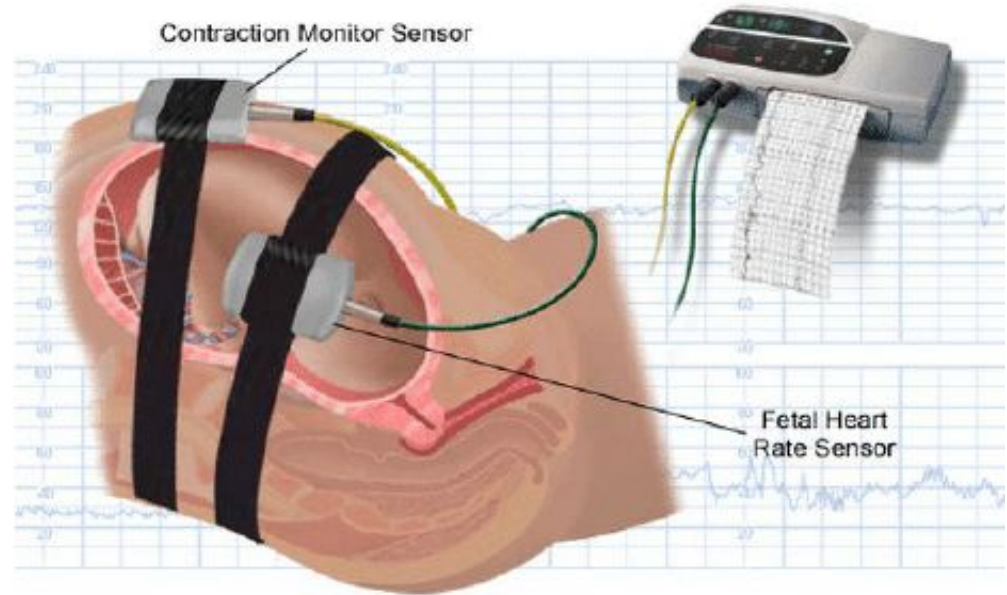


Classification of anomalous fetal status from cardiotocographies

Ilaria Bonavita

Cardiotocography

- Method for monitoring the fetal heart rate (**FHR**) e the uterine contractions (**UC**)
- The analysis of a cardiotocography (CTG) and of the **features** extracted from it, allow to assess the **health status of the fetus**



Non-Invasive Fetal Heart Rate Monitoring Techniques. Available from:
https://www.researchgate.net/figure/An-external-fetal-cardiotocography-CTG-monitor_fig9_268515126

The problem

Given a set of features extracted from cardiotocographies, create a model of health status of the fetus (normal, suspect or pathologic)

Motivation

- Some features are difficult to be analysed by **human eye**
- Visual analysis of CTGs has proven **low consistency**
- Automatised tools can **help the experts** in the more ambiguous cases
- **Optimisation** in the usage of human and technological resources of the hospitals

Workflow



Problem **Understanding** (bibliographic research, etc.)

Data **preprocessing**

Explorative analysis (visualisation, descriptive statistics)

Modelling (parameter tuning, validation)

Results **interpretation** (evaluation metrics)

