

CLASSIFICATION OF HEALTH OF FOETUS USING MACHINE LEARNING

Submitted in partial fulfillment of the
requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of SHUBHAM KUMAR (40111212) and AYUSHI JAYARAJ (40110142) who carried out the Project Work entitled "CLASSIFICATION OF HEALTH OF FOETUS USING MACHINE LEARNING" under my supervision from November 2023 to April 2024.

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ABSTRACT

Health complications during the gestation period have evolved as a global issue. These complications sometimes result in the mortality of the foetus, which is more prevalent in developing and underdeveloped countries. Several studies have been done in an effort to find a way to prevent the loss of fetal as well as maternal life. The well-being of fetal and mother is the primary concern of the doctors, and many equipment have been made and are in use in order to diagnose and take preventable measures for it. Even after having equipment like CTGs, it is still not hundred percent accurate and sometimes are unable to detect abnormalities. The main reason behind this is not having enough expert obstetrician all around the world. So, in minor cities and villages, the chance of fetal mortality becomes high. The genesis of machine learning (ML) algorithms in the healthcare domain have brought remarkable progress in disease diagnosis, treatment, and prognosis. The recent growth of such technologies requires that these algorithms be improved to evaluate their accuracy in identifying essential features like fetal heart rate (FHR) and uterine contraction. There are numerous machine learning algorithm present for processing enormous data. Researchers apply several data mining and machine learning techniques to analyze huge complex data, helping health care professionals to predict fetal health. However, classifying the health of foetus is a challenging task as it requires high accuracy and evaluation of some essential features. So, there is a need for proper care including the prediction of risk levels before, during and after the delivery for the safety of both mother and child. This study takes a novel approach by comparing different machine learning algorithm and the best model is used to predict the health of the foetus. When paired with proper guidance, the said hybrid approach would produce the best solution in real-time to such issues in the future.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Pregnancy is a transformative and vulnerable period in a woman's life, marked by the anticipation of bringing new life into the world. Ensuring the health and well-being of both the mother and the developing fetus is of paramount importance. Fetal health assessment is a critical aspect of prenatal care, as it helps in early detection and management of potential complications, thereby reducing maternal and fetal morbidity and mortality rates. Traditionally, fetal health assessment has relied on various medical tests and diagnostic tools, including ultrasound scans and fetal heart rate monitoring. However, the advent of machine learning (ML) has opened up new avenues for enhancing the accuracy and efficiency of fetal health classification. Machine learning, a subfield of artificial intelligence, has demonstrated remarkable capabilities in analyzing complex and large datasets, making it an ideal candidate for improving the accuracy and speed of fetal health assessment. This introduction aims to provide an overview of the significance of fetal health assessment, the challenges it presents, and the potential of machine learning techniques to address these challenges.

The health and well-being of the developing fetus are crucial factors that directly influence the outcome of pregnancy. Early detection of fetal health issues can enable timely interventions and medical care, which can be life-saving for both the mother and the unborn child. Fetal health assessment serves several critical purposes. Fetal health assessment can identify developmental abnormalities, such as congenital heart defects, neural tube defects, and chromosomal disorders. Timely detection of these issues can help parents and healthcare providers make informed decisions about the pregnancy and prepare for any necessary medical interventions after birth. Monitoring fetal well-being throughout pregnancy is essential to ensure that the fetus is receiving adequate oxygen and nutrients. Any

disruptions in this supply can lead to complications such as intrauterine growth restriction (IUGR) and fetal distress, which may require immediate medical attention. Fetal health assessment can help assess risk factors for conditions like preeclampsia, gestational diabetes, and preterm labor. Identifying these risk factors early allows healthcare providers to implement preventative measures and provide appropriate care during pregnancy.

While the importance of fetal health assessment is undeniable, it is not without its challenges. Traditional methods of assessment, such as ultrasound and fetal heart rate monitoring, have limitations in terms of accuracy and sensitivity. Moreover, they often rely heavily on the expertise of the healthcare provider, which can introduce subjectivity into the assessment process. There are various key challenges in fetal health assessment. Interpreting ultrasound images and fetal heart rate patterns can be subjective and vary among different healthcare providers. This subjectivity can lead to inconsistencies in diagnoses and treatment decisions. Fetal health assessment generates complex and multidimensional data, making it challenging for healthcare providers to analyze and interpret accurately. Traditional methods may not fully leverage the wealth of information available. Continuous monitoring of fetal health in real-time is difficult with conventional methods. This limitation means that intermittent assessments may miss critical changes in fetal well-being between monitoring sessions.

Machine learning techniques offer a promising solution to address the challenges in fetal health assessment. These techniques can analyze large volumes of data quickly and objectively, leading to more accurate and consistent results. Machine learning algorithms can analyze ultrasound images and detect anomalies or developmental abnormalities with a high degree of accuracy. This can assist healthcare providers in making more informed decisions regarding the fetus's health. Machine learning models can recognize patterns in fetal heart rate data, allowing for continuous monitoring and early detection of fetal distress or abnormalities in heart rate patterns. ML algorithms can assess risk factors for pregnancy complications by analyzing a wide range of patient data, including

medical history, demographics, and biomarkers. This enables healthcare providers to tailor their care plans to individual patients.

In conclusion, fetal health assessment is a critical component of prenatal care, with profound implications for both the mother and the developing fetus. While traditional methods have their limitations, machine learning offers a promising avenue for improving the accuracy, efficiency, and objectivity of fetal health classification. This study sets the stage for a deeper exploration of the role of machine learning in advancing fetal health assessment, as we delve into specific techniques, challenges, and the potential for transforming prenatal care in the pages that follow.

