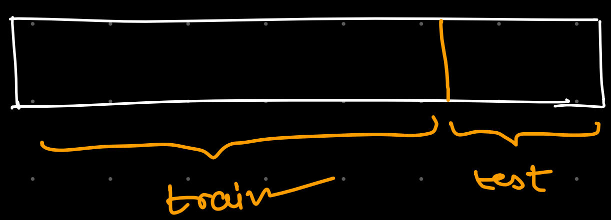
Welcome

→ Ridge and Lasso

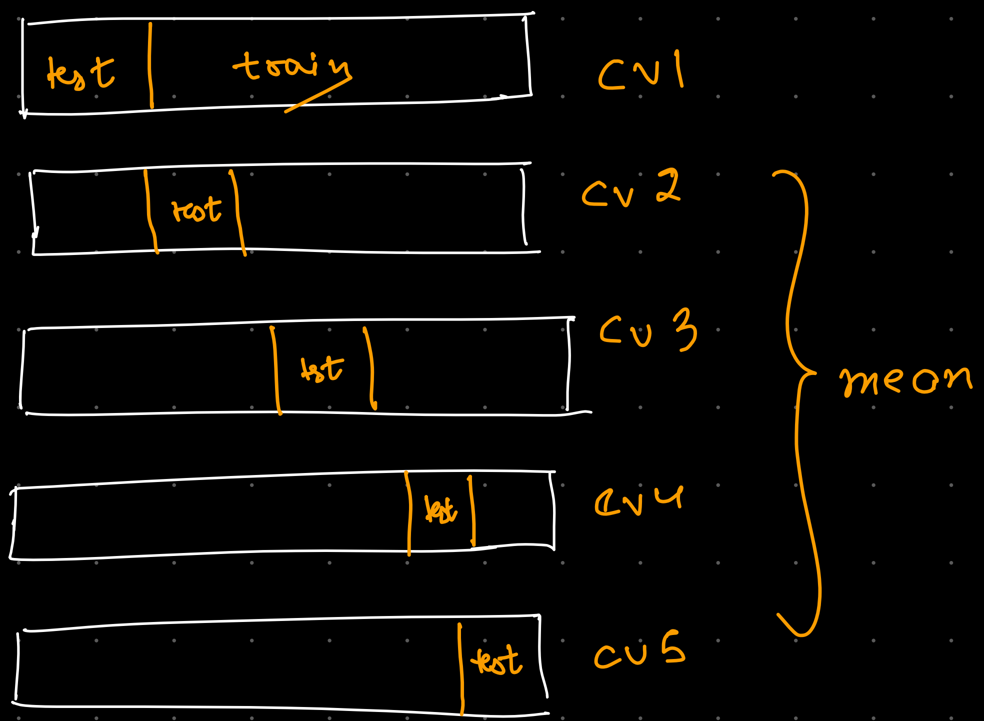
→ LoR complete

→ Naive Bayes

Cross-validation



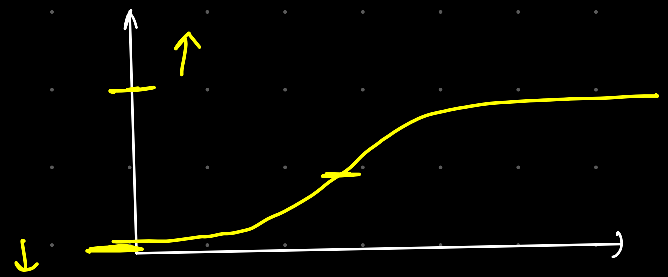
80:20
70:30



Logistic Regression

1. Ridge, Lasso is possible
2. All the assumptions are same as of LR.

Multiclassification with LoR



⇒ cat, dog, horse

One vs rest

LoR1 $\underbrace{\text{dog}}_{1}$, $\underbrace{\text{cat, horse}}_{0}$

LoR2 dog 0, cat 1, horse 0

LoR3 dog 0 cat 0 horse 1

} lor1, lor2, lor3 → max( )

