Automated Cardiotocogram Analysis

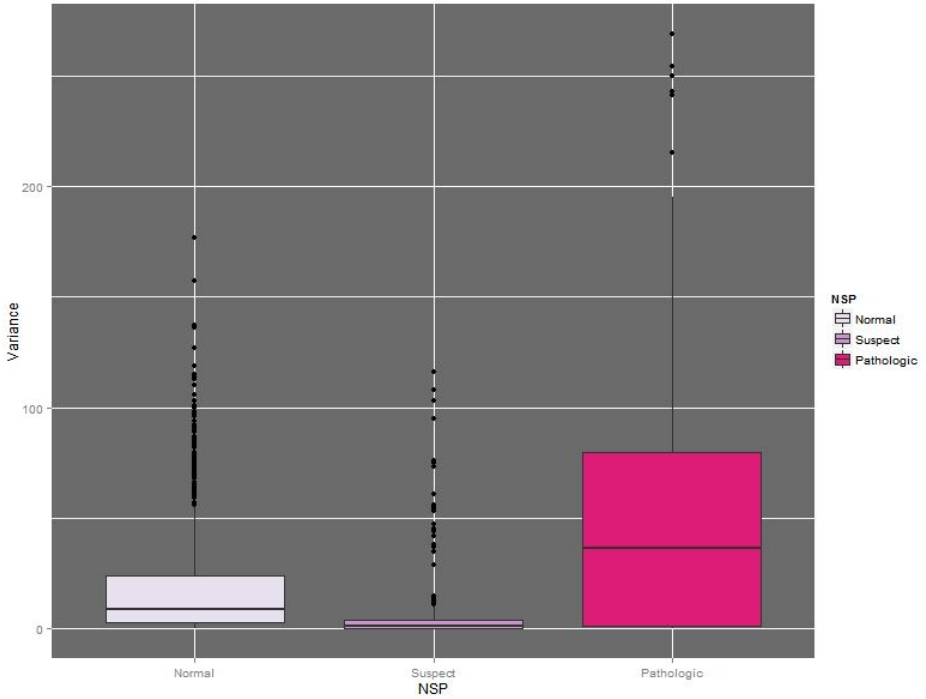
COMP417 Group Project, Fall 2015
Group 13

Cardiotocography

- A Mean to monitor fetal heart rate and uterine contraction
  - Invented by Dr. Orvan W. Hess
- Used by Obstetrics to
  - Determine if unborn child suffers lack of oxygen
  - Check if fetal heart rate is affected by contraction
- Problem
  - Large number of predictors, only per attribute normal range, no overall interpretation method
  - Depend on Doctors' knowledge experience
  - Time consuming
  - Wrong interpretation exposes mother and child to unnecessary intervention
- Our solution
  - An automated CTG classification model
  - Raw data set contains 23 predictors and 3 class result

