Date 3/1/18
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Human Perception - sense the env. and take the actions/decisions based on the env.

Pattern - is an object, process or event that can be given a name. Independent existence.

Pattern Recognition - is the study of how machines can
i) Observe the env.
ii) learn to distinguish pattern of interest
iii) make sound and reasonable decisions about the categories of the pattern.

Class (Pattern of class) - A pattern class (category) is a set of patterns sharing common attributes and usually originating from the same source.

Feature Extraction and Classification -
- extracting distinguishable features
- To categorise an object to be recognized by measurements whose values are very similar for objects in the same category (or class) and very diff^n for objects in diff^n categories.
- classification - To assign a category or class to the object based on feature vector provided during feature extraction.

10/1/19

Basic structure of P.R. system

1. Data Acquisition and sensing

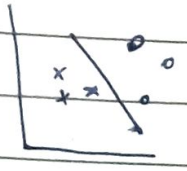
- Image contains multiple information (there are several objects)
- distortion

instruments also involved in sensing.

2. Pre-processing
- remove noise in the data
- isolation of patterns of interest from the background (segmentation)

3. Feature Extraction
find a new representation in terms of features (discriminating features)

4. Model learning and estimation
- learning a mapping mechanism b/w features and patterns, groups and categories.

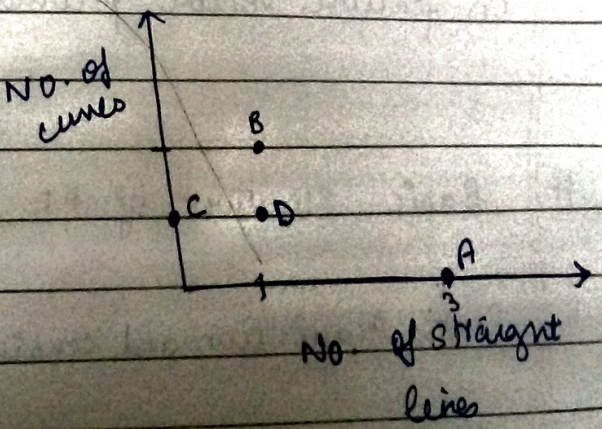


5. Classification
- assigning unknown objects | data points into one of the pre-defined class labels if it is supervised.

6. Post-processing
- Exploitation of content
combination of experts view.

Handwriting Recognition System

	No. of straight lines	No. of curves
A	3	0
B	1	2
C	0	1
D	1	1



Previous info ⇒ Generate additional data

Bayes Theorem

Ques A desk lamp produced by one lumina company was found to be defected (D). There are 3 factories A, B, C where such desk lamps are manufactured. A quality control manager (QCM) is responsible for investigating the source of found defects. That is what the QCM knows about the companies desk lamp production and possible source of defects:

Based on previous history

Factory	A priori probabilities: % of total production	Conditional probability: Probability of defected lamp
A	0.35 = P(A)	0.015 = P(D/A)
B	0.35 = P(B)	0.010 = P(D/B)
C	0.30 = P(C)	0.020 = P(D/C)

The QCM would like to answer the following questions:

1. If a randomly selected lamp is defected then what is the probability that lamp was mfd in C.
2. If a randomly selected lamp is defected then what is the probability that lamp was manufactured in A.
3. If randomly selected lamp is defected then what is the probability that lamp was manufactured in B.

Posteriori Probabilities

Soln

1) $$P(C/D) = \frac{P(D/C) * P(C)}{P(D/A)*P(A) + P(D/B)*P(B) + P(D/C)*P(C)}$$

$$= \frac{0.30 * 0.020}{0.35*0.015 + 0.35*0.010 + 0.30*0.020}$$

$$= \frac{0.006}{0.01475}$$

$$= 0.406$$

2) $$P(BA/D) = \frac{0.00525}{0.01475}$$

$$= 0.356$$

3) $$P(B/D) = \frac{0.0035}{0.01475}$$

$$= 0.237$$

Previous info ⇒ generate additional data

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2. If a randomly selected lamp is defected then what is the probability that lamp was manufactured in A.
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Posteriori Probabilities

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1) $P(C/D) = \frac{P(D/C) * P(C)}{P(D/A)*P(A) + P(D/B)*P(B) + P(D/C)*P(C)}$

$= \frac{0.30 * 0.020}{0.35*0.015 + 0.35*0.010 + 0.30*0.020}$

$= \frac{0.006}{0.01475}$

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$= 0.356$

3) $P(B/D) = \frac{0.0035}{0.01475}$

$= 0.237$

X ← variable (points of material)

Example

(ω₁) Accept < good, very good, excellent

2. (ω₂) Reject < bad, poor

A priori probabilities

class conditional probabilities

$$P(\omega_1 / x) > P(\omega_2 / x) \rightarrow \text{Accept}$$

else class reject

if $P(\omega_1 / x) = P(\omega_2 / x)$ then will say additional data, post processing

Bayes Theorem used to classify / for classification.

