ICU Mortality Rate Estimation Using Machine Learning and Artificial Neural Networks (ANN)

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Abstract - Predicting the mortality of patients is a difficult task & important problem. Several severity grading methods and machine learning mortality prediction have been developed during the last few decades. The critical care unit treats patients with conditions that are life-threatening (ICU). Success in treatment and death rates in the ICU rely on how well human and technology resources are used. The Deep learning and machine learning based approach is applied to 3999 patients, which generate mortality prediction model based on their features. The results showed that the factors including duration of hospital stay, clinical state, immobilization, drowsiness, neurological disorders, agitation, coma, intubation, mechanical ventilation, usage of vasopressors, glycemic index, sociodemographic traits, and delirium could be used for mortality prediction with 89 percent of accuracy. The chance of dying appears to be doubled in hospitals with extended ICU stays. In summary, this study offers an enhanced chance of predicting whether a patient will live or pass away depending on how long they remain in the hospital. It also serves as an anchor for the analytical techniques used to forecast mortality and hospital stay.

Key Words: ML algorithm, Neural Network, SVM, Logistic regression, Random Forest Classifier, Decision Tree Classifier, XGBoost Classifier, Gaussian NB.

1. INTRODUCTION

An important aspect of planet Earth is Human- life. Multiple reasons account for the illness of an individual which may lead to death. ICU specialist works to cure and treat this illness. With the advancement of innovation, the odds of survival of a patient have been expanded. One of the biggest emerging technology is Artificial Intelligence. Machine learning. running text should match with the list of references at the end of the paper. algorithms can serve as a better option for the prediction of mortality rate and severity of illness. Doctors and nurses ask many questions about patients and use specialized instruments like stethoscopes, syringes, portable sensors, printed reports, etc. to gather any data about them. The dataset includes a variety of characteristics, including heart rate, respiration rate, glucose level, and if a disease is present or whether any symptoms are present. For prediction, we have considered a training data set which consists of 3999 rows and 42 columns without an output column. The output columns are integrated into a separate file which contains details about whether the patient survives or not. Out of 42 features columns, 4 columns possess data type as int64 and the remaining 38 features columns are float64 data type. From the output column file, we have recognized that our problem was "Binary Classification" related. Binary classification is a problem which provides output to be either 0 or 1. With the real-life application, we can consider that 0 specifies surviving whereas 1 specifies death. The remaining paper content is organized in different Sections included is as follows: section II describes related work required, the Methodology followed is discussed in Section III, Section IV describes all the Experimental Results and last i.e., and section V concludes the overall outcome of the paper.

2. Related Work

Mortality Prediction is a Binary Classification problem. So there have been various approaches to tackle this problem. Some have chosen neural networks while others chose various Machine learning Classifiers to have a better result [2]. There is a list of Machine Learning and deep learning algorithms which can be brought into play to tackle the problem. But we have had maximum accuracy using the ANN model. We have opted Artificial Neural Network Model, which is providing us with better results than other Neural and Machine learning algorithms. Implementation of the model supports the features of the scikit-learn [5] to get on accuracy score implementations.

3. Methodology

In order to solve this dilemma, we must determine if a patient will live or die while receiving treatment at the hospital. A Binary Classification Problem exists. We employed a variety of models to solve the issue and forecast the outcome, including: Logistic Regression

1. Logistic Regression

2.SupportVector Classifier

3. Random Forest Classifier

4. Decision Tree Classifier

5. Xgboost Classifier

6. Gaussian Naive Bayes

4. Dataset Description

For training and testing, we have considered a random data set. The Dataset contains 3999 patient entries with 42 features and a multilabel status which describes whether the patient survived or not with two different values as 0 and 1. A snapshot of the dataset used is displayed in Appendix 1.

4.1 Preliminary Data Analysis

The first important step before applying Algorithms was to explore the dataset and understand the relationship between different features of the dataset and output values. Which in succession helps to drop the features which have minimum or null influence on labels i.e., output. The data set we considered is vacant of missing values. Also, labels and training datasets were given separately but in order to visualize the data its necessity to concatenate both separated file in a combining form.