1.2 TECHNOLOGIES USED

1.2.1 PYTHON

Python has become a dominant force in the realm of scientific research, steadily garnering favor among researchers across diverse disciplines. Its inherent versatility, coupled with its intuitive syntax and robust ecosystem of libraries, has propelled its position as a preferred tool for conducting cutting-edge research. This essay aims to delve into the numerous features that render Python a game-changer in the scientific community.

First and foremost, Python boasts a remarkably accessible syntax, readily understood by individuals with varying levels of programming expertise. Its focus on English-like keywords and its emphasis on code readability significantly reduces the learning curve, making it immensely appealing to researchers who may not possess extensive coding backgrounds. This inherent ease of use allows for greater accessibility and empowers researchers to quickly grasp the fundamentals and delve into specific research areas with relative ease.

Furthermore, Python's expansive library ecosystem provides researchers with readily available tools for tackling diverse research problems. Its arsenal includes highly-regarded libraries such as NumPy for numerical computation, Pandas for data

manipulation and analysis, Matplotlib for data visualization, and Scikit-learn for machine learning. These powerful libraries enable researchers to efficiently process datasets, create intricate visualizations, and implement complex machine learning models with minimal effort.

Beyond its inherent design and comprehensive libraries, Python flourishes within a vibrant and supportive community. Overflowing with online resources, Python boasts a multitude of tutorials, guides, and forums where researchers can readily seek assistance and knowledge sharing. This fosters a collaborative environment where researchers can troubleshoot roadblocks, exchange knowledge and best practices, and ultimately contribute to the collective advancement of scientific research.

In conclusion, Python's ascendancy within the scientific research arena stems from a confluence of valuable attributes. Its user-friendly syntax, combined with its expansive library ecosystem and a deeply supportive community, provides researchers with a comprehensive and adaptable toolset for conducting innovative research across a wide array of disciplines. As scientific inquiries continue to evolve and broaden, Python's capacity to readily adapt and empower researchers positions it as an indispensable tool for shaping the future of scientific discovery.

1.2.2 MACHINE LEARNING

Machine learning (ML) has emerged as a transformative force in scientific research, empowering researchers to analyze vast amounts of data, uncover hidden patterns, and make informed predictions. ML encompasses a diverse range of algorithms and techniques that enable computers to learn from data without explicit programming. These algorithms can identify complex relationships, make generalizations, and adapt to new information, making them invaluable tools for scientific discovery.

In various research domains, ML is revolutionizing the way data is analyzed and interpreted. In biology, ML algorithms are used to analyze genomic data to identify disease-causing mutations, predict drug efficacy, and understand complex biological processes. In astronomy, ML is employed to classify celestial objects, detect anomalies in astronomical data, and model the evolution of the universe. In social

sciences, ML is utilized to analyze large-scale social media data, study human behavior, and model economic trends.

The power of ML lies in its ability to extract meaningful insights from massive and complex datasets. Traditional statistical methods often struggle with such data, but ML algorithms can handle high-dimensional data, identify nonlinear relationships, and make predictions with remarkable accuracy. This capability has led to breakthroughs in various fields, from predicting protein structures to forecasting financial markets.

One of the key advantages of ML is its ability to adapt and improve over time. As more data becomes available, ML algorithms can be trained to refine their models, leading to increasingly accurate predictions and insights. This continuous improvement cycle is essential for scientific research, as it allows researchers to stay ahead of the curve and make discoveries that were previously impossible.

The integration of ML into scientific research has led to significant advancements in various disciplines. ML algorithms have enabled researchers to identify new drug targets, predict natural disasters, and understand the dynamics of complex systems. As ML continues to evolve, its impact on scientific research is expected to grow, paving the way for groundbreaking discoveries and transformative applications.

1.3 OBJECTIVES OF THE PROJECT

- The objective of the proposed method is to classify whether the gestation foetal is normal or not. This can be done by using a machine learning model.
- In order to achieve this type of high performing yet explainable model, various machine learning algorithms were implemented and the best one is used to classify the health of the foetus.

- The goal is to develop a machine learning model for fetal health Prediction, to potentially replace the updatable supervised machine learning classification models by predicting results in the form of best accuracy by comparing supervised algorithm.

1.3 SCOPE OF THE PROJECT

Here the scope of the project is that integration of fetal health with computer-based prediction could reduce errors and improve prediction outcome. This suggestion is promising as data modelling and analysis tools, e.g., data mining, have the potential to generate a knowledge-rich environment which can help to significantly improve the quality of fetal health prediction.

CHAPTER 2

LITERATURE SURVEY

This problem statement has been extensively studied over the past few years by researchers and doctors in a bid to create a solution, and all their solutions vary from analyzing various features of cardiotocography data to analyzing health vitals of the fetal and mother.

TITLE: Fetal Health Classification from Cardiotographic Data using Machine Learning

AUTHOR: Abolfazl Mehbodniya, Arokia Jesu et al

YEAR: 2021

Health complications during the gestation period have evolved as a global issue. These complications sometimes result in the mortality of the fetus, which is more prevalent in developing and underdeveloped countries. The genesis of machine learning (ML) algorithms in the healthcare domain have brought remarkable progress in disease diagnosis, treatment, and prognosis. This research deploys various ML algorithms to predict fetal health from the cardiotocographic (CTG) data by labelling the health state into normal, needs guarantee, and pathology. This work assesses the influence of various factors measured through CTG to predict the health state of the fetus through algorithms like support vector machine, random forest (RF), multi-layer perceptron, and K-nearest neighbours. In addition to this, the regression analysis and correlation analysis revealed the influence of the attributes on fetal health. The results of the algorithms show that RF performs better than its peers in terms of accuracy, precision, recall, F1-score, and support. This work can further enhance more promising results by performing suitable feature engineering in the CTG data.

