Top 30 data science interview questions

Nitin Panwar Dec 31, 2018 · 17 min read

Data science, also known as data-driven decision, is an interdisciplinary field about scientific methods, process and systems to extract knowledge from data in various forms, and take decision based on this knowledge. There are a lot of things that a data scientist should know, I will give you a list of data science interview questions that i faced during several interviews, if you are a aspiring data scientist then you can start from here, if you have been for a while in this field then it might be repetition for you, but you will get a lot of things from here. I will try to start from very basic interview questions and cover advance ones later, So let's get started.

1. What is the difference between supervised and unsupervised machine learning?

Supervised Machine learning:

Supervised machine learning requires training labelled data. Let's discuss it in bit detail, when we have

Unsupervised Machine learning:

Unsupervised machine learning doesn't required labelled data.

2. What is bias, variance trade off ?

Bias:

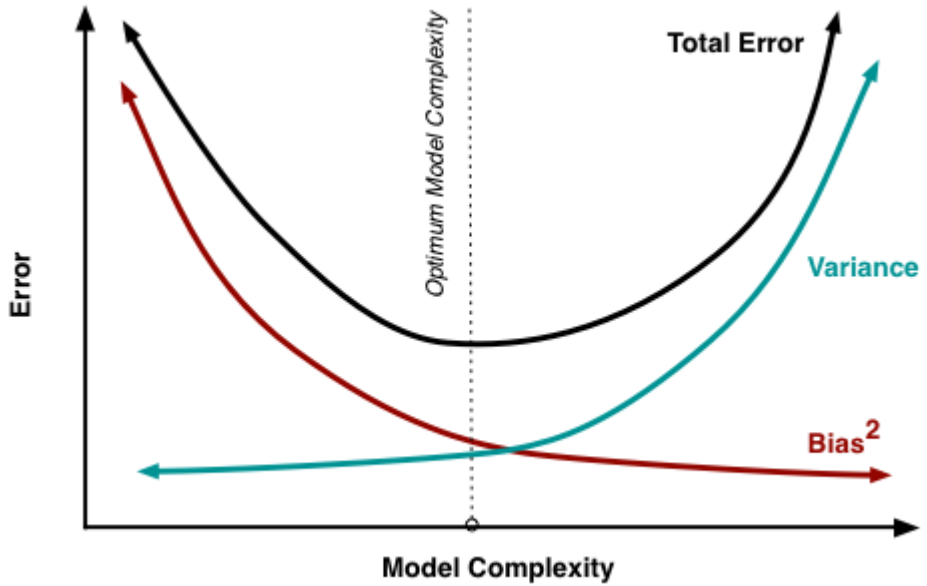
"Bias is error introduced in your model due to over simplification of machine learning algorithm." It can lead to under fitting. When you train your model at that time model makes simplified assumptions to make the target function easier to understand.

Low bias machine learning algorithms — Decision Trees, k-NN and SVM
High bias machine learning algorithms — Linear Regression, Logistic Regression

Variance:

"Variance is error introduced in your model due to complex machine learning algorithm, your model learns noise also from the training data set and performs bad on test data set." It can lead high sensitivity and over fitting.

Normally, as you increase the complexity of your model, you will see a reduction in error due to lower bias in the model. However, this only happens till a particular point. As you continue to make your model more complex, you end up over-fitting your model and hence your model will start suffering from high variance.



Bias, Variance trade off:

The goal of any supervised machine learning algorithm is to have low bias and low variance to achieve good prediction performance.

1. The k-nearest neighbours algorithm has low bias and high variance, but the trade-off can be changed by increasing the value of k which increases the number of neighbours that contribute to the prediction and in turn increases the bias of the model.
2. The support vector machine algorithm has low bias and high variance, but the trade-off can be changed by increasing the C parameter that influences the number of violations of the margin allowed in the training data which increases the bias but decreases the variance.

There is no escaping the relationship between bias and variance in machine learning. Increasing the bias will decrease the variance. Increasing the variance will decrease the bias.

3. What is exploding gradients ?

Gradient:

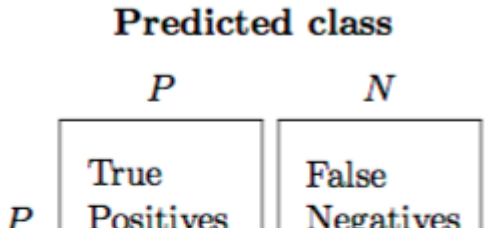
Gradient is the **direction and magnitude** calculated during training of a neural network that is used to update the network weights in the right direction and by the right amount.

"Exploding gradients are a problem where **large error gradients** accumulate and result in very large updates to neural network model weights during training." At an extreme, the values of weights can become so large as to overflow and result in NaN values.

This has the effect of your model being unstable and unable to learn from your training data. Now let's understand what is the gradient.

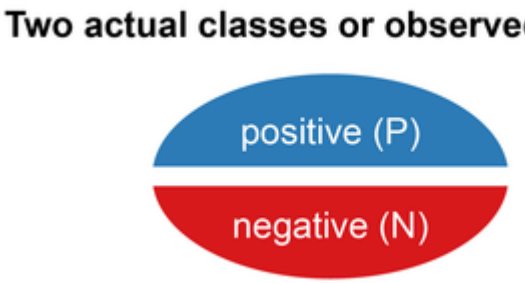
4. What is a confusion matrix ?

The confusion matrix is a 2X2 table that contains 4 outputs provided by the **binary classifier**. Various measures, such as error-rate, accuracy, specificity, sensitivity, precision and recall are derived from it. *Confusion Matrix*

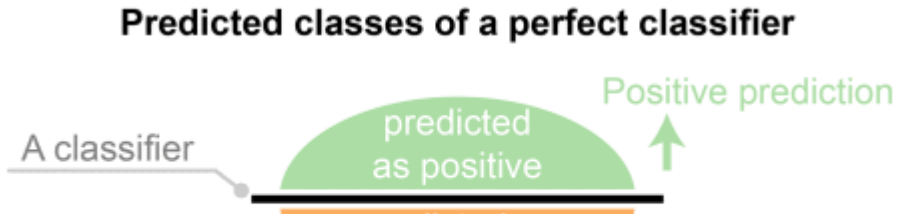


		(TP)	(FN)
Actual Class			
	N	False Positives (FP)	True Negatives (TN)

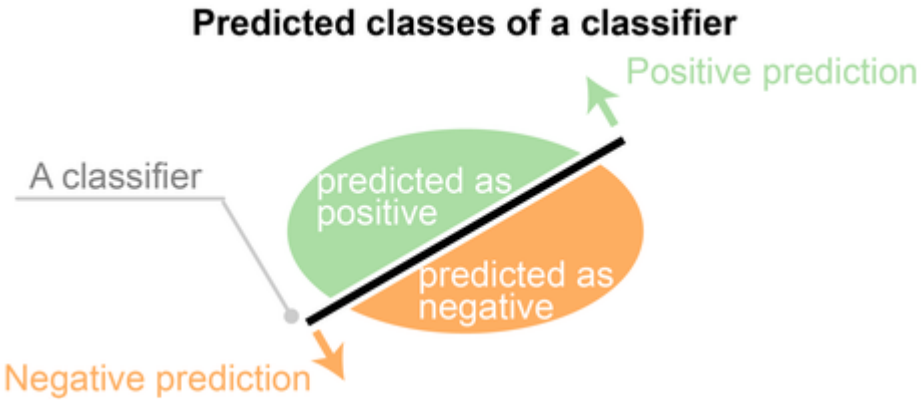
A data set used for performance evaluation is called test data set. It should contain the correct labels and predicted labels.