⇓

category

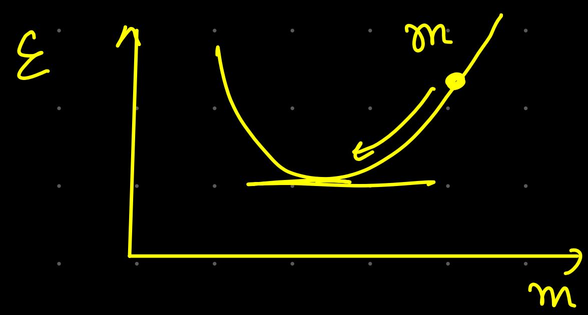
$$\underset{(x,y)}{E} = \frac{1}{m} \sum -y^i \log(h(x)) - (1-y^i)(1-\log h(x))$$

$$\Downarrow$$

$$\frac{1}{1+e^{-mx}}$$

Gradient descent

$$m_{new} = m_{old} - \alpha \frac{\partial E}{\partial m}$$



$$\log(h(x)) = \log\left(\frac{1}{1+e^{-mx}}\right)$$

$$\boxed{\log\frac{U}{V} = \log U - \log V}$$

$$\boxed{\log UV = \log U + \log V}$$

$$\cancelto{0}{\log 1} - \underline{\log(1+e^{-mx})}$$

Performance Metrics (Binary Classification)

$x_1 \quad x_2 \quad x_3 \quad x_4$

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

0 → fail
1 → pass

Actual (y)

Pred ($\hat{y}$)	1	0
1	3	2
0	1	1

accuracy ⇒ $\frac{3+1}{7}$

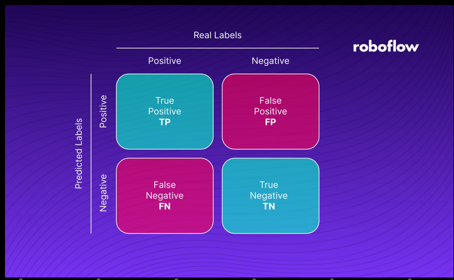
⇓

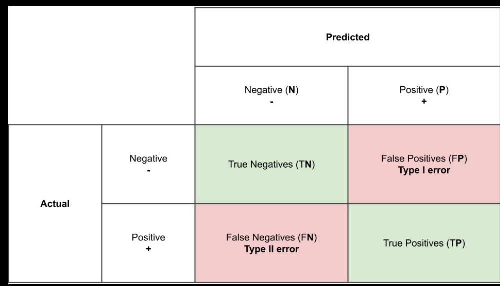
Actual

Predicted	1	0
1	TP	FP
0	FN	TN

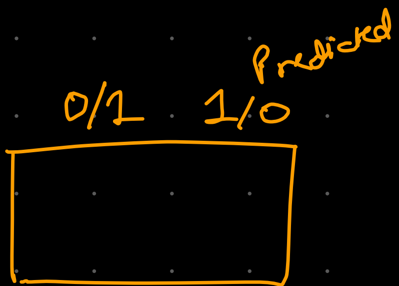
1 → Positive
0 → negative

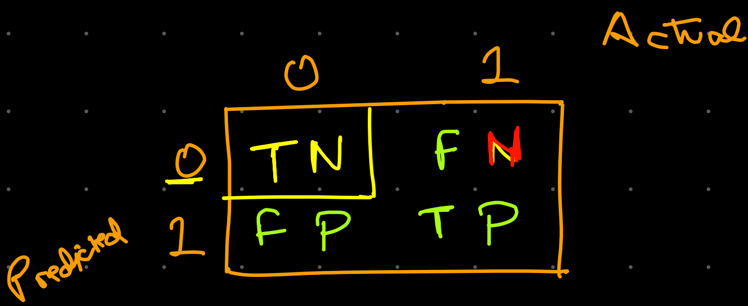
→ out of values you have predicted 'positive', how many are 'true'.





		Predicted	
		Negative (N) -	Positive (P) +
Actual	Negative -	True Negatives (TN)	False Positives (FP) **Type I error**
	Positive +	False Negatives (FN) **Type II error**	True Positives (TP)





We have to reduce FN FP
& increase TN TP

⇒ balance 500 Y 500 N

imbalance 900 Y 100 N ⟵

Cancer

ŷ \ y	1	0
1	TP	~~FP~~
0	FN	TN

⇐ Accuracy

Spam

ŷ \ y	1	0
1	TP	FP
0	FN	TN

1 → Scam
0 → not scam

0	10
0	90

Precision (Based on class)

Out of all the values predicted output of class, how many are correct.

