



# AI-Driven Predictive Modelling and Machine Learning Framework for Classification of Fetal Health Conditions

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**Abstract:** Fetal health monitoring plays a crucial role in ensuring maternal and neonatal well-being by enabling the early identification of potential complications during pregnancy. Conventional fetal assessment methods often depend on manual interpretation of cardiotocography (CTG) signals and clinical expertise, which may lead to inconsistencies and delayed diagnosis. This paper presents an AI-driven predictive modeling and machine learning framework for the classification of fetal health conditions using cardiotocography data. The proposed framework integrates data preprocessing, feature engineering, and machine learning algorithms to classify fetal conditions into Normal, Suspect, and Pathological categories. Various predictive models including Random Forest, Support Vector Machine, Decision Tree, and XGBoost are employed and evaluated based on performance metrics such as accuracy, precision, recall, and F1-score. The framework enhances diagnostic reliability and supports healthcare professionals in making timely clinical decisions. Experimental results demonstrate that the proposed system achieves high classification accuracy and provides an efficient solution for intelligent fetal health assessment.

**Keywords:** Fetal Health Classification, Machine Learning, Predictive Modeling, Cardiotocography, Artificial Intelligence, Healthcare Analytics, Clinical Decision Support.

## I. INTRODUCTION

Fetal health assessment is an essential component of prenatal care aimed at ensuring the safety and development of the fetus during pregnancy. Cardiotocography is commonly used to monitor fetal heart rate and uterine contractions. However, manual interpretation of CTG recordings requires significant clinical expertise and may be subject to variability among healthcare professionals. Recent advancements in artificial intelligence and machine learning have enabled automated analysis of medical data, improving diagnostic accuracy and efficiency. Machine learning algorithms can identify hidden patterns in fetal monitoring data and assist in early detection of abnormal fetal conditions. This study proposes an AI-driven predictive framework capable of classifying fetal health conditions into Normal, Suspect, and Pathological categories using CTG datasets.

## II. LITERATURE SURVEY

### Related Work

SisPorto et al. developed computerized cardiotocography analysis systems for automated fetal monitoring. Their study demonstrated the effectiveness of machine learning in identifying fetal distress but highlighted challenges related to noisy signal interpretation.



Ayres-de-Campos et al. investigated fetal heart rate analysis techniques and emphasized the importance of early detection of fetal abnormalities. Their research indicated that automated systems could improve consistency in diagnosis.

Santos et al. proposed machine learning-based fetal health classification using decision tree algorithms. The study achieved promising classification accuracy but suffered from limited generalization on diverse datasets. Moumita et al. applied ensemble learning approaches to fetal monitoring datasets and reported improved predictive performance. However, computational complexity remained a challenge for real-time clinical deployment.

### III. EXISTING SYSTEM

Traditional fetal health assessment primarily relies on manual interpretation of cardiotocography recordings by obstetricians and healthcare professionals. Clinicians evaluate fetal heart rate variability, accelerations, decelerations, and uterine contractions to determine fetal well-being.

Limitations of Existing Systems:

Dependence on expert interpretation. • Possibility of human error and inconsistent diagnosis. • Time-consuming assessment process. • Limited ability to analyze large-scale clinical datasets. • Reduced efficiency in real-time monitoring environments. Although computerized CTG analysis systems have been introduced, many existing approaches lack advanced predictive capabilities and robust machine learning integration.

### IV. PROPOSED SYSTEM

The proposed system introduces an AI-driven machine learning framework for automated classification of fetal health conditions. The framework utilizes cardiotocography data collected from fetal monitoring systems and applies advanced preprocessing and feature engineering techniques.

The processed data are fed into machine learning models including Random Forest, Support Vector Machine, Decision Tree, and XGBoost classifiers. The system automatically predicts fetal conditions as Normal, Suspect, or Pathological based on extracted clinical features.

The proposed framework provides:

- Automated fetal health classification
- High prediction accuracy
- Reduced diagnostic time
- Real-time decision support
- Improved clinical reliability

### V. SYSTEM ARCHITECTURE

The architecture consists of multiple interconnected modules:

#### 1. Data Acquisition Module

- Collection of cardiotocography records.
- Extraction of fetal heart rate parameters.

#### 2. Data Preprocessing Module

- Missing value handling.
- Noise removal.
- Data normalization.
- Feature scaling.

#### 3. Feature Engineering Module

- Selection of significant clinical parameters.
- Dimensionality reduction.
- Feature importance analysis.

#### 4. Machine Learning Module

- Model training.
- Hyperparameter optimization.



- Cross-validation.

#### 5. Prediction and Classification Module

- Classification into Normal, Suspect, and Pathological classes.

#### 6. Visualization Module

- Performance metrics.
- Confusion matrix.
- ROC curves.
- Prediction reports.