The predicted labels will exactly the same if the performance of a binary classifier is perfect.

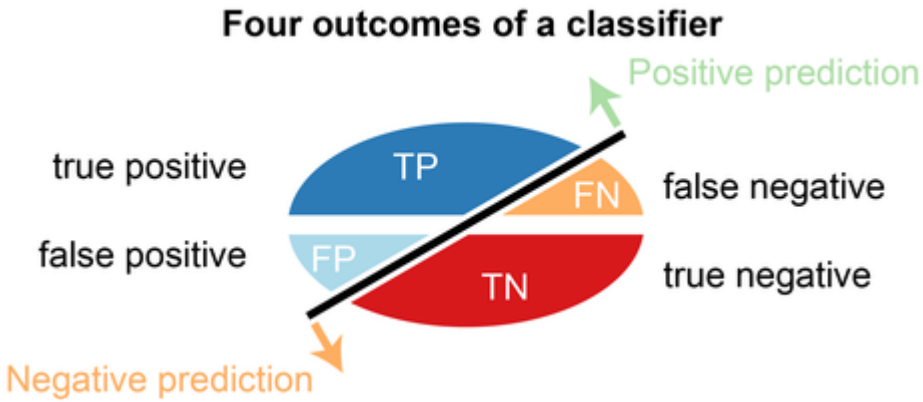


The predicted labels usually match with part of the observed labels in real world scenarios.



A binary classifier predicts all data instances of a test dataset as either positive or negative. This produces four outcomes-

1. True positive(TP) — Correct positive prediction
2. False positive(FP) — Incorrect positive prediction
3. True negative(TN) — Correct negative prediction
4. False negative(FN) — Incorrect negative prediction

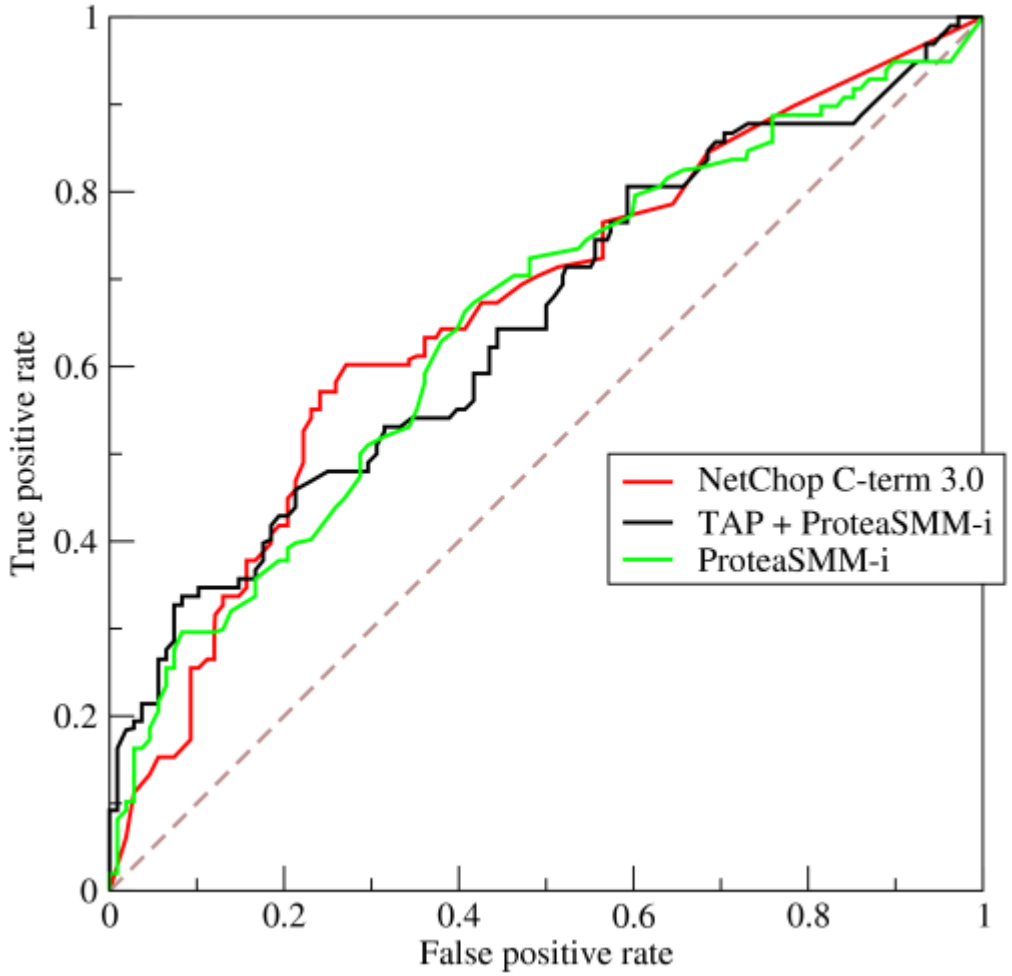


Basic measures derived from the confusion matrix

1. Error Rate = (FP+FN)/(P+N)
2. Accuracy = (TP+TN)/(P+N)
3. Sensitivity(Recall or True positive rate) = TP/P
4. Specificity(True negative rate) = TN/N
5. Precision(Positive predicted value) = TP/(TP+FP)
6. F-Score(Harmonic mean of precision and recall) = (1+b)(PREC.REC)/(b^2PREC+REC) where b is commonly 0.5, 1, 2.

6. Explain how a ROC curve works ?

The **ROC** curve is a graphical representation of the contrast between true positive rates and false positive rates at various thresholds. It is often used as a proxy for the trade-off between the sensitivity(true positive rate) and false positive rate.

