

Machine Learning Approaches to Predict Health Status of Fetus based on Maternity Data: A Review

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Abstract— Afetus is an incipient infant that is still an embryo in the womb. During this gestation period, the infant develops and expands, making routine tests extremely necessary. As we all know, gestation period is nine months, and there can be a variety of factors that might result in the newborn's impairment or death, which is a very serious crime that should be avoided. Another key tool for diagnosing fetal health is CTG (Cardiotocography) which is commonly used to check the heartbeat and cervical mucus which is why the information produced is utilized by the physician to evaluate fitness and well-being. But there will be lot of errors while evaluating it manually which is why doctors are not reliable in analysing data which is why different Machine Learning methods were available that could analyse data and predict an infant's condition based on it. The paper's major goal is to review the various accuracy score of the prediction using several categorization models and to differentiate models that work finest.

Index Terms— Gestation period, Machine Learning, Fetal Health, Cardiotocography, heartbeat, cervical mucus, infant, Random Forest (RF), Decision Tree, SVM.

I. INTRODUCTION

Infants are released from the mother's womb, and obtaining details on the fetus prior to this is very challenging. We can only get details that an embryo exists and that it will be dispatched. As a result of the scarcity of knowledge, obstetricians and gynaecologists rely on erroneous information. The baby's heartbeat is one of the most dependent pieces of information, and electronic cardiac monitoring of the baby's heart has a limit where these variables interfere with proper communication and time maintenance records and is widely used to record the heartbeat of a baby, which is the primary means by which obstetricians rely on information. But the trend that doctors are seeing these days is that there is a much higher inter and intra spectator variation in FHR (Fetal Heart Rate) samples. But there is a worst situation that false fetal pain may result in unnecessary intervention. As an outcome, the major motivation for this research is to use ML algorithms to differentiate technique because there may be an area for physician errors, but the predictive algorithm can do a better job of monitoring outcomes and providing more accurate predictions than the physician can see in his or her perception.

One of the most frequent symptomatic tools like Cardiotocography (CTG) for assessing the baby's and mother's well-being during pregnancy and prior to birth. During the CTG analysis phase, obstetricians manually detect FHR patterns. High interest rates were paid on the child's first rate of cardiac rate and periodicity analysis thirty years ago. FHR (Fetal heart rate) monitoring is still routinely utilised to detect fetal perfusion abnormalities that may occur after birthing. Even in industrialised countries, however, death and long-term impairment caused by

intrapartum hypoxia continue to be a significant source of pain. According to confidential enquiries, almost half of these deaths could have been prevented if anomalous FHR patterns had been recognised sooner, or if personnel had communicated more effectively, or if necessary action had been taken sooner. To eliminate human errors and assist physicians in making educated judgments, statistics and other ML methods can be used to analyse and categorize CTG samples.

II. REVIEW OF MACHINE LEARNING TECHNIQUES TO PREDICT HEALTH STATUS OF FETUS

The reviews based on the methodology used by various authors in there research works for fetal health condition following are:

A. Analysis of Fetal Health using WEKA Techniques

The research work carried out in [1], the authors have used WEKA software to discuss frequently worn cataloguing algorithms. The metrics used to compute the execution of classifiers are FMeasure, Precision, ROC curves, and Recall. While some previous studies were unable to distinguish between the patterns like pathologic and suspicious, the findings of this investigation were able to precisely distinguish between pathologic and suspicious situations. Random Forest, classification via Regression, and J48 produced the greatest outcomes. Exploration conditioning analysed the alike data and discovered that ANN achieves 92.42 per cent delicacy. The division produced outcomes. The CTG in this research demonstrates that the findings are quite promising, and they were obtained using a tree-grounded method (J48) with an MAE of 0.0408, kappa numbers of 0.8716, and accuracy of 94.33 per cent with a high degree of delicacy metrics. The J48 was near the Random Forest and Regression division. High perfection three-dimensional Random Forest (RF), J48, and Regression Divisions are indicated below the ROC wind.

Figure 1 represents the steps involved in the information retrieval process to gain insight from CTG samples.