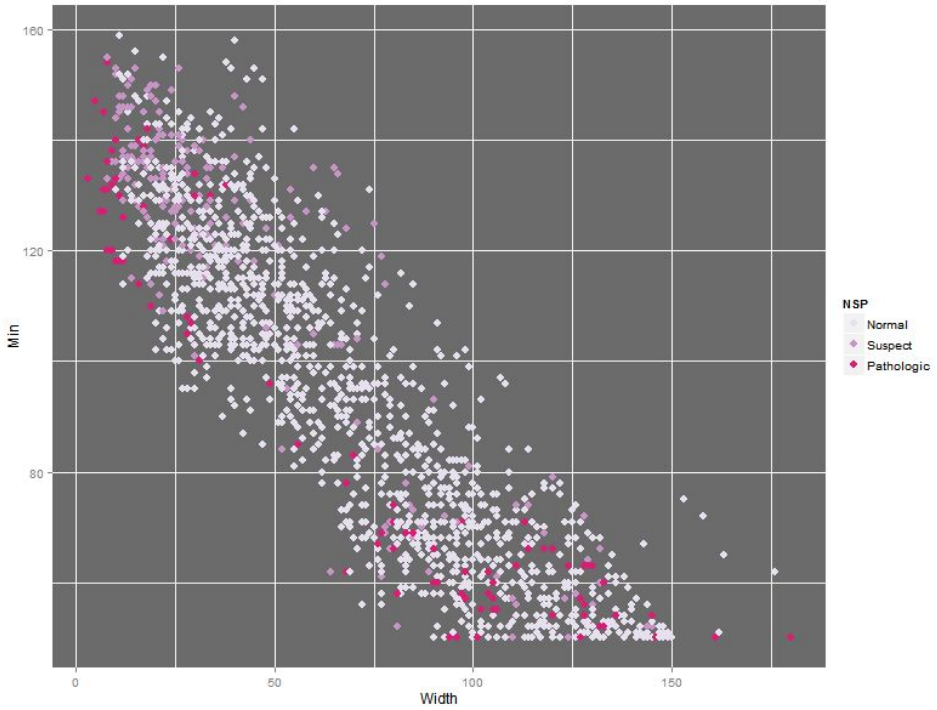
Explorative analysis: statistics

- Pathologic
  - Higher mean “Variance”
  - Higher variance of “Variance of pathologic cases”
- Query with higher than average “Variance of pathologic cases” increases probability of classifying into pathologic



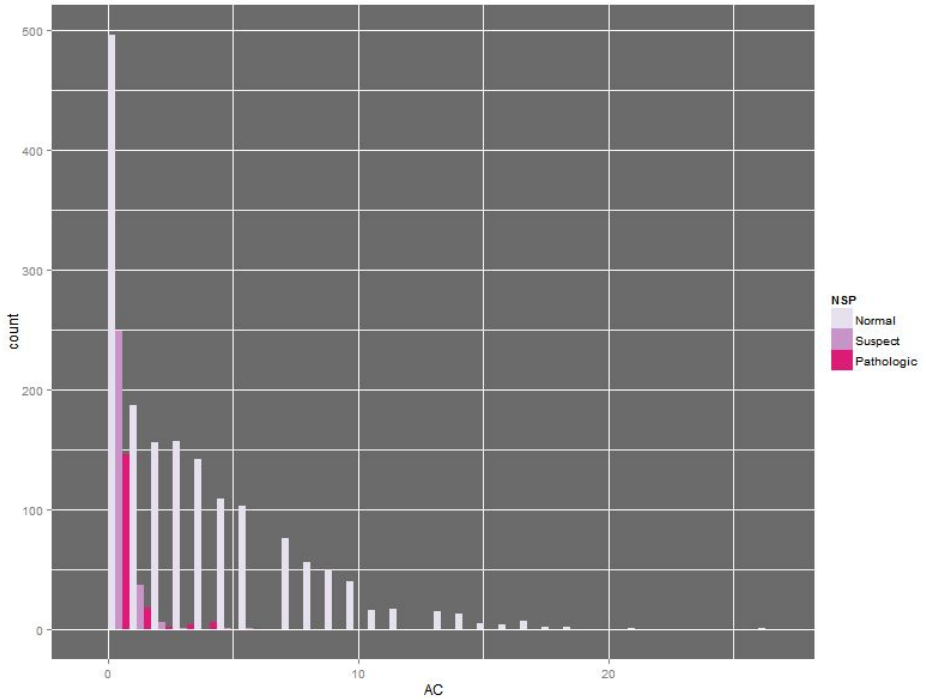
Explorative analysis: Correlation

- Width of FHR and Minimum of FHR negatively correlated
- Not much Pathologic cases when Width FHR and Min values near means
    - Less likely to classify as Pathologic if Width of FHR close to mean



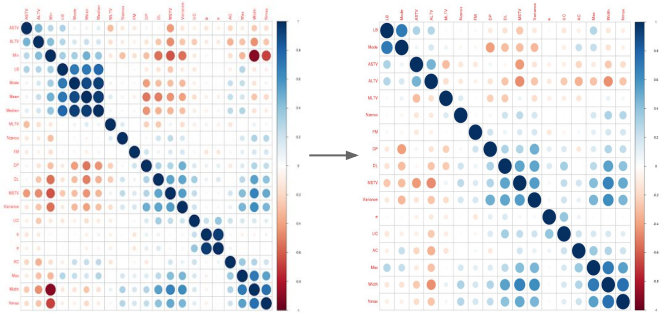
Explorative analysis: No. of Ac per sec.