### VI. WORKING SCENARIO

The workflow begins with collecting cardiotocography data from fetal monitoring systems. The acquired dataset undergoes preprocessing to remove inconsistencies and normalize features.

After preprocessing, significant fetal health indicators such as baseline fetal heart rate, accelerations, fetal movements, uterine contractions, and variability measures are extracted. These features are supplied to machine learning algorithms for training and prediction.

The trained model evaluates the incoming fetal data and classifies the fetal condition into one of three categories:

- \* Normal
- \* Suspect
- \* Pathological

The classification results are displayed through a graphical interface, enabling clinicians to make informed decisions regarding pregnancy management and intervention planning.

The integration of machine learning techniques with fetal monitoring systems contributes to improved diagnostic accuracy, faster analysis, and enhanced prenatal care. The proposed approach supports healthcare providers in making evidence-based decisions and ensures better monitoring of fetal health throughout pregnancy. The proposed system provides real-time decision support for healthcare professionals by automatically analyzing fetal monitoring data and generating instant classification results. Early detection of abnormal fetal conditions enables timely medical intervention, reducing potential risks to both mother and fetus.

Furthermore, the system offers a user-friendly graphical interface that allows clinicians to upload cardiotocography data, view extracted features, and obtain classification outcomes efficiently. This improves workflow management in hospitals and maternity care centers while minimizing manual interpretation errors.

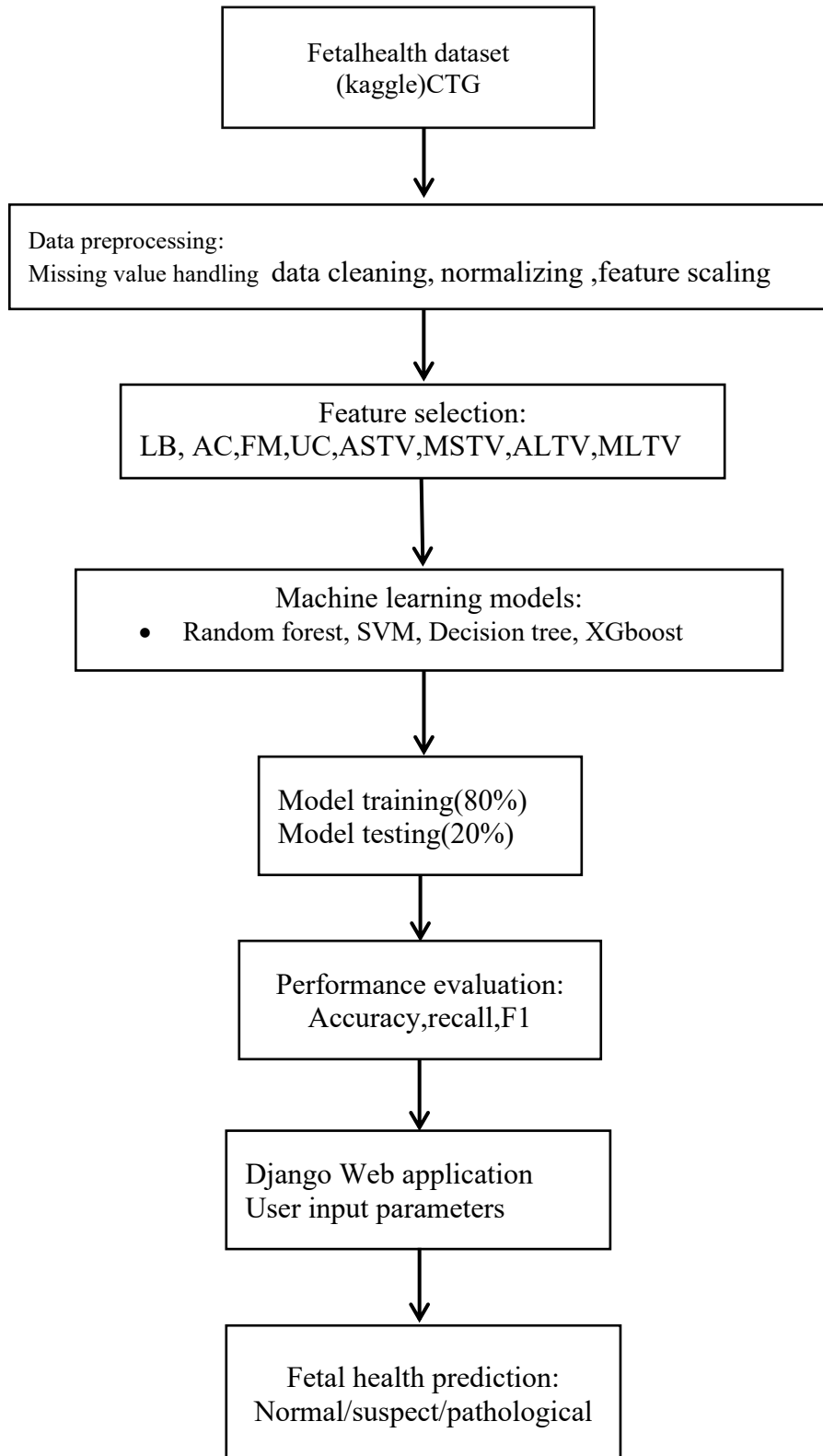


FIG 1. WORKING SCENARIO OF FETEL HEALTH MONITORING



## VII. TECHNICAL METHODOLOGY

The technical methodology consists of the following stages:

