1-	ii	11	B	21	True	31	C
2-	viii	12	C	22	Not Given	32	B
3-	v	13	A	23	False	33	D
4-	i	14	curved hook	24	C	34	B
5-	iii	15	paired leaflets	25	E	35	A
6-	ix	16	thorn	26	G	36	E D
7	New Zealand Company	17	steps	27	A	37	H
8	Argon	18	True	28	D	38	L
9	seaweed	19	False	29	C	39	A
10	cough mixture	20	False	30	B	40	I

38/40

1	11	21	31
2	12	22	32
3	13	23	33
4	14	24	34
5	15	25	35
6	16	26	36
7	17	27	37
8	18	28	38
9	19	29	39
10	20	30	40

The bar chart illustrates and compares the involvement of Australian men and women in regular physical activities in the year 2010.

Overall, females tend to do more physical work in comparison with males. Males of age between 15 to 24 did most physical activities in comparison with males of other age groups, while females in the age group of 45 to 54 were involved in most in their own category. ~~Males only have beaten females of age group 15 to 24~~

Males of age group of 15 to 24 were only the ones to beat women in the age group's category.

Introduction - Background
- Thesis statement

$$P(\omega_i|x) = \frac{P(x|\omega_i)\, P(\omega_i)}{P(x)}$$

$$P(x|\omega_i) = \frac{1}{(2\pi)^{d/2} |\Sigma_i|^{1/2}} \exp\left[-\frac{1}{2} (x-\mu_i)^T \times \Sigma_i^{-1} \times (x-\mu_i) \right]$$

$$\omega_1 \longrightarrow \begin{bmatrix} 13 \\ 5 \end{bmatrix}, \begin{bmatrix} 13.5 \\ 6 \end{bmatrix}, \begin{bmatrix} 14 \\ 5.5 \end{bmatrix}, \begin{bmatrix} 14.5 \\ 6.5 \end{bmatrix}$$

$$\omega_2 \longrightarrow \begin{bmatrix} 16.5 \\ 7 \end{bmatrix}, \begin{bmatrix} 16 \\ 7.5 \end{bmatrix}, \begin{bmatrix} 17.5 \\ 8.5 \end{bmatrix}, \begin{bmatrix} 17 \\ 8 \end{bmatrix}$$

$$\mu_1 = \begin{bmatrix} 13.75 \\ 5.75 \end{bmatrix}, \quad \mu_2 = \begin{bmatrix} 16.75 \\ 7.75 \end{bmatrix}$$

$$\omega_1 \longrightarrow \begin{bmatrix} -0.7 & -0.2 & 0.3 & 0.8 \\ -0.7 & 0.3 & -0.2 & 0.8 \end{bmatrix}$$

$$\omega_2 \longrightarrow \begin{bmatrix} -0.2 & -0.7 & 0.8 & 0.3 \\ -0.7 & -0.2 & 0.8 & 0.3 \end{bmatrix}$$

$$\Sigma_1 = \begin{bmatrix} -0.7 & -0.2 & 0.3 & 0.8 \\ -0.7 & 0.3 & -0.2 & 0.8 \end{bmatrix} \quad \begin{bmatrix} -0.7 & -0.7 \\ -0.2 & 0.3 \\ 0.3 & -0.2 \\ 0.8 & 0.8 \end{bmatrix}$$

$$\boxed{\Sigma_1 = \frac{1}{4}\begin{bmatrix} 1.26 & 1.01 \\ 1.01 & 1.26 \end{bmatrix}} = \begin{bmatrix} 0.315 & 0.2525 \\ 0.2525 & 0.315 \end{bmatrix}$$

$$\Sigma_2 = \frac{1}{4}\begin{bmatrix} 1.26 & 1.01 \\ 1.01 & 1.26 \end{bmatrix} = \begin{bmatrix} 0.315 & 0.2525 \\ 0.2525 & 0.315 \end{bmatrix}$$

$$\Sigma_1^{-1} = \Sigma_2^{-1} = \begin{bmatrix} 8.8 & -7.1 \\ -7.1 & 8.8 \end{bmatrix}$$

$$|\Sigma_1| = |\Sigma_2| = 0.035$$

$$x = \begin{bmatrix} 1.5 \\ 7 \end{bmatrix}$$

$$P(w_2|x) = \frac{1}{2\pi\sqrt{0.035}} \exp\left[-0.5 \begin{bmatrix} 1.3 & 1.3 \end{bmatrix} \begin{bmatrix} 8.8 & -7.1 \\ -7.1 & 8.8 \end{bmatrix} \begin{bmatrix} 1.3 \\ 1.3 \end{bmatrix}\right]$$