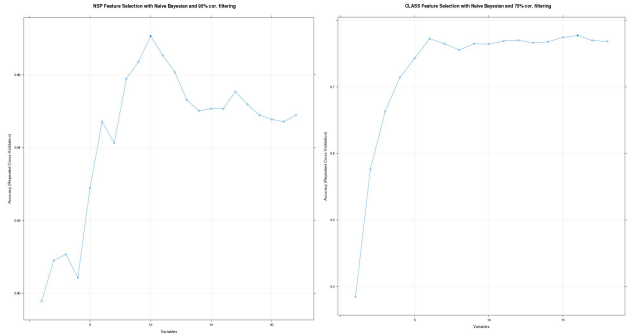
- Near zero number of acceleration per second for Suspect and Pathologic
- Higher average number of accelerations per second for normal cases
- Small AC reduces the probability of classifying into Normal



Pre-processing

- Standard data cleaning procedure
  - Null data removal
  - Zero variance filtering
- Filtering predictors that correlates
  - 75% cutoff
  - 95% cutoff
- Recursive Feature Elimination
  - Naive Bayesian approach
  - Random Forest approach





Our models

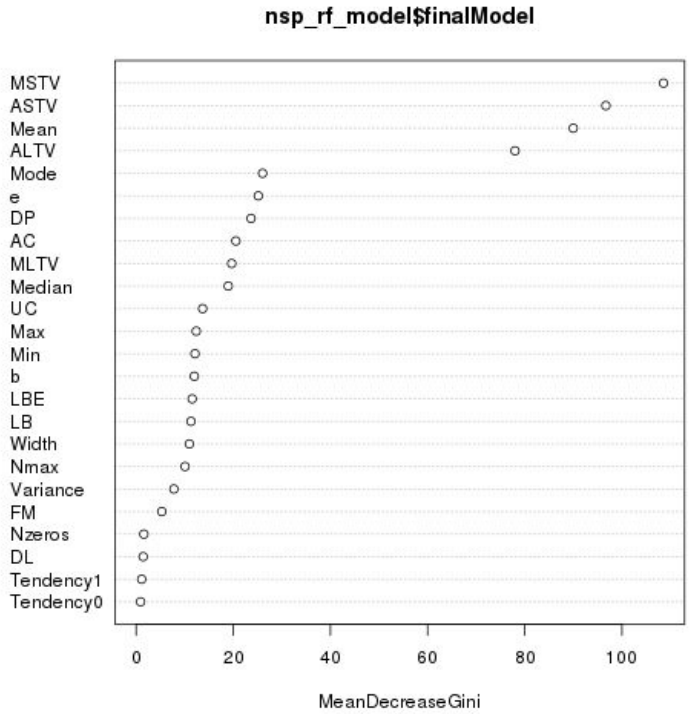
- K-NN
  - Distance based approach
  - Simple and fast
- Naive Bayesian
  - Probabilistic approach
  - Simple and fast; capable of processing large number of predictors
- Support Vector Machine
  - Mathematical optimization
  - Reliable and accurate
  - Exhaustive tuning of Cost
- Random Forest
  - Tree based ensemble approach, with probabilistic element
  - Most accurate classification model, resilient to overfitting