#### 1.Dataset Collection

The fetal health dataset is obtained from publicly available cardiotocography repositories containing multiple fetal monitoring parameters.

#### 2.Data Preprocessing

- \* Handling missing values.
- \* Outlier detection and removal.
- \* Data normalization.
- \* Feature scaling.

#### 3.Feature Selection

Important features are selected using correlation analysis and feature importance techniques to improve model performance and reduce computational complexity.

#### 4.Model Development

Several machine learning algorithms are trained and evaluated:

- \* Random Forest Classifier
- \* Support Vector Machine
- \* Decision Tree
- \* XGBoost
- \* Logistic Regression

#### 5.Model Evaluation

Performance is measured using:

- \* Accuracy
- \* Precision
- \* Recall
- \* F1-Score
- \* ROC-AUC

#### 6.Prediction System

The optimized model is integrated into a user-friendly application capable of real-time fetal health classification and decision support.

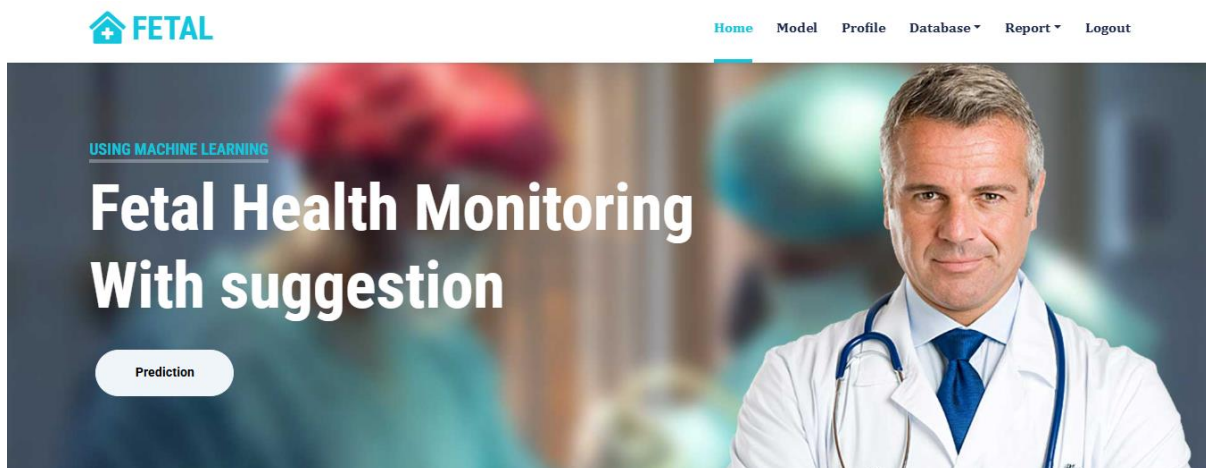


Fig.2 Home page – AI-Based fetal monitoring



```

from django import forms
from django.contrib.auth.models import User
from django.contrib.auth.forms import UserCreationForm, AuthenticationForm
from .models import FetalHealthData

from .models import Profile

class RegisterForm(UserCreationForm):
    # fields we want to include and customize in our form
    first_name = forms.CharField(max_length=100,
                                required=True,
                                widget=forms.TextInput(attrs={'placeholder': 'First Name',
                                                                'class': 'form-control',
                                                                }))
    last_name = forms.CharField(max_length=100,
                                required=True,
                                widget=forms.TextInput(attrs={'placeholder': 'Last Name',
                                                                'class': 'form-control',
                                                                }))

```

Fig.3 Python-Based Architecture for fetal monitoring system

Fig.4 fetal health Prediction Result Page

## VIII.CONCLUSION

This study presents an AI-driven predictive modeling and machine learning framework for fetal health classification using cardiotocography data. The proposed system automates fetal condition assessment and assists healthcare professionals in early detection of abnormalities. By leveraging advanced machine learning techniques and clinical feature analysis, the framework achieves reliable classification performance and supports timely medical intervention. The proposed model improves diagnostic efficiency, reduces dependence on manual interpretation, and enhances prenatal healthcare outcomes. Future work may include deep learning integration, real-time IoT-based fetal monitoring, and deployment in clinical decision support systems for large-scale healthcare applications.

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