$$P(w_2|x) = \frac{1}{2\pi\sqrt{0.035}} \exp(-2.873) = 0.048$$

$$P(c|x) = \frac{P(x|c)\,P(c)}{P(x)} \approx P(x|c)\,P(c)$$

$$P(c|x) = P(x_1|c)\,P(x_2|c) \ldots P(x_n|c)\,P(c)$$

$$X = (\text{Sunny}, \text{Cool}, \text{High}, \text{Strong})$$

$$P(\text{Yes}|x) = P(\text{Sunny}|\text{Yes})\,P(\text{Cool}|\text{Yes})\,P(\text{High}|\text{Yes})\,P(\text{Strong}|\text{Yes})\,P(\text{Yes})$$

$$= \frac{2}{9} \times \frac{3}{9} \times \frac{3}{9} \times \frac{3}{9} \times \frac{9}{14}$$

$$P(\text{Yes}|x) = \frac{1}{189} = 0.00529$$

$$P(\text{No}|x) = \frac{3}{5} \times \frac{1}{5} \times \frac{4}{5} \times \frac{3}{5} \times \frac{5}{14}$$

$$P(\text{No}|x) = \frac{18}{875} = 0.02057$$

$$P(\text{Yes}|x) = 20\%$$

$$P(\text{No}|x) = 80\%$$

Person	Height	Weight	Foot Size
Male	6	180	12
Male	5.92	190	11
Male	5.58	170	12
Male	5.92	165	10
Female	5	100	6
Female	5.5	150	8
Female	5.42	130	7
Female	5.75	150	9

$$X = (6, 130, 8)$$

$$P(\text{Male} \mid X) = P(\text{Height}=6 \mid \text{Male})\, P(\text{Weight}=130 \mid \text{Male})\, P(\text{Foot size}=8 \mid \text{Male})\, P(\text{Male})$$

$$P(\text{Height}=6 \mid \text{Male}) = \frac{1}{\sqrt{2\pi}\,\sigma_{HM}} \exp\left[-\frac{1}{2}\left(\frac{6-\mu_{HM}}{\sigma_{HM}}\right)^2\right] \rightarrow (1)$$

$$\mu_{HM} = \frac{6 + 5.92 + 5.58 + 5.92}{4} = 5.855$$

$$\sigma^2_{HM} = \frac{1}{4}\left[(6-5.855)^2 + (5.92-5.855)^2 + (5.58-5.855)^2 + (5.92-5.855)^2\right]$$

$$\sigma^2_{HM} = 0.026275$$ ← biased

For unbiased divide by 3 instead of 4.

$$\boxed{\sigma^2_{HM} = 0.035033}$$

Putting values in (1)

$\boxed{P(H=6|Male) = 1.5789}$ ← OK

Similarly

$$P(W=130|Male) = \frac{1}{\sqrt{2\pi}\,\sigma_{W_m}} \exp\left[-\frac{1}{2}\left(\frac{130-\mu_{W_m}}{\sigma_{W_m}}\right)^2\right]$$

$\mu_{W_m} = 176.25$

$\sigma_{W_m} = 122.92$

$\boxed{P(W=130|Male) = 5.9881 \times 10^{-6}}$

Similarly

$\boxed{P(FS=8|Male) = 1.3112 \times 10^{-3}}$

$\boxed{P(Male) = 0.5}$

$P(Male|X) = 1.5789 \times 5.9881 \times 10^{-6} \times 1.3112 \times 10^{-3} \times 0.5$

$P(Male|X) = 6.1984 \times 10^{-9}$ ← Numerator

In same vein

$P(\text{Female}|X) = P(H=6|F)\, P(W=130|F)\, P(FS=8|F)\, P(F)$

$P(F) = 0.5$

$$P(H|F) = \frac{1}{\sqrt{2\pi}\,\sigma_{H_F}} \exp\left[-\frac{1}{2}\frac{(6-\mu_{H_F})^2}{\sigma^2}\right]$$

$\mu_{H_F} = 5.4175$

$\sigma_{H_F} = 0.097225$

$P(H=6|F) = 0.22346$

Similarly

$P(W=130|F) = 1.6789 \times 10^{-2}$

$P(FS=8|F) = 2.8669 \times 10^{-1}$

$P(F|X) = 0.22346 \times 1.6789\times10^{-2} \times 2.8669\times10^{-1} \times 0.5$