The dataset

Ayres de Campos et al. (2000) , UCL Machine Learning repository

2126 samples

CTGs collected between
1980-98 by Porto
Universitary Hospital

21 features

Extracted and processed
from FHR according to
medical guidelines

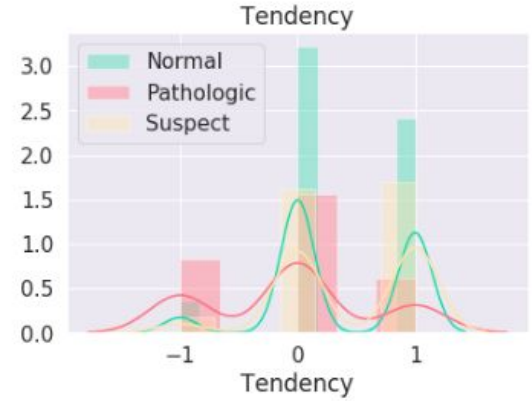
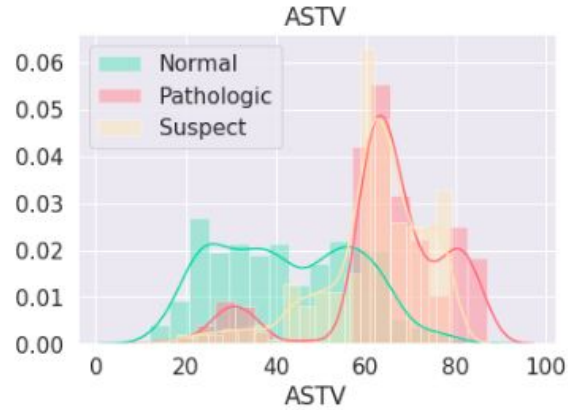
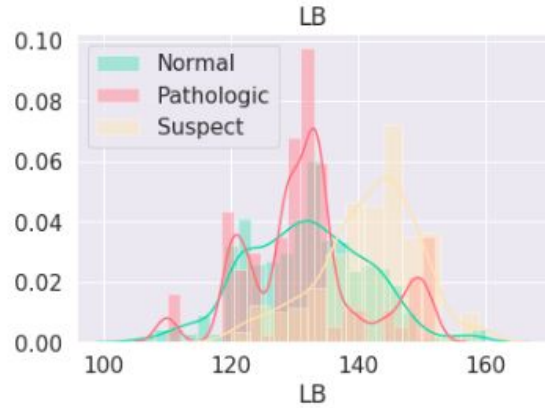
3 classes

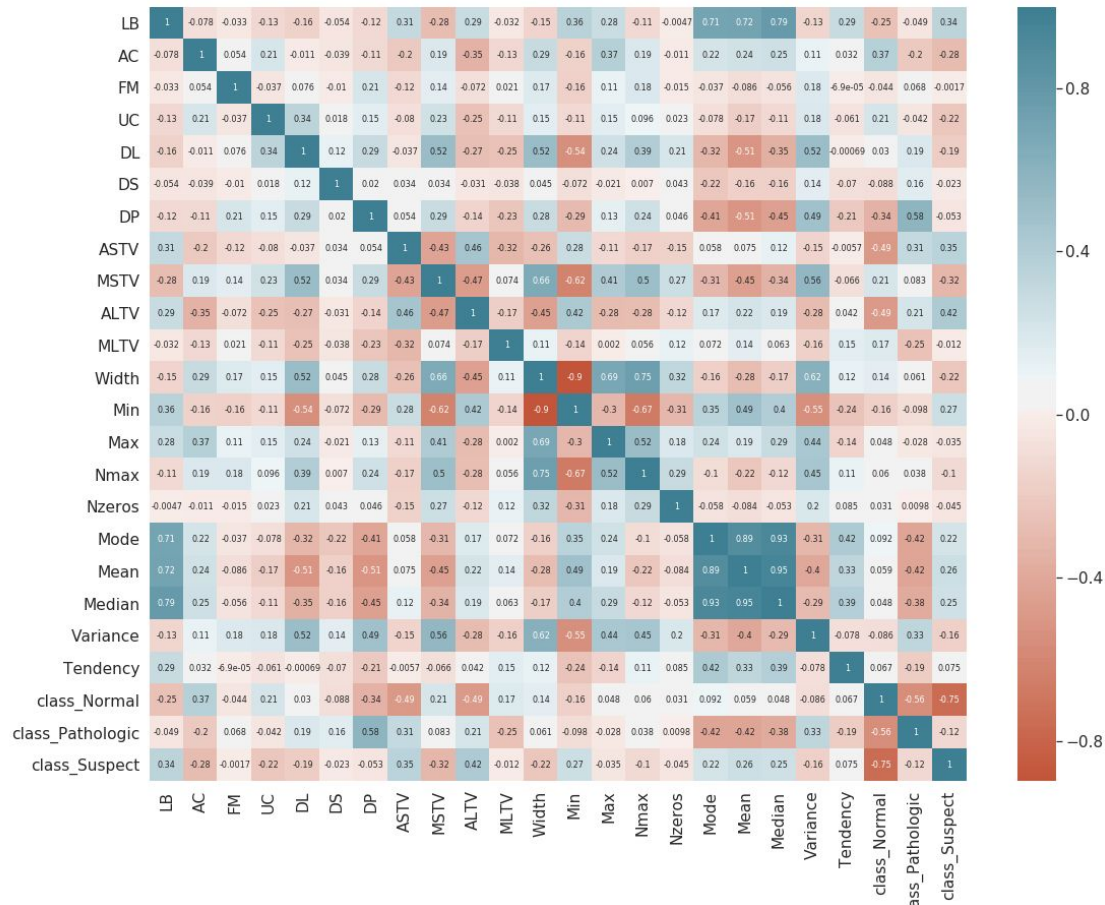
obtained with majority
vote by 3 experts
obstetricians

