

Classification Metrics

https://colab.research.google.com/drive/16MNOx09cutXevG_YICgC4UYYzcOdfsU?usp=sharing

Agenda

- Review Acc., Problems with Acc.
- Confusion Matrix
- TP, TN, FP, FN
- Type-1 and Type-2 Error
- Precision and Recall.

Lecture - Classification Metrics

Business - Gmail - classifier (spam/ NOT spam)

Binary classification

| | | |
|-------|--------------|----|
| 1 / + | \downarrow | S |
| 0 / - | | NS |

- Spam - 1 (+ve) ← Spam Detector
- Not spam - 0 (-ve)

Prod. related accuracy

ML Algo? logistic Reg

Test Data 1200

| | | |
|--------|---|-----|
| 850 NB | } | 71% |
| 350 S | | 29% |

Acc = 94%

Q Is 94% Acc good?

Dumb Model - Predicts everything as N. spam.

Test Data 1200 → 850 N& (-)
→ 350 S (+)

How many correct pred. would make?

$$850 \checkmark \quad 350 \times \quad \text{Acc Dumb} = \frac{850}{1200} \approx 71\%$$

Extreme case: Major class imbalance

Test Data → 1100 N&
→ 100 S

$$\text{Acc Dumb} = \frac{1100}{1200} \approx 92\%$$



~~Is it a good model?~~

This dumb model is not doing anything

Is Accuracy a good metric?

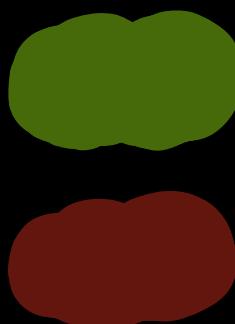
No, If major class imbalance.