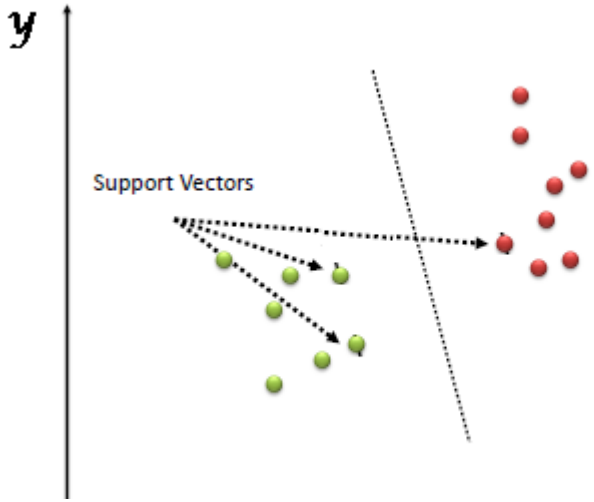


7. What is selection Bias ?

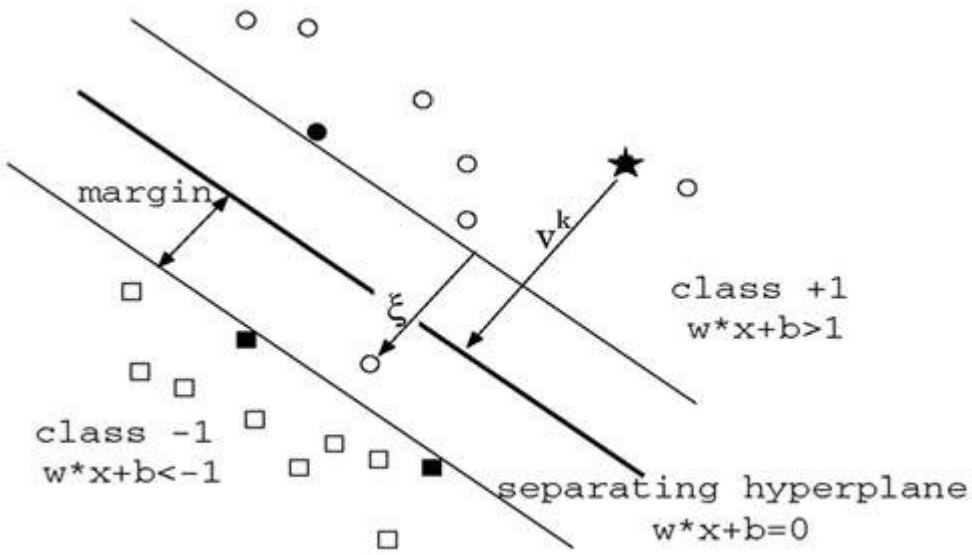
Selection bias occurs when sample obtained is not representative of the population intended to be analysed.

8. Explain SVM machine learning algorithm in detail.

SVM stands for support vector machine, it is a supervised machine learning algorithm which can be used for both **Regression and Classification**. If you have n features in your training data set, SVM tries to plot it in n-dimensional space with the value of each feature being the value of a particular coordinate. SVM uses hyper planes to separate out different classes based on the provided kernel function.



9. What are support vectors in SVM.



In the above diagram we see that the thinner lines mark the distance from the classifier to the closest data points called the support vectors (darkened data points). The distance between the two thin lines is called the margin.

10. What are the different kernels functions in SVM ?

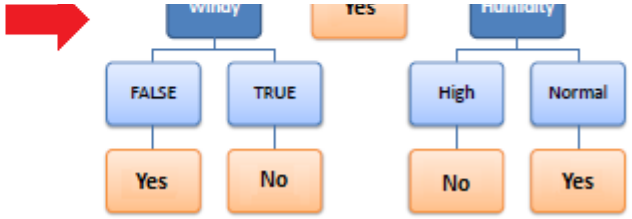
There are four types of kernels in SVM.

1. Linear Kernel
2. Polynomial kernel
3. Radial basis kernel
4. Sigmoid kernel

11. Explain Decision Tree algorithm in detail.

Decision tree is a supervised machine learning algorithm mainly used for the **Regression and Classification**.It breaks down a data set into smaller and smaller subsets while at the same time an associated decision tree is incrementally developed. The final result is a tree with decision nodes and leaf nodes. Decision tree can handle both categorical and numerical data.

Overcast	Cool	Normal	True	Yes
Rainy	Mild	High	False	No
Rainy	Cool	Normal	False	Yes
Sunny	Mild	Normal	False	Yes
Rainy	Mild	Normal	True	Yes
Overcast	Mild	High	True	Yes
Overcast	Hot	Normal	False	Yes
Sunny	Mild	High	True	No

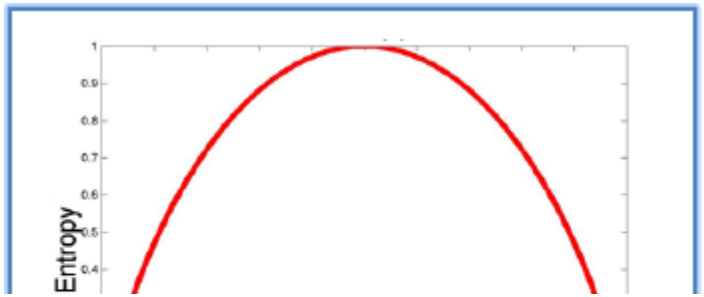


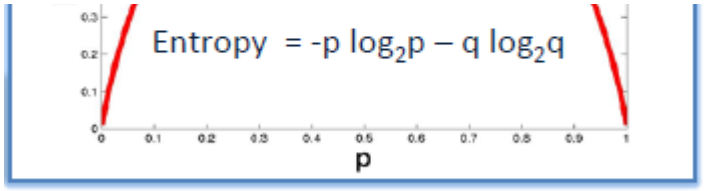
12. What is Entropy and Information gain in Decision tree algorithm ?

The core algorithm for building decision tree is called **ID3**. **ID3** uses **Enteropy** and **Information Gain** to construct a decision tree.

Entropy

A decision tree is built top-down from a root node and involve partitioning of data into homogenious subsets. **ID3** uses enteropy to check the homogeneity of a sample. If the sample is completely homogenious then entropy is zero and if the sample is an equally divided it has entropy of one.





Entropy = $-0.5 \log_2 0.5 - 0.5 \log_2 0.5 = 1$

Information Gain

The **Information Gain** is based on the decrease in entropy after a dataset is split on an attribute. Constructing a decision tree is all about finding attributes that returns the highest information gain.

		Play Golf	
		Yes	No
Outlook	Sunny	3	2
	Overcast	4	0
	Rainy	2	3
Gain = 0.247			

		Play Golf	
		Yes	No
Temp.	Hot	2	2
	Mild	4	2
	Cool	3	1
Gain = 0.029			

		Play Golf	
		Yes	No
Humidity	High	3	4
	Normal	6	1
Gain = 0.152			

		Play Golf	
		Yes	No
Windy	False	6	2
	True	3	3
Gain = 0.048			

$$Gain(T, X) = Entropy(T) - Entropy(T, X)$$

$$Gain(T, X) = Entropy(T) - Entropy(T, X)$$

G(PlayGolf, Outlook) = **E**(PlayGolf) – **E**(PlayGolf, Outlook)

= 0.940 – 0.693 = 0.247

13. What is pruning in Decision Tree ?

When we remove sub-nodes of a decision node, this process is called pruning or opposite process of splitting.