Features	Meaning
LB	Baseline FHR
FM	Fetal movement
UC	Uterine Contractions
AC, DL, DS, DP	Accelerations, light/severe/prolonged decelerations
ASTV, MSTV, ALTV, MLTV	Short and long term variability stats
Width, Min, Max, Nmax, Mean, Mode, Median, Variance, Tendency, Nzeros	FHR Histogram stats

Class	N samples	Percentage
Normal	1655	77.8 %
Suspect	295	13.9 %
Pathological	176	8.3 %

Explorative Analysis





Principal Components, dimensions 1 to 4



4 PCs -> 60 % variability
11 PCs -> 90% variability

Useful observations for choosing the model

- Highly **imbalanced** classes
- Presence of highly **correlated** features
- **Heterogeneous** features (different ranges, type and distribution)
- N samples \gg N features
- Non-trivial separation among classes

Random Forest Classifier

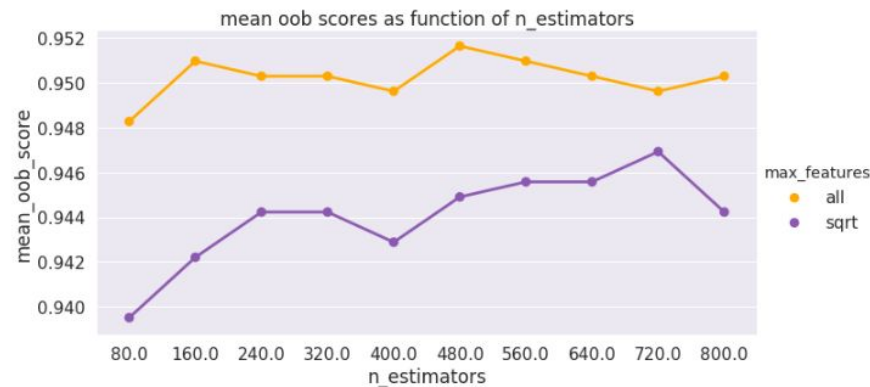
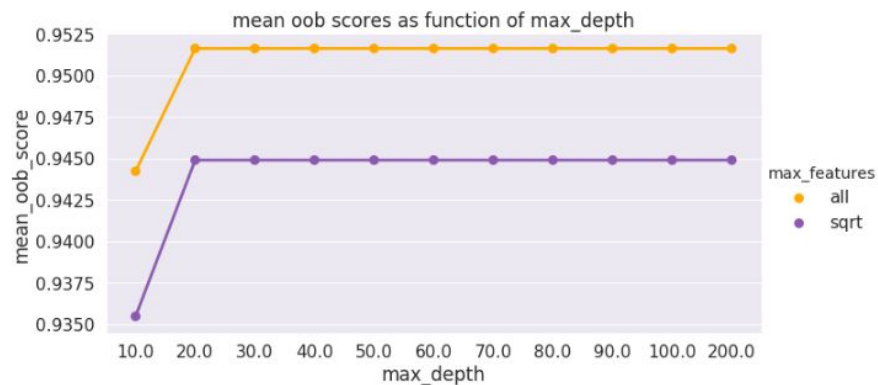
- + Dataset annotated through a **decision process**
- + Suitable for a wide range of problems
- + **Robust** with respect to outliers, collinearity and heterogenous variables
- + Does not require statistical hypothesis on the data
- + Suitable for cases of **class imbalance**
- Computational times
- Hypertuning of the parameters usually needed

