Ensemble Deep Learning

NEVADA NATIONAL NNSS SECURITY SITE

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Aim: To improve the accuracy of machine learning predictions by utilizing deep learning. The project's objective is to determine the comparative differences between the efficiency of the ensemble neural network versus each individual neural network

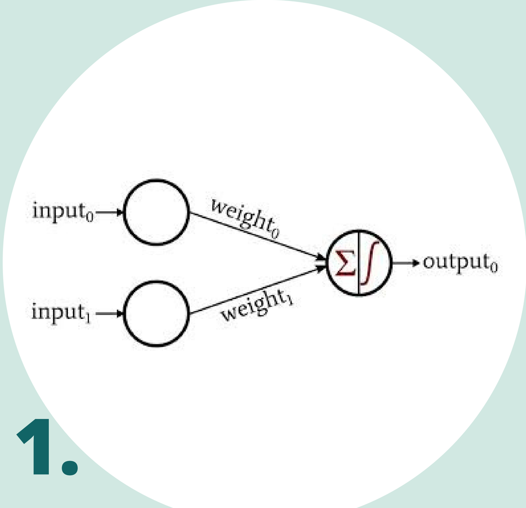
Abstract

Machine learning has become a common tool within the tech industry due to its high versatility and efficiency with large datasets. Partnering with the Nevada National Security Site, our goal is to improve accuracy of machine predictions by utilizing deep learning, which will enable the power and accuracy of a prediction to grow from the model. To build a deep learning model, multiple neural network architectures were developed and combined to create an ensemble neural network. The project's objective is to determine the comparative differences between the efficiency of the ensemble neural network versus each individual neural network. The data set used to validate and train the networks is 1D regressive/categorical. After testing architecture and determining accuracy of certain networks, the model was updated and tested again to increase accuracy. As model precision is a key aspect of machine learning, emphasis is placed on the efficiency of ensemble neural networks to make valid predictions.

Introduction

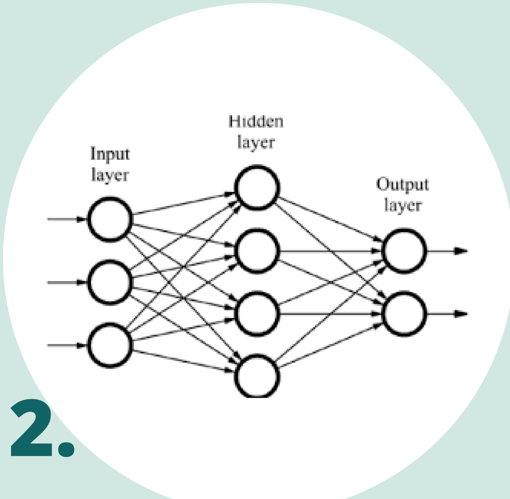
Neural Networks:
Neural networks are algorithms modeled after the neurons in the human brain. They identify relationships in a set of data and are trained using a set of data with known desired output values. The model is given a set of inputs with a known set of labels or outputs. The input and output data is fed into the neural network and trains the algorithm to assign different weights and biases to get from the input to the output.

Ensemble Neural Networks:
Ensemble models in machine learning combine the decisions from multiple models to improve the overall performance. The architecture of each model can be identical or vary to produce different accuracies and the actual prediction is calculated as the average of those accuracies.



