## Last class (Aug 17)

1) Overview of AT&T Churn Prediction
2) Accuracy Metric
3) Hyper-parameter Tuning
4) Logit / Log Odds
5) Impact of Outliers
6) Multi-class classification – OVR vs multi-nomial

## Today's class

1) Spam vs Non-Spam: Business Case
2) Issue with Accuracy
3) Confusion Matrix & Code
4) Precision & Code
5) Recall & Code
6) F1 score & Code

$850 + 350 = 1200$

← class 0: non-spam $\quad \frac{850}{1200} \times 100\% = 70.83$

← class 1: spam $\quad \frac{350}{1200} \times 100\% = 29.17$

850 → 1100 1200

class 0: $\frac{1100}{1200} \times 100\% = 91.67\%$

Dumb Model → 91.67%

ref ↑

ML Model → 92% Acc

| dumb model ← Ref | ML Model | |
|---|---|---|
| ↓ majority class | 50% | 93% ✓ very good |
| | 71% | 93% |
| | 92% | 93% → almost useless model |

class 0 :
class 1 : → 50%

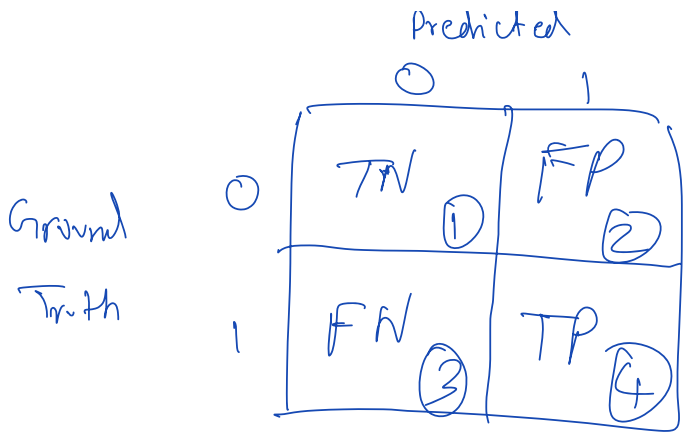
class 0, 1, 2 → 33.33%

Acc → class 0 class 1

✗ doesn't give

↓ ↓

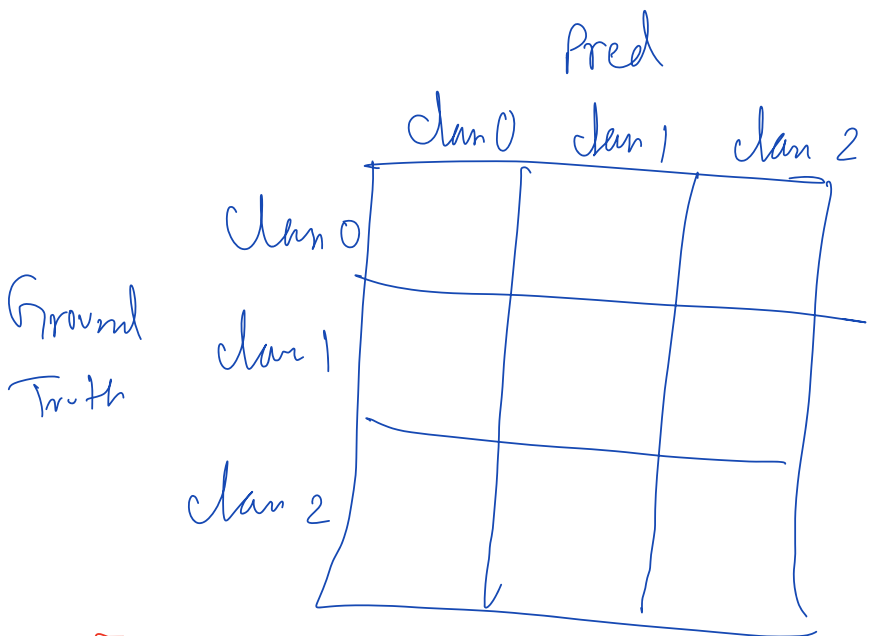
Separate performance




2 × 2 matrix for 2 classes

| $y$ | $\hat{y}$ | Name |
|---|---|---|
| 0 | 0 | TN |
| 0 | 1 | FP |
| 1 | 0 | FN |
| 1 | 1 | TP |

$$ACC = \frac{\#\text{ correct pred}}{\#\text{ total pred}} = \frac{TP + TN}{TP + TN + FP + FN}$$