Training

- Train - test 70-30 split
- Grid search for hyperparameters tuning
 - *N estimators, max depth, min samples leaf, max features*
 - 660 configurations
 - ~ 19 minutes,
- **Out-of-bag (OOB) score: 0.95161**

Final model

Parameter	Value
Criterion	Gini
N estimators	480
Max depth	20
Max features	all
Min samples leaf	2
Class weight	balanced
Bootstrap	True



Results

95 %

Accuracy

91 %

F1-score*

91 %

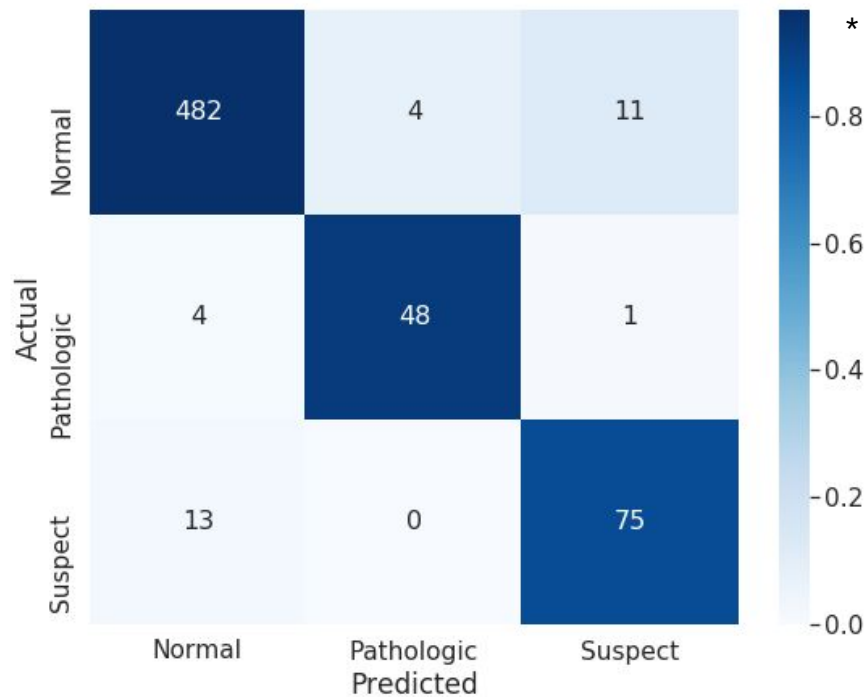
Precision*

92 %

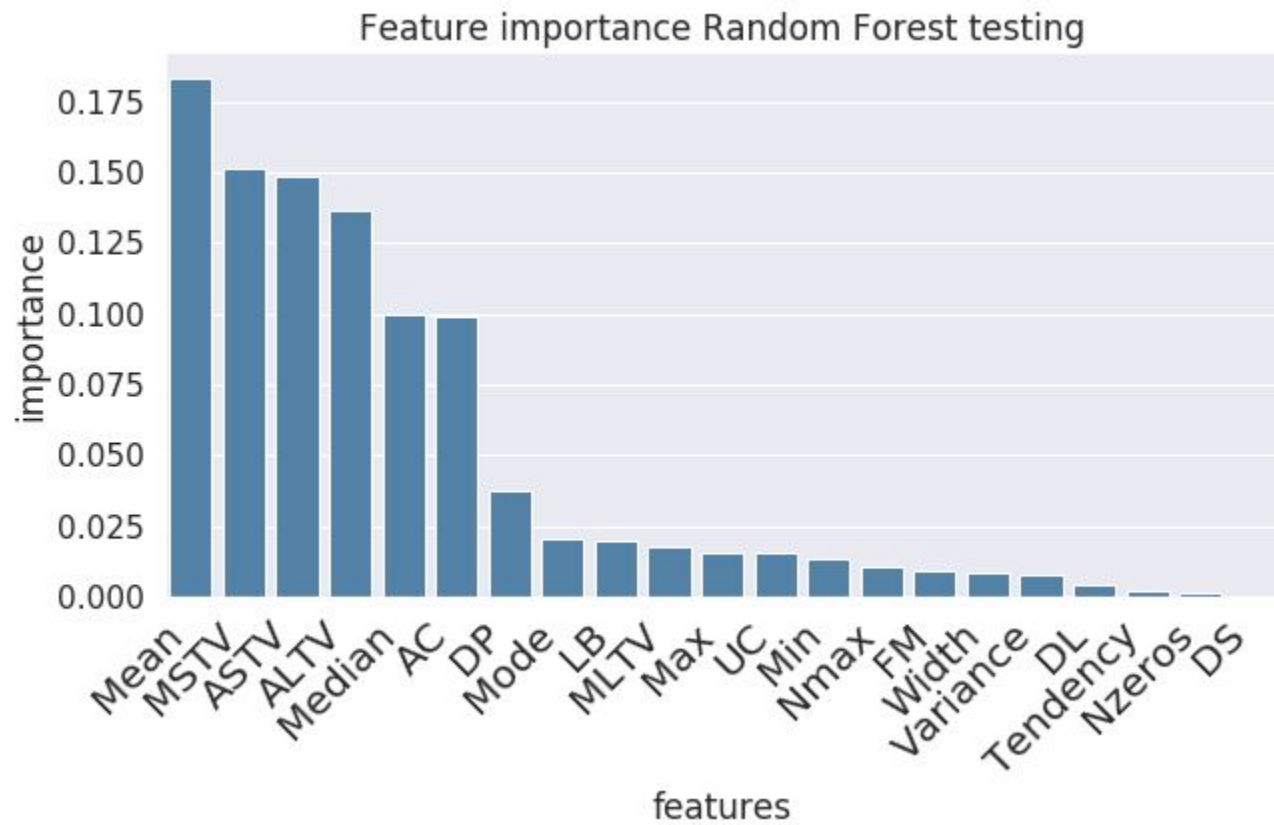
Recall*

* macro average

	Precision	Recall	F1-score
Normal	0.97	0.97	0.97
Pathologic	0.91	0.92	0.91
Suspect	0.85	0.86	0.86



* the color refers to the normalised values per predicted



Results on a reduced features set

- 7 most important features
- Random forest with optimal obtained parameters
- Prediction on the same Test set

94% Accuracy

90% F1-score

Future steps

- Systematic analysis of the **stability** of the model (cross validation vs oob error, confidence intervals for metrics...) and of the **features importances**.
- Deeper inspection of the features of the misclassified **Suspect** samples
- Testing on at least another **independent dataset**
- Collecting **feedback** from obstetricians and medical experts
- Literature research and application of state-of-the-art models

Conclusions

- The model has a **high predictive** (91% F1-score) and **generalization** (OOB score 95%) **abilities**
- **7 features** are particularly informative and interpretation of FHR could focus on these
- The model could provide useful **support** in difficult clinical decisions
- CTGs classified as **suspect** require more in-depth analysis

Thanks!