$P(F|X) = 5.3778 \times 10^{-4}$ ← numerator

$6.1984\times10^{-9} + 5.3778\times10^{-4}$

$= 5.37786 \times 10^{-4}$

$$P(M|X) = \frac{6.1984\times10^{-9}}{5.37786\times10^{-4}} = 1.1525\times10^{-5}$$

$P(F|X) = 1$ We Predict Female

Perceptron :

	A	B	Output
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

① **1st :**

$W = [0 \quad 0 \quad 0]^T$

$X = [1 \quad 0 \quad 0]^T$

$W^T X = [0 \quad 0 \quad 0][1 \quad 0 \quad 0]^T = 0 + 0 + 0 = 0$

$0 \leq 0.5$

output = 0

old weight   target   output

$W_{new} = [0 \quad 0 \quad 0]^T + 0.1 \times (1 - 0)[1 \quad 0 \quad 0]^T$

$= [0 \quad 0 \quad 0]^T + [0.1 \quad 0 \quad 0]^T$

$\boxed{W_{new} = [0.1 \quad 0 \quad 0]^T}$

② **2nd :**

$W = [0.1 \quad 0 \quad 0]^T$

$X = [1 \quad 0 \quad 0]^T$

$W^T X = [0.1 \quad 0 \quad 0][1 \quad 0 \quad 0]^T$

$W^T X = 0.1 + 0 + 0 = 0.1$

$0.1 \leq 0.5$

output = 0

$W_{new} = [0.1 \quad 0 \quad 0]^T + 0.1(1 - 0)[1 \quad 0 \quad 1]^T$

$W_{new} = [0.1 \quad 0 \quad 0]^T + [0.1 \quad 0 \quad 0.1]^T = [0.2 \quad 0 \quad 0.1$

3

3rd

$W^T x = [0.2 \quad 0 \quad 0.1][1 \quad 1 \quad 0]^T = 0.2 \leq 0.5 = 0$

$W_{new} = [0.2 \quad 0 \quad 0.1]^T + (0.1)(1-0)[1 \quad 1 \quad 0]^T$

$W_{new} = [0.2 \quad 0 \quad 0.1]^T + [0.1 \quad 0.1 \quad 0]^T$

$W_{new} = [0.3 \quad 0.1 \quad 0.1]^T$

4

4th

$W^T x = [0.3 \quad 0.1 \quad 0.1][1 \quad 1 \quad 1]^T = 0.5 \leq 0.5 = 0$

$W_{new} = [0.3 \quad 0.1 \quad 0.1]^T + (0.1)(0-0)[1 \quad 1 \quad 1]^T$

$W_{new} = [0.3 \quad 0.1 \quad 0.1]^T$

No Change

5

5th

$W^T x = [0.3 \quad 0.1 \quad 0.1][1 \quad 0 \quad 0]^T = 0.3 \leq 0.5 = 0$

$W_{new} = [0.3 \quad 0.1 \quad 0.1]^T + (0.1)(1-0)[1 \quad 0 \quad 0]^T$

$W_{new} = [0.4 \quad 0.1 \quad 0.1]^T$

2

6th

$W^T x = [0.4 \quad 0.1 \quad 0.1][1 \quad 0 \quad 1]^T = 0.5 \leq 0.5 = 0$

$W_{new} = [0.4 \quad 0.1 \quad 0.1]^T + (0.1)(1-0)[1 \quad 0 \quad 1]^T$

$W_{new} = [0.5 \quad 0 \quad 0.2]^T$

At a later Stage

$$W = [0.7 \quad -0.2 \quad -0.2]$$
$$X = [1 \quad 0 \quad 0]$$

$$W^T X = [0.7 \quad -0.2 \quad -0.2][1 \quad 0 \quad 0]^T = 0.7 > 0$$
$$W_{new} = [0.7 \quad -0.2 \quad -0.2]^T + 0.1(1 - 1)[1 \quad 0 \quad 0]$$
$$W_{new} = [0.7 \quad -0.2 \quad -0.2]$$

$W^T X =$

$$i(N) = -\sum P(\omega_i) \log_2 P(\omega_i)$$

$$\Delta i(N) = i(N) - (P_L\, i(N_L) + P_R\, i(N_R))$$

ω_1		Avg	ω_2	
0.15	0.83		0.10	0.29
0.09	0.55		0.08	0.15
0.29	0.35		0.23	0.16
0.38	0.70		0.70	0.19
0.52	0.48		0.62	0.47
0.57	0.73		0.91	0.27
0.73	0.75		0.65	0.90
0.47	0.06		0.75	0.36

