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ORIGINAL ARTICLE **OPEN ACCESS**

Patient Monitoring System in the context of Artificial Intelligence in ICU

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ABSTRACT
In the modern-day world, patients with critical conditions get monitored in the intensive care units in which every condition of the patient is monitored and necessary treatment is taken in a timely. These patients are susceptible to many diseases and that's why many of their important and damaged organs are taken special care of. To provide such an amount of care to a single patient, much of the staff is required on a single patient for 24 hours. Due to such an amount of care, a lot of useful data is generated which can play an important role to understand many important factors which get ignored usually. To make sense of such large data on paper for a doctor is a very difficult task that can consume a lot of time and still we don't know the analyzed finding are correct or not. To detect high risks and failure of the organs, machine learning can play an important role to detect such events and actions can be taken place promptly. In this paper, findings from a lot of research papers have been discussed and summarized to give the best possible solution. The goal of this research article is to give useful insights that can improve the already available models.
Keywords: *Patient Monitoring System, Artificial Intelligence, Intensive Care Unit (ICU)*

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INTRODUCTION

The field of artificial intelligence is greatly inspired by the brain process and functions of humans and machine learning is now in the vast range of technologies that can be used for the case of predictions. Artificial intelligence has many sub-fields and machine learning is one of them. In machine learning models, algorithms are created that help computers extract patterns from data without using programming. This is the thing that distinguishes machine learning from various other computing domains it doesn't use the programming to create any model doesn't use any programming to make any predictions and forecasting about the data. In the health care department, machine learning can be used in various clinical applications which can be used to form a lot of predictions.

LITERATURE REVIEW

Invasive/non-invasive healthcare technologies paired with artificial intelligence (AI) can assist hospital personnel perform more efficiently [1]. For instance, radio frequency (RF) sensor technology can collect data from a patient's body, and when that data is run via AI algorithms, significant conclusions are produced without the intervention of medical personnel [2,8]. Remote non-contact sensing technologies paired with sophisticated machine learning algorithms can deliver accurate results in real time, enabling physicians to easily monitor and diagnose disorders [9]. Artificial intelligence has been credited with numerous breakthroughs in seizure diagnosis when data from conventional electroencephalography is used (EEG). Although it was regarded as having reasonable sensitivity and specificity [4,5], it was not accepted as standard technique. In 15% of patients with no behavioural responses to motor commands following an acute brain damage, supervised learning methods utilising EEG validated evidence of hidden awareness [10]. Additionally, 12 hours after cardiac arrest, a deep-learning artificial neural network

trained on EEG data from comatose patients was able to predict the 6-month functional prognosis [3]. The AI experts are mostly concerned with the technical aspects of the algorithms, with little care for human interaction. The objective of creating and evaluating AI-based healthcare algorithms should be to augment, not to replace, human intelligence [6,7]. However, AI-based decision support systems sometimes lack the ability to comprehend their own reasoning (the dreaded "black box problem"), posing a challenge to traditional medical decision-making. As a result, the challenge is to maintain the forefront of the creation and review process for new AI applications.

MATERIALS AND METHOD

Proposed Work

The ability of the machine learning models to give better predictions can be optimized and its efficiency can be increased by increasing the number of samples. There are two types of machine learning algorithms.

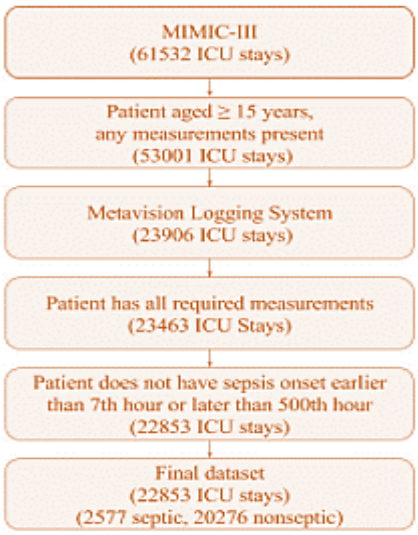
1: supervised
2: unsupervised

The data that is trained in case of the supervised learning is the well-labeled data. The results are obtained by using the information from the trained data to make predictions. The most commonly used supervised learning algorithms are:

- Supervised vector machine
- Random forest
- Decisions Tree.

