Predicting Breast Cancer Tumor Behavior through Deep Learning

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CIS435 Practical Data Science Using Machine Learning

Assignment 3: Neural Networks

February 20, 2022

**Business Problem**

The field of modern medicine continues to grow and evolve. Recently, due to a worldwide pandemic, medical science has been put to the test to contain the coronavirus and return the world to normal. Coronavirus is an extreme example, but it represents how far the medical field has come in triaging problems. AI/ML has come a far way since its creation and can now be used to assist the medical field even further. Using the power of AI/ML, we can help doctors diagnose and treat patients at records speeds. One of the hardest steps in treating a patient, is correctly diagnosing the cause. With AI/ML, we can use the power of historical data to predict potential medical issues. Armed with neural network models, medical professionals can have a quick and accurate second opinion before diagnosing a patient. Having an automatic second opinion can be the difference of life and death to a patient. In this assignment, we will apply a neural network to assist medical professionals in accurately diagnosing breast cancer tumors. The ultimate output of the machine learning model will predict if a tumor is malignant or benign based on information provided.

**Machine Learning Applications**

Before we start looking into breast cancer tumors, I want to walk through some other examples in the medical field where machine learning can be used. One example is reading chest X-Ray images to determine if a patient has COVID. A neural network can be used to inform a medical professional if a patient had COVID, pneumonia, or normal scans. Coronavirus is a deadly virus and quick feedback from a neural network model will enable doctors to apply preventative measures and reduce the chance of death or significant damage.

A second example we could apply a neural network in the medical field is assisting in prescription choice. When I was diagnosed with migraines, they immediately let me know it was going to be a trial-and-error process to find the correct medicine for me. What if we could collect information from a patient and best fitting medicine outcomes to predict what medicine might be the best fit for the next patient. Although it is no harm to try a medicine and have it be unsuccessful, trying the best medicine first can provide the maximum relief and quality of life to a patient.

A final example is using a neural network to determine whether a patient has type 1 or type 2 diabetes. Both types of diabetes are major life altering diagnoses, but treatment of each differs. Type 2 diabetes with proper treatment and lifestyle changes, it can be put into remission. However, type 1 diabetes must be controlled with insulin and there is no chance of remission. Both type 1 and type 2 diabetes present the same symptoms but approaches to managing it is very different. Using a neural network, you could assist in diagnosis of which type of diabetes much earlier. A patient could be treated for that specific type of diabetes and greatly increase their quality of life.

**Machine Learning Algorithms**

To best assist medical professionals in predicting breast cancer tumors, I will be using a neural network algorithm. A neural network algorithm is a machine learning technique used to imitate the function of the brain. Building on the core of how brains transmit information, neural networks were designed to process data the same way. It begins with the idea of neurons. Multiple inputs can be read in and multiplied by a weight, depending on importance. Next, the weighted inputs are added together with a variable known as the bias (*b*) as shown A picture containing text

Description automatically generatedbelow.

Diagram

Description automatically generatedLastly, this total sum is passed into an activation function where it outputs a value between 1 and 0. A sigmoid function is an example of an activation function to determine the 1 and 0 values. If a large positive number is passed into the function, it returns a 1, while a large negative number results in a 0. We use these 1 and 0 binary results to determine if a value should fit into a particular grouping. One of the main advantages of a neural network is that there can be multiple layers of the processing above before it is passed to the activation function. Below is a graphical example of the Multi-layer Perceptron (MLP) algorithm we are using for this assignment.

From the example above, we can see how x values can be assigned a weight (each line) as they are passed to the next layer. Once it reaches the next layer, the bias is added to the value and the process starts over until it reaches the output or activation function.

**Data Preprocessing Discussion**

To ensure maximum accuracy from our machine learning models, we need prepare our data for analysis. The first step I took to understand the data is seeing its shape. Our dataset contains 569 entries with 23 features. Each of the features are floating values describing the tumor except for ID and Diagnosis which were integers. Next, I looked across the 569 entries to ensure we did not have any null values. Null values would have a large impact on the models and removal of those entries would have been critical. Lastly, I gathered summary metrics on each feature to check for any irregular values.

