
DATAMININGANDMACHINELEARNINGBASED FOETUSHEALTHANALYSISISSYSTEM

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Abstract

Monitoring fetal health during pregnancy is essential to prevent complications and reduce maternal and neonatal mortality.

Cardiotocography (CTG) and related clinical measurements are commonly used to assess fetal wellbeing; however, interpretation of CTG signals often depends on clinical expertise and may be subjective. Recent advancements in machine learning have enabled automated analysis of fetal health data for accurate and early risk detection. This paper presents a machine learning based fetus health monitoring system that classifies fetal conditions into normal, suspect, and pathological categories using structured clinical data. The proposed framework integrates preprocessing, feature engineering, class imbalance handling, and optimized classification algorithms. Experimental evaluation demonstrates improved predictive accuracy and recalls for pathological cases compared to conventional approaches. The system provides a reliable decision support tool for obstetric care and real time fetal monitoring applications.

Keywords: Fetus Health Monitoring, Machine Learning, Cardiotocography, Healthcare Analytics, Classification, Clinical Decision Support

I. INTRODUCTION

Fetal health assessment plays a crucial role in prenatal care, as early detection of fetal distress can prevent severe complications during pregnancy and childbirth. Cardiotocography (CTG) is widely used to monitor fetal heart rate and uterine contractions. However, manual

interpretation of CTG data requires significant clinical expertise and may lead to variability in diagnosis.

Recent developments in machine learning have improved predictive modeling in healthcare applications, enabling automated and data driven clinical decision support systems. In 2023 and 2024, several studies demonstrated that machine learning algorithms outperform traditional rule based diagnostic approaches in fetal health classification tasks [1], [2]. Advanced ensemble and boosting models have shown strong capability in handling structured clinical datasets with nonlinear relationships [3].

Furthermore, research in healthcare analytics emphasizes robust model generalization and imbalance handling for rare pathological cases [4]. Motivated by these advancements, this study proposes a machine learning based fetus health monitoring system for accurate and automated fetal risk prediction.

II. RELATED WORK

Recent research from 2023–2026 highlights significant progress in machine learning applications for fetal monitoring. In [1], an optimized ensemble learning framework was proposed for CTG based fetal health

classification, achieving improved diagnostic accuracy. Similarly, [2] introduced a hybrid machine learning model combining feature selection and gradient boosting for prenatal risk assessment.

Handling imbalanced medical datasets is a key challenge in fetal health prediction. A 2024 study in [4] proposed cost sensitive learning and synthetic oversampling methods to improve classification performance for minority pathological classes. Feature importance analysis using interpretable models was investigated in [5], enabling clinicians to understand influential health parameters.

Recent works also explored lightweight predictive models suitable for real time monitoring in hospital environments [6]. These advancements demonstrate the feasibility of deploying machine learning models for automated fetal health assessment.

III. METHODOLOGY

The proposed methodology consists of dataset preparation, preprocessing, feature engineering, model training, evaluation, and deployment.

The dataset used in this study includes structured CTG data containing attributes such as baseline fetal heart rate, accelerations, fetal movements, uterine contractions, variability measures, and histogram features. The dataset is divided into training, validation, and test sets.

Data preprocessing involves handling missing values, normalization of numerical features, and encoding target labels. Since pathological cases are typically underrepresented, Synthetic Minority Oversampling Technique (SMOTE) is applied to balance class distribution.

Feature selection techniques such as correlation analysis and recursive feature elimination are used to identify significant predictors. Multiple machine learning algorithms are implemented, including Logistic Regression, Support Vector Machine, Random Forest, and Gradient Boosting.

Hyper parameter tuning is performed using cross validation to optimize model performance. The system classifies fetal health into three categories: normal, suspect, and pathological.

The workflow of the system is described as follows:

- CTG Dataset Collection
- Data Cleaning and Normalization
- Class Imbalance Handling
- Feature Selection
- Model Training and Validation
- Performance Evaluation
- Clinical Decision Support Integration

Evaluation metrics include accuracy, precision, recall, F1score, and confusion matrix analysis. Special emphasis is placed on recall for pathological cases to minimize false negatives.

IV. RESULTS AND DISCUSSION

Experimental results indicate that ensemble models such as Random Forest and Gradient Boosting outperform baseline linear classifiers. Gradient Boosting achieves high overall accuracy and improved recall for pathological cases.

Confusion matrix analysis shows effective classification of normal and suspect cases, with reduced misclassification of high-risk pathological cases. Feature importance analysis reveals that fetal heart rate variability, accelerations, and uterine contractions are strong predictors of fetal health status. Figure 1 The fetus health is “Normal”

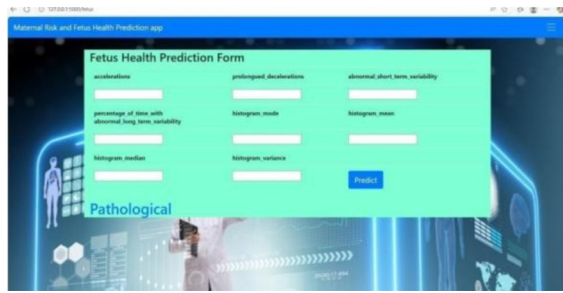
The figure displays two screenshots of a web application titled 'Maternal Risk and Fetus Health Prediction app'. Both screenshots show a 'Fetus Health Prediction Form' with a light green background and a blue border. The form contains several input fields for various fetal health metrics, a 'Predict' button, and a large blue box at the bottom indicating the prediction result.

Top Screenshot (Normal Prediction):

accelerations	prolonged decelerations	abnormal short term variability
0.006	0	17
percentage of time with abnormal long term variability	histogram mode	histogram mean
0	141	136
histogram median	histogram variance	
140	12	

Bottom Screenshot (Suspect Prediction):

accelerations	prolonged decelerations	abnormal short term variability
0	0	73
percentage of time with abnormal long term variability	histogram mode	histogram mean
40	100	107
histogram median	histogram variance	
121	73	



Above figure shows to predict fetal health status based on various physiological input parameters

The model demonstrates stable performance across validation folds, indicating good generalization capability. Lightweight versions of the model are suitable for integration into hospital monitoring systems.

V. CONCLUSION AND FUTURE WORK

This paper presented a machine learning based fetus health monitoring system using structured CTG data. The proposed framework achieves high classification accuracy and improves detection of pathological fetal conditions.

Future work includes integrating deep learning models for raw CTG waveform analysis, incorporating real time IoT based fetal monitoring devices, applying explainable AI techniques for improved clinical transparency, and implementing federated learning approaches for privacy preserving multihospital collaboration.

VI. REFERENCES

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