No labeling of data is required in the case of unsupervised learning. In this case, the machine learns on its own from the unstructured and unlabeled data. The following Figure 1 represents the criteria in intensive care unit for training and testing the data.

Figure 1: Monitoring criteria in ICU



Machine Learning Methods

The steps of machine learning in the intensive care unit are as follows:

- Partitioning of the data
- Construction of the features
- Classified training
- Classified testing

The overall process of patient monitoring in the intensive care unit is represented in the Figure 2.

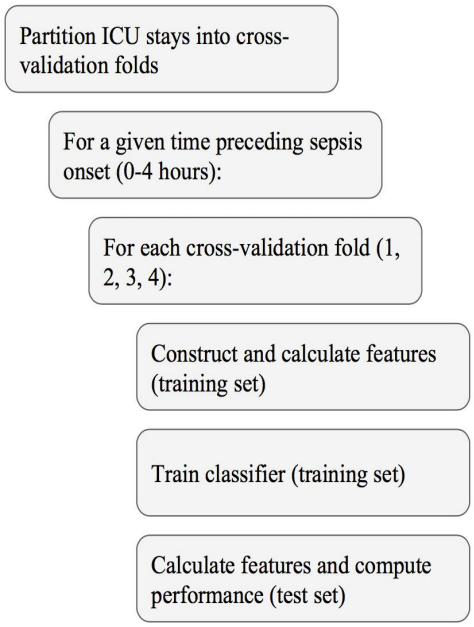


Figure 2: Processes involved in Patient Monitoring in ICU

For the cross-validation, data is partitioned into four-folds which is then used for testing. The other three folds are then used for creating training. With the help of that set that is trained, the feature is constructed for the cross-validations of the folds.For every two hours, important clinical variables are chosen and are represented in Equation (1).

$$E = \{X_1, X_2 .. P(s = 1|x_1) \dots\ p(s = 1|\Delta X) \dots\ \ p\langle s = 1|\Delta X_1, \Delta X_2\rangle \dots\ p\langle s = 1|\Delta X_1, \Delta X_2, \dots \Delta X_n\rangle \quad (1)$$

PROPOSED MODEL

To collect the data, three main sources such as Web of Science, PubMed, and CINAHL were being considered for this research paper. Figure 3 represents the chart for the selection criteria.