Result

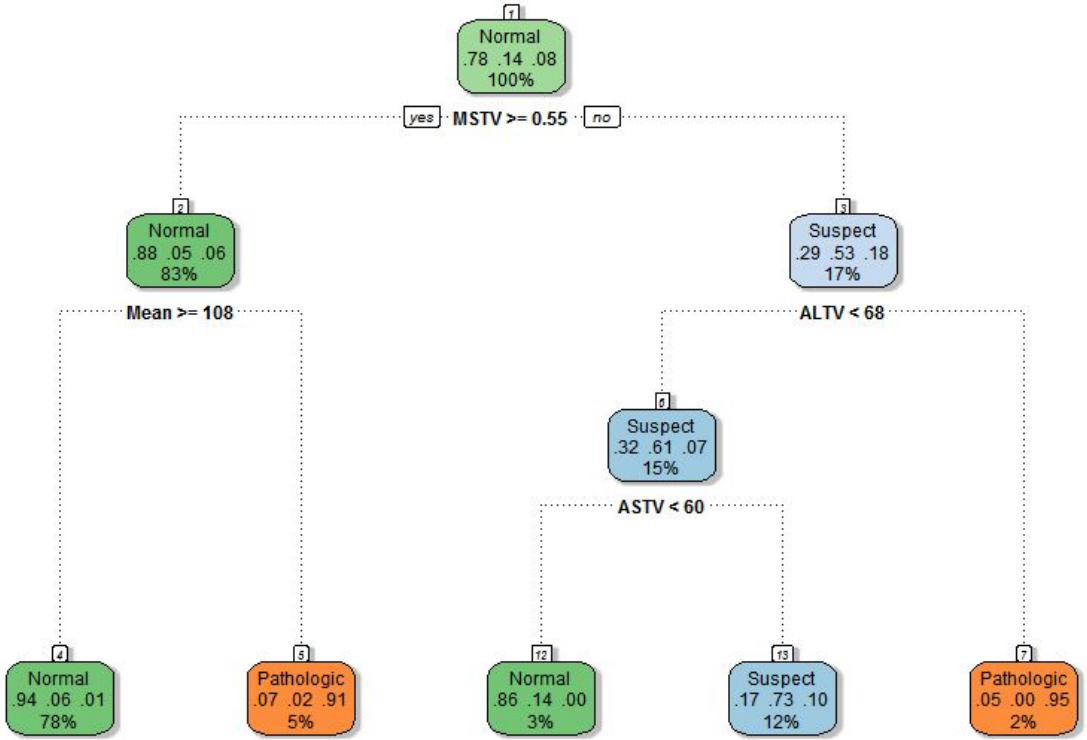
	NB (75%)	RF (75%)	NB (95%)	RF (95%)	No filters	WIN
KNN	0.9106	0.8494	0.9082	0.8541	0.8165	NB (75%)
NB	0.8682	0.8871	0.8565	0.8753	0.8541	NB (75%)
SVM	0.8965	0.9035	0.9012	0.9129	0.9176	No filter
RF	0.9341	0.9341	0.9224	0.9388	0.9318	RF (95%)

Explorative analysis: predictors

- Importance of predictors according to Random Forest
  - MSTV
  - ASTV
  - Mean
  - ALTV

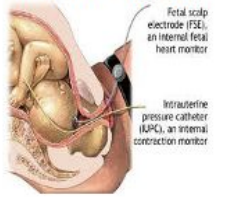


Result Analysis: pruned decision tree

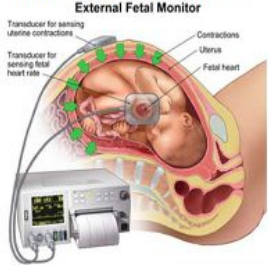


Deployment: Before

Internal Fetal Monitor



External Fetal Monitor



Cardiotocogram printout

Cardiotocogram interpreted by experienced obstetricians

CTG sticker

Date	Time	Indication	Gestation	Antenatal	Intrapartum

	Normal	Non-reassuring	Abnormal
Baseline	110-160 ☐	100-109	<100 >170 ☐
Variability	normal (5-25)	reduced (3-5 for >40mins)	absent <3
Decelerations	None Early decelerations	Variable decelerations	Complicated variables Prolonged decelerations > 3 mins Late decelerations
Accelerations	2 present in 20 mins	Do not consider the absence of accelerations in intrapartum interpretation as being abnormal	

Contractions	none	irregular	regular	mild	mod	strong	expulsive

Normal- antenatal: all 4 features present
Normal- intrapartum: exclude accelerations in interpretation
Non-reassuring: 1 non-reassuring feature present
Abnormal: 2 or more non-reassuring features present
1 or more abnormal features present

No action required ☐

ACTION REQUIRED
Referred to senior midwife ☐ Medical Officer ☐

Signed **Name** **Designation**

Deployment: After

- Save time
  - Doctors and lab technicians can serve more patients
- Accurate classification result
  - No human intervention
  - Follow up only when necessary
- Reduce risk of administering unnecessary intervention