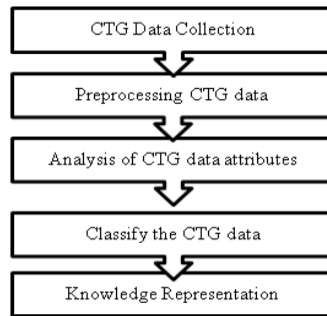


Fig. 1: Process flow in this study [1]

B. Analysis of Fetal Health using XGBoost Approach

The research work carried out in [2], uses the accuracy of ML algorithm strategies in CTG dataset to identify unsafe embryos is discussed. Ten distinct learning categorization stereotypes are instructed using CTG data in this paper. The predicted suspected, normal, and fetal pathological conditions were used to determine the sensitivity, F1 score, and accuracy of each class and the comprehensive accuracy of each stereotype. The most effective model was then chosen in terms of specific metrics. According to obstetricians' definitions of CTGs as the criterion, 70% were normal, 10% were pathological, and 20% had a suspected fetal disease. Partitions produced by decision tree, random forest, and XGBoost models with high accuracy > 96 per cent in training data. Based on the CTG follow-up, predicting a sick child's state and suspicion was done. However, when the data was analysed, the XGBoost model showed the highest accuracy > 92% in predicting the fetal pathogenic state. In terms of forecasting child adverse effects, the confinement model constructed using the XGBoost approach had the highest accuracy. This technique can be used by rare and low-paid health workers in territory to evaluate enceinte women in rural places for early birth and treatment.

C. Analysis using CART Algorithm

In the research work carried out in [3], the CART suggested in this study is an effective technique to anticipate a risky parturiency firm the baby's health status. CART seems to be a decision tree technique that can be utilized to resolve problems like both cataloguing and regression forecast. A binary tree can be used to represent CART. The response element, which is utilised to create forecast, is found in the tree's leaf nodes. Decision tree of

CART is known as binary DT that utilizes a recursive partitioning strategy. CART selects the attribute with the most information using the Gini index. Other algorithms, such as Boosted Trees, Random Forest, and Bagged Trees, are built on their basis. The binary tree can be used to illustrate CART. Each root node in this tree represents a solitary input element with a fragmented fact. For categorization, the CTG database containing 2126 samples from the machine learning repository from UCI was used. The proposed approach is utilised, and the opposite endorsement is repeated for 5 times. Recall, accuracy, and F-score were used to assess CART. The CART algorithm is tested using CTG samples, and the results are compared using the Gini index and entropy calculations. Entropy calculation yields a precision of 88.87 per cent, while the Gini index yields a precision of 90.12 per cent. Development methods and money can help to extend this for more precise achievement. Python is used to implement the effects, which are then filtered.

D. SVM and DT Techniques for Fetal Health Analysis

In this research work [4], the author employs a model from CTG data grade in this paper. A method that can classify CTG data using a Decision Tree and supervised SVM based on its training samples. The root node, following decision nodes, branch nodes, and leaf nodes make up a decision tree. It starts at the root node and progresses along the tree, with each branch forming a new decision node or a new leaf node. We make a decision at each decision node between two or more viable options. "SVM" is a technique that uses method called kernel mapping for partitioning, retrieval, and other learning activities that may be utilised for non-fragmented data and split. Kernel-based algorithms operate in a very conventional manner and perform well in practise. As per the findings, the technique of categorization based on learning delivered substantial performance during the operation of the monitored device. Accuracy, NPV, Specification are all terms that can be used. Also, consider ROC as a performance testing statistic. The efficiency of the four techniques in terms of the matrix of confusion and accuracy was evaluated in this paper. Decision Tree and SVM were checked with the neural network based differentiation prototype. The carrying out of the cataloguing system hinge on the review of the monitored system offered notable performance, according to the data collected. The Support Vector Machine category has been proven to have great accuracy in identifying a Normal, Pathologic, and Suspicious Condition from the CTG data environment. This function trains the system and all types of data; it's possible that a well-trained system will be able to recognise a suspicious record.

E. Analysis using Logistic Regression, Naïve Bayes and RF Classification Techniques

In [5], the purpose of this research is to present a successful approach for forecasting a risky pregnancy based on the baby's health state utilising the CTG website and a 2126 samples from the Machine Learning repository of UCI. RF, SVM, Logistic Regression and Naive Bayes are among the partitioning techniques used. The Algorithm Random Forest is categorized into a supervised learning that congregates trials from huge repositories and estimates the finest result. It's accepting the form of a DT. It's also huge detailed than the Decision Tree. However, prophecy is deliberate and creation is huge problematic. "SVM" is a technique that uses method called kernel mapping for partitioning, retrieval, and other learning activities that may be utilised for non-fragmented data and split. There are only two probable results in Logistic Regression, e.g. 1 or 0, True or False. Because Logistic Regression utilizes one or many Sovereign elements to predict results, the subsequent feature hustles up and improves the algorithm's performance. The Bayes Theorem from algorithm, Naive Bayes is utilized to tackle complications that are Probabilistic of ML in order to forecast the class of unidentified samples. It's one of the modest and profligate methods of Machine Learning for addressing difficulties. After considering all of these species, the authors concluded that Logistic Regression delivers 99.5% precision, whereas RF delivers 98 %, Naive Bayes delivers 97 %, and Support Vector Machine delivers 96.5 %. As a result, after examining each of the accuracies, it is clear that Logistic Regression is doing admirably.

