De La Salle University - Manila

Term 2 A.Y. 2022-2023

In partial fulfillment

of the course

INTRODUCTION TO INTELLIGENT SYSTEMS

MCO3:
Machine Learning

CSINTSY - S12

SUBMITTED BY:
DELA CRUZ, Frances Julianne R.
GAMBOA, Mikkel Dominic
VERANO, Carl Matthew
YU, Hanz Patrick

SUBMITTED TO:
Mr. Thomas James Tiam-Lee, Ph.D.

I. Introduction

In the Philippines, the infant mortality rate in the year 2022 was approximately 18 deaths per 1000 live births(*Philippines Infant Mortality Rate 1950-2020*, n.d.). This problem is significant not only locally but also globally that it is one of the SDG targets by the UN. Newborns that die within the first 28 days are due to lack of immediate care and neglect. Usually this is a reflection of issues faced in sanitation. healthcare, and nutrition (macrotrends, n.d.).

Fetal health can range from being healthy to having birth defects, and in the worst case, a miscarriage. A healthy fetus is characterized by consistent growth development. This is shown by seeing its major organs properly functioning and being responsive with its 5 senses(*Fetal Health and Development*, n.d.). A sick fetus can be detected with irregular heartbeat and it does not move much in the stomach of the mom (WhatToExpect, n.d.).

Prevention can start from awareness and understanding of the fetus' health amidst pregnancy. Fetal mortality does not only cause the loss of a child, but it can cause medical problems to the mother. Some sample problems that may arise are infection in the uterus and possibly hemorrhage (Cerebral Palsy Guide, n.d.) .

Fetal mortality can be preventable if we are able to identify if it needs immediate attention or care. The researchers have chosen to analyze quantitative characteristics of data such as heart rate and fetal movement to be fed to an algorithm, so that we may identify and predict fetal health. By doing so, we are able to keep track of the right course of action to take care of an infant that is to be born.

II. The Dataset

Details of the dataset (cited from kaggle):

Data	Description
baseline value	Baseline Fetal Heart Rate (FHR)
accelerations	Number of accelerations per second
fetal_movement	Number of fetal movements per second
uterine_contractions	Number of uterine contractions per second
light_decelerations	Number of LDs per second
severe_decelerations	Number of SDs per second

prolongued_decelerations	Number of PDs per second
abnormal_short_term_variability	Percentage of time with abnormal short term variability
mean_value_of_short_term_variability	Mean value of short term variability
percentage_of_time_with_abnormal_long_term_variability	Percentage of time with abnormal long term variability
mean_value_of_long_term_variability	Mean value of long term variability
histogram_width	Width of the histogram made using all values from a record
histogram_min	Histogram minimum value
histogram_max	Histogram maximum value
histogram_number_of_peaks	Number of peaks in the exam histogram
histogram_number_of_zeroes	Number of zeroes in the exam histogram
histogram_mode	Histogram mode
histogram_mean	Histogram mean
histogram_median	Histogram Median
histogram_variance	Histogram variance
histogram_tendency	Histogram trend
fetal_health	Fetal health: 1 - Normal 2 - Suspect 3 - Pathological

Features, labels, and classes of the dataset.

- Features - baseline value, accelerations, fetal_movement, uterine_contractions, light_decelerations, severe_decelerations, prolongued_decelerations, abnormal_short_term_variability, mean_value_of_short_term_variability, percentage_of_time_with_abnormal_long_term_variability, mean_value_of_long_term_variability, histogram_width, histogram_min, histogram_max, histogram_number_of_peaks, histogram_number_of_zeroes, histogram_mode, histogram_mean, histogram_median, histogram_variance, histogram_tendency
- Labels - fetal_health

- Classes - The dataset has a multiclass classification since it has more than two classes. The classes being what classification of the fetal health, those being normal, suspect, and pathological which are represented as 1, 2 and 3 respectively in the data set table.

III. Methodology

For the framework, the dataset was first obtained from kaggle, and the software that was used for both machine learning algorithms to implement libraries for machine learning algorithms was scikit-learn. Moreover, data obtained will go through a series of preprocessing steps, and then the next step would be to implement the learning algorithm and the machine learning model, which would then process the data and give the predictions.

The raw data from the csv file is read through the pd.read() method of pandas. The import from pandas allows easier data manipulation and procession. We are then able to split the features and labels (the answer/classification) to X and y respectively. Splitting the data into training and testing sets will lead us to predict the performance of the algorithms accurately and prevent overfitting. Furthermore, the features/input data were scaled so that the gradient descent would require less iterations to find the minima. Scikit learn's StandardScaler() was used for this.

Logistic regression and neural networks were used by the students to predict fetal mortality. Even though the problem is a multi-classification problem, logistic regression's flexibility to handle both simple and complex datasets made the students choose it. And although the model is commonly used for binary classification, it is able to handle multi-classification problems by doing one versus all comparisons. On the other hand, neural networks is a type of algorithm for machine learning. It is a model that can be trained, through adjusting its parameters, to recognize patterns and relationships in data. Neural network was also chosen since it can handle both simple and complex input and target variables. Since the data is also quite complex (with over 20 features), then using a neural network algorithm may be better since it can be used to catch nonlinearities that linear models like logistic regression may not. Both of the algorithms utilized have their own strengths and weaknesses.