TITLE: Comparison of machine learning algorithms to classify fetal health using cardiotocogram data

AUTHOR: Nabillah Rahmayanti, Humaira Pradani

YEAR: 2021

Cardiotocogram (CTG) is one of the monitoring tools to estimate the fetus health in womb. CTG mainly yields two results fetal health rate (FHR) and uterine contractions (UC). In total, there are 21 attributes in the measurement of FHR and UC on CTG. These attributes can help obstetricians to classify whether the fetus health is normal, suspected, or pathological. This paper compares 7 algorithms to predict the fetus health: Artificial Neural Network (ANN), Long-short Term Memory (LSTM), XG Boost (XGB), Support Vector Machine (SVM), K-Nearest Neighbour (KNN), Light GBM (LGBM), and Random Forest (RF). By employing three scenarios, this paper reports the performance measurements among those algorithms. The results show that 5 out of 7 algorithms perform very well (89-99% accurate). Those five algorithms are XGB, SVM, KNN, LGBM, RF. Furthermore, only one from five algorithm that always performs well through three scenarios: LGBM.

Title: Cardiotocographic Diagnosis of Fetal Health based on Multiclass Morphologic Pattern Predictions using Deep Learning Classification

Author: Julia H. Miao, Kathleen H. Miao

Year: 2018

Medical complications of pregnancy and pregnancy-related deaths continue to remain a major global challenge today. Internationally, about 830 maternal deaths occur every day due to pregnancy-related or childbirth-related complications. In fact, almost 99% of all maternal deaths occur in developing countries. In this research, an alternative and enhanced artificial intelligence approach is proposed for cardiotocographic diagnosis of fetal assessment based on multiclass morphologic pattern predictions, including 10 target classes with imbalanced samples, using deep learning classification models. The developed model is used to distinguish and

classify the presence or absence of multiclass morphologic patterns for outcome predictions of complications during pregnancy. The testing results showed that the developed deep neural network model achieved an accuracy of 88.02%, a recall of 84.30%, a precision of 85.01%, and an F-score of 0.8508 in average. Thus, the developed model can provide highly accurate and consistent diagnoses for fetal assessment regarding complications during pregnancy, thereby preventing and/or reducing fetal mortality rate as well as maternal mortality rate during and following pregnancy and childbirth, especially in low resource settings and developing countries.

Title: HUMAN FETUS HEALTH PREDICTION USING DECISION TREE

Author: Rajasekhar Nannapaneni

Human unborn baby health is monitored by electronic fetal monitor equipment which generates cardiotocographic data. This cardiotocographic data consists of fetal heart rate (FHR), uterus contractions rate, etc. The inference achieved from analyzing the cardiotocographic data lets us know whether the fetus is normal, suspect with action needed or pathologic with immediate action needed. It is very important and critical to making this inference quickly as any delay could be a risk to both fetal and mother. This article details the development of machine learning-based decision tree algorithm that will classify any given fetus health into normal, suspect and pathologic based on the given cardiotocographic data. In this article, a dataset consisting of 2126 observations with 22 attributes or readings is considered and 90% of this data is used for training the decision tree model and the rest 10% is used to test the accuracy of the developed model.

Title: Fetal Health Prediction using Classification Techniques

Author: Naveen Reddy Navuluri

Year: 2021

A fetal is basically an unborn offspring which is in the embryo stage until it comes to the world. During the pregnancy process, each three month period is known by a name called trimester. During this process the fetus grows and develops and along with it the regular checkups are very important. As we all know that a pregnancy lasts for 9 months and in this long period there may be various reasons which may cause disability or mortality in the newborn which is a very severe case and this needs to be avoided. One of the main tool to analyse the health of the fetal in the womb is by doing a CTG(Cardiotacagraphy) which generally is used to evaluate the heart beat and the uterine contractions hence the data generated is used by the doctor to analyse the health and give his wording. But there is a room for error hence the doctors are not reliable to analyse the data hence different machine and deep learning algorithms have been there which can analyse the data and predict the fetals health based on it. The main motive of the paper is to prove the prediction accuracy using the different classification models and compare which model performs better.

Title: Prediction of Fetal Health State during Pregnancy: A Survey

Author: Tadele Debisa Deressa [1], Kalyani Kadam [2]

Year: 2018

Fetal Health is the indicator of fetal wellbeing and regular contact in the uterus of pregnant women during pregnancy. Most pregnancy period complication leads fetus to a severe problem which restricts proper growth that causes impairment or death. Safe pregnancy period by predicting risk levels before the occasion of complications encourage proper fetal growth. Prediction of fetal health state from a set of pre-classified patterns knowledge is a common important in developing a predictive classifier model using data mining algorithms. In this paper the University of California Irvine (UCI) Cardiotocogram (CTG) dataset is the source of information required for building a model which predicts whether the fetal is healthy or unhealthy.

It consists of 2126 instances with 22 attributes obtained from FHR and UC which are multivariate datatypes. The major goal of this study is to choose efficient data mining algorithm which develops the accurate predictive model to manage knowledge of fetal health during pregnancy.

Title: Fetal Health Classification Based on Machine Learning

Author: Jiaming Li, Xiaoxiang Liu

Year: 2021

Cardiotocogram (CTG) is the most widely used in the clinical routine evaluation of the main approach to detect fetal state. In this paper, twelve machine learning single models have firstly experimented on CTG dataset. Secondly, the soft voting integration method is used to integrate the four best models to build the Blender Model, and compared with the stacking integration method. Compared with the traditional machine learning models, the model proposed in this paper performed excellently in various Classification Model evaluations, with an accuracy rate of 0.959, an AUC of 0.988, a recall rate of 0.916, a precision rate of 0.959, a F1 of 0.958 and a MCC of 0.886.