F. Analysis using SVM and RF Methods

In the research work carried out in [6], the authors examine approaches for assessing fetal status predictions based on Cardiotocography (CTG) samples in this research. Prenatal Fetal Monitoring collects data that can be used to forecast the fetal state during birthing and warn of the potential of fetus acidosis (low oxygen levels due to low blood pH). The accuracy of these predictions is evaluated in a present system to aid clinical judgments, and other characteristics that could provide further information regarding fetal state are excluded. This is unique study in that it considers all three prenatal states (normal, suspected, and Pathologic). The usefulness of Machine Learning in supporting midwives in unsuspected scenarios is discussed in the paper. The data samples are distributed into various subdivisions as support vectors by a edge in the technique SVM, and among them is a region designated the Hyperplane. It is a algorithm which is commonly used with numerous practical

applications. The Algorithm Random Forest is categorized into a supervised learning that collects trials from huge repositories and predicts the finest result. It's earns the appearance like Decision Tree. It's also much particular than the Decision Tree. Though, prophecy is deliberate and creation is much problematic. The findings reveal that both SVM and RF can accurately predict fetal outcomes with over 96 per cent accuracy, with SVM doing pretty better in suspected situations.

G. Analysis using Hybrid K-Means Technique

In [7], the algorithm K-Means is employed in this analysis. Following the analysing of significant samples, the data is learned using a SVM to determine the category of new CTG data. The goal of this study is to create a new prenatal condition that combines K-Means and also SVM. To decrease feature measurement, each CTG category is divided to obtain an intangible attribute outline for every category. The K-Means technique is used to extract and select features in order to determine the concealed configuration of suspicious, pathologic, and normal infant condition individually. By identifying the smallest interval amongst the centre (centroid) gathering and its associates, K-Means groups the attributes that huge distress infant status. This strategy has a reasonable outcome of 90.64 % hinge on 10 cross authentication using the Cardiotocography samples from UCI. Data was categorised based on seven abstract criteria derived from 21 real factors, and then fitted utilizing the algorithm Hybrid K-SVM. The potential of K-SVM Hybrid to discriminate CTG databases is showcased in this study. The K-SVM Hybrid test result demonstrates the best SVM categorizing in general. Data mining was used in this work to categorize Cardiotocography (CTG) samples using Hybrid K-SVM. This method extracts samples for each class and continues data using the function called membership to extract data samples. Figure 2 represents the flowchart in [7], which contains the steps involved to classify samples using above method.

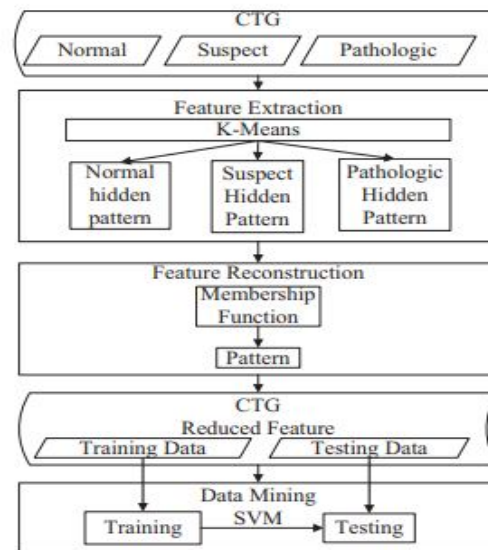


Fig. 2: Dataflow of this study [7]