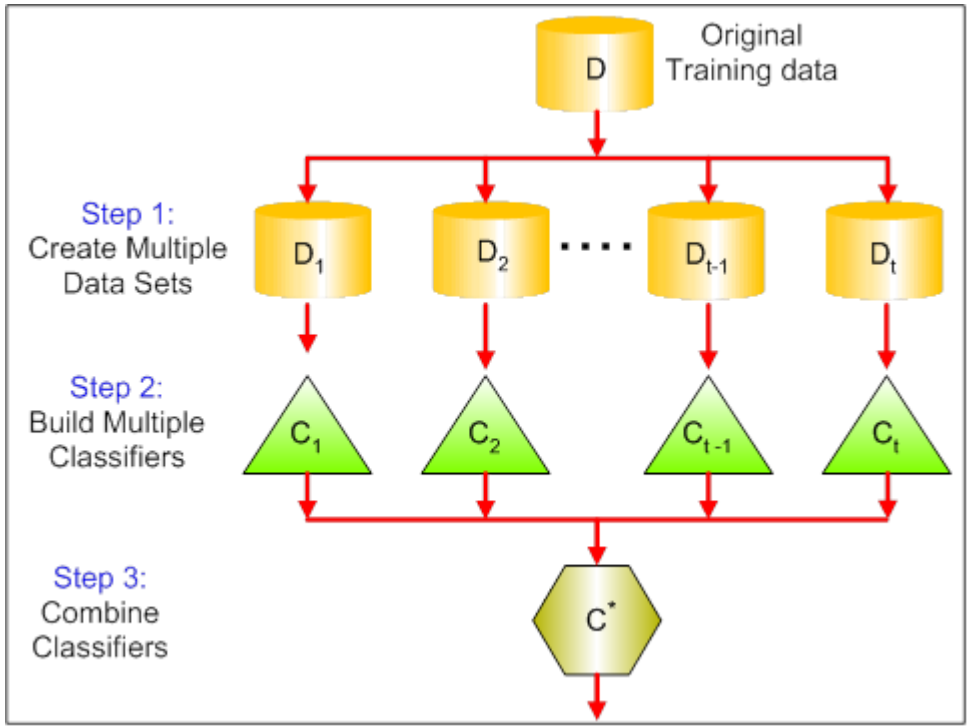
14. What is Ensemble Learning ?

Ensemble is the art of combining diverse set of learners(Individual models) together to improvise on the stability and predictive power of the model. Ensemble learning has many types but two more popular ensemble learning techniques are mentioned below.

Bagging

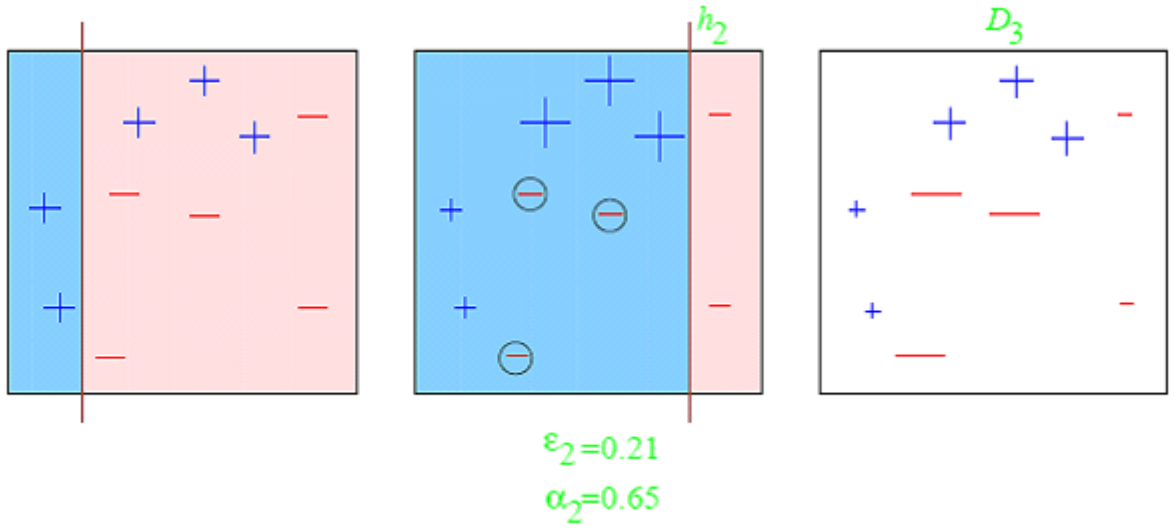
Bagging tries to implement similar learners on small sample populations and then takes a mean of all the predictions. In generalised bagging, you

can use different learners on different population. As you expect this helps us to reduce the variance error.



Boosting

Boosting is an iterative technique which adjust the weight of an observation based on the last classification. If an observation was classified incorrectly, it tries to increase the weight of this observation and vice versa. Boosting in general decreases the bias error and builds strong predictive models. However, they may over fit on the training data.



15. What is Random Forest? How does it work ?

Random forest is a versatile machine learning method capable of performing both regression and classification tasks. It is also used for dimentionality reduction, treats missing values, outlier values. It is a type of ensemble learning method, where a group of weak models combine to form a powerful model.

In Random Forest, we grow multiple trees as opposed to a single tree. To classify a new object based on attributes, each tree gives a classification. The forest chooses the classification having the **most votes**(Over all the trees in the forest) and in case of regression, it takes the **average** of outputs by different trees.

16. What cross-validation technique would you use on a time series data set.

Instead of using k-fold cross-validation, you should be aware to the fact that a time series is not randomly distributed data — It is inherently ordered by chronological order.

In case of time series data, you should use techniques like forward chaining — Where you will be model on past data then look at forward-facing data.

fold 1: training[1], test[2]

fold 1: training[1 2], test[3]

fold 1: training[1 2 3], test[4]

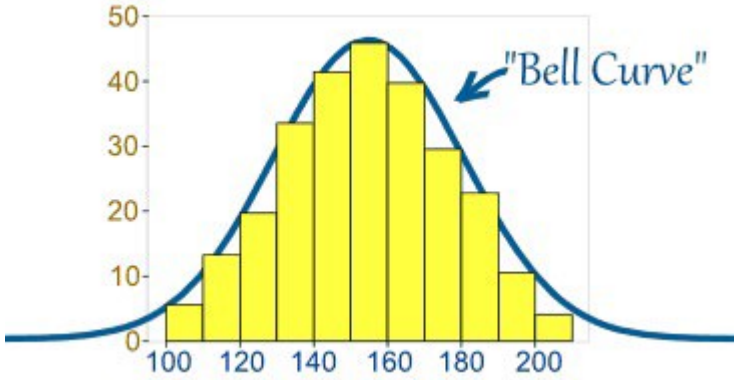
fold 1: training[1 2 3 4], test[5]

17. What is logistic regression? Or State an example when you have used logistic regression recently.

Logistic Regression often referred as logit model is a technique to predict the binary outcome from a linear combination of predictor variables. For

example, if you want to predict whether a particular political leader will win the election or not. In this case, the outcome of prediction is binary i.e. 0 or 1 (Win/Lose). The predictor variables here would be the amount of money spent for election campaigning of a particular candidate, the amount of time spent in campaigning, etc.

