MLP – Assignment 2
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Project Report

Background and Methods:

IRIS Data Classification: The IRIS database has 50 samples distributed among three different species of IRIS. These samples have specific characteristics to classify into *Iris Setosa, Iris Virginica, and Iris Versicolor*. This study proposes a multilayer perceptron with a *SOFTMAX/RELU* transfer and Categorical Cross-Entropy loss function to separate and classify the IRIS data.

Diabetes Prediction: This study proposes a machine learning model based on Multilayer Perception Neural Network (MLP) with *SIGMOID/RELU* transfer and Binary Cross-Entropy loss function to identify diabetes patients.

Apple Stock Price Time Series Forecasting: This study includes time series forecast to predict Apple stock prices using Multilayer Perceptron (MLP) with *LINEAR* transfer function, Mean Squared Error (MSE) loss, and Regressor Attributes.

Pre-processing:

IRIS Data Classification	**1.** Check for missing values **2.** One-hot encoding of categorical data **3.** Scaled the dataset
Diabetes Prediction	**1.** Check for missing values **2.** Impute missing values with mean values **3.** Scaled the dataset
Apple Stock Price Time Series Forecasting	**1.** Check for missing values **2.** Determine the best regressor input **3.** Create regressor attributes **4.** Scaled the dataset

Justification of Choosing Activation and Loss Function:

MLP Model	Transfer Function	Loss Function	Justification
IRIS Data Classification	*SOFTMAX*	*CATEGORICAL _CROSSENTROPY*	Categorical cross-entropy leveraged for multi-class classification problems where one attribute could belong to one out of many possible classes that the model must decide. The SOFTMAX transfer function is generally recommended for classification with the categorical cross-entropy loss function for better performance.
Diabetes Prediction	*SIGMOID*	*BINARY _CROSSENTROPY*	Binary cross-entropy leveraged for binary classification tasks where one attribute could belong to one out of two classes that the model must decide. RELU with SIGMOID transfer function is recommended with the binary cross-entropy loss function for better performance.
Apple Stock Price Time Series Forecasting	*LINEAR*	*MSE*	Mean Squared Error (MSE) define as the average of squared differences between the predicted and actual values. In general, the MSE loss is the default loss function recommended for regression problems with the *LINEAR* transfer function.

Hyper-Parameter Tuning:

MLP Model	Grid Search with Cross-Validation	Justification
IRIS Data Classification	GridSearchCV (From Scikit-learn)	To find the best activation function, optimizer, & other parameters.
Diabetes Prediction	GridSearchCV (From Scikit-learn)	To find the best activation function, optimizer, & other parameters.
Apple Stock Price Time Series Forecasting		Not applicable

Model Performance:

MLP Model	Regularization/Dropout	Justification
IRIS Data Classification	L2 Regularization with Dropout	**L2regularization** and **dropout** methods are leveraged to improve model performance with training and test set to overcome the issues with overfitting and bias-variance dilemma.
Diabetes Prediction	L2 Regularization with Dropout	**L2regularization** and **dropout** methods are leveraged to improve model performance with training and test set to overcome the issues with overfitting and bias-variance dilemma.
Apple Stock Price Time Series Forecasting	L2 Regularization with Dropout	**L2regularization** and **dropout** methods are leveraged to improve model performance with training and test set to overcome the issues with overfitting and bias-variance dilemma.