H. Prediction using ANN Algorithm

In [8], the goal of the research was to develop the best effective ML algorithm for detecting a baby's heartbeat signals. Therefore, The SVM, machine for extreme learning, ANN, Random Forest, and Radial Base Operating Network were among the most commonly used and effective Machine Learning approaches studied. ELM is training algorithm that selects hidden nodes at random and delivers emergent learning. Radial basis functions are used as activation functions in RBFN, which is a useful feedforward neural network architecture. It's usually set up using a single hidden layer that employs Gaussian or other kernel functions. ANNs (Artificial Neural Networks) are dispensation procedures that are based on the neural pattern of the cortex of mammalian cerebral but on a lesser scale. A big neural network may have hundreds or millions of processor units, which is a small number when compared to the billions of neurons in a mammalian brain. Similarly, using the algorithms of Machine Learning outlined above, a child's cardiac signals are differentiated as normal or abnormal. The success of dividers is measured using carrying-out measures derived from the confusion matrix. As per the test

performances, the ANN delivered favourable results with 99.73 percent sensitivity and 97.94 percent specificity, despite the fact that all Machine Learning algorithms produced excellent outcomes. The ANN outperformed other methods, according to the findings.

I. Analysis using Gradient Boosting Technique

In [9], according to this research, the accuracy score of the models may be continuously improved by picking only the necessary arguments and rejecting the non-essential arguments. Compared to a simple neural network or random forest, Gradient Boosting is thought to be more precise and effective. It includes tree learning techniques as well as linear problem solvers. Its speed is due to its capacity to perform simultaneous computations on a single processor. Using Gradient Boosting technique, the author identified 16 main attributes and used methods such as SVM, DT, Random Forest, Neural Networks, Gradient Boosting, and Neural Networks to obtain high accuracy. This work proposes a new algorithm that enhances accuracy by 99.25 percent over previous research findings. Figure 3 represents the algorithm used in [9].

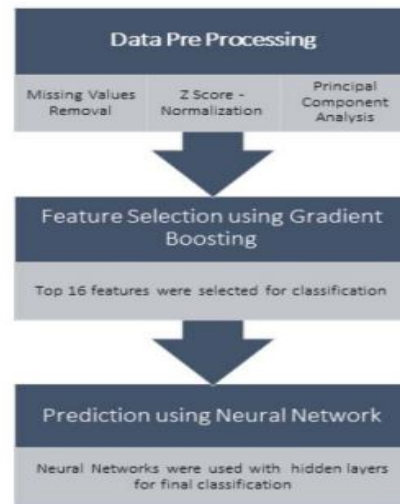


Fig. 3: Process flow used of this study [9]

J. Prediction based on PCA and AdaBoost Technique

In [10], the intention of the work was to create a system to help for clinical opinions for detecting prenatal risk using an advanced Machine Learning technique and relevant CTG recording attributes. The samples is learned and evaluated through an AdaBoost technique incorporated with SVM to get a robust detachable data separator for CTG and prediction after selecting the most relevant attributes from the full features using PCA (Principle Component Analysis). The AdaBoost (Adaptive Boosting) method, a common supervised learning technique, presents a revolutionary design concept and has had a lot of success in a variety of applications. By boosting an algorithm that is learning pathetic, with cataloguing accurateness that is slightly improved than arbitrary presumption, the method obtains an exact and robust learning algorithm. For picking more relevant qualities, use the PCA (Principle Component Analysis) approach, which is based on Ranker search. PCA is a statistical technique that is mostly used in feature selection in order to build prediction and classification models. The fetus's condition is split into two categories: pathologic and normal. According to the findings of this study, the ideal category accuracy of the whole and selected attributes using the AdaBoost approach is 93.0 percent and 98.6 percent, respectively, with computation durations of 11.6 seconds and 2.4 seconds. The efficacy of the PCA Hybrid and AdaBoost for categorizing CTG samples and analysing fetal status is demonstrated in this study.

K. Fetal Growth Analysis based on ANN

In [11], an ANN-firm technique to monitoring fetal heartbeat is proposed in this research. Numerous estimations are obtained and fed into an ANN-firm separator to assess the child's health status, which is classified as "Suspect," "Normal," or "Pathologic". Artificial Neural Networks (ANNs) are dispensation set of rules that are based on the neural pattern of the cortex of mammalian cerebral but on a lesser scale. A big neural network may have hundreds of millions of processor units, which is a small number when compared to the billions of neurons in a mammalian brain. MATLAB software is used for all design and simulation operations. After the network

has been trained, it is put to the test using a variety of scenarios. In terms of finding child health, the prospective technique is proven to be 99.9% accurate. As a result, the suggested ANN-firm method can be utilised to adequately monitor neonatal health. The following figure 4 showcase how the Neural Network is structured [11].