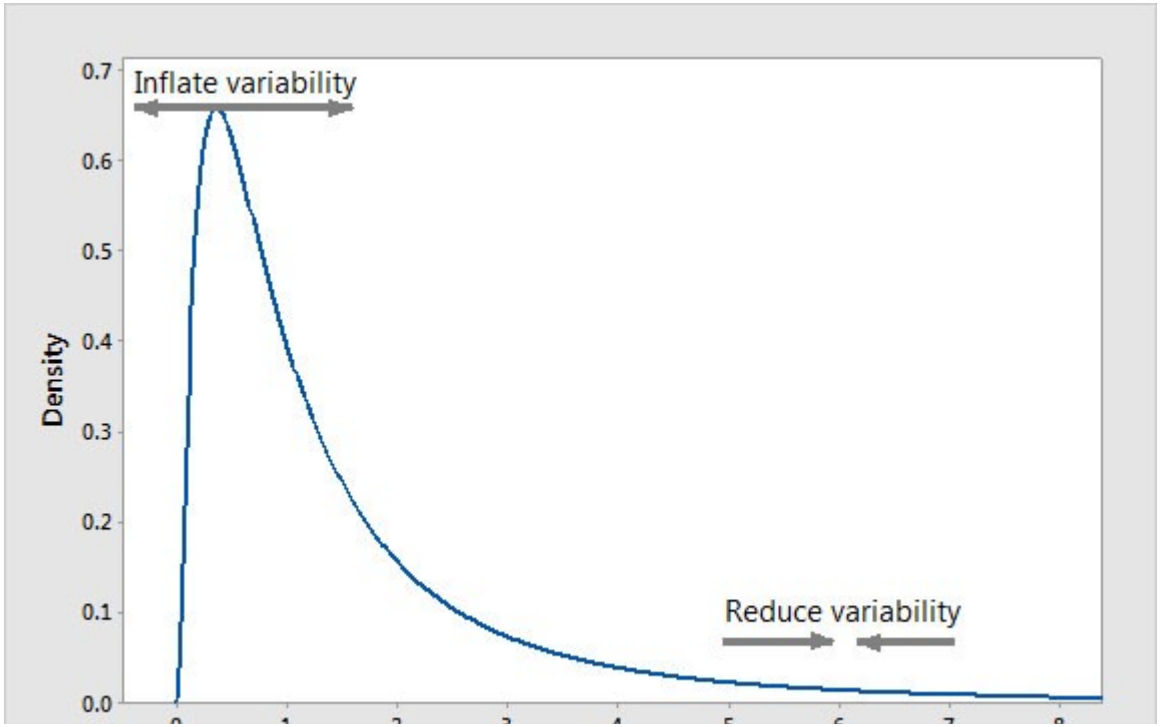
18. What do you understand by the term Normal Distribution?



Data is usually distributed in different ways with a bias to the left or to the right or it can all be jumbled up. However, there are chances that data is distributed around a central value without any bias to the left or right and reaches normal distribution in the form of a bell shaped curve. The random variables are distributed in the form of an symmetrical bell shaped curve.

19. What is a Box Cox Transformation?

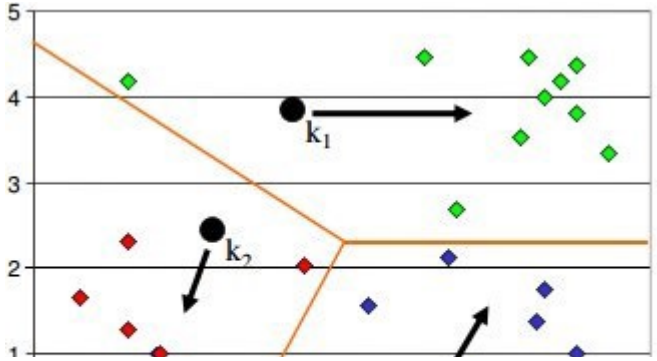
Dependent variable for a regression analysis might not satisfy one or more assumptions of an ordinary least squares regression. The residuals could either curve as the prediction increases or follow skewed distribution. In such scenarios, it is necessary to transform the response variable so that the data meets the required assumptions. A Box cox transformation is a statistical technique to transform non-normal dependent variables into a normal shape. If the given data is not normal then most of the statistical techniques assume normality. Applying a box cox transformation means that you can run a broader number of tests.

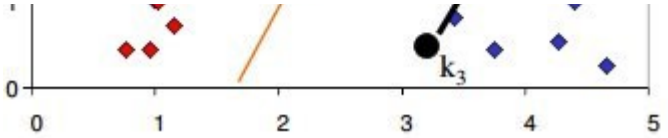


A Box Cox transformation is a way to transform non-normal dependent variables into a normal shape. Normality is an important assumption for many statistical techniques, if your data isn't normal, applying a Box-Cox means that you are able to run a broader number of tests. The Box Cox transformation is named after statisticians ***George Box*** and ***Sir David Roxbee Cox*** who collaborated on a 1964 paper and developed the technique.

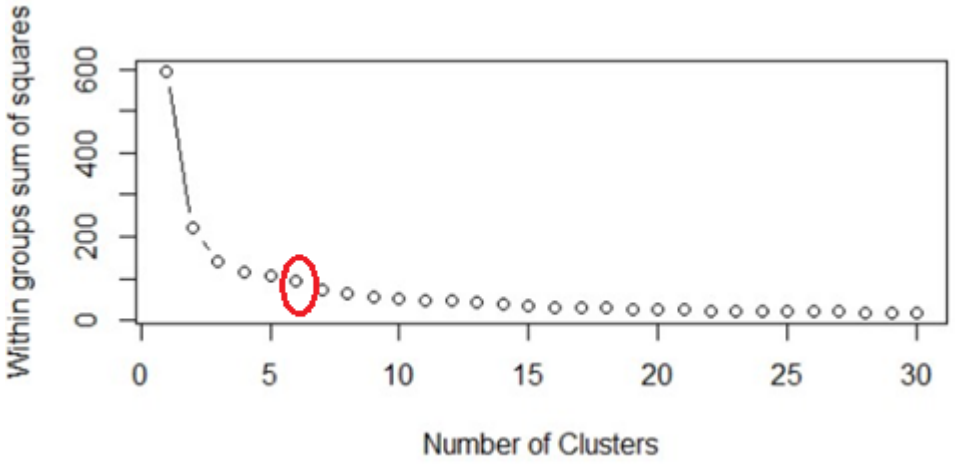
20. How will you define the number of clusters in a clustering algorithm?

Though the Clustering Algorithm is not specified, this question will mostly be asked in reference to K-Means clustering where "K" defines the number of clusters. For example, the following image shows three different groups.





