

# AN INVESTIGATION INTO TECHNIQUES USED FOR FETAL HEALTH CLASSIFICATION

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## **ABSTRACT**

*The natural birth of a mentally and physically sound child is the yearning of all mothers. Still, perinatal mortality is a huge concern that needs immediate heed. Prenatal attention towards the well-being of the mother and the child plays a vital role in this regard. Early detection of any abnormalities can give further insights into the pregnancy and will provide more time to parents and doctors to prepare for these unnatural circumstances. Cardiotocography (CTG) is a technique used for monitoring fetal heart rate, it is widely used to ensure fetal well-being during pregnancies at high risk. Usage of machine-learning techniques can automate this task and can reduce the chances of diagnostic errors. Deep Learning also has powerful algorithms for learning complicated characteristics and higher-level semantics. The principal objective of this paper is to dissect the boundaries of different classification algorithms and contrast their prescient exactnesses to discover the best classifier for ordering fetal wellbeing*

## **KEYWORDS**

*Cardiotocography (CTG), Machine Learning, Classification algorithms, perinatal mortality.*

## **1. INTRODUCTION**

### **1.1. Perinatal Mortality**

The perinatal period reaches out from the 28th week of incubation to under 7 days of life after birth. The term "Perinatal Mortality" includes both still births and early neonatal passings. There are a number of factors that are known to increase the risk of prenatal mortality some of them are high parity, malnutrition and severe anaemia.

So perinatal care is of extreme significance for figuring out the correct delivery approach, making ready the mother psychologically and physically. Fig 1 shows the classification of infant deaths based on deaths before or after birth.

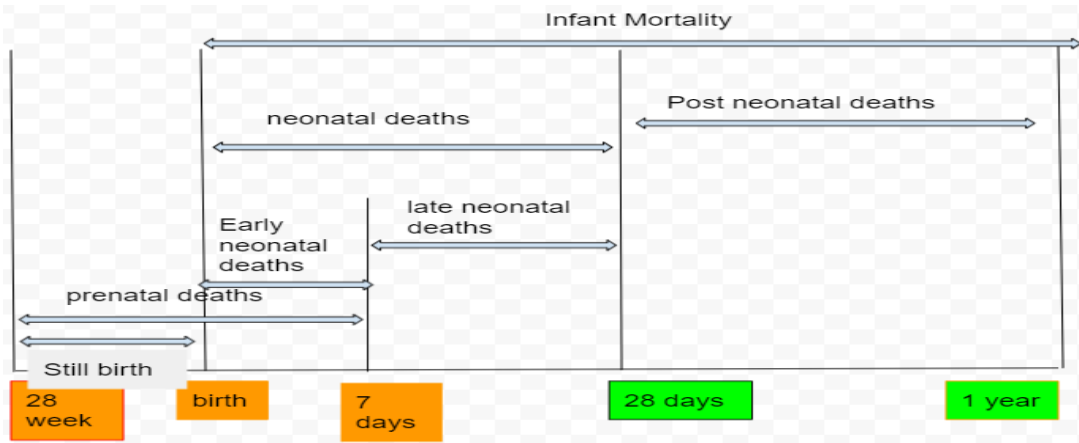


Fig. 1

## 1.2. Cardiotocography (CTG)

It's a method of measuring the fetus's heart rate in proportion to the pressure inside the uterus. Electronic Fetal Monitoring is another name for it. The ultimate intention of fetal monitoring is to avert death/morbidity of the fetus due to hypoxia.. Fig 2 shows the major tracings on a CTG, the upper tracing is the fetal heart rate and lower tracing is the uterine contractions