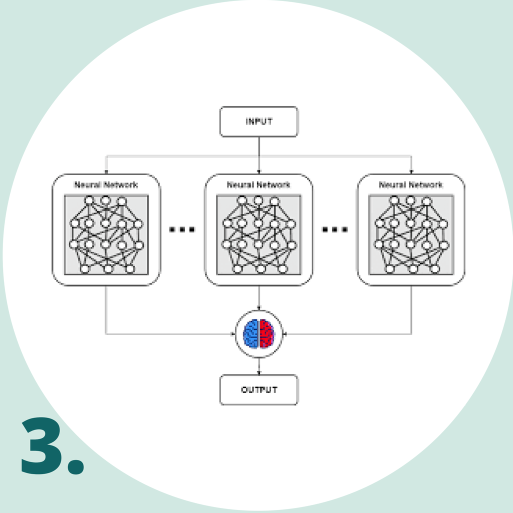
1. Perceptron

Y = mx + b
Y = output, M = weight, b = bias



2. Neural Network

Multiple layers of many perceptrons



3. Ensemble Neural Network

The average output sum of multiple neural networks

Methodology

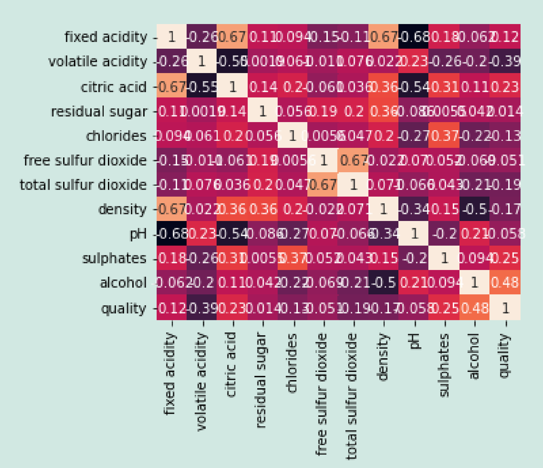


Figure 1. is a heatmap of the 12 different attributes including the quality. Density and fixed acidity and citric acid and fixed acidity have the highest correlation of 0.67.

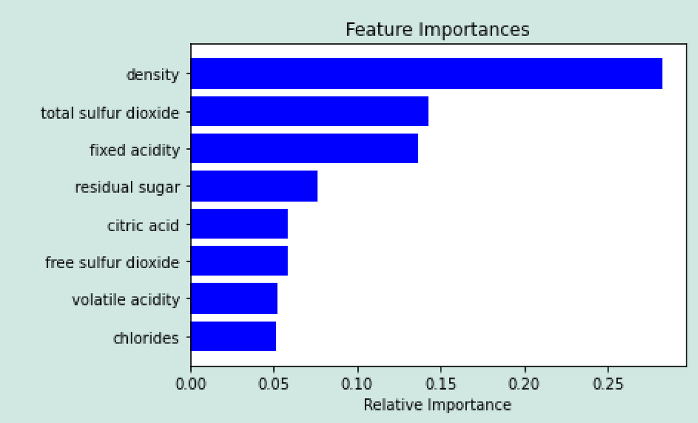


Figure 2. shows the default feature importance from RandomForestRegressor*. This figure confirms that alcohol, sulfates and volatile acidity are 3 top most influential variables in this model.

Dataset: Red Wine Quality (11 attributes, 1 label, 4898 instances)

- Wine quality based on physicochemical tests, such as alcohol, density, and fixed acidity.
- The data was split randomly into two parts. 80% of the data was dedicated to training the model, and the other 20% was used to validate the training done to the models.

The ensemble network architecture each model has the same base structure. they start with an input layer that accepts 8 inputs, which are the 8 most important features of the dataset. From there, the data is parsed through two Dense layers. As more models are created and trained, each of these two layers will gain neurons per model created. These layers are both activated by Rectified Linear Unit (ReLU) functions. Finally, the data is processed by a final Dense layer that contains 6 neurons. This produces 6 outputs to signify the quality of the wine. It is activated by a Sigmoid activation function; it produces an output between 0-1, which allows us to determine the wine quality between 3-8.

Results/Analysis

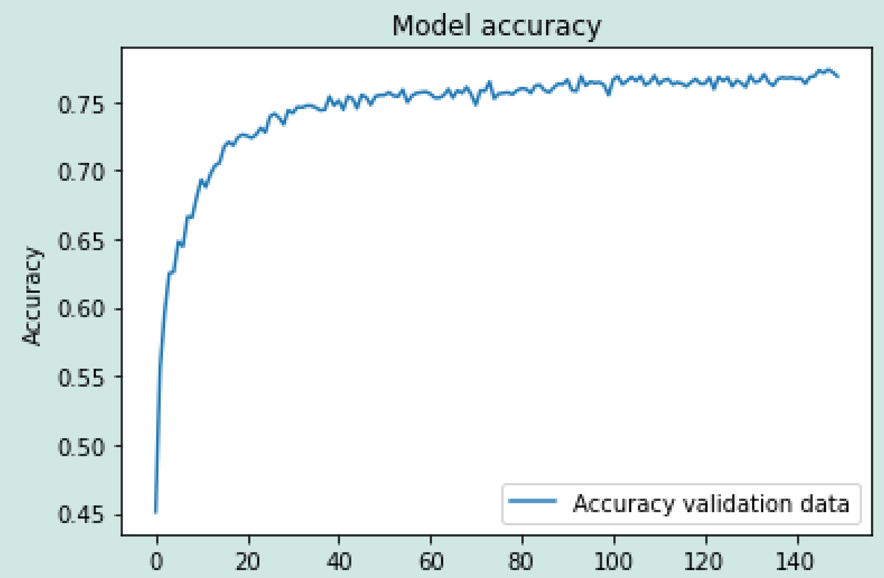


Figure 3. is the accuracy of the validation data of the neural network as the epochs increase. Accuracy can be defined as the number of correct predictions over the total number of predictions. This graph confirms the black-box algorithm created by the neural network when the training data set was applied.