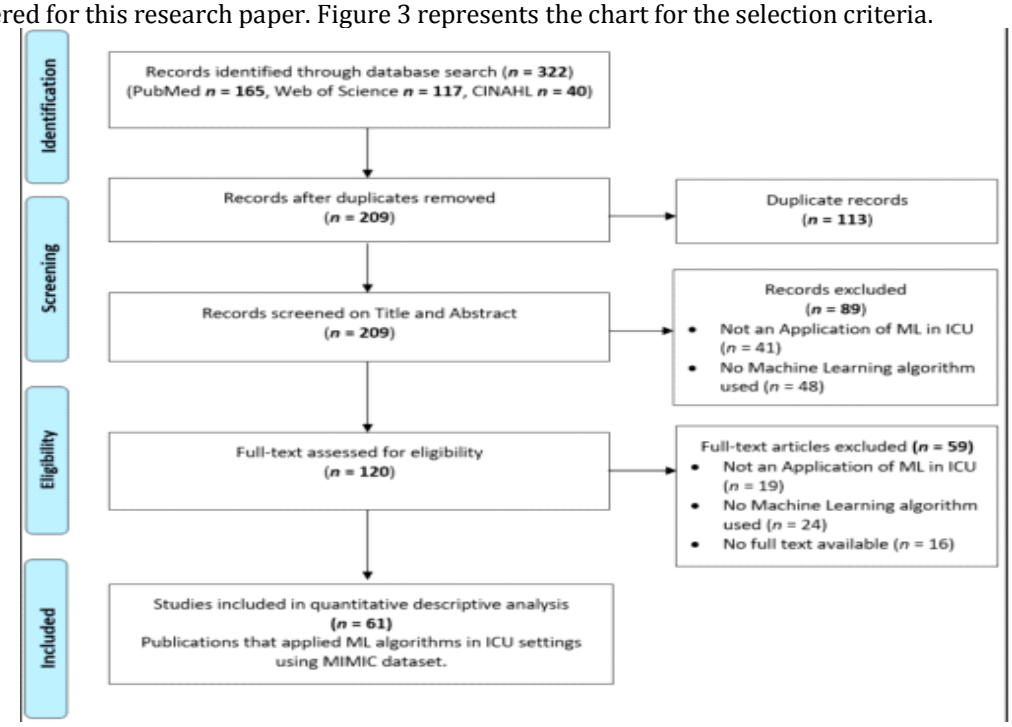


Figure 3: Data sources for Patient Monitoring

RESULTS AND DISCUSSION

The main focus of this paper is to provide an overall view and present-day technologies of machine learning that are being used in the field of the medical especially intensive care unit. The main

applications of machine learning in the patient monitoring involves mortality tracking, risk estimation, spreading of infectious disease, and others. The number of frames from the image is obtained using the succeeding Equation (2).

$$f_i = N_i/N \quad (2)$$

In Equation (2), N_i is the number of the frames that are being observed and N is the total number of frames. The following Equation (3) is also being used in the intensive care unit for calculation of the Sound Pressure Ratio (SPR).

$$SPR = \ln(p/p_0)\, N_p = 2\log 10(p/p_0)\ B = 20\log 10(p/p_0)\text{dB} \quad (3)$$

With the help of the retrospective data, the condition of the critically ill patients is analyzed.This paper highlighted the important variables and the machine learning models that are more useful in the intensive care units. The application of machine learning is growing a lot in the ICU. It has enabled the analysis of a large amount of data and to derive valuable conclusions from it. The Figure 4 shows the result of the ICU data being generated.

Measurement	Mean (SD) (h^{-1})	Median (IQR[a]) (h^{-1})	Fraction of ICU stays (F[b])
GCS[c]	0.29 (0.16)	0.25 (0.21-0.29)	1
Heart rate	1.31 (3.32)	1.07 (1.01-1.16)	1
Respiration rate	1.30 (3.26)	1.06 (1.00-1.16)	1
SpO_2[d]	1.27 (3.01)	1.06 (0.99-1.17)	1
Temperature	0.31 (0.21)	0.27 (0.23-0.314)	1
NIDiasABP[e]	0.76 (0.39)	0.88 (0.46-1.02)	0.99
NISysABP[f]	0.76 (0.39)	0.88 (0.46-1.02)	0.99
SysABP[g]	0.41 (1.55)	0 (0-0.76)	0.43
DiasABP[h]	0.41 (1.55)	0 (0-0.76)	0.43

Figure 4: Data generated from ICU

The following figures show us the graphical analysis of various diseases data by using different models.