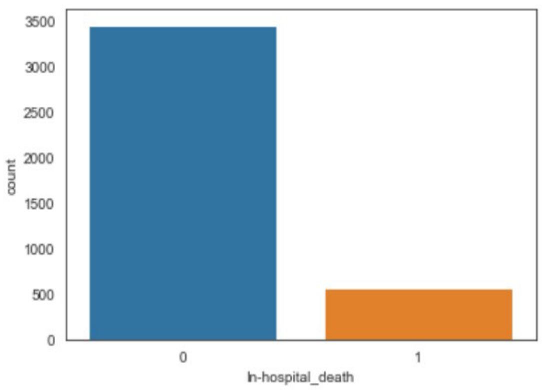

Fig 1- In-Hospital Death Ration

4.2. Data Visualization

As our dataset contains 42 features its essential to figure out the correlation between different features and remove those features which contain minimum or null correlation. Besides, it reduces the size of our features but it's helpful to attain more accuracy.

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['ALP', 'ALT', 'AST', 'Age', 'Albumin', 'BUN', 'Bilirubin',
 'Cholesterol', 'Creatinine', 'DiasABP', 'FiO2', 'GCS', 'Gender',
 'Glucose', 'HCO3', 'HCT', 'HR', 'Height', 'ICUType', 'K', 'Lactate',
 'MAP', 'MechVent', 'Mg', 'NIDiasABP', 'NIMAP', 'NISysABP', 'Na',
 'PaCO2', 'PaO2', 'Platelets', 'RecordID', 'RespRate', 'SaO2', 'SysABP',
 'Temp', 'TroponinI', 'TroponinT', 'Urine', 'WBC', 'Weight', 'pH'],
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The most important features from dataset are as [ALP', 'ALT', 'AST', 'Age', 'Albumin', 'BUN', 'Bilirubin', 'Creatinine', 'DiasABP', 'FiO2', 'GCS', 'Glucose', 'HCO3', 'HR', 'K', 'Lactate', 'MAP', 'MechVent', 'Mg', 'NIDiasABP', 'NIMAP', 'NISysABP', 'Na' , 'PaCO2', 'PaO2', 'Platelets', 'RecordID', 'RespRate', 'SaO2', 'SysABP','Temp', 'TroponinI', 'TroponinT', 'Urine', 'WBC', 'Weight', 'pH'] For finding correlation we have had taken help of HeatMap . This have helped us to figure out that there is minimum correlation of following features ['Gender','Cholesterol','HCT','ICUType','Height'] with output so we can consider to drop them. Fig 3 shows correlation of features.

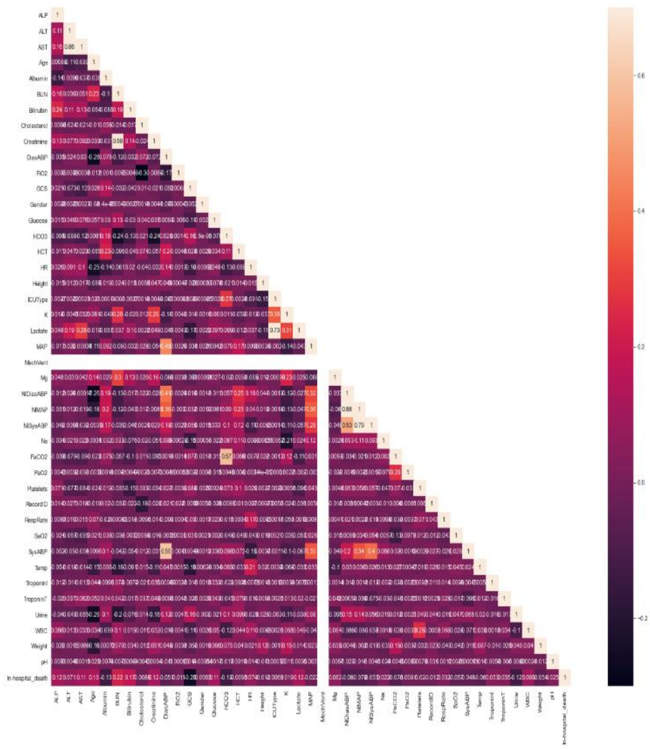

Fig-2 Correlation matrix between different Columns

In order to transform all features in a particular range we have opted technique of the Min-Max scalar from sci-kit - learn. These scales and translate each feature, by scaling individually such that it is in the range of training sets [5]. This feature helps the model to work more efficiently with the biased condition. A snapshot of the processed data set is displayed in Fig 3.