Results/Analysis Cont.

Each network contains four layers, but is structured differently each time a new model is generated. For each iteration of the ensemble neural network, the number of neurons in the second and third layers of the model increased; the layers would start with 16 and 8 neurons respectively. For each model created, the current value of the iteration would be multiplied by 2 and be added towards the total number of neurons for each network. For example, if the network were creating its second model, 4 neurons would be added to both the second and the third layer. This would mean that the layers now have 20 and 12 neurons respectively.

15 models were trained using this method. As the number of trained models increased, the overall accuracy of the ensemble network increased. Figure 4 shows the accuracy of each network individually, while Figure 5 shows the average accuracy of all the models produced.

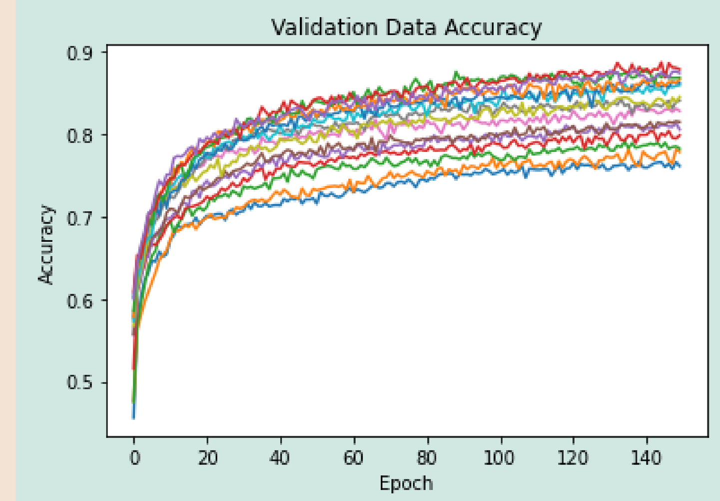


Figure 4. Validation Accuracy for 15 single neural network models

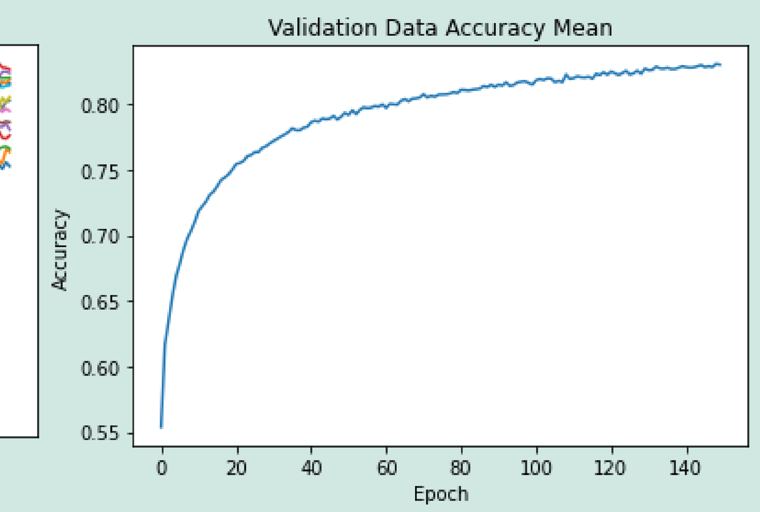


Figure 5. Validation Accuracy for Ensemble Neural Network (Average of all neural networks)

Applications

Figure 6. is a spaghetti model of a predicted hurricane path. Each individual colored line represents a singular neural network. They combine to form an ensemble neural network as shown on the figure. The area inside the white perimeter represents a new concept known as the uncertainty quantification of the ensemble neural network. This concept poses the question, "given the data of uncertainty in the input data and the models used, is it possible to quantify the effect that the data has on the output?"

Life Tip: Be like a neural network. Learn from your mistakes.

Citations:
P. Cortez, A. Cerdeira, F. Almeida, T. Matos and J. Reis Modeling wine preferences by data mining from physicochemical properties. In Decision Support Systems, Elsevier, 47(4):547-553, 2009.
News19WLTX. (2019, August 31). Hurricane Dorian Update: Latest track, Spaghetti Models. YouTube. Retrieved April 5, 2022, from https://www.youtube.com/watch?v=PGhI6Qist3w&ab_channel=News19WLTX