$x1 < 0.6$

$w1$		$w2$	
0.15	0.87	0.18	0.29
0.09	0.55	0.08	0.15
0.29	0.35	0.23	0.16
0.38	0.70	0	
0.52	0.48		
0.57	0.73		
0.47	0.06		

$x1 \not< 0.6$

$w1$		$w2$	
0.73	0.75	0.70	0.19
		0.62	0.47
		0.91	0.27
		0.65	0.90
		0.75	0.36

$$i(N) = -\left(\frac{8}{16}\log_2\frac{8}{16} + \frac{8}{16}\log_2\frac{8}{16}\right)$$

$$i(N) = 1$$

$$P_L = \frac{10}{16} \quad ; \quad P_R = \frac{6}{16}$$

$$i(N_L) = -\left(\frac{7}{10}\log_2\frac{7}{10} + \frac{3}{10}\log_2\frac{3}{10}\right) = 0.8813$$

$$i(N_R) = -\left(\frac{1}{6}\log_2\frac{1}{6} + \frac{5}{6}\log_2\frac{5}{6}\right) = 0.6500$$

likelihood

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

$$P(B) = \sum_{i=0}^{n-1} P(B_i|A)$$

$$N(\mu,\sigma) = \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left[\frac{(x-\mu_i)^2}{2\sigma^2}\right]$$

f	class
20	0
30	0
40	1
50	0
70	0
110	1
150	?

$P(\omega_0) = 4/6$

$P(\omega_1) = 2/6$

$P(x|\omega_0) = ?$

$$\mu_0 = \frac{20+30+50+70}{4}$$

$$\sigma_0 = \frac{\sum_{i=0}^{n-1}(x-\mu_i)^2}{n}$$

$$P(x|\omega_0) = \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left[\frac{(x-\mu_0)^2}{2\sigma^2}\right]$$

$$P(x) = P(\omega_0|x) + P(\omega_1|x)$$

AI

$$P(\omega_i|x) = \frac{P(x|\omega_i)\,P(\omega_i)}{P(x)}$$

$\omega_1 \rightarrow \begin{bmatrix} 13 \\ 5 \end{bmatrix}, \begin{bmatrix} 13.5 \\ 6 \end{bmatrix}, \begin{bmatrix} 14 \\ 5.5 \end{bmatrix}, \begin{bmatrix} 14.5 \\ 6.5 \end{bmatrix}$

$\omega_2 \rightarrow \begin{bmatrix} 16.5 \\ 7 \end{bmatrix}, \begin{bmatrix} 16 \\ 7.5 \end{bmatrix}, \begin{bmatrix} 17.5 \\ 8.5 \end{bmatrix}, \begin{bmatrix} 17 \\ 8 \end{bmatrix}$

$\mu_1 = \begin{bmatrix} 13.7 \\ 5.7 \end{bmatrix}$ Test sample $= \begin{bmatrix} 15 \\ 7 \end{bmatrix}$

$\mu_2 = \begin{bmatrix} 16.7 \\ 7.7 \end{bmatrix}$

~~$\omega_1 \rightarrow \begin{bmatrix} -0.7 \\ \end{bmatrix}, \begin{bmatrix} -0.2 \\ \end{bmatrix}, \begin{bmatrix} 0.3 \\ \end{bmatrix}, \begin{bmatrix} 0.8 \\ \end{bmatrix}$~~

$\omega_2 \rightarrow \begin{bmatrix} -0.2 \\ -0.7 \end{bmatrix}, \begin{bmatrix} -0.7 \\ -0.2 \end{bmatrix}, \begin{bmatrix} 0.8 \\ 0.8 \end{bmatrix}, \begin{bmatrix} 0.3 \\ 0.3 \end{bmatrix}$