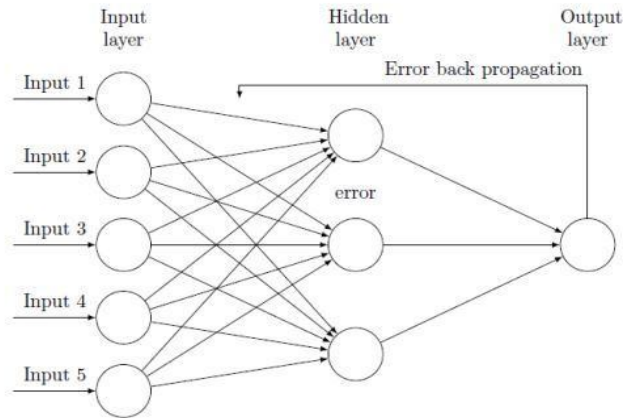


Fig. 4: Neural Network diagram used in [11]

L. Data Mining Approach for Analyzing Premature Delivery of Infant

In [12], the reviews are written by keeping two conditions in mind. Firstly the application of data mining procedures for analysing and forecasting, and another is the consideration of hazard variables for preterm infant. The authors made an effort to study Data Mining methodologies for forecasting premature births and main hazard factors for premature delivery because the authors did not use standard or standard research / analysis data in their research projects, making task comparisons impossible. The conventional SVM approaches and Logistic Regression are the majority often used data mining methods. Social demographic risks include behaviour (lifestyle) and previous pregnancies.

M. ML Approach for Analysing Premature Delivery of Infant

In [13], a Machine Learning technique for identifying preterm birth (PTB) hazardous factors was introduced. The data for the predictions is gathered from local infirmary in Mysuru. The SMOTE (Synthetic Minority Oversampling Technique) is utilised to solve the problem of data inequality. Precision, accuracy, and sensitivity are used to evaluate model performance. For prediction, Logistic Regression and SVM are utilised. In a database of enceinte women with gestational diabetes mellitus or diabetes, compare the two stages of early birth prediction. According to the findings, SVM achieves 86 percent data accuracy for both phases linear and radial. Together, GDM and DM are important hazard factors for immature labour, according to the findings. The mean accuracy of uneven samples is around 86 percent, however accuracy drops when the database is balanced with several samples using SMOTE.

III. DISCUSSION

TABLE 1. SUMMARY OF THE PAPERS REVIEWED

Sl. No	Title	Year of Publication	Methodology employed and Accuracy obtained
1	WEKA classification of cardiotocography data [1]	2016	- Decision Tree based algorithm (J48) -> 94.33% - Random Forest -> 98.1% - Classification via Regression -> 98.13%

2	Using Cardiotocographic Data and Machine Learning Algorithms to Predict Fetal Risk [2]	2019	- In training data, Decision Tree (DT), XGBoost, and RF(Random Forest) -> (> 96%). - In experimental data, XGBoost model had the highest accuracy of predicting fetal pathological condition -> (> 92%).
3	Monitoring Fetal Health Status Using Cardiotocography Measurements and a Decision Tree Classifier [3]	2018	- The CART algorithm Entropy calculation yields a precision of -> 88.87%. - The CART algorithm Gini Index yields a precision of -> 90.12 %.
4	A Comparison of Support SVM and Decision Tree Algorithms in Cardiotocography [4]	2017	- SVM-> 97.9304% - Decision Tree-> 97.4130%
5	Fetal Health Prediction using Classification Techniques [5]	2021	- Logistic Regression-> 99.5% - Random Forest-> 98% - SVM->96.5% - Naive Bayes->97%
6	Random Forest and SVM based classifiers for Fetal Monitoring System [6]	2017	- Random Forests and Support Vector Machines both exhibited an accuracy of ->96%. - Above in envisaging fetal outcomes. SVM marginally outperformed Random Forests in suspect cases.
7	SVM and Hybrid K-Means based feature extraction for Fetal State Classification from Cardiotocography [7]	2015	- The prospective and capacity of Hybrid K-SVM to distinguish samples of CTG is demonstrated. - In comparison to SVM, the K-SVM Hybrid evaluation outcomes indicate the finest classification. This approach has a decent accuracy of-> 90.64% upon 10 cross validation.
8	Fetal Heart Rate Classification: A Comparison of Machine Learning Techniques. [8]	2017	- Artificial Neural Network, with a sensitivity of ->99.73 %. - Artificial Neural Network, with a specificity of ->97.94 %. - The Artificial Neural Network outperformed the other methods in the study.
9	Analysis of Cardiotocography Using a Combination of Machine Learning Algorithms. [9]	2017	- Decision Tree (DT)->90.58% - SVM->93.41% - Random Forest->93.41% - Neural Networks->94.16% - Gradient Boosting->95.86% - Utilizing Gradient Boosting, the best 16 features were chosen, and the methods above were used to achieve a high precision of 99.25 % utilizing Neural Networks.