14/1/19

	cx_1	cx_2	cx_3	cx_4	cx_5	cx_6	cx_7	cx_8	cx_9	cx_{10}
variable	good	bad	very good	poor	very good	bad	good	excellent	good	bad
category	accept	reject	accept	reject	accept	accept	reject	accept	accept	reject

A priori probabilities

$P(\text{accept}) = 6/10 = 0.6$

$P(\text{reject}) = 4/10 = 0.4$

class conditional probabilities

$P\left(\frac{\text{good}}{\text{accept}}\right) = 0.55 / 0.33$

$P\left(\frac{\text{bad}}{\text{accept}}\right) = \frac{1/6}{6/10} \frac{1}{6} = 0.16$

$P\left(\frac{\text{very good}}{\text{accept}}\right) = \frac{2/6}{6/10} = 0.55 / 0.33$

$P\left(\frac{\text{bad}}{\text{reject}}\right) = \frac{2}{4} = 0.5$

$P\left(\frac{\text{excellent}}{\text{accept}}\right) = \frac{1/6}{6/10} = 0.27 / 0.16$

$P\left(\frac{\text{poor}}{\text{reject}}\right) = \frac{2}{4} = 0.5$

X ← variable [points of material]

Measures

1. (ω_1) Accept ← good, very good, excellent
2. (ω_2) Reject ← bad, poor

A priori Probabilities — class conditional probabilities

$P(\omega_1/x) > P(\omega_2/x) \rightarrow$ Accept

else reject

if $P(\omega_1/x) = P(\omega_2/x)$ then will use additional data. Post processing.

Bayes Theorem used to classify / for classification.

14/1/19

	Ex1	Ex2	Ex3	Ex4	Ex5	Ex6	Ex7	Ex8	Ex9	Ex10
variable	Good	bad	very good	poor	very Good	bad	poor	excellent	good	bad
category	accept	reject	accept	reject	accept	accept	reject	accept	accept	reject

A priori Probabilities

$P(\text{accept}) = 6/10 = 0.6$

$P(\text{reject}) = 4/10 = 0.4$

class conditional probabilities

$P(\frac{\text{good}}{\text{accept}}) = 0.55/0.33$ $\quad P(\frac{\text{bad}}{\text{accept}}) = \frac{1/6}{6/10} = 0.16$

$P(\frac{\text{very good}}{\text{accept}}) = \frac{2/6}{6/10} = 0.55 \text{ or } 0.33$ $\quad P(\frac{\text{bad}}{\text{reject}}) = \frac{2}{4} = 0.5$

$P(\frac{\text{excellent}}{\text{accept}}) = \frac{1/6}{6/10} = 0.27 \text{ or } 0.16$ $\quad P(\frac{\text{poor}}{\text{reject}}) = \frac{2}{4} = 0.5$

$$P(\text{accept} / \text{very good}) = \frac{0.6 * 0.33}{0.33 \times 0.6 + 0.33 \times 0.6 + 0.16 \times 0.6 + 0.16 \times 0.6 + 0.5 \times 0.4 + 0.5 \times 0.4}$$

$$= \frac{0.198}{0.988} = 0.2004$$

$$P(\text{reject} / \text{very good}) = 0$$

$$P(\text{accept} / \text{bad}) = \frac{0.6 * 0.16}{0.988}$$

$$= \frac{0.096}{0.988} = 0.0971$$

$$P(\text{reject} / \text{bad}) = 0.202$$

$$P(\text{reject} / \text{bad}) > P(\text{accept} / \text{bad}) \rightarrow \text{reject}$$

Bayes Decision Theory

$$P(\omega_i, x) = P(\omega_i / x)\, P(x)$$

$$= P(x / \omega_i)\, P(\omega_i)$$

$$\Rightarrow P(\omega_i / x)\, P(x) = P(x / \omega_i)\, P(\omega_i)$$

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

$P(\omega_i / x)$ → Posterior Probability

Decision rule $P(x/\omega_1)P(\omega_1) > P(x/\omega_2)P(\omega_2) \Rightarrow \omega_1$