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

Recall

Out of all the actual values, how many are correct/recalled

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

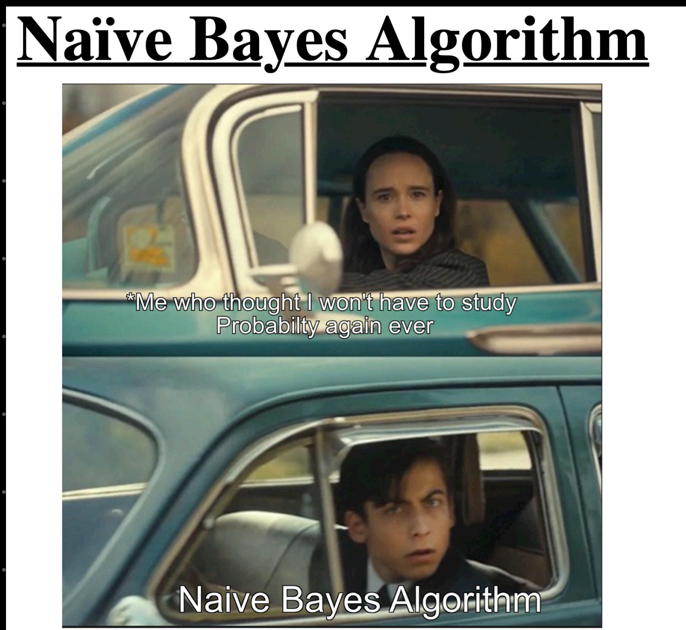
F-Beta

$$(1 + \beta^2) \frac{\text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

$\beta = 1$ Harmonic mean

Naive Bayes

Probability



Bayes Theoram

- Bayes theorem provides a way of calculating posterior probability P(c|x) from P(c), P(x) and P(x|c). Look at the equation below:

$$\underbrace{P(c \mid x)}_{\text{Posterior Probability}} = \frac{\overbrace{P(x \mid c)}^{\text{Likelihood}}\,\overbrace{P(c)}^{\text{Class Prior Probability}}}{\underbrace{P(x)}_{\text{Predictor Prior Probability}}}$$

$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

- P(c|x) is the posterior probability of class (c, target) given predictor (x, attributes).
- P(c) is the prior probability of class.
- P(x|c) is the likelihood which is the probability of predictor given class.
- P(x) is the prior probability of predictor.

dice = $\{1, 2, 3, 4, 5, 6\}$

$P(6) = \frac{1}{6}$

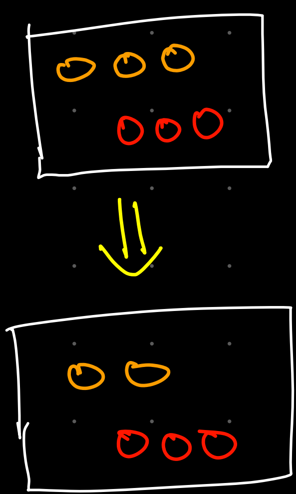
$1^{st} \Rightarrow 6$ $\qquad$ $2^{nd} \Rightarrow 4 \Rightarrow 1/6$

Independent $\Rightarrow$ Probability not changing.

Dependent Events

P(orange)

P(red)



P(red given we got orange)

$\Rightarrow 3/5$

Conditional Probability

Above are dependend events.

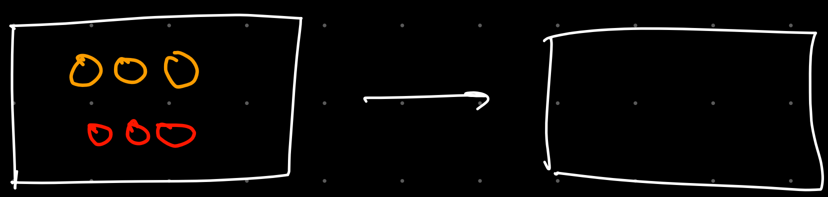
$$P(6 \text{ and } 6) = 1/6 \quad 1/6$$

$$P(\text{orange } \& \text{ red}) = P(\text{orange}) * P\left(\frac{\text{red}}{\text{orange}}\right)$$

$$P(A \text{ and } B) = P(A) * P\left(\frac{B}{A}\right)$$

Conditional Probability

$$P(A \text{ and } B) = P(B \text{ and } A)$$



$$P(\text{orange}) \cdot P\left(\frac{\text{red}}{\text{orange}}\right) \qquad P(\text{red}) \; P\left(\frac{\text{orange}}{\text{red}}\right)$$

