EMPOWERING PRENATAL DIAGNOSTICS & CARE

Mulitclassification of fetal health status using CTG and interpretable clustering for diagnosis

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PROBLEM WITH CURRENT FETAL MONITORING PRACTICES





"One death every 7 seconds among women and babies during pregnancy and childbirth, mostly from preventable or treatable causes"



Cardiotocography (CTG) is a non-invasive fetal surveillance method



Complex CTG patterns associated with fetal hypoxia (common risk factor) are generally assessed visually; results poorly reproducible and inconsistent

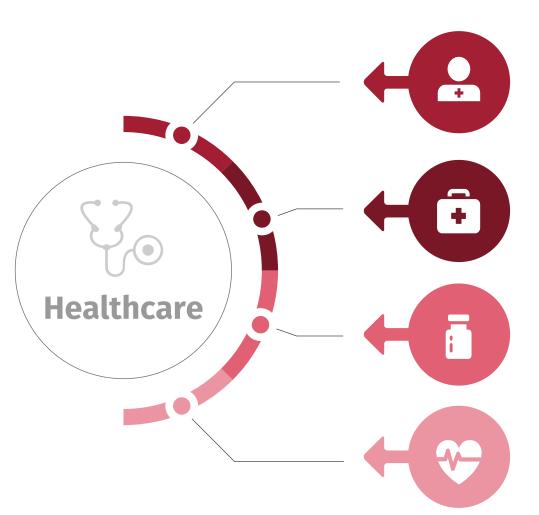


Automated CTG Classification could help optimize the diagnostic accuracy



BENEFITS

SAFER PREGNANCIES AND HEALTHIER BABIES



Automated health status classification reduces time doctors spend analyzing CTG data manually (esp. during labor) and increases reaction time

Early identification of potential risks, crucial for timely interventions

Better management of the pregnancy; reducing complications, preterm births, and stillbirths

Actionable insights, esp. in high-risk cases (suspect & pathological), reduction of litigation



DATA

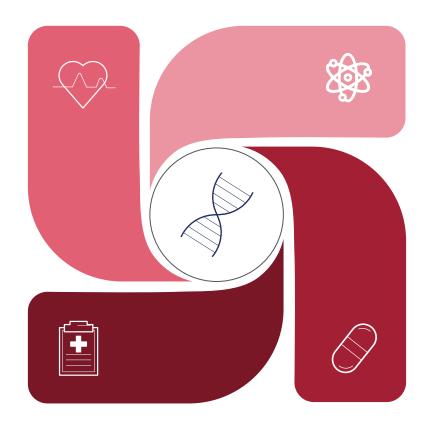
IMBALANCED DATA, 2126 CASES WITH 21 PREDICTORS

Heart Rate

Baseline
Accelerations
Decelerations (# of light, severe, prolonged)

Fetal Movement and Uterine Activity

of fetal Movements # of uterine Contractions



Variability

% and mean of abnormal short-term Variability % and mean of abnormal long-term Variability

Histogram Characteristics

Histogram width, min, max # of peaks and zeroes Mode, mean, median Variance, tendency



METHODOLOGY

5 Tuned Classifiers

with cross validation using average F1-Score



Interpretable Clustering

with cross validation using average F1-Score

Data **Standardization** Different scales or units (e.g., heart rate in bpm, number of movements per second) Non-linear transformations Multiplying features & Individual transformations (squared, square roots) **SMOTE** Synthetic Minority Oversampling to balance the training set 5

Other Methods & Experiments





Removing / Swapping out highly correlated predictors

Consulting with resident doctor for interpretability and clinical relevance of clusters and data