Polish (x) / quantize / thick thin

	ex_1	ex_2	ex_3	ex_4	ex_5	ex_6	ex_7	ex_8
Polish	thick	thick	thin	thin	thin	thick	thick	thick
class	accept	accept	accept	accept	Reject	Reject	Reject	Reject

$P(\text{accept}) = 4/8 = 0.5$

$P(\text{reject}) = 4/8 = 0.5$

$P(\text{thick}/\text{accept}) = 2/4 = 0.5$ $\quad P(\text{thick}/\text{reject}) = 3/4 = 0.75$

$P(\text{thin}/\text{accept}) = 2/4 = 0.5$ $\quad P(\text{thin}/\text{reject}) = 1/4 = 0.25$

$P(\text{accept}/\text{thick}) =$

$P(\text{accept}/\text{thin}) =$

$P(\text{reject}/\text{thick}) =$ → P1

$P(\text{reject}/\text{thin}) =$

$P(A/\text{Thick}) = \dfrac{0.5 \times 0.5}{0.625} = 0.4$

$P(R/\text{thick}) = 0.6$

$P(A/\text{thin}) = 0.25 / 0.375 = 0.375$

$P(R/\text{thin}) = / 0.375$

$P(\text{error}/x) = \begin{cases} P(\omega_1/x) & \text{if we decide in favour of } \omega_2 \\ P(\omega_2/x) & \text{if we decide in favour of } \omega_1 \end{cases}$

$P(\text{error}/x) = \min \{ P(\omega_1/x), P(\omega_2/x) \}$

Multiple Class

clothing(n) < shirt, jeans, shoes

Class: top, bottom, foot

	ex1	ex2	ex3	ex4	ex5	ex6	ex7	ex8
Clothing	Shirt	Shoes	Jeans	Jeans	Jeans	Shoes	Shirt	Shoes
Class	top	top	bottom	foot	bottom	foot	bottom	top

$P(\text{top}) = 3/8$

$P(\text{bottom}) = 3/8$

$P(\text{foot}) = 2/8$

$P(\text{shirt}/\text{top}) = 2/3$ $\quad P(\text{shirt}/\text{bottom}) = 1/3$ $\quad P(\text{shirt}/F) = 0$

$P(\text{jeans}/\text{top}) = 0$ $\quad P(S/B) = 2/3$ $\quad P(S/F) = 1/2$

$P(\text{shoes}/\text{top}) = 1/3$ $\quad P(S/B) = 0$ $\quad P(S/F) = 1/2$

$$P(\text{top}/\text{shirt}) = \frac{2/3 \times 3/8}{2/3 \times 3/8 + 1/3 \times 3/8 + 0 \times 2/8} = \frac{0.25}{0.25 + 0.125 + 0} = 0.66$$

$$P(\text{top}/B)\,P(\text{bottom}/\text{shirt}) = \frac{1/3 \times 3/8}{0.25 + 0.125} = 0.33$$

shirt $\Rightarrow P(\text{top}/\text{shirt}) > P(\text{bottom}/\text{shirt}) \Rightarrow$ top wear

$$P(\text{top}/\text{shoes}) = \frac{1/3 \times 3/8}{1/3 \times 3/8 + 0 \times 3/8 + 1/2 \times 2/8} = \frac{0.125}{0.125 + 0 + 0.125} = 0.5$$

$$P(\text{error}/x) = \begin{cases} P(\omega_1/x) & \text{if we decide in favour of } \omega_2 \\ P(\omega_2/x) & \text{if we decide in favour of } \omega_1 \end{cases}$$

$$P(\text{error}/x) = \min\{P(\omega_1/x), P(\omega_2/x)\}$$

Multiple Class

clothing(x) = shirt / jeans / shoes

Classes = Top / Bottom / Foot

	ex1	ex2	ex3	ex4	ex5	ex6	ex7	ex8
Clothing	shirt	shirt	jeans	jeans	jeans	shoes	shirt	shoes
Class	top	top	bottom	foot	bottom	foot	bottom	top

$P(\text{top}) = 3/8$

$P(\text{bottom}) = 3/8$

$P(\text{foot}) = 2/8$

$P(\text{shirt}/\text{top}) = 2/3$ $\quad P(\text{shirt}/\text{bottom}) = 1/3$ $\quad P(\text{shirt}/F) = 0$