$$\frac{3}{6} * \frac{3}{5} \qquad \frac{3}{6} \cdot \frac{3}{5}$$

$$P(A \text{ and } B) = P(B \text{ and } A)$$

$$P(A)\, P\left(\frac{B}{A}\right) = P(B)\, P\left(\frac{A}{B}\right)$$

$$\boxed{P\left(\frac{B}{A}\right) = \frac{P(B)\; P(A/B)}{P(A)}}$$

Bayes Theoram

$$\overbrace{X_1 \quad X_2 \quad X_3 \quad \ldots X_n}^{\text{independe variable}} \qquad y \nearrow \text{target}$$

$$P\left(\frac{y}{x_i}\right) = \frac{P(y) * P(x_i/y)}{P(x_i)}$$

$$= \frac{P(y) \cdot P(x_1/y) \cdot P(x_2/y) \ldots P(x_n/y)}{P(x_1) \cdot P(x_2) \cdot P(x_3)}$$

$X_1 \quad X_2 \quad X_3 \quad Y\,(O/P)$

Yes
NO
Yes
N

$$P\left(\frac{y=yes}{x_i}\right) = \frac{P(Yes) * P(x_1/yes) * P(x_2/yes) * P(x_3/yes)}{\boxed{P(x_1)\ P(x_2)\ P(x_3)}}$$

$$P\left(\frac{y=no}{x_i}\right) = \frac{P(NO) \cdot P(x_1/NO)\ P(x_2/NO) \cdot P(x_3/NO)}{\boxed{P(x_1)\ P(x_2)\ P(x_3)}}$$

$$P\left(\frac{y}{x_i}\right) = 0.2 \qquad P\left(\frac{N}{x_i}\right) = 0.35$$

$$P(\text{Yes overall}) = \frac{0.2}{0.2 + 0.35} =$$

Play Tennis

PlayTennis: training examples

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

$P(Y) = 9/14$

Outlook	P(Yes)	P(No)
Sunny	2/9	3/5
Overcast	4/9	0/5
Rain	3/9	2/5

Temp	P(Y)	P(N)
Hot	2/9	2/5
Mild	4/9	2/5
Cool	3/9	1/5

Outlook = Sunny

Temp = Cool

$$P\left(\frac{Yes}{O=Sunny,\ T=Cool}\right) = P(Yes) * P\left(\frac{Sunny}{Yes}\right) \cdot P\left(\frac{Cool}{Yes}\right)$$

$$= \frac{\cancel{9}}{14} * \frac{2}{\cancel{9}} * \frac{3}{9} = \frac{6}{126}$$

$$P\left(\frac{No}{Sunny/Cool}\right) = P(No) * P\left(\frac{Sunny}{No}\right) \cdot P\left(\frac{Cool}{No}\right)$$

$$= \frac{\cancel{5}}{14} * \frac{3}{\cancel{5}} * \frac{1}{5} = \frac{3}{70}$$

$$P\left(\frac{Y}{\text{Sunny}, \text{Cool}}\right) = \frac{6}{126}$$

$$= 0.0476$$

$$P\left(\frac{No}{\text{Sunny}, \text{Cool}}\right) = \frac{3}{70}$$

$$= 0.042$$

$$P(Y) = \frac{6/126}{6/126 + 3/70} = 52.63\%$$

$$P(N) = \qquad = 47.37\%$$

$$P($$

Sunny , Cool, High , Strong

High ⇓ Hum

Strong ⇓ Wind

P(Yes)

$$\frac{3}{567}$$

0.0053

P(No)

$$\frac{18}{875}$$

0.0205

Income	Loan Approval
H	Yes
M	Yes
L	Yes
H	Yes
M	Yes
L	Yes
	Yes
M	No
L	No
M	No
M	No
L	No
	No

$P\left(\frac{Low}{Yes}\right) = \frac{2}{6}$

$P\left(\frac{Low}{No}\right) = \frac{2}{5}$

$P\left(\frac{high}{No}\right)$

Income ⇒ high

Laplace Correction

$P\left(\frac{high}{No}\right) = \frac{0 \quad + 1}{} = a + 1$

$P(Mid/No) \qquad = b + 1$

$P(low/No) \qquad = c + 1$

$$\frac{a+1}{a+b+c+|3|}$$

$$\frac{a+b+c+|3|}{a+b+c+|3|}$$

$$P\left(\frac{X = x_i}{y = y_i}\right) = \frac{\text{Count}(y = y_i \text{ and } x = x_i) + 1}{\text{Count}(y = y_i) + 1 \times 1}$$