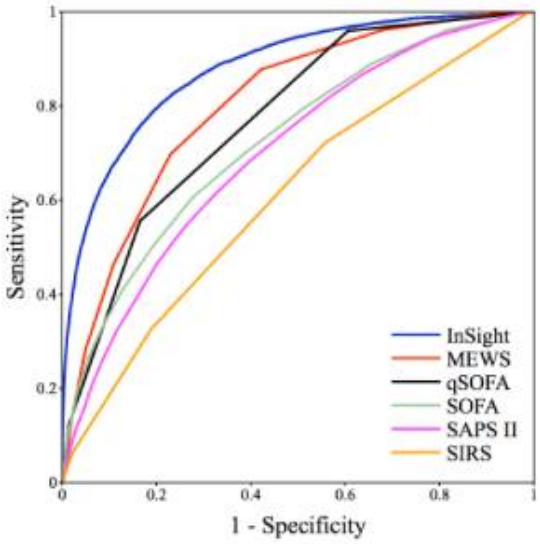


Figure 5: Specificity of the process

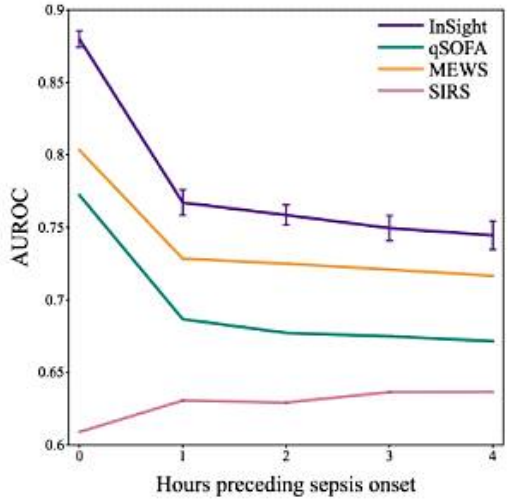


Figure 6: Accuracy of Classification

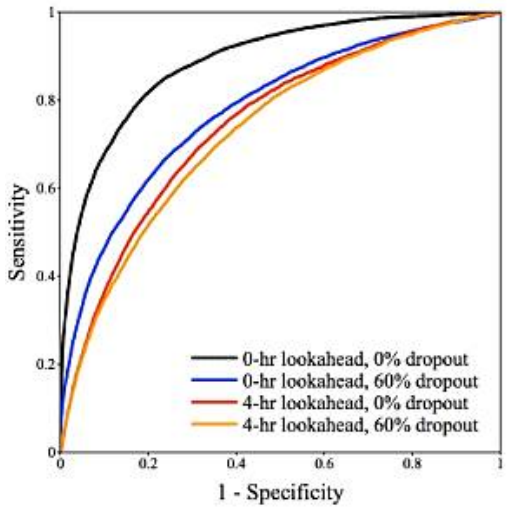


Figure 7: Sensitivity vs. Specificity

MODEL ANALYSIS

The model used here is called insight which requires significantly fewer data to draw valuable insights. The data that's being considered for the testing is called sepsis. First trained this data, and predictions

were made about the performance. Much better insights were obtained by using insights that only use age data and analyzed very vital signs.

The vital signs include systolic blood pressure, pulse pressure, respiration rate, heart rate, the oxygen level of the body, temperature of the body, and glucose level of the body. The scoring system of the model, as mentioned above, is shallow. The performance can be improved by using its learning ability to analyze different patterns among the trends and correlations in the extended vitals with the help of a machine learning algorithm.

Optimization of the machine learning model:

The performance of any machine learning model depends on the pre-processing of the data, identification of the features, and finally model validation. The most commonly encountered problem in this model is the missing essential data. This issue causes serious problems when applying the models in the field of health care. One such solution for this missing data is to use the mean data. It can also be done by using some complex techniques and some optimization techniques. The following algorithm of the machine learning is used for the purpose of the image processing:

Algorithm

Step 1:

Inputs:

Ix- input the images
Cx: input the convolutional layer
Sb: the size of the box
Fx: Feature map

Procedure:

For each size of the box
Identify features boxes
Fm{minimum IC, minimum Cx}
End
for
Each Ic do
If Ix==1
Then calculate
Width =Cx*Ix
Height=C/I
Else
Resize the box with other possible dimensions
End if
End for

CONCLUSION

Machine learning has gained a lot of importance in recent years in the intensive care unit as there is a lot of data generated from a single patient in the intensive care unit. This data can draw essential findings from these data about the patient's condition, susceptibility of the patient, mortality period. The main focus of this paper was to give an overview of the machine learning algorithms employed in medicine, especially intensive care units. This paper's main focus was on the essential variables used in intensive care units for many purposes, such as the event of mortality, the spread of infectious disease, condition of the critically ill units such as heart and liver. This data is further used to create the models that can predict the condition of any patient having a particular disease and having a certain age and gender. Therefore, the machine learning algorithms have a lot of data to train and test and eventually give insights and predictions about specific events.When these models work, the results can be used like an application where any patient can enter has age and disease. Instead of going in a detailed analysis of the patient, that will consume a lot of time. A simple machine learning algorithm can give so many findings that will provide results that humans do not achieve. Even though all machine learning algorithms are inspired by nature and mainly how human perception works. It can work better than humans since significantly less brain capacity can be used. Still, in the case of machine learning, it can be trained by millions of data and will give you its findings in significantly less time and with minimal accuracy. As a result, machine learning improves every field of life, whether tech, medicine, or manufacturing. In the case of medicine, apart from the intensive care unit, it can be used in many necessary fields, such as the spread of viruses, how deadly a single virus is, and how it can affect humans. By getting so many insights promptly, valuable solutions can be quickly obtained with perfect accuracy at least 60-70%.

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest for this study

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