10	Using PCA and AdaBoost, fetal state extraction using parameters of cardiotocography [10]	2017	- The AdaBoost approach to the generalization ability of total with execution times of 11.6 seconds -> 93.0 %. - The AdaBoost approach to the chosen features utilising with execution times of 2.4 seconds ->98.6 %. - As a result, this study shows that the AdaBoost and hybrid PCA method for determining fetal status and categorizing CTG data is effective.
11	Innovative Fetal Health Monitoring Method Using Cardiotocography Measurements Based on Artificial Neural Networks. [11]	2017	ANN -> 99.9%
12	A survey on the use of data mining to predict preterm birth. [12]	2019	- The research evaluated for survey is examined depending on the hazardous samples utilised for execution and the techniques of Data Mining employed; nevertheless, a comparative analysis was challenging because not a one of the authors investigated the data samples or exogenous variables in the same way. - Categorization is the most widely used technique in data mining, with the most familiar techniques being Logistic Regression and SVM (Support Vector Machine).
13	Preterm Birth Prediction Using Machine Learning Based on Maternal Chronic Conditions [13]	2018	- SVM yields a data accuracy for both the classifiers like radial and linear of ->86 %. - Both GDM and DM are significant variables for pregnancy complications, according to the findings. - The overall result is around -> 86% for imbalance data; however when the sample is normalized by over-sampling and applying SMOTE, the accuracy drops.

IV. DATASET DESCRIPTION

The following are the datasets and the attributes used by various authors from different repositories in there research works.

TABLE 2- DATASET SAMPLE USED BY VARIOUS RESEARCHERS TO PREDICT INFANT HEALTH STATUS

Sl. No	Author Names	No. of Attributes	Dataset Type
1	DivyaBhatnagar [1]	21	UCI The Data Mining Repository
2	Zahra Hoodbhoy [2]	21	UCI Machine Learning Repository

3	M.Ramla [3]	21	UCI Machine Learning Repository
4	Jagannathan D [4]	21	UCI The Data Mining Repository
5	Naveen Reddy Navuluri.[5]	21	Fetal Health stroke dataset
6	VinayakaNagendra, HarikishanGude, DivyaSampath [6]	21	SisPorto data set
7	NurulChamidah [7]	21	Machine Learning Repository UCI
8	Z.Comert and A.F. Kocamaz [8]	21	SisPorto data set
9	AnishBatra [9]	21	Machine Learning Repository UCI
10	Yang Zhang and Zhidong Zhao [10]	21	Machine Learning Repository UCI
11	SubrotaMazumdar and RohitChoudhary [11]	21	UCI Machine Learning Repository
12	Prema N. S [12]	8	The samples were taken from health centres in Mysuru.
13	Prema N. S [13]	8	The samples were taken from health centres in Mysuru.

V. CONCLUSION AND FUTURE SCOPE

Neonatal fatality is a universal concern that requires prompt response to ensure the communities long-term viability. Therefore monitoring infant health condition is necessary to address this problem. Regular monitoring of fetal leads to early detection and treatment of health concerns that may emerge during pregnancy, such as an irregular heart rate, boosting the chances of a normal pregnancy and the birth of a healthy baby. This paper discusses a review of various Machine Learning algorithms and the data used for the healthy diagnosis of a baby during pregnancy. CTG data has been identified as data intended to control important fetal health during pregnancy using ML techniques. RF (Random Forest), ANN, SVM (Support Vector Machine) and Decision Trees using this algorithm are the preferred methods to properly differentiate infant health status with a set of recent pregnancy data. There is plenty of informed improvement as we can collect modern real-time data, explore all the different models currently in use, and develop new precision accordingly. Additional mechanism way you can do this is to test the author's prototype to the trial and make a differentiation with the novel sample. Because sample gathering will take a long period, data should be acquired from various sources many times until then. The aim is to generate a hybrid system of machine learning that includes a thorough analysis of interval sequence, extraction of feature, and prophecy in the future. A real-time clinical decision support system could use a fuzzy yield of the infant condition with an affiliation function over divergent epochs of interval.

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