$P(\text{jeans}/\text{top}) = 0$ $\quad P(J/B) = 2/3$ $\quad P(J/F) = 1/2$

$P(\text{shoes}/\text{top}) = 1/3$ $\quad P(S/B) = 0$ $\quad P(S/F) = 1/2$

$$P(\text{top}/\text{shirt}) = \frac{2/3 \times 3/8}{2/3 \times 3/8 + 1/3 \times 3/8 + 0 \times 2/8}$$

$$= \frac{0.25}{0.25 + 0.125 + 0} = 0.66$$

$$P(\text{top}/B)\,P(\text{bottom}/\text{shirt}) = \frac{1/3 \times 3/8}{0.25 + 0.125} = 0.33$$

shirt $\Rightarrow$ $P(\text{top}/\text{shirt}) > P(\text{bottom}/\text{shirt})$ $\Rightarrow$ top near

$$P(\text{top}/\text{foot}) = \frac{1/3 \times 3/8}{1/3 \times 3/8 + 0 \times 3/8 + 1/2 \times 2/8}$$

$$= \frac{0.125}{0.125 + 0 + 0.125} = 0.5$$

$P(\text{spam}) = \frac{}{2 \times 0.125} =$

Feature Vector

$$P(C_i/x) = \frac{P(x/C_i)\,P(C_i)}{P(x)}$$

Mutually Independent attributes (Naive Bayes)

$$x = (x_1, x_2, \ldots, x_n)$$

$$P(x/C_j) = \prod_{i=1}^{n} P(x_i/C_j)$$

$$P(C_j) \prod_{i=1} P(x_i/C_j)$$

↑ class maximizes

chills	runnynose	headache	fever	Flu ?
Y	N	Mild	Y	N
Y	Y	No	N	Y
Y	N	Strong	Y	Y
N	Y	Mild	Y	Y
N	N	No	N	N
N	Y	Strong	Y	Y
N	Y	Strong	N	N
Y	Y	Mild	Y	Y

A priori probability

$P(N) = 3/8$

$P(Y) = 5/8$

Class conditional probability

~~P(chills / Y) =~~

P(-chills / N) =

P(chills = Y | flu = N) = 1/3
P(chills = N | flu = N) = 3/5 2/3

P(chills = Y | flu = Y) = 3/5
P(chills = N | flu = Y) = 2/5

P(RN = Y | F = N) = 1/3
P(RN = N | F = N) = 2/3

P(RN = Y | F = Y) = 4/5
P(RN = N | F = Y) = 1/5

P(H = Mild | F = Y) = 2/5
P(H = No | F = Y) = 1/5
P(H = Strong | F = Y) = 2/5

P(H = Mild | F = N) = 1/3
P(H = No | F = N) = 1/3
P(H = Strong | F = Y) = 1/3

P(Fever = N | F = Y) = 1/5
P(Fever = Y | F = Y) = 4/5

P(Fever = N | F = N) = 2/3
P(Fever = Y | F = N) = 1/3

(Y, N, Mild, N) ⇒ Flu?

$$P(F=Y) = \frac{5}{8} \times \frac{3}{5} \times \frac{1}{5} \times \frac{2}{5} \times \frac{1}{5} = 0.006$$

$$P(F=N) = \frac{3}{8} \times \frac{1}{3} \times \frac{2}{3} \times \frac{1}{3} \times \frac{2}{3} = 0.018$$

P(F=N) > P(F=Y) ⇒ NO Flu.

