March 2025

ESE 588
Project Description

Goal

During labor and delivery, clinicians monitor the fetal heart rate (FHR) to assess the well-being of the fetus. This is done using a technique known as Cardiotocography (CTG), which records both the FHR and the mother's uterine contractions over time.

The fundamental idea is that the pattern of the FHR provides valuable information about how the fetus is responding to the stress of labor. For example,

- A healthy fetus typically has
  - a stable baseline heart rate,
  - natural fluctuations in heart rate, known as variability, and
  - temporary increases in heart rate, called accelerations.
- A compromised fetus may have abnormal patterns, such as
  - reduced variability,
  - abnormally high or low baseline heart rate, and
  - prolonged or repetitive decelerations (drops in heart rate).

These patterns serve as indicators of fetal well-being. Abnormal patterns may suggest that the fetus is under stress or is not receiving sufficient oxygen.

The classification task

In this project, we use features extracted from FHR tracings to build a machine learning (ML) model that classifies fetuses into two categories,

- normal (non-compromised) and
- abnormal (compromised).

The objective is to develop an automated tool based on a ML method of your choice to identifying potentially compromised fetuses. You are asked to implement *two* different ML methods.

Description of the training and test data

An annotated training dataset $\{\boldsymbol{x}_n, y_n\}_{n=1}^{N}$ is provided, where $N = 185$ is the number of FHR segments. Each $\boldsymbol{x}_n$ is a vector of 21 features extracted from the n-th 10-minute FHR segment, and $y_n \in \{0, 1\}$ is the corresponding label. Specifically, $y_n = 0$ indicates a healthy fetus, while $y_n = 1$ indicates a compromised fetus. Each row in the dataset contains the feature values of a segment, and the associated label classifies the tracing.

The test dataset consists of four distinct groups of data, where each group contains the same set of features as the training set. There are $M = 100$ vectors of features in each group. You are required to apply your classification methods (two of them) to the test data and enter the predicted labels in the provided Excel spreadsheet.

Instructions for preparing the report and uploading

Your final project report must clearly communicate your modeling goals, design decisions, and experimental insights. Please ensure your report includes the following components:

1. Introduction (0.5 pages)

- Clearly describe the prediction or classification task.
- Explain the motivation behind your chosen dataset.
- Identify the challenges in modeling this data.

2. Dataset description (0.5 pages)

- Describe key properties of the dataset (size, number of features, label balance, missing data, etc.).
- Include one visual (e.g., histogram, scatter plot, correlation matrix) that helps illustrate a data feature or challenge.

3. Method selection and rationale (1 page)

- Describe the two learning methods you selected.
- Provide a clear rationale for choosing each model, linking the choice to properties of the dataset (e.g., dimensionality, sparsity, class imbalance).
- Additionally, discuss one method you considered but rejected, and explain why.

4. Modeling and evaluation (2 pages)

- Detail your implementation: preprocessing steps, feature selection (if any), and cross-validation procedure.
- Report and compare test accuracy, AUC (if applicable), confusion matrix, and any relevant error analysis.
- Include a discussion of the results:
  - Which model performed better, and why?
  - Were the results consistent across cross-validation folds?
  - What patterns did you observe in misclassified examples?

5. Reflection and alternatives (1 pages)

- Reflect on what you would do differently if you had more time, more data, or additional compute.
- Mention one promising next step or alternative model you would like to explore.
- A challenge you encountered and how you resolved it

8. Test set submission and evaluation

In addition to your report, you will be evaluated on your model's performance on the separate unlabeled test set tha has been provided to you.

- You must submit a file named `test_predictions.csv` with predictions for the unlabeled test inputs. There are four test sets. You should provide the labels for each set in a different column in your csv file.
- To label the test sets, please use the file Myresults.xlsx. Enter the labels for each group from your first model on the first sheet, and the labels from your second model on the second sheet.

These predictions will be compared against the hidden ground truth labels for evaluation purposes. While your grade will primarily reflect your report quality and modeling justification, performance on the test set may be used to break ties or verify claims in your report.

Submission Format: PDF. Maximum length: 5 pages