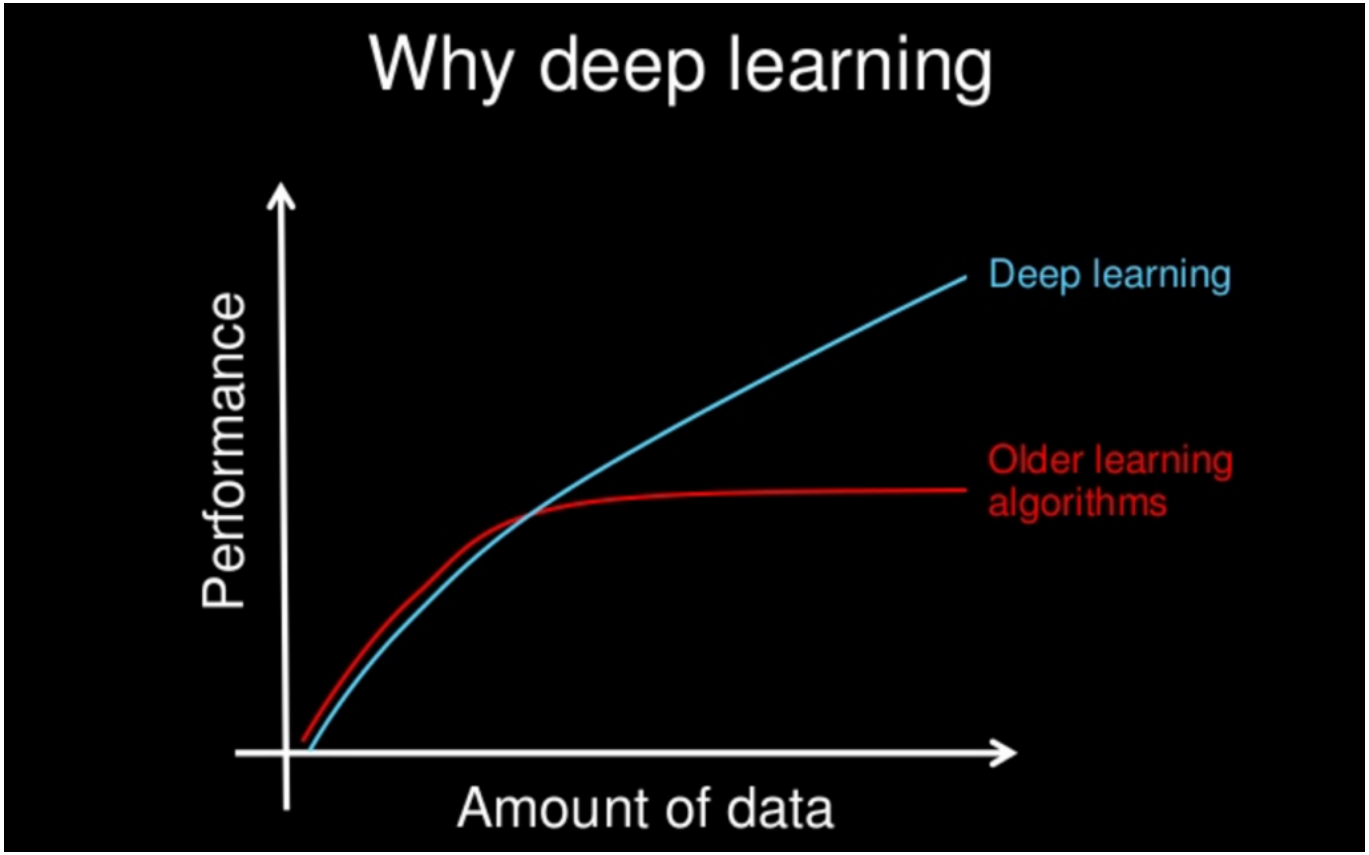
Within Sum of squares is generally used to explain the homogeneity within a cluster. If you plot WSS for a range of number of clusters, you will get the plot shown below. The Graph is generally known as Elbow Curve.



Red circled point in above graph i.e. Number of Cluster =6 is the point after which you don't see any decrement in WSS. This point is known as bending point and taken as K in K — Means.This is the widely used approach but few data scientists also use Hierarchical clustering first to create dendograms and identify the distinct groups from there.

21. What is deep learning?

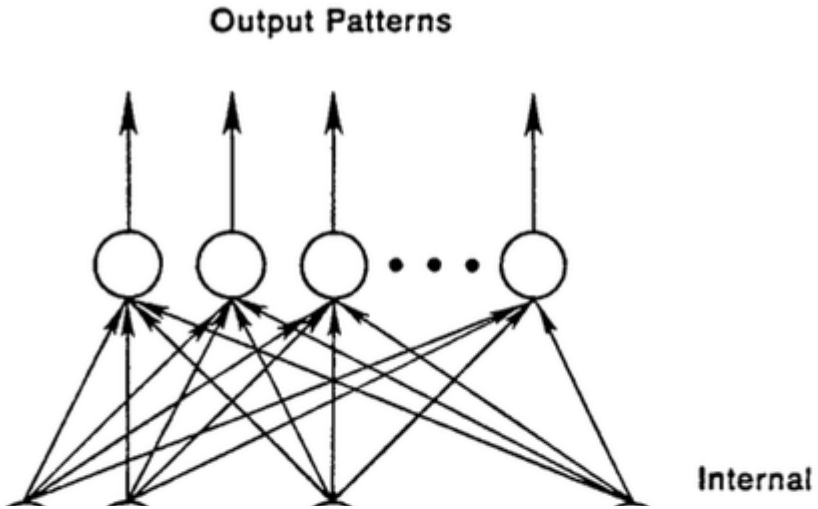
Deep learning is sub field of machine learning inspired by structure and function of brain called artificial neural network. We have a lot numbers of algorithms under machine learning like Linear regression, SVM, Neural network etc and deep learning is just an extension of Neural networks. In neural nets we consider small number of hidden layers but when it comes to deep learning algorithms we consider a huge number of hidden layers to better understand the input output relationship.

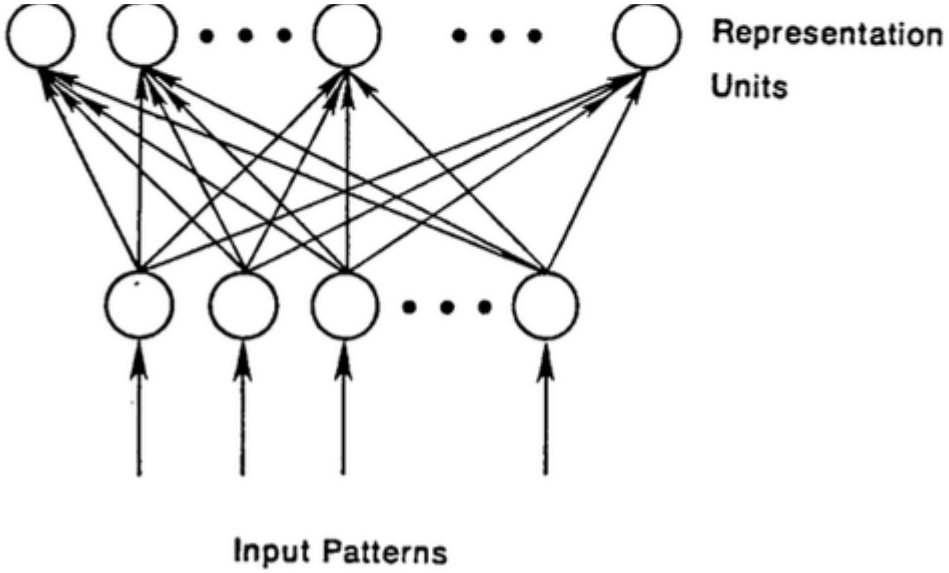


How do data science techniques scale with amount of data?