Title: Fetal Health Status Prediction During Labor and Delivery Based On Cardiotocogram Data Using Machine Learning and Deep Learning

Author: Anu Singha, Joe Raj S. Noel, Nived Suthahar

Year: 2023

A fetus is an unborn progeny which is in the embryo period until it comes to the world. The fetus grows and develops during every three month period in the pregnancy process. Obstetricians may identify prenatal defects and choose whether to intervene medically through cardiotocogram (CTG) data. However, the obstetrician's visual assessment of the CTG data could be subjective or incorrect. Therefore, an automatic analysis of CTG data is very essential. In this chapter, the

machine and deep learning models are experimented on CTG data. Before evaluating the models, data visualization of CTG data has played a huge role to make an understanding of the data and corresponding requirements of data pre-processing. The various classification models are used to the experiments show that compared with the traditional machine learning models and deep learning models, the data augmentation demonstrations clear benefits in terms of performance metrics.

Title: Antepartum Fetal Heart Rate Feature Extraction and Classification Using Empirical Mode Decomposition and Support Vector Machine

Author: N Krupa, E Zahedi, S Ahmed

Year: 2011

The FHR were recorded from 15 subjects at a sampling rate of 4 Hz and a dataset consisting of 90 randomly selected records of 20 minutes duration was formed from these. All records were labelled as 'normal' or 'at risk' by two experienced obstetricians. A training set was formed by 60 records, the remaining 30 left as the testing set. The standard deviations of the EMD components are input as features to a support vector machine (SVM) to classify FHR samples. For the training set, a five-fold cross validation test resulted in an accuracy of 86% whereas the overall geometric mean of sensitivity and specificity was 94.8%. The Kappa value for the training set was .923. Application of the proposed method to the testing set (30 records) resulted in a geometric mean of 81.5%. The Kappa value for the testing set was .684.

Title: A Comprehensive Feature Analysis of the Fetal Heart Rate Signal for the Intelligent Assessment of Fetal State

Author: Zhidong Zhao, Yang Zhang, Yanjun Deng

Year: 2018

Continuous monitoring of the fetal heart rate (FHR) signal has been widely used to allow obstetricians to obtain detailed physiological information about newborns. However, visual interpretation of FHR traces causes inter-observer and intra-observer variability. Therefore, this study proposed a novel computerized analysis software of the FHR signal (CAS-FHR), aimed at providing medical decision support. First, to the best of our knowledge, the software extracted the most comprehensive features (47) from different domains, including morphological, time, and frequency and nonlinear domains. Then, for the intelligent assessment of fetal state, three representative machine learning algorithms (decision tree (DT), support vector machine (SVM), and adaptive boosting (AdaBoost)) were chosen to execute the classification stage. To improve the performance, feature selection/dimensionality reduction methods (statistical test (ST), area under the curve (AUC), and principal component analysis (PCA)) were designed to determine informative features. Finally, the experimental results showed that AdaBoost had stronger classification ability, and the performance of the selected feature set using ST was better than that of the original dataset with accuracies of 92% and 89%, sensitivities of 92% and 89%, specificities of 90% and 88%, and F-measures of 95% and 92%, respectively. In summary, the results proved the effectiveness of our proposed approach involving the comprehensive analysis of the FHR signal for the intelligent prediction of fetal asphyxia accurately in clinical practice.

Title: Impact of Cross-Validation On Machine Learning Models for Early Detection of Intrauterine Fetal Demise

Author: Jayakumar Kaliappan, Apoorva Reddy Bagepalli, Shubh Almal

Year: 2023

Intrauterine fetal demise in women during pregnancy is a major contributing factor in prenatal mortality and is a major global issue in developing and underdeveloped countries. When an unborn fetus passes away in the womb during the 20th week of pregnancy or later, early detection of the fetus can help reduce the chances of intrauterine fetal demise. Machine learning models such as Decision Trees, Random Forest, SVM Classifier, KNN, Gaussian Naïve Bayes, Adaboost, Gradient Boosting, Voting Classifier, and Neural Networks are trained to determine whether the fetal health is Normal, Suspect, or Pathological. This work uses 22 features related to fetal heart rate obtained from the Cardiotocogram (CTG) clinical procedure for 2126 patients. Our paper focuses on applying various cross-validation techniques, namely, K-Fold, Hold-Out, Leave-One-Out, Leave-P-Out, Monte Carlo, Stratified K-fold, and Repeated K-fold, on the above ML algorithms to enhance them and determine the best performing algorithm. We conducted exploratory data analysis to obtain detailed inferences on the features. Gradient Boosting and Voting Classifier achieved 99% accuracy after applying cross-validation techniques. The dataset used has the dimension of 2126×22 , and the label is multiclass classified as Normal, Suspect, and Pathological condition. Apart from incorporating cross-validation strategies on several machine learning algorithms, the research paper focuses on Blackbox evaluation, which is an Interpretable Machine Learning Technique used to understand the underlying working mechanism of each model and the means by which it picks features to train and predict values.

2.1 INFERENCES FROM LITREATURE SURVEY

Abolfazl et al[1] research deploys various ML algorithms to predict fetal health from the cardiotocographic (CTG) data by labelling the health state into normal, needs guarantee, and pathology. This work assesses the influence of various factors measured through CTG to predict the health state of the fetus through algorithms like support vector machine, random forest (RF), multi-layer perceptron, and K-nearest neighbour. In addition to this, the regression analysis and correlation analysis revealed the influence of the attributes on fetal health. The results of the algorithms show that RF performs better than its peers in terms of accuracy, precision, recall, F1-score, and support. This work can further enhance more promising results by performing suitable feature engineering in the CTG data.