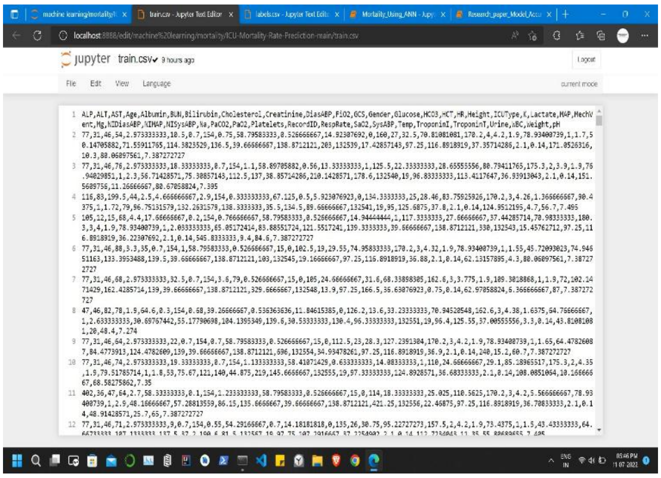

Fig-3 Pre-process Dataset

5. Model Selection and Building

In an effort to fulfil our needs we have considered trying different models. We tried 7 models out of which 6 models were more effective in consideration of the other two models. In order to maximize the result, we tried and tuned 6 models. The table below describes a list of different models we used along with their respective accuracy and description.

SNo.	Machine Learning Model	Score
1.	Logistics Regression Model	0.8550
2.	Support Vector Classifier	0.8687
3.	Random Forest Classifier	0.8501
4.	Decision Tree Classifier	0.8287
5.	Artificial Neural Network	0.8937
6.	XGBoost Classifier	0.8575
7.	Gaussian NB	0.5400

Fig -4 Different Accuracy of Machine Learning Model and Artificial Neural Network

Firstly, we tried with Logistic Regression Model which provided an accuracy of 0.8550. For Support Vector Classifier accuracy is about 0.8687. For Random Forest Classifier accuracy is about 0.8501. For the decision Tree Classifier accuracy was around 0.8287, for Xgboost Classifier we tried to increase our accuracy up to 0.8575. We got the best result which is maximum accuracy with ANN which is 0.8937. Processing of ANN algorithm can be described as shown in Fig. 4

We tried 7 different models. Out of the used models, SVM is giving 0.8687 as an accuracy value then Xgboost Classifier shows an accuracy of 0.8575 and Artificial Neural Network contributes with maximum accuracy of 0.8937. So, from this statistic, we can conclude that ANN is a best best-trained model for the prediction of ICU mortality. Comparative analysis of accuracies associated with different models is graphically represented in Fig. 6,7