Within a set of input features, logistic regression tries to determine if it is a certain label or not. It uses a sigmoid function and maps the training input between the values of 0 and 1(Zornoza, 2020). The gradient descent algorithm is done to find the minima of the model; this is done to minimize the error between the predicted and true values(Tokuç, 2021). To allow the model to identify the multi-classification(in our case normal, suspected, and pathological), Scikit-Learn uses a one-vs-all algorithm, and this tries to detect if a label is positive and treats the other labels as negatives(Shrivastava et al., 2022).

In a neural network, there are three layers, input layer, hidden layer, and output layer. The input layer processes the data, then the hidden layer is a layer of neurons between the input layer and the output layer in a neural network (aws, n.d.). The term "hidden" denotes the fact that the neurons in this layer are not immediately visible or reachable from either the input layer or the output layer. There are types of neural networks, but the group used the multi-layer perceptron (MLP) that trains the data using backpropagation. A hidden layer is a layer of neurons between the input layer and the output layer in a neural network. The term "hidden" denotes the fact that the neurons in this layer are not immediately visible or reachable from either the input layer or the output layer (Bushaev, 2017).

IV. Results and Analysis

Logistic Regression

- Compute performance metrics

```
In [22]: import sklearn.metrics as metrics
```

- Accuracy, Recall, Precision

```
In [23]: metrics.accuracy_score(y_test, y_pred)
Out[23]: 0.8990610328638498

In [24]: metrics.recall_score(y_test, y_pred, average='micro')
Out[24]: 0.8990610328638498
```

- Confusion Matrix

```
In [25]: metrics.confusion_matrix(y_test, y_pred)
Out[25]: array([[324,  17,   2],
                [ 15,  31,   4],
                [  1,   4,  28]])
```

Neural Network

```
In [58]: import sklearn.metrics as metrics

In [59]: clf.score(X_test, y_test)
Out[59]: 0.9366197183098591

In [60]: metrics.accuracy_score(y_test, y_pred)
Out[60]: 0.9366197183098591

In [61]: metrics.recall_score(y_test, y_pred, average='micro')
Out[61]: 0.9366197183098591

In [62]: metrics.confusion_matrix(y_test, y_pred)
Out[62]: array([[323,   8,   1],
                [ 11,  45,   3],
                [  2,   2,  31]], dtype=int64)
```

In the code snippet above, for neural networks, it calculates the trained MLP classifier's accuracy score on the test set.the accuracy_score function from metrics import compares the predicted labels y_pred with the true labels y_test and returns the fraction of correctly classified samples. Rounding off the values and turning them into percentages, logistic regression had an accuracy of 89.91% accuracy; at the same time, neural networks had an accuracy of 93.66%.

On the other hand, the recall_score function figures out the recall score, which is the proportion of true positives to the total of true positives and false negatives. The function will calculate the score by totaling the true positives, false negatives, and false positives, and it will be using that information to calculate the average parameter, which is set to 'micro'. The recall score for both logistic regression and neural networks are the same with their respective accuracy score.

The accuracy and recall score of neural networks being higher than that of logistic regression implies that the performance of it for the data set is better. In some cases recall score or accuracy would be more prioritized depending on the problem but since in this case both predictions from the neural network are higher, then it's safe to say that it's more accurate. Although it is more accurate, it does not immediately mean that it is better. This is because we also have to take into account the computational expense of the model. Since this dataset has a sample size of 2125 respondents, it is rather relatively small than what is considered a large data

set (around a million rows), neural networks' being more computationally expensive is less significant. Furthermore, both of the models having the same recall score as their accuracy might mean that the dataset is imbalanced, and this would mean that it would have biases in identifying the majority class more accurately.

V. Conclusions and Recommendations

The project aimed to classify a fetus as normal, suspected, or pathologic when given a range of quantitative characteristics. By using logistic regression and neural networks, the students were able to utilize machine learning to aid in this problem. The accuracy of the models used were high, but the data set is suspected to be imbalanced due to having the same accuracy and recall scores.

For future references to improve on, the researchers may take a look into other models and other kinds of datasets. In multi classification, there are other useful machine learning models such as decision trees and super vector machines. These algorithms have their own different use cases and it would be interesting to test their performance if they would have better metrics. We can also experiment with other datasets with more complex features in the future. The chosen dataset had purely quantitative variables, and in the case that the dataset has qualitative data included, such as week of pregnancy and sex characteristics, this may lead to different results.

VI. References

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VII. Contributions of Each Members

DELA CRUZ, Frances Julianne R.	Code for logistic regression, write-up
GAMBOA, Mikkel Dominic	Code for neural network, write-up
VERANO, Carl Matthew	Leader. Code for neural network, write-up
YU, Hanz Patrick	Code for logistic regression, write-up