22. What are Recurrent Neural Networks(RNNs) ?

Recurrent nets are type of artificial neural networks designed to recognise pattern from the sequence of data such as Time series, stock market and government agencies etc. To understand recurrent nets, first you have to understand the basics of feed forward nets. Both these networks RNN and feed forward named after the way they channel information through a series of mathematical orations performed at the nodes of the network. One feeds information through straight(never touching same node twice), while the other cycles it through loop, and the latter are called recurrent.





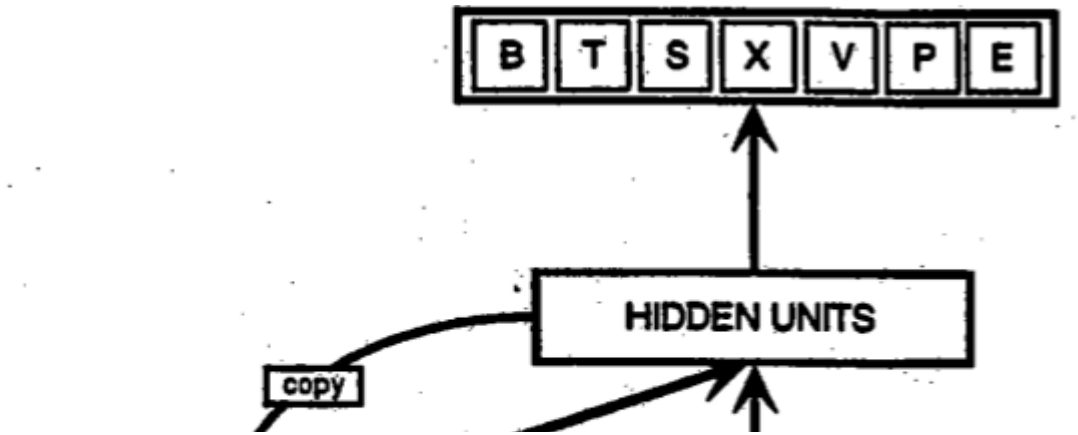
Recurrent networks on the other hand, take as their input not just the current input example they see, but also the what they have perceived previously in time. The BTSXPE at the bottom of the drawing represents the input example in the current moment, and CONTEXT UNIT represents the output of the previous moment. The decision a recurrent neural network reached at time t-1 affects the decision that it will reach one moment later at time t. So recurrent networks have two sources of input, the present and the recent past, which combine to determine how they respond to new data, much as we do in life.

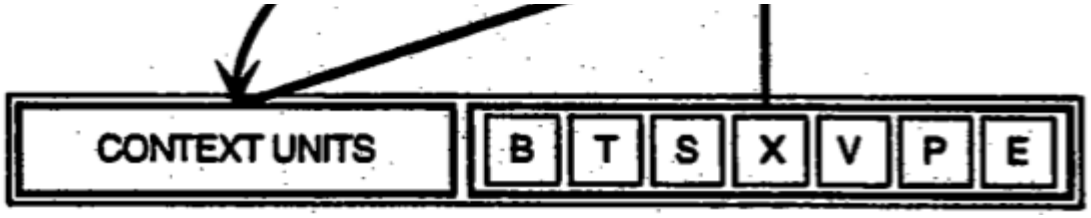
The error they generate will return via back propagation and be used to adjust their weights until error can't go any lower. Remember, the purpose

of recurrent nets is to accurately classify sequential input. We rely on the back propagation of error and gradient descent to do so.

Back propagation in feed forward networks moves backward from the final error through the outputs, weights and inputs of each hidden layer, assigning those weights responsibility for a portion of the error by calculating their partial derivatives — $\partial E/\partial w$, or the relationship between their rates of change. Those derivatives are then used by our learning rule, gradient descent, to adjust the weights up or down, whichever direction decreases error.

Recurrent networks rely on an extension of back propagation called back propagation through time, or BPTT. Time, in this case, is simply expressed by a well-defined, ordered series of calculations linking one time step to the next, which is all back propagation needs to work.





23. What is the difference between machine learning and deep learning?

Machine learning:

Machine learning is a field of computer science that gives computers the ability to learn without being explicitly programmed. Machine learning can be categorised in following three categories.

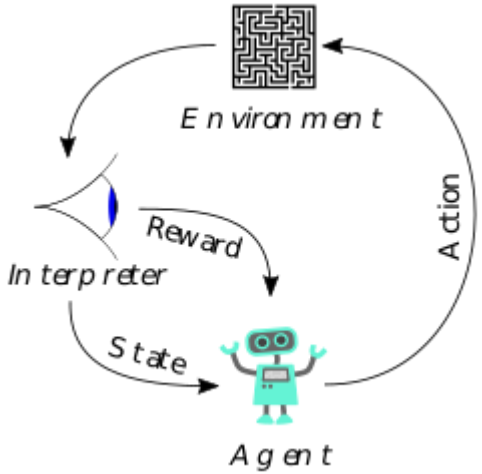
1. Supervised machine learning,
2. Unsupervised machine learning,
3. Reinforcement learning

Deep learning:

Deep Learning is a sub field of machine learning concerned with algorithms inspired by the structure and function of the brain called artificial neural networks.

24. What is reinforcement learning ?

Reinforcement learning



Reinforcement Learning is learning what to do and how to map situations to actions. The end result is to maximise the numerical reward signal. The learner is not told which action to take, but instead must discover which action will yield the maximum reward.Reinforcement learning is inspired by the learning of human beings, it is based on the reward/panelity mechanism.

25. What is selection bias ?

Selection bias is the bias introduced by the selection of individuals, groups or data for analysis in such a way that proper randomisation is not achieved, thereby ensuring that the sample obtained is not representative of the population intended to be analysed. It is sometimes referred to as the selection effect. The phrase “selection bias” most often refers to the distortion of a statistical analysis, resulting from the method of collecting samples. If the selection bias is not taken into account, then some conclusions of the study may not be accurate.

26. Explain what regularisation is and why it is useful.

Regularisation is the process of adding tunning parameter to a model to induce smoothness in order to prevent overfitting. This is most often done by adding a constant multiple to an existing weight vector. This constant is often the L1(Lasso) or L2(ridge). The model predictions should then minimize the loss function calculated on the regularized training set.