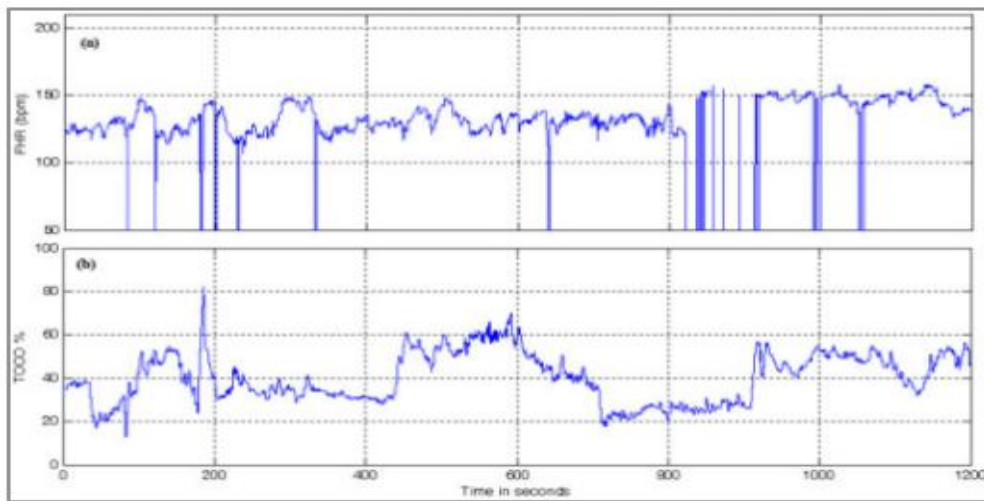


Fig. 2 A typical CTG signal  
 (a) The FHR signal and (b) The UA signal

Image Source: [https://openi.nlm.nih.gov/detailedresult.php?img=PMC3033856\\_1475-925X-10-6-1&req=4](https://openi.nlm.nih.gov/detailedresult.php?img=PMC3033856_1475-925X-10-6-1&req=4)

The further sections now contain the related work done using machine learning and deep learning techniques and then a comparative analysis of different novel approaches followed by the conclusion.

## 2. MACHINE LEARNING-BASED APPROACH

The results of CTG are used for identification of pathological state of fetus and help doctors to identify any complications. Wrong diagnosis of fetal heart rate [FHR] recordings can lead to

serious repercussions and even death. Therefore machine learning techniques can be used to classify CTG data as healthy or unhealthy. A great amount of work have been done in this field with promising results. Fig. 3 shows classification algorithms that have been used

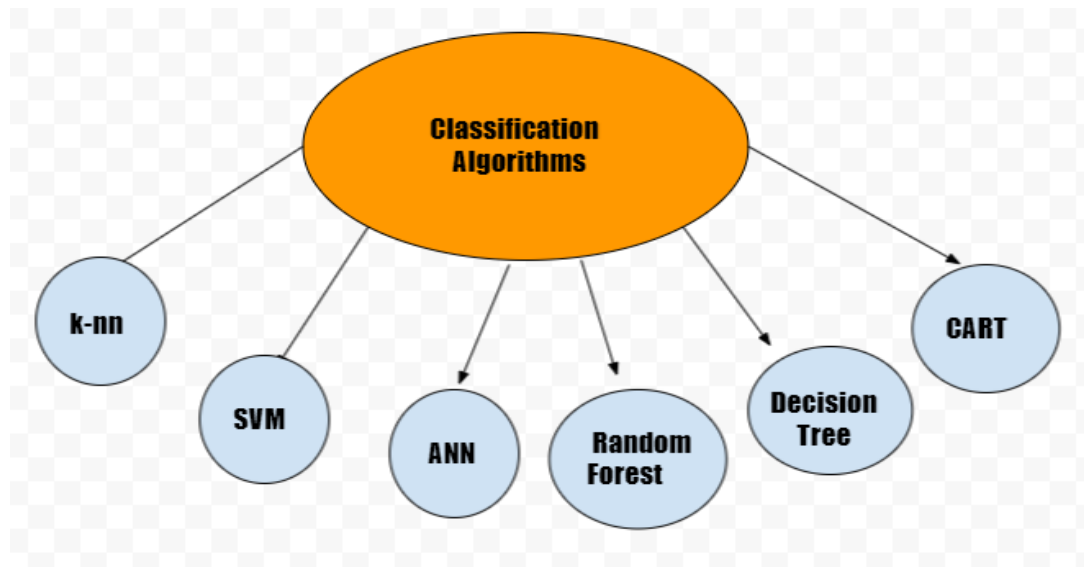


Fig. 3

Random Forest Classifier is machine learning algorithm, which makes use of a collection or an ensemble of decision trees. A collection of N number of trees is a random forest wherein each tree gives some predicted value (in this case either class 1 or class 2

Hakan Sahin, et. al [10], deployed eight machine learning algorithms over UCI dataset to classify the ECG data into normal or pathological, a 10-fold cross-verification was done handout of SVM, ANN, CART ,K-NN, logistic regression, C4.5, RF, and RBFN . Random forest came out to be a comparatively better algorithm for classifying the available data. M. Ramla et al[2] used proposed a Approach to expect excessive chances of threatening pregnancies primarily based on CART algorithm ,they used a 5 fold cross validation and concluded that CART incorporated testing ang cross validation to check the accuracy of fit. Moreover, this work can be extended using bagging and boosting procedures.