$\omega_1 \rightarrow \frac{1}{4}\left(\begin{bmatrix} 0.04 & 0.14 \\ 0.14 & 0.49 \end{bmatrix} + \begin{bmatrix} 0.49 & 0.14 \\ 0.14 & 0.04 \end{bmatrix} + \begin{bmatrix} 0.64 & 0.64 \\ 0.64 & 0.64 \end{bmatrix} + \begin{bmatrix} 0.09 & 0.09 \\ 0.09 & 0.09 \end{bmatrix} \right)$

$$\begin{bmatrix} 0.315 & 0.25 \\ 0.25 & 0.315 \end{bmatrix}$$

$$P(x|\omega_i) = \frac{1}{(2\pi)^{d/2} |\Sigma_i|^{1/2}} \exp\left[-\frac{1}{2}(x-\mu_i)^t \Sigma_i^{-1} (x-\mu_i)\right]$$

$$= \frac{1}{(2\pi)^{2/2}(0.036)} \exp\left[-\frac{1}{2}\begin{bmatrix} 15-16.7 & 7-7.7 \end{bmatrix}\begin{bmatrix} 8.75 & -6.94 \\ -6.94 & 8.75 \end{bmatrix}\begin{bmatrix} 15-16.7 \\ 7-7.7 \end{bmatrix}\right]$$

$$p(w_i|x) = \frac{P(x|w_i)\,P(w_i)}{P(x)}$$

$$p(c|x) = \frac{P(x|c)\,p(c)}{\cancel{P(x)}}$$

$$p(c|x) \cong P(x|c)\,P(c)$$

$$= p(x_1, x_2, x_3, \ldots, x_n)\,P(c)$$

Naive assumption, features are independent

$$= \left[P(x_1|c)\,p(x_2|c) \ldots P(x_n|c)\right] P(c)$$

$P(Yes) = \frac{9}{14}$; $P(No) = \frac{5}{14}$

Outlook	Play = Yes	Play = No
Sunny	2/9	3/5
Overcast	4/9	0/5
Rain	3/9	2/5

$P(\text{outlook} = \text{Overcast} \mid \text{Yes}) = \frac{4}{9}$

$P(\text{outlook} = \text{overcast} \mid \text{No}) = \frac{0}{5}$

Temp	Yes	No
Hot	2/9	2/5
Mild	4/9	2/5
Cool	3/9	1/5

Test,

Outlook = Sunny
Cool
high
Strong

$$P(Yes|X) = \left[P(\text{outlook}=\text{Sunny}|Yes)\,P(\text{temp}=\text{Cool}|Yes)\,P(\text{hum}=\text{high}|Yes)\,P(\text{wind}=\text{Strong}|Yes) \right] P(Yes)$$

$$= \frac{2}{9} \times \frac{3}{9} \times \frac{3}{9} \times \frac{3}{9} \times \frac{9}{14} = 0.0053$$

$$P(No|X) = \frac{3}{5} \times \frac{1}{5} \times \frac{4}{5} \times \frac{3}{5} \times \frac{5}{14} = 0.0206$$

K=3

Training

15	95	1	1
33	90	1	2
78	70	0	3
70	45	0	4
80	18	0	5
35	65	1	6

Test

45	70	
31	61	
50	63	
98	80	
73	81	
50	18	

$(45-15)^2 + (70-95)^2$

$= (30)^2 + (-25)^2$

$=$

(45,70):

1 → 39

2 → 23 ✓ 1

3 → 33 ✓ 0

4 → 35

5 → 41

6 → 11 ✓ 1

(45,70) → 1

(31,61),

1 → 37.5 ✓ 1

2 → 29 ✓ 1

3 → 48

4 → 42

5 → 65

6 → 5.6 ✓ 1

(31,61) → 1

(73,81),

1 → 60

2 → 41 ✓ 1

3 → 12 ✓ 0

4 → 36

5 → 63

6 → 41 ✓ 1

	0	1
0	60	30
1	80	20

	0	1
0	TN	FP
1	FN	TP

Sensitivity ~~Specificity~~ $= \dfrac{20}{100} = \dfrac{20}{20+80}$

Specificity $= \dfrac{60}{60+30} =$

	8	3	6
8	420	30	50
3	60	400	40
6	20	30	450

Specification :

8 : $\dfrac{400+40+30+450}{500+500} = 0.92$

3 : $\dfrac{20+450+420+50}{500+500} = 0.94$

6 : $\dfrac{60+400+420+30}{500+500} = 0.91$

	8	3	6
8	420	30	50
3	60	400	40
6	20	30	450

TP	FN
FP	TN

$$\frac{TN}{TN+FP} = \frac{400+40+30+450}{400+40+30+450+60+20}$$

$$= 0.92$$

	8	3	6
8	420	30	50
3	60	400	40
6	20	30	450

TN	FP	TN
FN	TP	FN
TN	FP	TN

$$\frac{420+50+20+450}{420+50+20+450+30+30} = 0.94$$

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

$$\text{Specificity} = \frac{TN}{TN+FP}$$