Machine Learning

Date / /

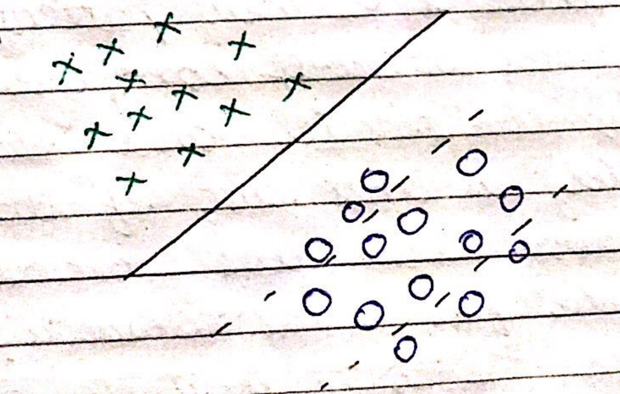
Generative Learning Algorithms:

Generative approaches try to build a model of 'Positives' and a model of the 'Negatives'. A 'decision boundary' is formed where one model becomes more likely. As these create model for each class they can be used for generation.

Example:

Let us take binary classification as an example:

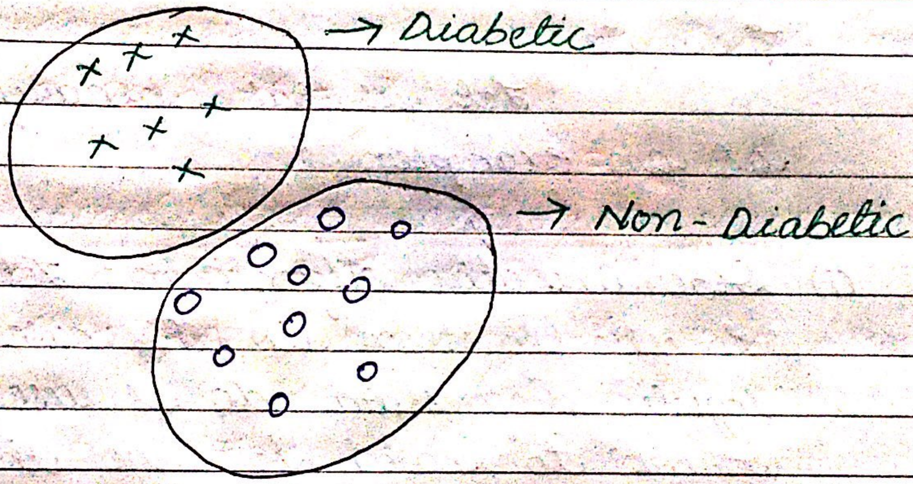
(i) Discriminative Algorithm: Let's consider 'Logistic Regression' in this case. So what logistic regression do is use 'Gradient Descent' to search for line that separates positive and negative examples.



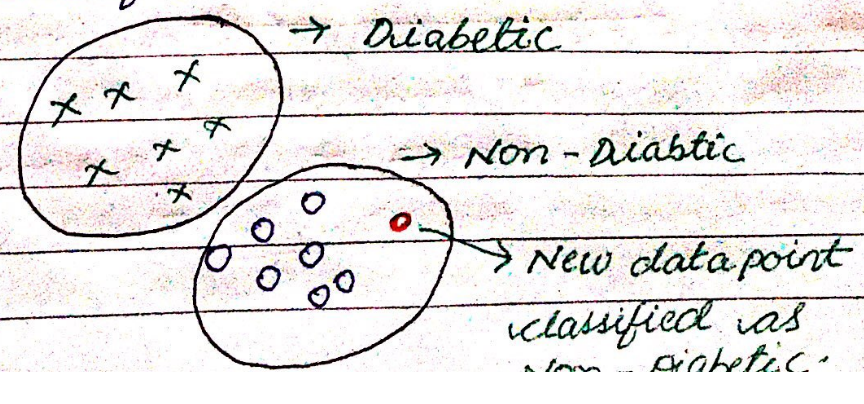
'x' → Diabetic
'O' → Non Diabetic
'---' → Initial Separation at a random point
'—' → Final Separation