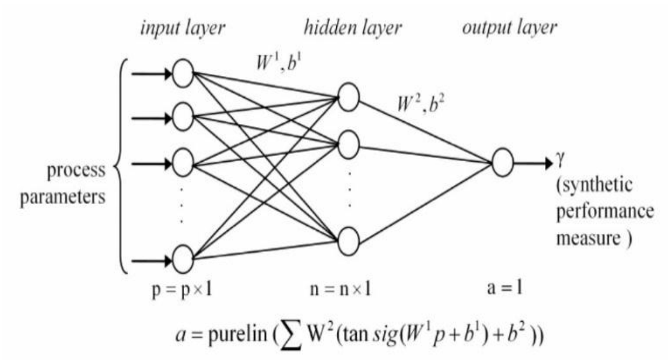

Fig-5 Diagram of Artificial Neural Network

6. Accuracy

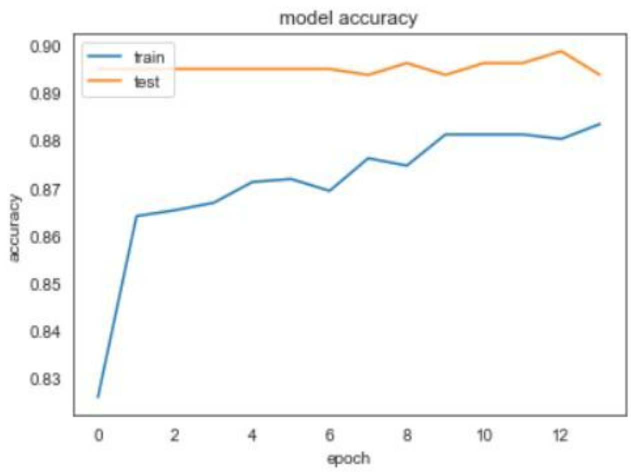

Fig-6 ANN model Accuracy Graph

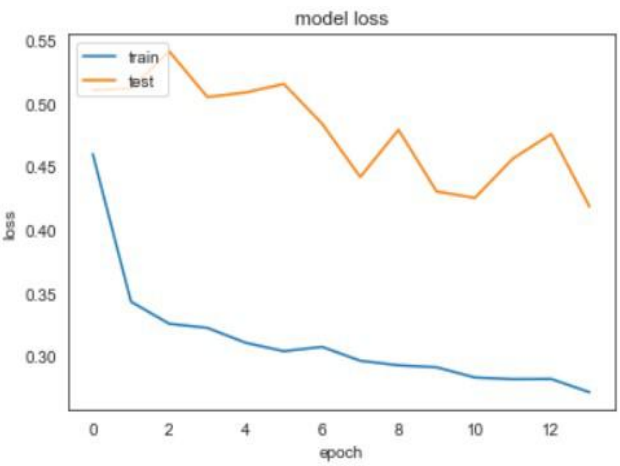

Fig-7 ANN model Loss Graph

6.1 Confusion Matrix

A confusion matrix is an N x N matrix used for evaluating the performance of a classification model, where N is the number of target classes [6]. It specifically provides a comparative analysis of actual values and values predicted by the machine learning algorithm by providing a view of how our binary classification model is performing and what kinds of errors it is making.

		Predicted	
		Negative (N) -	Positive (P) +
Actual	Negative -	True Negatives (TN)	False Positives (FP) Type I error
	Positive +	False Negatives (FN) Type II error	True Positives (TP)

Confusion Matrix Values

- True Positive (TP) = 560 positive class data points were correctly classified by the model
- True Negative (TN) = 330 negative class data points were correctly classified by the model
- False Positive (FP) = 60 negative class data points were incorrectly classified as belonging to the positive class by the model
- False Negative (FN) = 50 positive class data points were incorrectly classified as belonging to the negative class by the model.

6.2 F1-Score, Accuracy, Recall Value:

Performance is typically estimated on the basis of synthetic one-dimensional indicators such as precision, recall or f-score [7]. For "Mortality Rate Prediction" which is medical related domain it's important to raise alarm for actual positive cases as compared to that specifying false cases. For this purpose, recall matrices are more useful as compared to that other. Table (02) specifies f1-score, recall and support value for the selected binary classification algorithm is ANN.

	Precision	Recall	F1-score	Support
0	0.85	1.00	0.92	680
1	1	0.01	0.02	120

Fig-7 Precision, Recall, F-1 Score Support Chart

7. RESULTS:

We tried 7 different models. Out of the used models Random Forest Classifier is giving 0.86875 as an accuracy value the Xgboost Classifier shows an accuracy of 0.8725 and the Artificial Neural Network contributes with maximum accuracy of 0.8765. The F-score value for ANN is 0.92 with a precision of 0.85 and it also acquires a high recall value that is 1. So, from this statistic, we can conclude that ANN is a best best-trained model for the prediction of ICU mortality. Table 3 consists value count of the number of patients dying in ICU that has been predicted by models of top accuracies.

8. Conclusion:

In this paper, we have worked on a random dataset related to ICU in order to predict mortality rates. For the sake of the training dataset, we have considered 7 different models such as (Logistic Regression, Support Vector Classifier, Random Forest Classifier, Decision Tree Classifier, Xgboost Classifier, Gaussian NB) and pre-processed available dataset. Among all the listed model's best accuracy was provided by ANN which is 0.8937 and the least accuracy is provided by GausianNB which is near 0.5400. Based on our analysis ANN will serve as the best option for the prediction of mortality rate in ICU.

9. REFERENCES: -

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