2.2 OPEN PROBLEMS IN EXISTING SYSTEM

In the existing system, the cardiotocography (CTGs) are a simple and cost accessible option to assess fetal health, allowing healthcare professionals to take action in order to prevent fetal and maternal mortality. The equipment itself works by sending ultrasound pulses and reading its response, thus shedding light on fetal heart rate (FHR), fetal movements, uterine contractions and more. Although we have developed instruments that can assess many aspects of fetal health, reading and interpreting CTG data is not always possible in regions that lack an expert obstetrician. Although CTGs are used very commonly worldwide, often doctors find difficulty in hearing the fetal heart and to count the fetal heart rate. It might also be uncomfortable for the mother, especially during the contraction. CTGs are often very time consuming and generally insufficient. It can sometimes go wrong meaning giving 'False-positive' signs when there is no abnormalities present. Sometimes it is difficult to hear and count the fetal heart rate. It is not highly accurate.

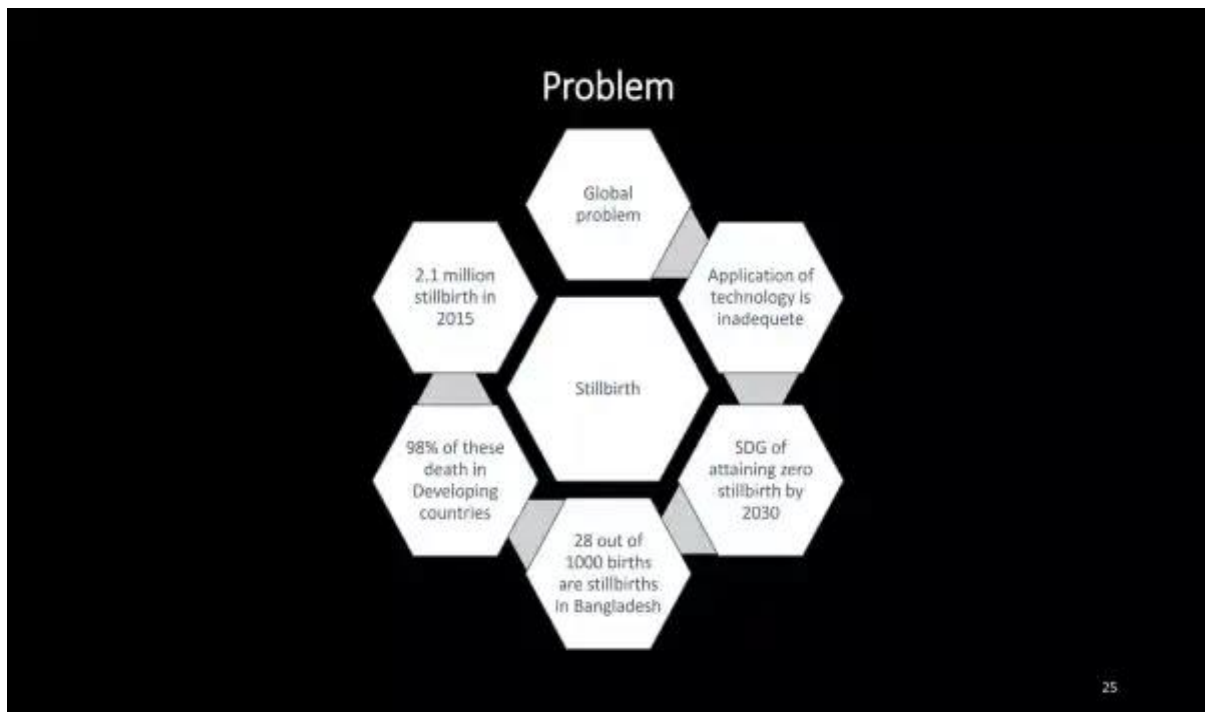


Fig 2.1: Problems regarding stillbirth around the world

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 FEASIBILITY STUDIES/ RISK ANALYSIS OF THE PROJECT

Fetal health classification is a critical aspect of prenatal care, as it allows healthcare professionals to identify fetuses at risk of complications and provide timely interventions. Machine learning (ML) has emerged as a promising tool for fetal health classification, offering the potential to improve diagnostic accuracy and efficiency.

TECHNICAL FEASIBILITY:

Several studies have demonstrated the technical feasibility of using ML for fetal health classification. Researchers have achieved high accuracy rates using a variety of ML algorithms, including support vector machines, random forests, and neural networks. These algorithms can effectively learn complex patterns from cardiotocography (CTG) data, which is the primary data source for fetal health monitoring.

DATA AVAILABILITY:

There is a growing availability of CTG data, which is essential for training and validating ML models for fetal health classification. Several public datasets are available, and many hospitals are also collecting and storing CTG data. This increasing availability of data will continue to support the development and refinement of ML models.

CLINICAL EXPERTISE:

The development of ML models for fetal health classification requires collaboration between ML experts and clinical professionals. Clinical experts provide valuable insights into the interpretation of CTG data and the identification of fetal distress patterns. This collaboration ensures that the developed models are aligned with clinical practice and can provide meaningful support to healthcare providers.

RISK OF FALSE POSITIVES:

False positives can lead to unnecessary anxiety for pregnant women and unnecessary interventions, such as cesarean deliveries. To minimize this risk, ML models should be trained and evaluated on large, high-quality datasets, ensuring that they have high specificity, meaning they can correctly identify healthy fetuses.

RISK OF FALSE NEGATIVES:

False negatives can lead to missed diagnoses of fetal distress, potentially resulting in adverse perinatal outcomes. To minimize this risk, ML models should have high sensitivity, accurately identifying fetuses at risk. Rigorous testing and validation on diverse datasets are essential to ensure the model's ability to detect subtle fetal distress patterns.