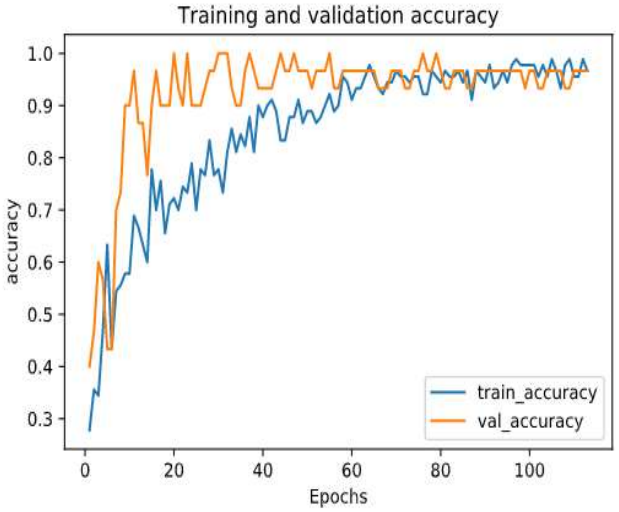
MLP Model Evaluation:

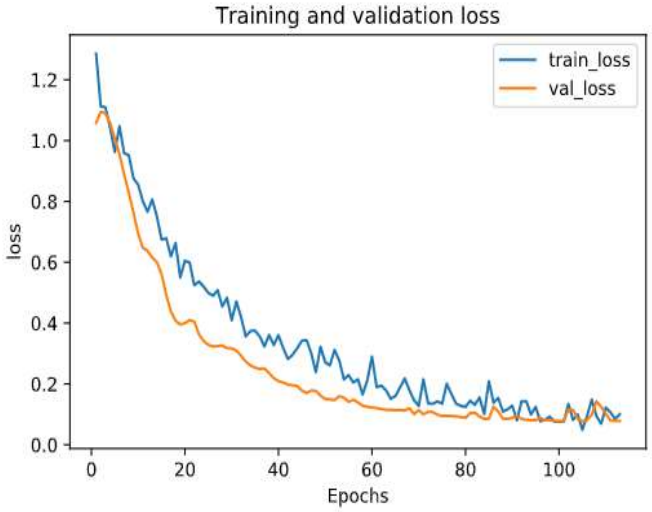
One way to measure models' performance on the training, validation, and test data is to compare the predictions' error for the actual values with AUC Score, Confusion Matrix, and Accuracy/Loss for training, validation, and test data. Please refer to the **MLP Model Summary Table** in the appendix below for details on model performance.

Summary:

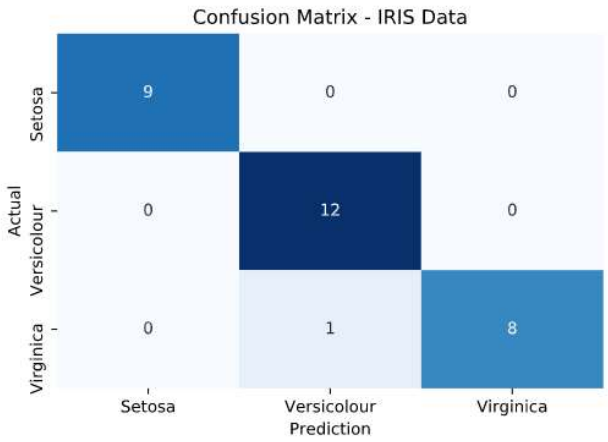
After comparing models' output, it turned out that accuracy, loss, and R Squared (or r2) score and the score for training, validation, and test data play a crucial role in evaluating the performance. The goals were to build MLP models to demonstrate the power of the neural network in terms of classification, prediction, and time series forecasting. The observations-based models' outputs are as follows:

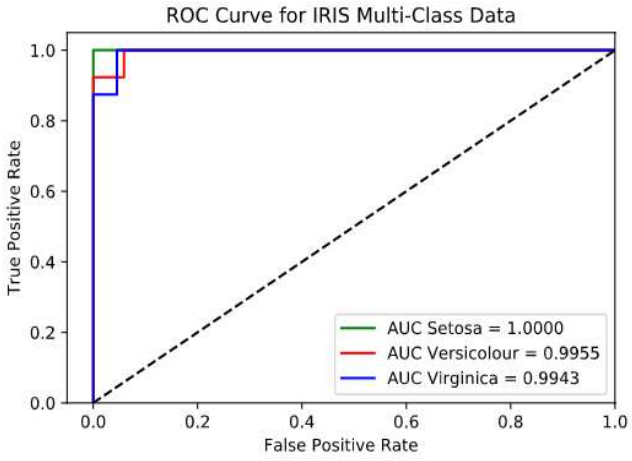
MLP IRIS species classification model with categorical cross-entropy performed well with high accuracy and lower loss rate, as demonstrated in the figure below. Grid-search with cross-validation is used for hyper-parameters tuning to find the best parameters.