49% 51%. ✓ Bal.
45% 55%. ✓

80% 20% X Imbalance.
92% 8% X

CONFUSION MATRIX

1 +ve - Spam



Correct Classification

0 -ve - NOT Spam



Incorrect Classification

| | | 0 | 1 |
|--------|---|----|-----|
| GT - y | 0 | TN | FP |
| | 1 | FN | TP |
| | | NS | 1 |
| | | 0 | 2x2 |

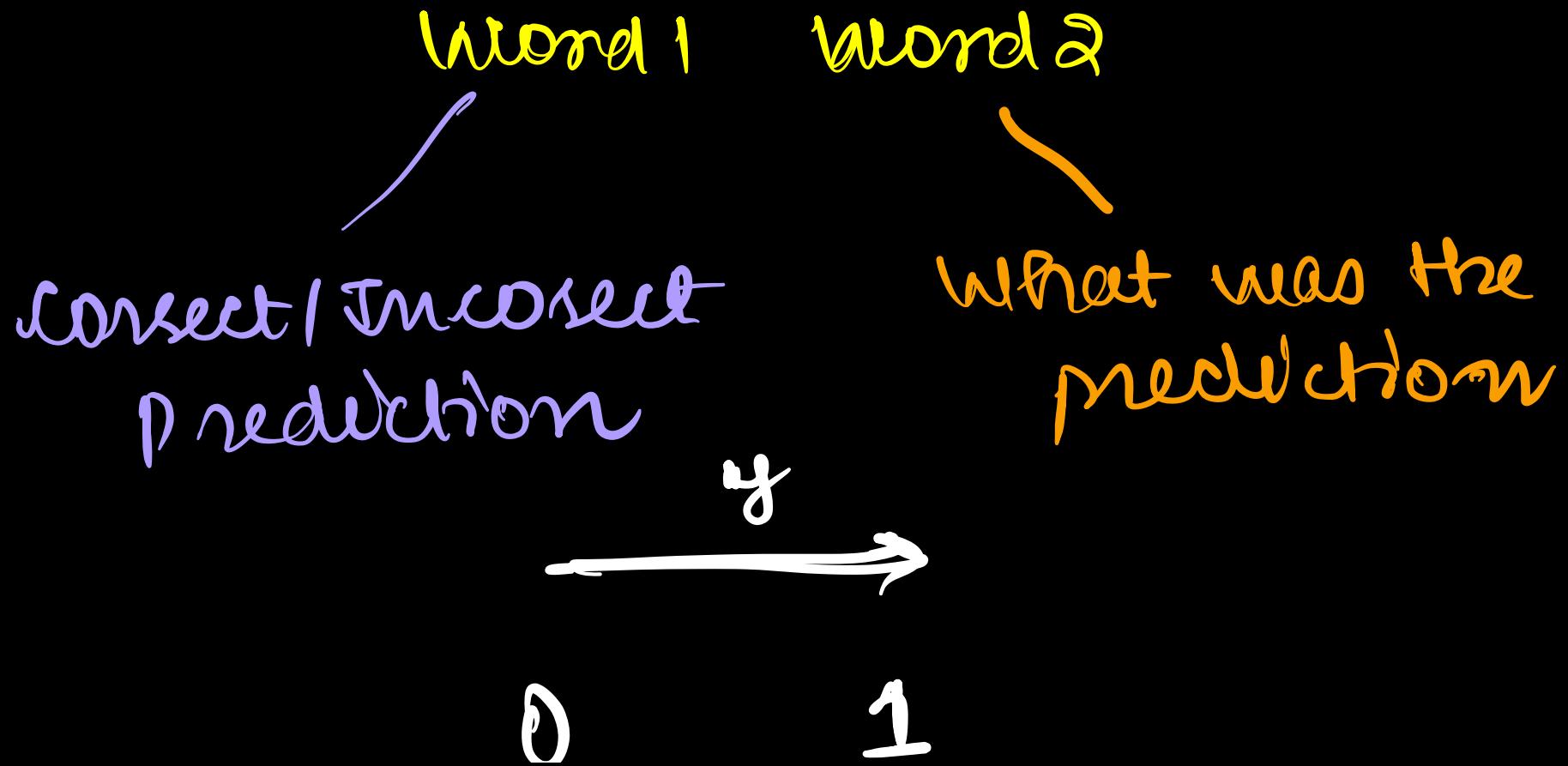
→ \hat{y} - Predicted

Patterns:

1. Correct classification will have T in the name.
Wrong classification will have F in the name.
2. Second part of the name is same as what is predicted.

X

~~TN is first all~~
~~FP is last all~~



| | | | |
|-----|--------------|---|--------------|
| y | \downarrow | 0 | |
| | | 1 | |
| | | | 2×2 |

spam:

- (T) - correctly classified as spam emails
- (TN) - correctly classified as N. spam emails
- (FP) - Incorrectly classified as spams
- (FN) - Incorrectly classified as N. spams

CM formuli-das

\hat{f}

| | | | | | | |
|---|---|---|---|---|-------|---|
| | 1 | 2 | 3 | 4 | | K |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| K | | | | | | |

$K \times K$

CM_{ij} - ith row
jth column

-

case whose true class is
① and the prediction value
②
If $d_{2j} > d_{1j}$ then ✓
 $d_{2j} \leq d_{1j}$ then X,

CM for ideal model \Rightarrow All wrong predictions.

400 emails \leftarrow 360 NS (0)
40 S (1)

Non-diagonal elements
will be zero.

| | 0 | \hat{y}_1 |
|---|-----|-------------|
| 0 | 360 | 0 |
| 1 | 0 | 40 |

for ideal model,

$$FP, FN \approx 0, 0$$

\downarrow \downarrow
Type-I Type-II
Errors Errors

CM for dumb model - predict all the samples as to be belonging to the majority class.

400 emails \leftarrow 360 NS(0)
40 S(1)

| | | 0 | 1 | |
|---|---|---|-----|----|
| | | 0 | 360 | 0 |
| | | 1 | 0 | FP |
| 0 | 1 | 0 | 40 | FN |
| | | 1 | 0 | TP |

One of the vertical or horizontal row/column
will be zero.

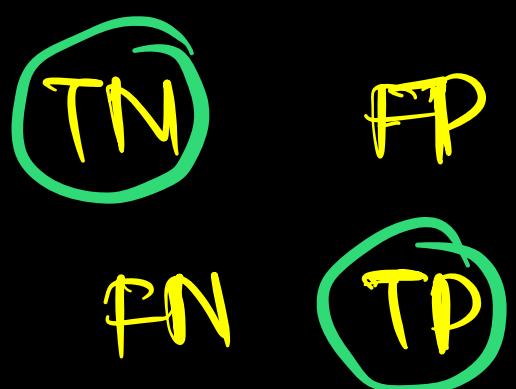
Type-1 (FP)

Type-2 (FN)

$$\begin{aligned}
 P &= \frac{TP}{TN + FP} \\
 &= \frac{0}{0 + 40 + 1} \\
 &= 0
 \end{aligned}$$



Q calculate Acc. using CM



$$Acc = \frac{\text{Correct Pred}}{\text{Total Pred}}$$

$$Acc = \frac{TN + TP}{TN + FP + FN + TP}$$

Precision

$\delta(+), N\delta(\leftarrow)$

Scenarios emails

i) Receiving a spam email in inbox FN

~~ii)~~ Missing an offer letter email FP

More dangerous.

Optimise FP ↓

Goal: FP↓, TP↑

Need: metric if FP↓ and TP↑

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

mails correctly classified
as spam

$$\text{Precision} = \frac{\# \text{ mails correctly classified as spams}}{\# \text{ mails classified as spams}}$$

→ In order to reduce the chance of missing out
on important emails optimise Precision (spam)
 $\downarrow + \forall C$

Optimise Metric for S/NS

$$\text{Metric} =$$

Ans.
Ques.

Precision Neg
NS

$$= \frac{\# \text{ mails correctly classified as non spam}}{\# \text{ mails classified non spams.}}$$

Recall - Cancer Screening Test Confirmatory

Not having cancer (0) ✓

having cancer (1) ✓

Misclassifying healthy patient as Cancerous - FP

Misclassifying Cancerous patient as healthy - FN

Start of the treatment
on healthy patient ✓/8 Undetectable
 diseases
 |
 Dangerous

Need: Reduce FN

Goal: Metric FN ↓, TP ↑

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

Recall. $\approx \frac{\# \text{ correctly predicted as cancer}}{\# \text{ cancer patients.}}$

Common Numerator

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} = \frac{\text{TP}}{\text{Predicted } +\text{ve}} = \frac{\text{TP}}{\text{P+ve}} \quad \text{Precision}$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}} = \frac{\text{TP}}{\text{Real/Actual } +\text{ve}} = \frac{\text{TP}}{\text{R+ve}} \quad \text{Recall.}$$