FP → Type 1 error

FN → Type 2 error

Spam vs Non-Spam Email

↓ ↓

+ve class −ve class

class 1 class 0

[Scenario I: inbox receives a promotional email
↳ FN

[Scenario II: Your Google often letter goes to Spam folder

Maximise Rec ⇒ minimize FP ← → FP ↓ Dangerous

class 0 class 1

↓ ↓

Non-Cancer Cancer

Scenario 1: ML model says a healthy patient has cancer → FP

Scenario 2: ML model says a Cancerous patient is healthy → FN very dangerous

Recall is maximized

FN is minimized

Class 0 → Non-Fraud (Legit)

Class 1 → Fraud

Scenario 1: ML model says a legit transaction is Fraud → FP
↳ Customer is facing inconvenience

Scenario 2: ML model says a fraud transaction is legit
↳ Bank / Person is suffering loss → FN

TP: Fraud labelled as Fraud

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

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

FP ↑, Prec ↓
$\text{Prec} \propto \frac{1}{FP}$

FN ↑, Prec ↓
$\text{Recall} \propto \frac{1}{FN}$

Precision ✗ FN

Recall ✗ FP

$$HM(v_1, v_2) = \frac{2 \times v_1 \times v_2}{v_1 + v_2}$$

| | | | diff |
|---|---|---|---|
| M1 | 0.30 | 0.80 | → 0.5 |
| M2 | 0.20 | 0.90 | → 0.7 |
| M3 | 0.70 | 0.40 | → 0.3 |
| M4 | 0.29 | 0.30 | → 0.01 |

Resume → 10:35

$$H \cdot M(v_1, v_2) = \frac{[GM(v_1, v_2)]^2}{AM(v_1, v_2)}$$

$$= \frac{\left(\sqrt{v_1 v_2}\right)^2}{} \times \frac{2}{v_1 + v_2}$$

**Dataset:** 400 email samples

→ 40 email → spam (class 1)

→ 360 email → non spam (class 0)

**Ideal Model**

TP, TN, FP, FN

↓ 0 ↓ 0

$$\text{Precision} = \frac{TP}{TP + FP} = 1$$

FP → 0

$$\text{Recall} = \frac{TP}{TP + FN} = 1$$

FN → 0

**Dumb Model**

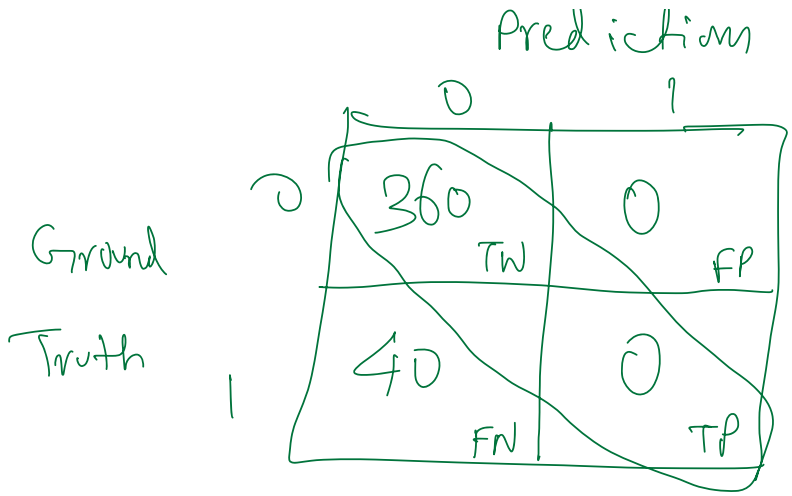
**Predictions = Majority**

= class 0

= -ve class

$$\text{Precision} = \frac{TP}{TP + FP} = \frac{0}{0+0} = \frac{0}{0} \rightarrow \text{undefined}$$

$$\text{Recall} = \frac{TP}{TP + FN} = \frac{0}{0+40} = 0$$




TN: $y = 0$, $\hat{y} = 0$

FN: $y = 1$, $\hat{y} = 0$

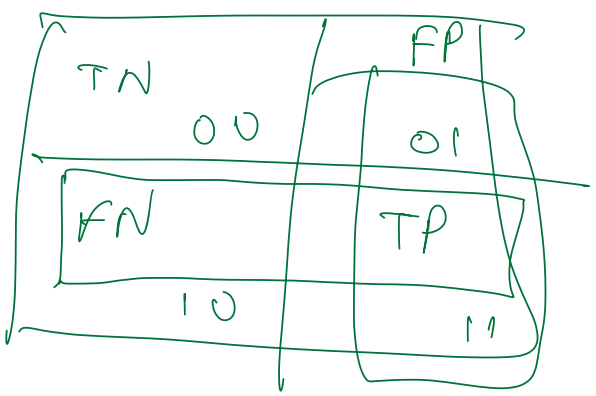
## Dumb Model (-ve class majority)