In 2019 authors came up with a Bagging ensemble classifier technique [1] To classify CTG information as healthful or pathological the use of bootstrap aggregation along with ensemble classifiers. The base prototypes are created by the use of bootstrap samples of training set and balloting for prediction. To compare the overall performance of different classifiers 10 fold go-validation was done and Random Forest Classifier resulted in accuracy 99.02%.

Later In 2018 Omneya Attallah et al. [3] used a pipeline process consisting of four phases: Segmentation, enhancement, feature extraction, and classification. The main motive of this paper is to devise a method for the early identification of abnormalities in the fetes. They have used unique classification algorithms such as LDA, k-nearest algorithm, SVM, Machine Assemble Subspace discriminate analysis to achieve the results. The technique used was able to classify abnormalities from different gestational ages as well as was able to classify different forms of fatal brain abnormality and not only one. The method is simple and has a low computational cost.[9]presented a method to detect chromosomal abnormalities, potential risk of euploidy,

T21 by making use of machine learning techniques such as ANN, SVM, K-NN out of these ANN showed exceptionally great results

[6] compared self-organizing maps, classification, and regression trees. In this research, RFC performed exceptionally well. K. Agrawal et al [4] used R-studio to analyze the proficiency of various algorithms such as Naive Bayes, decision tree, SVM on CTG data. The data were classified into three categories normal, suspect and pathological and the decision tree gave the highest accuracy. [7] collected their own maternal clinical dataset from 96 pregnant women and compared nine binary classification algorithms to predict fetal health. They found out that abortions, delivery numbers, age of mother, any disease are the major factors that can affect the fetal health. In 2015, [14] S. A. A. Shah et. al, proposed a bagging approach with combination of three decision tree algorithms-J48, REP Tree (Reduced Error Pruning Tree) and Random Forest. When performance was evaluated bagging approach with RF showed good results. The only limitation was that the approach was used on publicly available secondary data.

### 3. DEEP LEARNING TECHNIQUE:

Deep learning is a type of AI and machine learning that mimics the way people acquire specific types of information. Data science, which includes measurements and foresight demonstrating, includes profound learning as a key component.

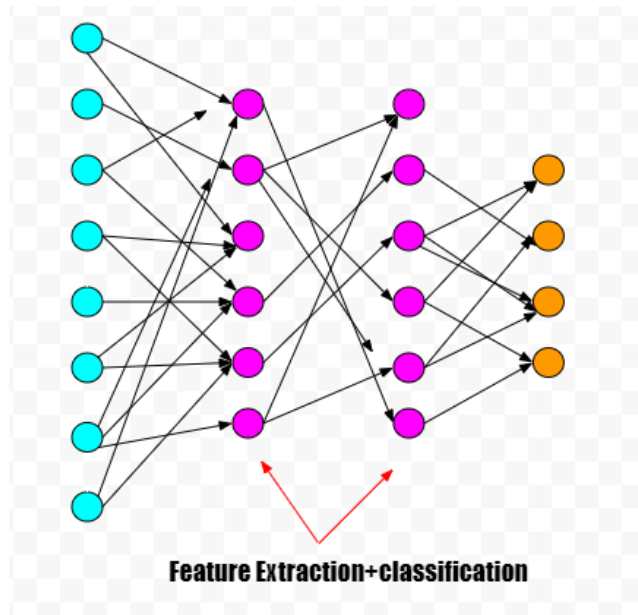


Fig. 4

Deriving conclusions from CTG data is a difficult task [5] used ANN with simple logistics to categorize data and sisporto 2.0 was used for analysis of data. [8] used multimodal convolutional neural network on data of 35429 births derived from oxford archives. [11] talks about the usage of deep learning algorithms in detecting the life-saving information from CTG data. It is an endeavour to dissect, and analyze the effect of data mining strategies by recognizing outliers, executing classification algorithms and bunching the records of the Cardiocography dataset. In 2020, RUOWEI QU [13] and The authors offer two approaches for classifying US pictures into six typical planes of foetal brains, both based on convolutional neural networks. A deep convolutional neural network (CNN) is one, and CNN-based domain transfer learning is the