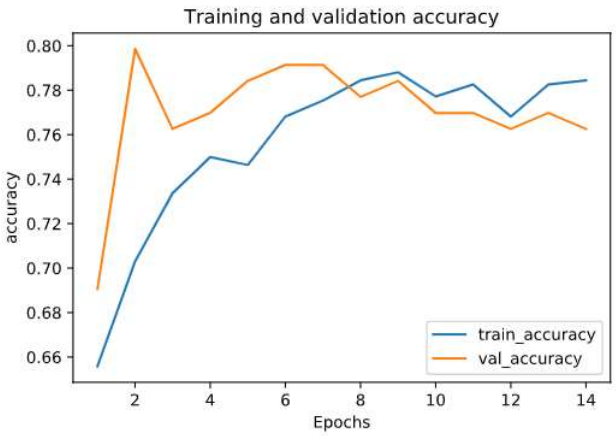


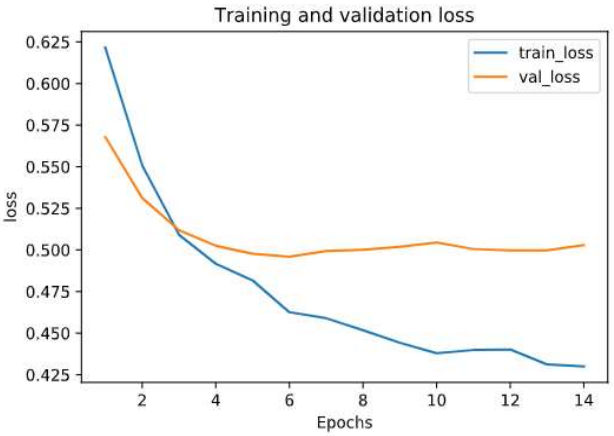
In addition to the training & validation score, the performance of this multi-class classification model is measured with confusion matrix and area under the AUC curve, and it seems the model performance is promising in classifying IRIS species, as demonstrated below.



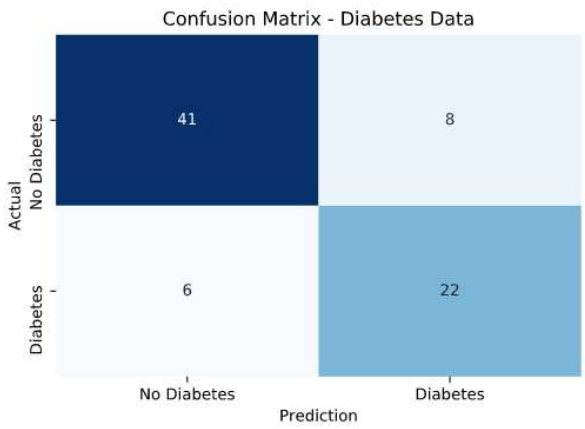


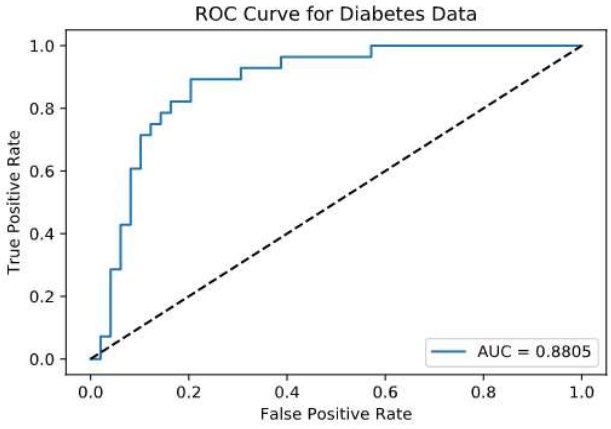
MLP Diabetes prediction model with binary cross-entropy has a slightly high loss that could improve with the model parameters optimizations. Grid-search with cross-validation is also leveraged for hyper-parameters tuning to find the best parameters.