(ii) **Generative Learning Algorithm:**

Rather than looking at the two classes and try to find the separation instead the algorithm is going to look at the classes one at a time. First it looks at the 'positive' values and build a model for how the positive values looks like and second it looks at the 'negative' values and a build a model how the negative value looks like



If there is a new patient with those features it will compare it with 'diabetic' model and 'Non-Diabetic' model in this case if the new patient features looks like more 'Diabetic' then it classifies it as 'Diabetic' else 'Non-Diabltic'



Formulae:

(i) Discriminative Learning Algorithm:

Learn's $x \to y$

$P(y|x)$ [i.e., learn's $P(y)$ given x]

(or)

$$h_\theta(x) \begin{cases} 0 \\ 1 \end{cases}$$

(ii) Generative Learning Algorithm:

It learn's $P(x)$ given 'y'. In other words given a class it learn's what are the features likely gonna be like.

$P(x|y)$ → y: class; x: Features

It also learns '$P(y)$'

$P(y) \to$ class Prior

So class prior in our example is when a new patient is not examined what is the probability that the patient is 'Diabetic' or 'Non-Diabetic'.

Algorithm can use Bayes rule to derive distribution of y given x: $P(y|x) = P(x|y)P(y) / P(x)$

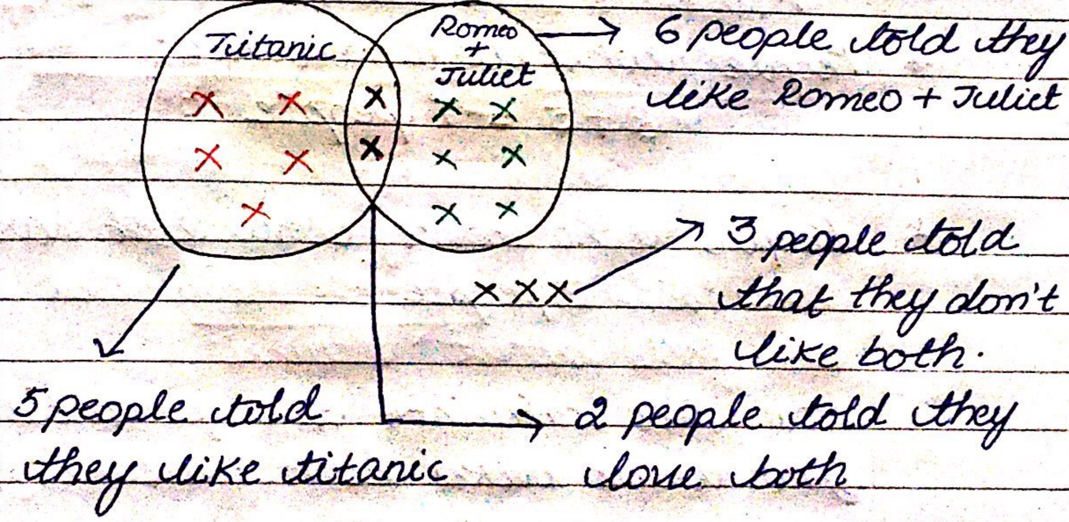
Conditional Probability:

It is the probability of one event occuring with some relationship to one or other. In real life it is used in many area's, in fields such as climate, insurance and politics etc.

Example: The weatherman might state that your area has a probability of rain of 40%. However, this fact is conditional on many things such as probability of:

(i) a cloud front coming to your area.
(ii) rain clouds forming.
(iii) another front pushing the rain clouds away.

Example 2: Let us say you have been to a party and joined your friends gang for drinks, including you the gang comprised of 16 members. While having drinks you started to speak about movies and you asked how many people here like 'Titanic', like 'Romeo + Juliet', both 'Titanic' and 'Romeo + Juliet' and dont like both 'Titanic' and 'Romeo + Juliet'. So, 5 people told that they like 'Titanic' but not 'Romeo + Juliet', 6 people told that they like 'Romeo + Juliet' but not 'Titanic', 2 people told that they like both 'Titanic' and 'Romeo + Juliet' and 3 people told that they dont like both 'Titanic' and 'Romeo + Juliet'. Now as you people are speaking your crush walked-in and your friend murmured in your ear that 'I bet you 10K that the next person i.e, your crush has same opinion like you [i.e, both 'Titanic' and 'Romeo + Juliet' (likes)]. Let us find the probability of the statement made by your friend.