other. They also established that the main reason for the lack of performance for most of the models is the lack of training data.[12]proposed deep forest algorithm to improve the current classification of CTG dataset. When Contrasted with widely used ml models, neural networks and the modern CTG grouping models, the outcomes show that the accuracy, F1 score, and Area Under the Curve (AUC) of deep forest were 92.64 %, 92.01 % and 0.990 individually

Table 1. Comparison Table of parameters used in different Classification Algorithms for fetal health classification.

Features	Hakin Sahin et al	A.Subasi et al	Kanika Agrawal et al
<b>Dataset</b>	UCI Repository	UCI Repository	UCI Repository
<b>Objective</b>	Classify dataset into normal /pathological And compare the performance of eight Classification algorithms.	Classify CTG dataset into normal and pathological using two methods	Classify dataset into normal,suspicious and pathological .
<b>Tool used</b>	WEKA	WEKA	R-Studio
<b>Algorithms used</b>	ANN,SVM,SL,RBFN, J48,CART,RF,K-NN	ANN and Simple logistics	Decision Tree,SVM,Naive Bayes
<b>Best Algorithm</b>	Random Forest	ANN	Decision Tree
<b>Accuracy</b>	99.18	98.47	91.54
<b>F-Measure</b>	0.992	-	0.95, 0.72 ,0.87
<b>Specificity</b>	99.74	88.77	0.93, 0.93, 0.98
<b>Sensitivity</b>	94.10	99.39	-
<b>AUC</b>		-	-
<b>ROC</b>	0.999	-	-
<b>Result</b>	The outcomes of this observation show that Random Forest stands out to be a very good classifier of normal and pathological	On Comparing two data mining techniques simple logistics is giving more accurate results.	Decision is best algorithm implemented on CTG data on R-studio as compared to SVM or Naive bayes.

Table 2. Comparison Table of parameters used in different Classification Algorithms for fetal health classification.

Features	Akhan Akbulut et al	S. A. A. Shah et. al	.A. Petrozziello et. al
<b>Dataset</b>	Clinical data from 96 pregnant women	UCI Repository	Oxford Archive
<b>Objective</b>	Comparison of nine binary classification algorithms and find out factors that can risk health of fetus	Classification of CTG data into healthy ,suspicious pathological cases	To identify babies who can benefit from C-section delivery based on CTG data.
<b>Algorithms used</b>	Bayes Point Machine, Decision Forest, Decision Jungle, SVM, Averaged Perceptron, Boosted Decision Tree,, Neural Network, Logistic Regression	J48, Random Forest, REPTree (Reduced Error Pruning Tree)	MCNN and the Stacked MCNN
<b>Best Algorithm</b>	Decision Forest	Random Forest	MCNN
<b>Accuracy</b>	0.895	94.73%	-
<b>F-Measure</b>	0.750	0.97, 0.82, 0.92	-
<b>Specificity</b>	-	-	-
<b>Sensitivity</b>	-	-	-
<b>Precision</b>	0.750	0.95, 0.88, 0.94	-
<b>Recall</b>	0.750	0.98, 0.76, 0.89	-
<b>AUC</b>	0.958	-	0.81
<b>ROC</b>	-	-	-
<b>Result</b>	Decision forest was chosen out of 9 algorithms based on Accuracy, F1 Score and AUC.	Random Forest performs slightly better than other two algorithms	MCNN demonstrated higher performance compared to modern-dayfeature extraction-based method.

#### 4. CONCLUSION

The main aim of this study was to investigate into different classification algorithms used to classify fetal health based on CTG data. In this survey, various classification algorithms were analyzed that help doctors to predict the fetal health and provide life-saving treatment. From this evaluation study, it can be concluded that Random Forest outperformed the other algorithms and should be further explored for an accurate classification of fetal health.

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