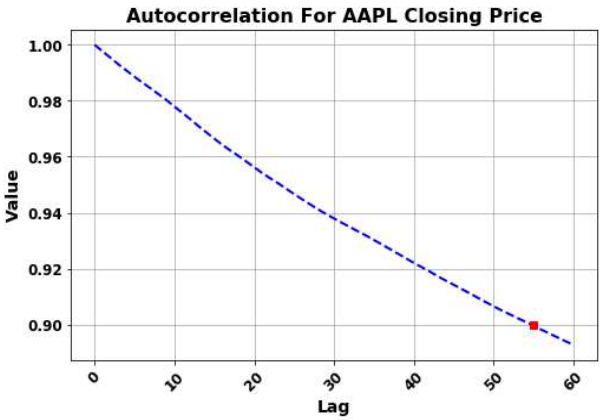


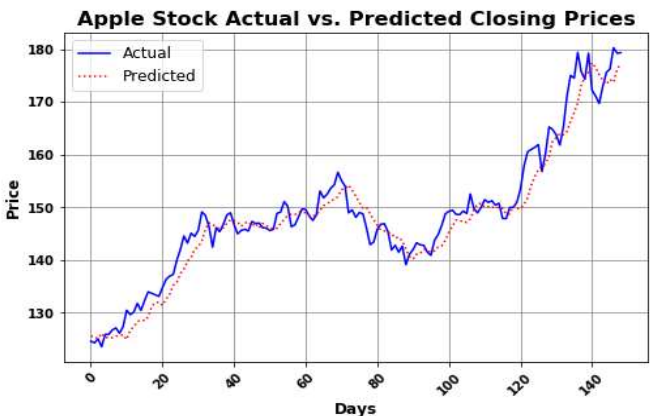
However, with an 88% AUC score, the Confusion Matrix could detect many possible diabetes cases.





MLP Apple stock price time-series forecasting model with mean squared error and regressor inputs from the autocorrelation chart below *(i.e., 55)* this time-series forecasting model performed well in predicting the closing price at least for a given day on the forecasting horizon.





In addition, the R-Squared Score, Mean Squared Log Error (MSLE) and Mean Absolute Percentage Error (MAPE) measured the distance between the actual values and values lying on the predictor hyperplane also seems promising in predicting the closing price reliably with this time-series forecasting model.

APPENDIX:

Model Summary:

Model Summary				Grid Search CV	Train Score		Validation Score		Test Score		R-2 Score, MSLE, & MAPE
MLP Model	**Dataset**	**Loss Function**	**Transfer Function**	**Score**	**Accuracy**	**Loss**	**Accuracy**	**Min Loss**	**Accuracy**	**Loss**	**N/A**
IRIS Data Classification	IRIS Data	*Categorical _crossentropy*	*SOFTMAX ADAM RELU*	**97.50**	**98.33**	**4.26**	**96.67**	**105**	**96.67**	**15.82**	**N/A**
Diabetes Prediction	Diabetes Data	*Binary _crossentropy*	*SIGMOID ADAM RELU*	**76.70**	**78.58**	**43.56**	**79.14**	**6**	**81.82**	**42.56**	**N/A**
Apple Stock Price Time Series Forecasting	AAPL Stock Data	*Mean Squared Error (MSE)*	*LINEAR*	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**93.70%** **0.0004** **1.69%**