DATA DEPENDENCY AND BIAS:

ML models are heavily reliant on the quality and representativeness of the data they are trained on. Biased or inaccurate data can lead to biased or inaccurate models, potentially exacerbating existing healthcare disparities. Careful data curation and evaluation are crucial to ensure that ML models are trained on unbiased, representative data.

OVERFITTING:

ML models are prone to overfitting, meaning they perform well on the data they were trained on but poorly on new, unseen data. To prevent overfitting, techniques such as regularization and cross-validation should be employed. Additionally, models should be evaluated on independent datasets to ensure their generalizability to real-world clinical scenarios.

CLINICAL INTEGRATION AND TRUST:

Integrating ML models into clinical practice requires careful consideration of workflow, user interface, and decision support mechanisms. Healthcare providers need to understand the models' limitations and be able to interpret their outputs effectively. Building trust and collaboration between ML experts and clinicians is essential for successful integration.

INTERPRETABILITY AND EXPLAINABILITY:

ML models can be complex and their decision-making processes can be difficult to understand. This lack of interpretability can hinder trust and adoption in clinical settings. Researchers are developing techniques to make ML models more explainable, enabling healthcare providers to understand the factors influencing the model's predictions.

CONTINUOUS MONITORING AND IMPROVEMENT:

ML models should be continuously monitored and updated as new data and knowledge become available. This iterative process ensures that the models remain accurate and relevant, adapting to evolving clinical practices and new insights into fetal health.

While ML holds immense promise for improving fetal health classification, its implementation requires careful consideration of the potential risks and challenges. By addressing these risks through rigorous data curation, model validation, and transparent communication, ML can become a valuable tool for enhancing prenatal care and improving perinatal outcomes.

3.2 SOFTWARE REQUIREMENTS SPECIFICATION DOCUMENT

Software Requirements:

- Operating System : Windows 10 or later
- Tool : Anaconda with Jupyter Notebook

Hardware requirements:

- Processor : intel i3 or above
- Hard disk : minimum 10 GB
- RAM : minimum 4 GB

Anaconda is a free and open-source distribution of the Python and R programming languages for specific computing that aims to simplify package management and deployment.

Anaconda Navigator is a desktop graphical user interface (GUI) included in Anaconda® distribution that allows us to launch applications and easily manage conda packages, environments, and channels without using command-line commands. Navigator can search for packages on Anaconda.org or in a local Anaconda Repository.

Jupyter acts as “meta” documentation for the Jupyter ecosystem. It has a collection of resources to navigate the tools and communities in this ecosystem, and to help you get started.

The Jupyter Notebook App is a server-client application that allows editing and running notebook documents via a web browser. The Jupyter Notebook App can be executed on a local desktop requiring no internet access or can be installed on a remote server and accessed through the internet.

CHAPTER 4

DESCRIPTION OF PROPOSED SYSTEM

Fetal health has been an important branch of research in public health, and the classification of fetal health has been conducted in various experiments. Most research was focused on classifying the fetal health with a high accuracy. Many different methods were used to achieve this high accuracy, such as filtering-based feature selection, classifying based on association (CBA), and classifying using only selected features. This problem has also been tackled using different types of models, such as deep learning neural networks, k-nearest neighbor, and even blended models. Generally, a 99% accuracy was obtained, with high precision and recall. This accuracy is very high and meets the threshold for real life applicability; however, many of the models used were black box models that lacked an explainable component. An explainable model can be beneficial to improving the ease of use of the technology, especially in cases where certain features can be detrimental in the overall prediction. Furthermore, explainable models are highly important for healthcare professionals because the previous models only return classifications, which can lead to questions being raised by patients over how the model came to that prediction. The proposed model aims to fix this issue by adding explainability to a high performing classifier.