Prec → undefined

Recall → 0

$$\text{Precision} = \frac{0}{0 + 0 + \boxed{10^{-6}}} = 0$$

$\varepsilon \rightarrow 1e^{-6}$




$$\frac{1,1}{1,1 + 0,1}$$

↓

Precision

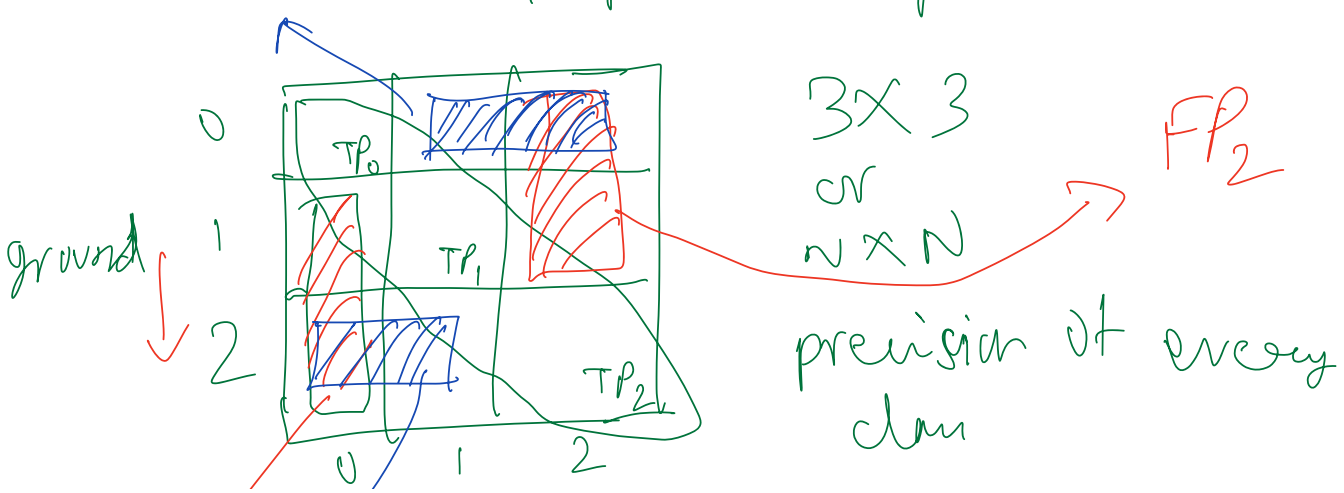
$$\frac{TP}{TP + FN} \qquad \text{Recall} = \frac{1,1}{1,0 + 1,1}$$

$$\varepsilon = 10^{-6}, \qquad \varepsilon_1 = 10^{-5}$$

$$F_\beta = (1+\beta^2)\frac{\text{precision} \cdot \text{recall}}{(\beta^2 \text{precision}) + \text{recall}}$$

$\beta = 2 \Rightarrow$ 2x imp. to precision as compared to recall

$\beta = 0.5 \Rightarrow$ recall is 2x more imp than precision



$FN_2$ pred →

$FP_0$

$$\text{Precision (class 0)} = \frac{TP_0}{TP_0 + FP_0}$$

$$\text{Precision (class 2)} = \frac{TP_2}{TP_2 + FP_2}$$

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

$y = 1$, $\hat{y} = 0$

pred = −ve

gd = +ve

$$\text{Recall (class 0)} = \frac{TP_0}{TP_0 + FN_0}$$

400 email →

360 spam → class 1

40 non-spam → class 0

↳ pred of dumb model ↳ class 1

GT

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

Pred

Precision = $\frac{360}{360+40} = 0.9$

Recall = $\frac{360}{360+0} = 1$

F1 = 0.947

dumb

ML → F1 → 0.95 — 0.947 (0.053)

ML → F1 = 0.98 — 0.947 (0.33)