**Explaining Metrics**

When first evaluating the model, I need to understand the data being passed into it. With the complexity of a neural network and its robust ability to adapt to many features, it made sense to leave all features in the dataset. If the dataset were to increase to +1 million records, I would suggest changing the model from MLP to another neural network that supports GPU processing. GPUs within a computer are great computational devices for complex calculations typically designed for graphics. GPUs can provide that same computational speed if the model supports its usage. To substitute the MLP model, I would use a backend of TensorFlow and switch to Keras as the new neural network because GPU computation is automatically enabled.

In this assignment, the row count is small, and the number of features is also low, leading me to conclude using MLP will perform very well in this scenario.

**Interpreting Results**

To review the accuracy of models above, we can use a few methods. I chose to use a confusion matrix, accuracy score, and ROC curve with corresponding area under curve to rate the results. The accuracy score is computed by counting each of the correct predictions and dividing it by the total number of possible predictions. For an accuracy score, we are looking for a value as close to 100% as possible. The accuracy score should be computed on both the training set and test set to see if the dataset properly trained the model. Below is the accuracy percentage taken from the MLP model.

Although accuracy seems promising, it does not tell the entire story. Accuracy is simply a measure of correctness but not a complete picture into the validity of your model. To ensure we are using a high performing model; we must also look at the Receiver Operating Characteristic (ROC) curve. An ROC curve is a graphical plot that illustrates the diagnostic ability of a binary classifier. In this case, it will illustrate the model’s ability to produce either malignant or benign outcomes. The ROC curve plots the true positive rate (y axis) against the false positive rate (x axis). The area under the line plotted with the curve is called the area under curve or AUC. The AUC is a value between 0 and 1 where a 1 is a perfect score. To have a better understanding of our model accuracy, we need to understand the AUC values. Below is an ROC curve of the MLP model.

Chart, line chart

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With an astounding result of 98.9% area under curve, I believe this model is highly accurate in determining whether a patient’s tumor is benign or malignant.

For the last comparison, we will use the confusion matrix to review our model performance. A confusion matrix is a 2 x 2 plot that details the true positive, true negative, false positive, and false negative results. True positive and true negative are results where the model accurately predicted the result. However, false positive and false negative results indicate that the model predicted the wrong result. When working within the healthcare industry, it is important to understand the implications of a false positive or false negative. A single false negative could mean the difference between life and death for a patient. In the case of a false positive, there is a bit more tolerance for this error because a patient would still get treatment, even if they didn’t need it. In the below graphic, I included the previous machine learning models applied to the dataset as a reference point for MLP.



I highlighted the false negative results in orange based on my explanation above. I believe that one false negative could cost a patient their life and ensure that number is as close to zero as possible is a great indicator for the best model to use. If given the full dataset above, I would be inclined to use Naïve Bayes to reduce the number of false negatives and save lives. However, we will use the Neural Network as other machine learning methods are out of scope for this assignment.

**Recommended Steps**

When implementing a Neural Network, we saw a massive spike in percentage of area under an ROC curve while also almost minimizing false negative results. I would optimize the model by adding more rows of training data to minimize the number of false negative results. If we were able to retain a large set of data to use for training and resting, I would recommend switching the model due to performance constraints. A Neural Network that can utilize a GPUs processing power will be scalable to quickly assist medical professionals in determining a tumor’s potential to be malignant or benign. However, I believe the model should only be used in an assisting capacity because it is still subject to error. Human review is necessary to weigh in external factors outside of what was input into the model to ensure the best patient diagnosis. Our goal is to accurately determine a tumors risk to a patient and intervene as fast as possible. With that in mind, doing whatever we can to reduce the false negative results, turn around a result as quickly as possible, and ensure scalability will keep patients out of harm’s way.

**References**

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