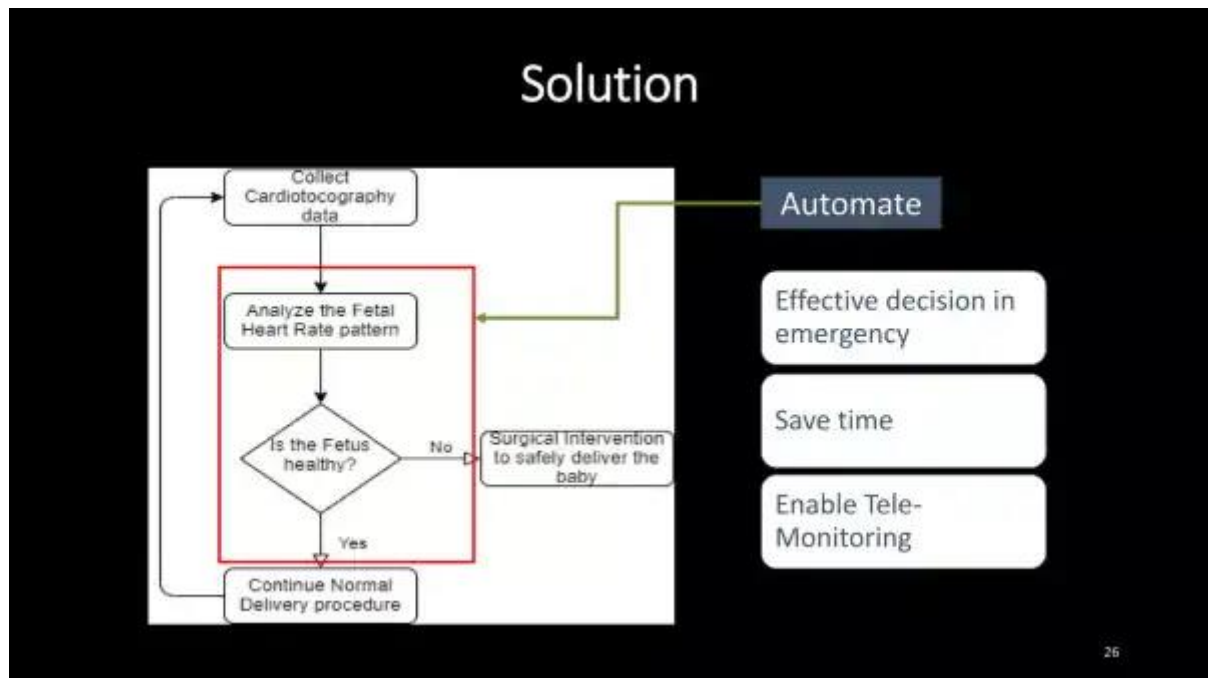


Fig 4.1: Feasible solution

Looking at the disadvantages of all the above methodologies used in previous systems, in the proposed system, machine learning algorithms can be used to classify the health of foetus and it can be done even without having an expert obstetrician and in a much more timely manner. These models can be highly accurate in their predictions, making them viable solutions to the problem of the classification of the fetal health. The implemented model should be an explainable model, meaning obstetricians can be able to inform their patients what the exact metric is that is abnormal, and also be able to better treat their patient based on abnormality.

4.1 SELECTED METHODOLOGY OR PROCESS MODEL

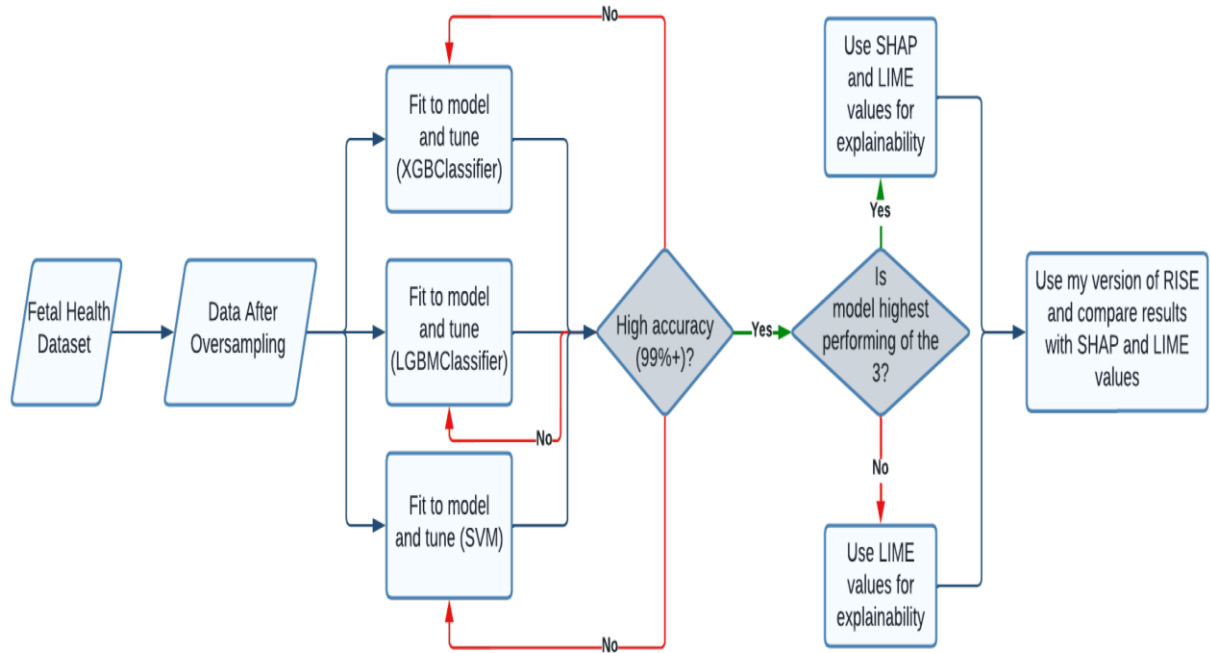


Fig 4.2: A representation of steps being taken to determine the best accurate model

The overarching goal of this research is to create an effective way of classifying fetuses by risk of death using cardiotocogram data. To be able to do this in a clinical setting, it is imperative that the model used has a high accuracy of over 99.5%. The next step would then be to make the black box model explainable. This ensures that doctors understand which features play an important role in the diagnosis of the fetus, and is useful to healthcare providers in determining why exactly the fetus is at risk. This allows more generalized doctors to better serve their patients.

4.2 ARCHITECTURE / OVERALL DESIGN OF PROPOSED SYSTEM

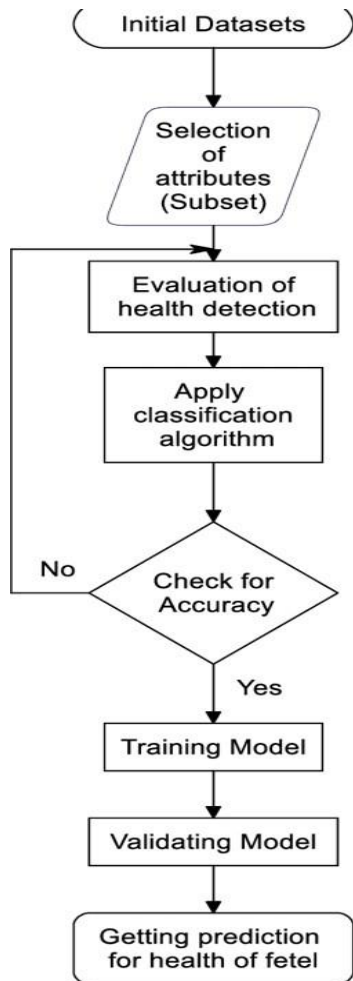


Fig 4.3: System Architecture for Classification of Fetal Health

The block diagram of the proposed system has been shown in the above figures. First and foremost, dataset is taken into consideration and it is preprocessed. After preparing the data, exploratory features of the given data are analyzed and visualized. Few attributes are selected which plays an important role in determining the health of foetus. Different machine learning algorithms are compared and the best of them is chosen based on high accuracy. The preferred model is then trained and tested for predicting the health of fetal correctly.

