	Pred 0	Pred 1
Actual 0	TN	FP
Actual 1	FN	TP

Recall Accuracy

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

Specificity

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

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

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

F1 Score

(→) P : able to predict the Cancer.

(N) N : not able to predicting.

Recall ← FP : Bad debts → Risk

Recall ← FN : opportunity lost → loss

Both are Imp.

	Precision	Recall
M1	0.50	0.80
M2	0.65	0.40
M3	0.70	0.40

Simple Avg. ⇒ $\frac{Pr + Re}{2}$

	Pr	Recall	Arth. Mean $\left(\frac{Pr+R}{2}\right)$
M1	0.7	0.7	0.7
M2	0.9	0.5	0.7

Harmonic Mean $HM(5, 8) \Rightarrow \frac{2}{\frac{1}{5} + \frac{1}{8}}$

$HM(Pr, Re) \Rightarrow \frac{2}{\frac{1}{Pr} + \frac{1}{Re}}$

$$\boxed{F1\text{-}Score \Rightarrow \frac{2 \cdot P \cdot R}{P + R}}$$

	Pr	Recall	Arth. Mean	Harmonic Mean (F1 Score)
M1	0.7	0.7	0.7	0.7
M2	0.9	0.5	0.7	0.64

Extreme Case

Pr = 0 ; Recall = 1

F1 ⇒ 0

Pr = 1 ; Recall = 0

F1 = 0

Range F1 ⇒ [0, 1]

worst → Best [Pr = 1, Pr = 1]