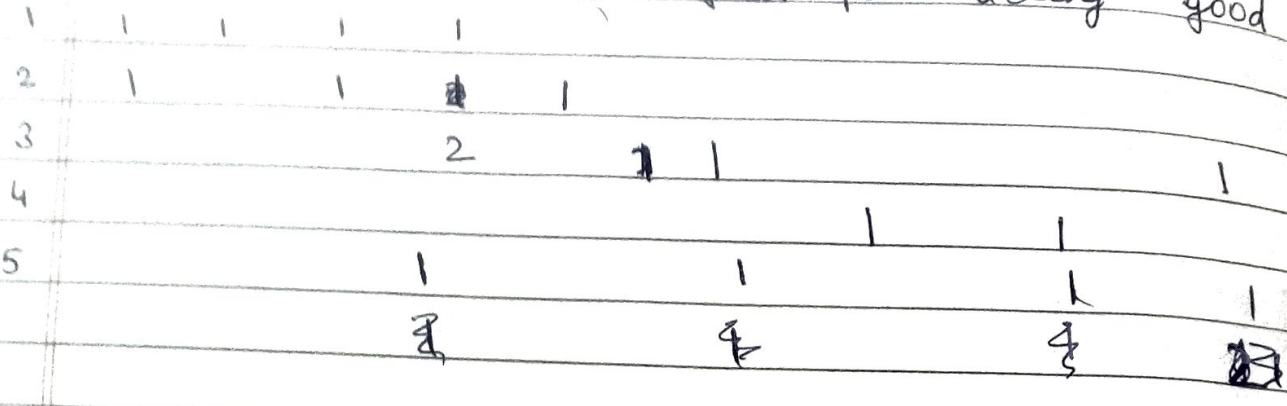
Text Classification

21/1/19

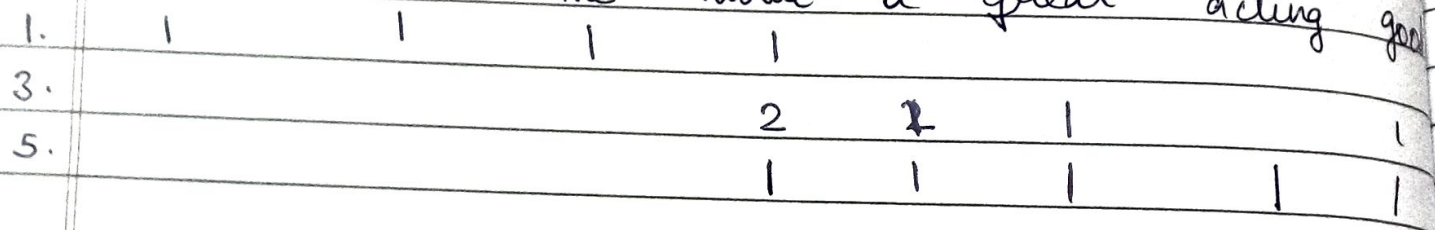
DOC	Text	Class
1	I loved the movie.	+
2	I hated the movie	−
3	A great movie, good movie.	+
4	POOR acting	−
5	Great acting, a good movie	+

I loved the movie

I loved the movie hated a great poor acting good

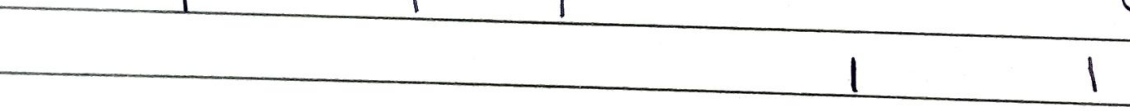


I loved the movie a great acting good



~~I loved the mov~~

I the movie hated a poor acting



$P(+) = 3/5$ $P(-) = 2/5$

$P(I/+) = \frac{1+1}{14+10}$ $P(love/+) = \frac{1+1}{14+10} = \frac{2}{24} = \frac{1}{12}$ $P(the/+) = \frac{1}{12}$

$P(movie/+) = \frac{5}{24}$ $P(a/+) = \frac{3}{24}$ $P(great/+) = \frac{3}{24}$

$P(hated/+) = \frac{1}{24}$ $P(poor/+) = \frac{1}{24}$ $P(acting/+) = \frac{2}{24}$

$P(good/+) = \frac{3}{24}$

$P(I/-) = \frac{2}{16} = \frac{1}{8}$ $P(\text{loved}/-) = \frac{1}{16}$ $P(\text{movie}/-) = \frac{1}{8}$

$P(\text{hated}/-) = \frac{1}{8}$ $P(\text{great}/-) = \frac{1}{16}$

$P(\text{poor}/-) = \frac{1}{8}$ $P(\text{good}/-) = \frac{1}{16}$

$P(\text{me}/-) = \frac{1}{8}$ $P(\text{a}/-) = \frac{1}{16}$ $P(\text{acting}/-) = \frac{1}{8}$

The movie is great

I hated the poor acting

(1, 0, 1, 0, 1, 0, 0, 1, 1, 0)

$$P(+) = \frac{3}{5} \times \frac{1}{12} \times \frac{1}{12} \times \frac{1}{24} \times \frac{1}{24} \times \frac{1}{12} = 6.02 \times 10^{-7}$$

$$P(-) = \frac{2}{5} \times \frac{1}{8} \times \frac{1}{8} \times \frac{1}{8} \times \frac{1}{8} \times \frac{1}{8} = 1.22 \times 10^{-5}$$

$P(-) > P(+) \Rightarrow -$

Doc	Text	Class
1.	Gang got AIDS	Sad
2.	gang is happy	Happy
3.	gang ~~met~~ was in accident	Sad
4.	gang found his iphone	Happy
5.	gand lost his iphone	Sad

~~gand got~~ AIDS Happy accident found iphone lost iphone