4.3 ALGORITHMS USED

The first model used was a special version of a gradient boosting model. It is an ensemble learning algorithm similar to random forest algorithms. Gradient Boosting models work by training ensembles of shallow decision trees; with each iteration, the model uses the residual error of the tree to help fit the ensuing decision tree. After many of these trees are built, the final prediction comes from a weighted sum. An Extreme Gradient Boost model differs in that the trees are built in parallel to each other instead of sequentially. This helps increase performance while also decreasing the time necessary to fit data to a model. This model is very popular in the scientific world, and tends to work well with a variety of problems.

The next model implemented was LightGBM, which stands for light gradient boosting machine. Similar to the previous XGBClassifier, this model is another ensemble gradient boosting algorithm. However, the main difference between the two is in the way the decision trees are made. In the XGBoost model, the decision trees grow by level, meaning that every new tree made would differ from the previous tree in that the new tree would have an extra level of leaves under it. On the other hand, LightGBM grows by individual nodes and leaves. Instead of a whole new level being added for every iteration, only some leaves are added. This is useful because LightGBM can be extremely accurate while also reducing the run time, hence the name. One potential problem with LightGBM is overfitting, but this can be combated with the use of the max depth parameter, which ensures that no individual tree has too many nodes.

After using 2 algorithms based on gradient boosting, the next step was to try a different type of model. A support vector machine (SVM) is useful because of how it is efficient and tends to work well with relatively smaller sets of data, such as the fetal health data. An SVM is a classification model that works by plotting data points on a plane. On a simple data set with 2 features, this would be a 2-dimensional plane, with all the data plotted using the x and y-axis for each feature. On this plane, the Support Vector

Classifier (SVC) would then create a hyperplane, or a decision boundary, in between the 2 classes of data, and use that in determining which class the data goes in. As we increase features, the data is plotted in more and more dimensions, and the hyperplane also becomes more dimensions. For our data, the hyperplane is created in a way where 3 different classes are formed: one class is formed for normal fetuses, one is formed for suspect cases, and the last is formed for pathological cases. From here, the test data is then classified into each group based on where it is located relative to the hyperplane.

4.4 PROJECT MANAGEMENT PLAN

4.4.1 EXECUTIVE SUMMARY

The project aims to develop a machine learning model for fetal health classification using cardiotocography (CTG) data. This model will assist healthcare professionals in identifying fetuses at risk of fetal distress, enabling early intervention and improved outcomes. The project will involve data collection, feature extraction, model development, evaluation, and clinical integration.

4.4.2 PROJECT SCOPE AND DELIVERABLES

SCOPE:

- Develop a machine learning model for fetal health classification using CTG data.
- Train the model to achieve high accuracy and reliability.
- Integrate the model into clinical practice.

DELIVERABLES:

- A machine learning model for fetal health classification
- Documentation of the model development process
- A clinical integration plan for the model

4.4.3 PROJECT SCHEDULE

- Month 1-3: Data collection and preparation
- Month 4-6: Feature extraction and selection
- Month 7-9: Model development and training
- Month 10-12: Model evaluation and validation
- Month 12: Clinical integration and deployment

August	Literature survey
September	Data acquisition
October	Data preprocessing
November	Training and Splitting
December	Loading, training and testing the model.
January	Predicting the output and generating the final report

4.4.4 PROJECT RESOURCES

- Requires developers proficient in Python, Machine Learning, clinical experts and deep learning technologies.
- Utilizes testing tools and project management software.
- Specific budget details are not provided.

4.4.5 RISK AND ISSUE MANAGEMENT PLAN

- Data Quality Issues
 - Implement rigorous data cleaning procedures.
- Difficulty in extracting meaningful features from CTG data
 - Explore a variety of feature extraction techniques
- Challenges in developing a highly accurate and reliable machine learning model
 - Use multiple machine learning algorithms and ensemble methods
- Integrating the model into clinical practice
 - Collaborate closely with clinic throughout the development process

4.4.6 COMMUNICATION MANAGEMENT PLAN

- Weekly project meetings - Discuss project progress and address any issues.
- Monthly status reports - Provide stakeholders with an overview of project status.
- Email updates as needed - Share important information with project team members.
- Project management tool (e.g., Asana, Trello) - Track project tasks and deadlines daily.

4.4.7 COST AND QUALITY MANAGEMENT PLAN

COST MANAGEMENT:

- Develop a detailed project budget
- Track project expenses against the budget

- Identify and implement cost-saving measures as needed

QUALITY MANAGEMENT:

- Implement a quality assurance process to ensure that all deliverables meet project requirements
- Conduct regular reviews of project documentation and code
- Use testing frameworks to ensure the accuracy and reliability of the machine learning model



Fig 4.4: GANTT CHART

CHAPTER 5

CONCLUSION AND FUTURE WORK

In conclusion, the project on the classification of fetal health using machine learning represents a significant step forward in the field of healthcare and prenatal care. Through the utilization of advanced machine learning algorithms, the project aimed to provide accurate and efficient classification of fetal health based on various parameters and features extracted from relevant medical data.

The successful implementation of these models could have a profound impact on improving maternal and fetal well-being, ultimately contributing to the advancement of healthcare practices in the field of obstetrics.

In the future, enhancements for fetal classification could include deploying the project in the cloud.

Optimization of work for the implementation of project in the IOT system.

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