27. What is TF/IDF vectorization ?

tf–idf is short for term frequency–inverse document frequency, is a numerical statistic that is intended to reflect how important a word is to a document in a collection or corpus. It is often used as a weighting factor in

information retrieval and text mining. The tf-idf value increases proportionally to the number of times a word appears in the document, but is offset by the frequency of the word in the corpus, which helps to adjust for the fact that some words appear more frequently in general.

28. What are Recommender Systems?

A subclass of information filtering systems that are meant to predict the preferences or ratings that a user would give to a product. Recommender systems are widely used in movies, news, research articles, products, social tags, music, etc.

29. What is the difference between Regression and classification ML techniques.

Both Regression and classification machine learning techniques come under **Supervised machine learning algorithms**. In Supervised machine learning algorithm, we have to train the model using labelled data set, While training we have to explicitly provide the correct labels and algorithm tries to learn the pattern from input to output. If our labels are discrete values then it will a classification problem, e.g A,B etc. but if our labels are continuous values then it will be a regression problem, e.g 1.23, 1.333 etc.

30. If you are having 4GB RAM in your machine and you want to train your model on 10GB data set. How would you go about this problem. Have you ever faced this kind of problem in your machine learning/data science experience so far ?

First of all you have to ask which ML model you want to train.

For Neural networks: Batch size with Numpy array will work.

Steps:

1. Load the whole data in Numpy array. Numpy array has property to create mapping of complete data set, it doesn't load complete data set in memory.
2. You can pass index to Numpy array to get required data.
3. Use this data to pass to Neural network.
4. Have small batch size.

For SVM: Partial fit will work

Steps:

1. Divide one big data set in small size data sets.
2. Use partial fit method of SVM, it requires subset of complete data set.
3. Repeat step 2 for other subsets.

31. What is p-value?

When you perform a hypothesis test in statistics, a p-value can help you determine the strength of your results. p-value is a number between 0 and 1. Based on the value it will denote the strength of the results. The claim which is on trial is called Null Hypothesis.

Low p-value (≤ 0.05) indicates strength against the null hypothesis which means we can reject the null Hypothesis. High p-value (≥ 0.05) indicates strength for the null hypothesis which means we can accept the null Hypothesis p-value of 0.05 indicates the Hypothesis could go either way. To put it in another way,

High P values: your data are likely with a true null. Low P values: your data are unlikely with a true null.

32. What is ‘Naive’ in a Naive Bayes ?

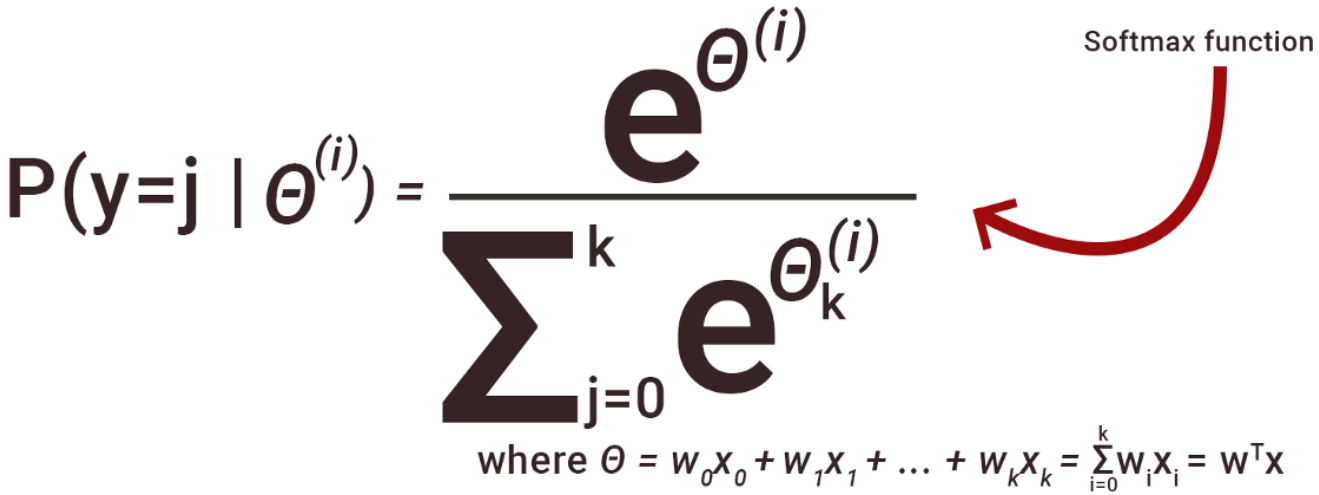
The Naive Bayes Algorithm is based on the Bayes Theorem. Bayes’ theorem describes the probability of an event, based on prior knowledge of conditions that might be related to the event.

What is Naive ?

The Algorithm is ‘naive’ because it makes assumptions that may or may not turn out to be correct.

33. Why we generally use Softmax non-linearity function as last operation in network ?

It is because it takes in a vector of real numbers and returns a probability distribution. Its definition is as follows. Let x be a vector of real numbers (positive, negative, whatever, there are no constraints). Then the i'th component of Softmax(*x) is* —



It should be clear that the output is a probability distribution: each element is non-negative and the sum over all components is 1.

34. What are different ranking algorithms?

Traditional ML algorithms solve a prediction problem (classification or regression) on a single instance at a time. E.g. if you are doing spam detection on email, you will look at all the features associated with that

email and classify it as spam or not. The aim of traditional ML is to come up with a class (spam or no-spam) or a single numerical score for that instance.

Ranking algorithms like LTR solves a ranking problem on a list of items. The aim of LTR is to come up with optimal ordering of those items. As such, LTR doesn't care much about the exact score that each item gets, but cares more about the relative ordering among all the items. **RankNet**, **LambdaRank** and **LambdaMART** are all LTR algorithms developed by Chris Burges and his colleagues at Microsoft Research.

1. **RankNet —** The cost function for RankNet aims to minimize the number of inversions in ranking. RankNet optimizes the cost function using Stochastic Gradient Descent.
2. **LambdaRank —** Burgess et. al. found that during RankNet training procedure, you don't need the costs, only need the gradients (λ) of the cost with respect to the model score. You can think of these gradients as little arrows attached to each document in the ranked list, indicating the direction we'd like those documents to move. Further they found that scaling the gradients by the change in NDCG found by swapping each pair of documents gave good results. The core idea of LambdaRank is to use this new cost function for training a RankNet. On experimental

datasets, this shows both speed and accuracy improvements over the original RankNet.

3. **LambdaMart —** LambdaMART combines LambdaRank and MART (Multiple Additive Regression Trees). While MART uses gradient boosted decision trees for prediction tasks, LambdaMART uses gradient boosted decision trees using a cost function derived from LambdaRank for solving a ranking task. On experimental datasets, LambdaMART has shown better results than LambdaRank and the original RankNet.

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