Applying Soft-Voting to improve performance

Applying different hyperparameters and scoring metrics







KEY RESULTS



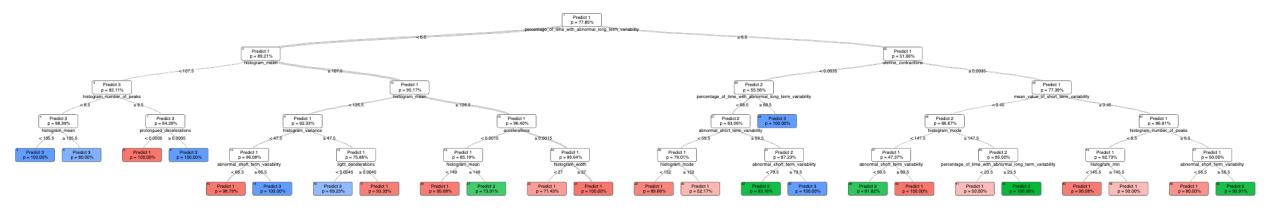
Model	Scaled	SMOTE	Non-linear Transformations	Accuracy	Weighted F1 Score	Weighted Precision	Weighted Recall
Support Vector Classifier	✓		✓	92.48%	92.30%	92.22%	92.49%
Random Forest Classifier		✓	✓	91.54%	91.83%	92.34%	91.55%
ОСТ				89.10%	89.73%	91.36%	89.10%
CART		/	/	89.10%	89.39%	89.84%	89.10%
Logistic Regression	✓	✓	✓	88.35%	89.20%	91.02%	88.35%

- o Best models in each category, sorted by weighted F1-Score, given that all individual scores are above 70%
- Vast improvement over Baseline Logistic Regression, with 85% weighted F1, individual scores as low as 40%
- o In the accuracy trade-off, we recommend the use of OCT, which has the sizable benefit of interpretability
- o Soft voting improves accuracy further (93%), but loses on the interpretability



HOW DO WE TO DIAGNOSE?



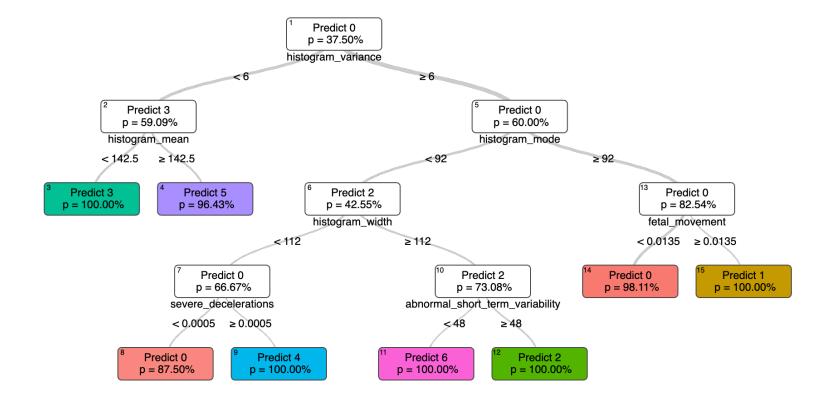


But what actions can we take if the fetus is diagnosed as Suspect or Pathological? Why? How?



ACTIONABLE INSIGHTS FOR PATHOLOGICAL CASES







ACTIONABLE INSIGHTS FOR PATHOLOGICAL CASES



Indicates a uniform heart rate. potentially non-reactive Action: Initiate NST, followed by BPP to check for fever, infection

> High Baseline reflects potential maternal or fetal stress Action: Evaluate for maternal fever or infection

> > Case of Low Mode & Width with few Severe decelerations suggests intermittent distress **Action**: Assess uteroplacental function and fetal oxygenation

p = 37.50%histogram_variance Predict 3 Predict 0 p = 59.09%p = 60.00%histogram_mode histogram_mean < 142.5 ≥ 142.5 ≥ 92 Predict 2 Predict 3 Predict 5 p = 96.43%p = 42.55%p = 100.00%histogram width < 112 ≥ 112 Predict 0 Predict 2 p = 66.67%p = 73.08%p = 98.11%abnormal_short_term_variability severe_decelerations < 0.0005 ≥ 0.0005 < 48 Predict 0 Predict 4 Predict 6 Predict 2 p = 87.50%p = 100.00%p = 100.00%p = 100.00%

Predict 0

Severe Decelerations signal acute distress **Action**: Consider emergency delivery if clinically appropriate

Implies less acute stress Action: Monitor and conduct serial assessments Could be a compensatory response to stress.

Action: Investigate with ultrasonography and monitor fetal heart rate

High Mode & Low Movement:

May indicate hypoxia **Action**: Intervene to enhance fetal oxygenation

High Abnormal Variability suggests acute distress, potentially due to umbilical cord complications or rapid changes in fetal oxygenation Action: Immediate assessment. potentially fetal blood sampling

Predict 1

p = 100.00%

Predict 0

p = 82.54%

fetal movement

< 0.0135 ≥ 0.0135

Predict 0



THANK YOU

Do you have any questions?

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