MACHINE LEARNING ASSIGNMENT - 5

Q1 to Q15 are subjective answer type questions, Answer them briefly.

1. R-squared or Residual Sum of Squares (RSS) which one of these two is a better measure of goodness of fit model in regression and why?

Ans- Both R-squared and Residual Sum of Squares (RSS) are measures of goodness of fit in regression analysis, but they capture different aspects of the model's performance. R-squared (also known as the coefficient of determination) measures the proportion of variation in the dependent variable that is explained by the independent variables in the model. In other words, it indicates how well the model fits the data, with values ranging from 0 to 1. Higher R-squared values indicate a better fit, as they mean that a larger proportion of the variation in the dependent variable is explained by the independent variables in the model.

On the other hand, RSS measures the total sum of squared differences between the actual values of the dependent variable and the predicted values by the model. It represents the amount of unexplained variation in the data, and lower RSS values indicate a better fit, as they mean that the model is able to explain more of the variation in the data.

Therefore, both measures are useful in evaluating the goodness of fit of a model, but they serve different purposes. R-squared is a useful measure to assess the overall fit of the model and to compare different models, while RSS is useful to identify the degree of the error in the model's predictions.

In general, a good model should have both a high R-squared value and a low RSS value, indicating that it explains a large proportion of the variation in the dependent variable and has a low degree of error in its predictions. However, in some cases, one measure may be more important than the other, depending on the research question and the nature of the data being analyzed.

2. What are TSS (Total Sum of Squares), ESS (Explained Sum of Squares) and RSS (Residual Sum of Squares) in regression. Also mention the equation relating these three metrics with each other.

Ans- The sum of squares is a statistical measure of deviation from the mean. It is also known as variation. It is calculated by adding together the squared differences of each data point. To determine the sum of squares, square the distance between each data point and the line of best fit, then add them together.

$$\mathrm{TSS} = \sum_{i=1}^{n}(y_i - \bar{y})^2$$

The residual sum of squares (RSS) measures the level of variance in the error term, or residuals, of a regression model. The smaller the residual sum of squares, the better your model fits your data; the greater the residual sum of squares, the poorer your model fits your data.

$$RSS = \sum_{i=1}^{n}(y_i - f(x_i))^2$$

The explained sum of squares (ESS) is the sum of the squares of the deviations of the predicted values from the mean value of a response variable, in a standard regression model .

$$\mathrm{ESS} = \sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2.$$

TSS= ESS+RSS

3. What is the need of regularization in machine learning?

Ans- Regularization refers to techniques that are used to calibrate machine learning models in order to minimize the adjusted loss function and prevent overfitting or underfitting. Using Regularization, we can fit our machine learning model appropriately on a given test set and hence reduce the errors in it.

4. What is Gini–impurity index?

Ans-Gini Impurity is a measurement used to build Decision Trees to determine how the features of a dataset should split nodes to form the tree.

5. Are unregularized decision-trees prone to overfitting? If yes, why?

Ans- Decision trees are prone to overfitting, especially when a tree is particularly deep. This is due to the amount of specificity we look at leading to smaller sample of events that meet the previous assumptions. This small sample could lead to unsound conclusions. An example of this could be predicting if the Boston Celtics will beat the Miami Heat in tonight's basketball game. The first level of the tree could ask if the Celtics are playing home or away. The second level might ask if the Celtics have a higher win percentage than their opponent, in this case the Heat. The third level asks if the Celtic's leading scorer is playing? The fourth level asks if the Celtic's second leading scorer is playing. The fifth level asks if the Celtics are traveling back to the east coast from 3 or more consecutive road games on the west coast. While all of these questions may be relevant, there may only be two previous games where the conditions of tonights game were met. Using only two games as the basis for our classification would not be adequate for an informed decision. One way to combat this issue is by setting a max depth. This will limit our risk of overfitting; but as always, this will be at the expense of error due to bias. Thus if we set a max depth of three, we would only ask if the game is home or away, do the Celtics have a higher winning percentage than their opponent, and is their leading scorer playing. This is a simpler model with less variance sample to sample but ultimately will not be a strong predictive model.Ideally, we would like to minimize both error due to bias and error due to variance. Enter random forests. Random forests mitigate this problem well. A random forest is simply a collection of decision trees whose results are aggregated into one final result. Their ability to limit overfitting without substantially increasing error due to bias is why they are such powerful models

6. What is an ensemble technique in machine learning?
Ans-Ensemble methods are techniques that create multiple models and then combine them to produce improved results. Ensemble methods usually produces more accurate solutions than a single model would.

7. What is the difference between Bagging and Boosting techniques?
Ans-In Boosting, each model is built on top of the previous ones. Whereas in bagging each model is built independently. The final boosting ensemble uses weighted majority vote while bagging uses a simple majority vote.Bagging is a method of merging the same type of predictions. Boosting is a method of merging different types of predictions. Bagging decreases variance, not bias, and solves over-fitting issues in a model. Boosting decreases bias, not variance.

8. What is out-of-bag error in random forests?
Ans-Out-of-bag (OOB) error, also called out-of-bag estimate, is a method of measuring the prediction error of random forests, boosted decision trees, and other machine learning models utilizing bootstrap aggregating (bagging).

9. What is K-fold cross-validation?
Ans-K-fold Cross-Validation is when the dataset is split into a K number of folds and is used to evaluate the model's ability when given new data. K refers to the number of groups the data sample is split into. For example, if you see that the k-value is 5, we can call this a 5-fold cross-validation.

10. What is hyper parameter tuning in machine learning and why it is done?
Ans- Hyperparameter tuning consists of finding a set of optimal hyperparameter values for a learning algorithm while applying this optimized algorithm to any data set. That combination of hyperparameters maximizes the model's performance, minimizing a predefined loss function to produce better results with fewer errors.

11. What issues can occur if we have a large learning rate in Gradient Descent?
Ans-In order for Gradient Descent to work, we must set the learning rate to an appropriate value. This parameter determines how fast or slow we will move towards the optimal weights. If the learning rate is very large we will skip the optimal solution.A learning rate that is too large can cause the model to converge too quickly to a suboptimal solution, whereas a learning rate that is too small can cause the process to get stuck.

12. Can we use Logistic Regression for classification of Non-Linear Data? If not, why?
Ans-Logistic regression is known and used as a linear classifier. It is used to come up with a hyperplane in feature space to separate observations that belong to a class from all the other observations that do not belong to that class. The decision boundary is thus linear.

13. Differentiate between Adaboost and Gradient Boosting.
Ans- AdaBoost is the first designed boosting algorithm with a particular loss function. On the other hand, Gradient Boosting is a generic algorithm that assists in searching the approximate solutions to the additive modelling problem. This makes Gradient Boosting more flexible than AdaBoost.

14. What is bias-variance trade off in machine learning?
Ans- In statistics and machine learning, the bias–variance tradeoff is the property of a model that the variance of the parameter estimated across samples can be reduced by increasing the bias in the estimated parameters.

15. Give short description each of Linear, RBF, Polynomial kernels used in SVM
Ans-The polynomial kernel is a general representation of kernels with a degree of more than one. It's useful for image processing.
RBF is the radial basis function. This is used when there is no prior knowledge about the data.
Linear kernel is one-dimensional and is the most basic form of kernel in SVM.