Now, Let us solve this by using contigency table.

	Love (Romeo + Juliet)	Doesn't Love (Romeo + Juliet)
Love Titanic		
Doesn't Love Titanic		

Let's fill the contigency table with our example.

	Love (Romeo + Juliet)	Doesn't Love (Romeo + Juliet)
Love Titanic	2 $p_1 = 2/16$	5 $p_3 = 5/16$
Doesn't Love Titanic	6 $p_2 = 6/16$	3 $p_4 = 3/16$

* People who love (Romeo + Juliet):
$2 + 6 = 8$ people

* People who love titanic:
$2 + 5 = 7$ people

* People who don't love both are:
3 people

Now let's calculate the probability tha your crush likes both 'Titanic' and 'Romeo + Juliet'

P(likes Titanic and Romeo + Juliet)

$$= \frac{\text{People who like both}}{\text{Total number of people}}$$

$$= \frac{2}{16} = 0.14$$

Scanned with CamScanner

P(likes Romeo + Juliet) $= \frac{6}{16}$

P(likes Titanic) $= \frac{5}{16}$

P(NOT likes Titanic and Romeo + Juliet):

$= \frac{3}{16}$

If we add the probabilities:

$$\frac{2}{16} + \frac{6}{16} + \frac{5}{16} + \frac{3}{16} = \frac{16}{16} = 1$$

This just means that the people in your friends gang when asked there is a 100% chance that they will either

(i) Love 'Titanic'
(ii) Love 'Romeo + Juliet'
(iii) Love both 'Titanic' and 'Romeo + Juliet'
(iv) Doesn't Love both 'Titanic' and 'Romeo + Juliet'.

* Probability that your crush likes 'Titanic' regardless of how she feels about 'Romeo + Juliet'

P(likes Titanic) $= P_1 + P_3$

$= \frac{2}{16} + \frac{5}{16} = \frac{7}{16}$

Probability that your crush likes 'Romeo + Juliet' regardless of how she feels about 'Titanic'

$P(\text{likes Romeo + Juliet})$

$$= P_2 + P_4$$

$$= \frac{6}{16} + \frac{2}{16} = \frac{8}{16}$$

Probability that your crush doesnot like 'Titanic' regardless of how she feels about 'Romeo + Juliet'

$$P(\text{doesn't like Titanic}) = P_2 + P_4$$

$$= \frac{6}{16} + \frac{3}{16} = \frac{9}{16}$$

Probability that your crush doesn't like 'Romeo + Juliet' regardless of how she feels about 'Titanic'

$$P(\text{doesn't like Romeo + Juliet}) = P_3 + P_4$$

$$= \frac{5}{16} + \frac{3}{16} = \frac{8}{16}$$

what is the probability that your crush likes 'Titanic' and 'Romeo + Juliet' given that we know they like 'Romeo + Juliet'.

Titanic → 'T' , 'Romeo + Juliet' → 'RJ'

P(likes 'T' and 'RJ' | likes 'RJ') = $\frac{2}{2+5} = \frac{2}{7}$

$= 0.29$

This probability is different from the original probability that was calculated without knowing whether or not they liked 'RJ'

P(likes 'T' and 'RJ') = 0.14

In this case, knowing they liked 'RJ' increased the probability that they would like 'T'

Now let's see what happens when we calculate the probability that your crush doesn't like 'titanic' given that she loves 'RJ'

P(not like 'T' and like 'RJ' | like 'RJ')

$= \frac{6}{2+6} = \frac{6}{8} = 0.75$

P(not like 'T' and like 'RJ') $= \frac{6}{16} = 0.37$

So, the conditional probability equation is as follows:

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

From the above example we can conclude that your crush likes 'RJ' but not 'Titanic'.

Math behind conditional Probability:

It is derived from the probability multiplication rule

Step1: Multiplication Rule.

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

Step2: Divide both sides with P(A)

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

Step3: Cancel P(A) on right hand side and rewrite the equation:

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