Automated detection of premature atrial contractions in non-invasive fetal heart rate recordings : a case report

Fetal arrhythmia detection in non-invasive heart rate recordings: a case report

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Where innovation starts

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   - Non-invasive fetal electrocardiogram
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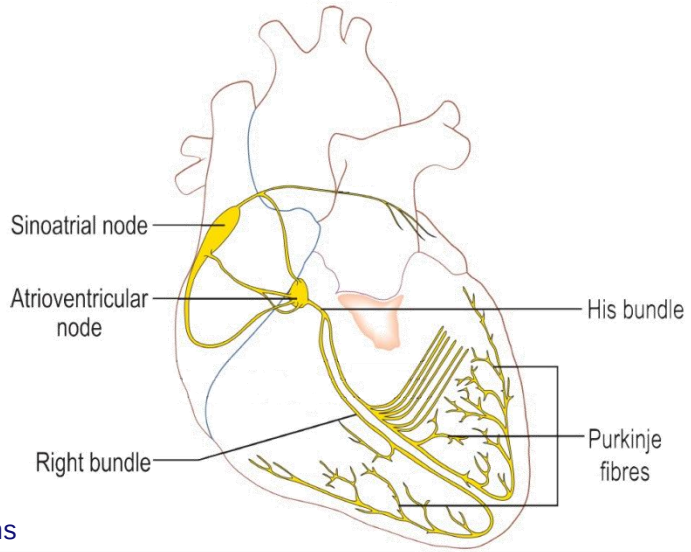
Fetal arrhythmias

Fetal Arrhythmias

- Occurs in 2% of all pregnancies
- Account for up to 20% of the referrals to fetal cardiologists
- Irregular heart rhythms, tachycardia (>180BPM), bradycardia (<100BMP)

Premature atrial contraction (PAC)

- Contraction that originates in the atria, but not at the sinoatrial-node
- Isolated PACs are not associated with fetal distress (no treatment required)



Fetal arrhythmias

Arrhythmia monitoring

- Doppler ultrasound (M-mode imaging, pulsed-wave Doppler, tissue-Doppler)
- Unsuited for long-term continuous monitoring:
  - Manually performed
  - Fetal orientation
  - Susceptible to movement
  - Transmits energy into the body

Additional information: non-invasive fetal ECG

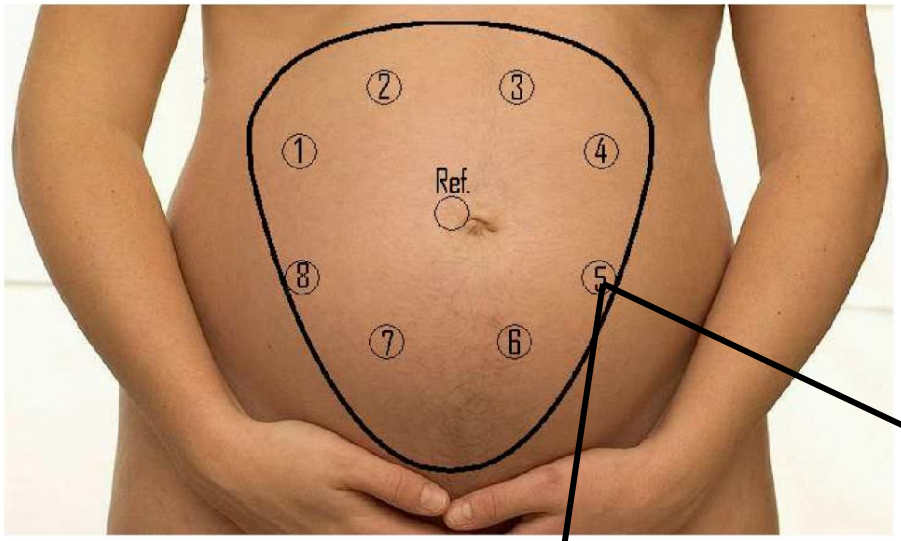
- Continuous monitoring
- Beat-to-beat heart rate
- ECG-waveform morphology

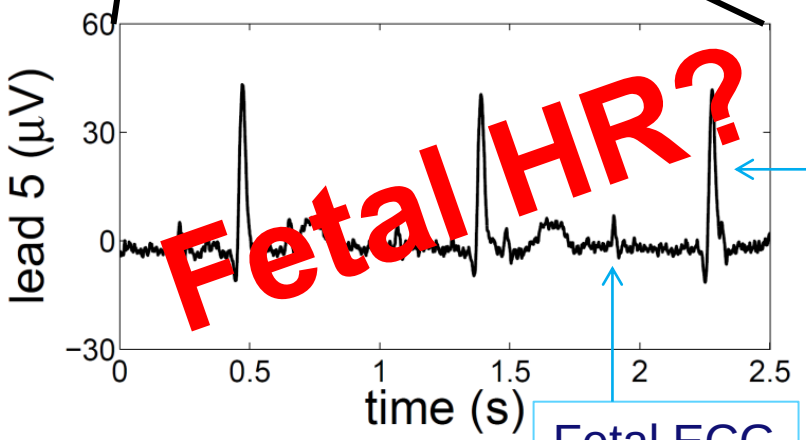
Goal

Show the potential of non-invasive fetal ECG for prolonged recording of arrhythmias

Non-invasive fetal ECG

Schematic electrode configuration



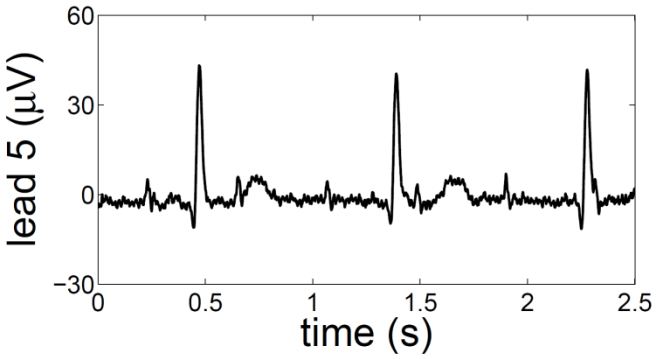


Maternal ECG

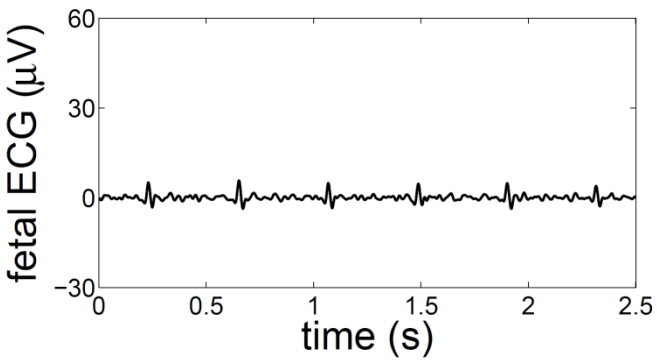
Fetal ECG

Extract fetal heart rate

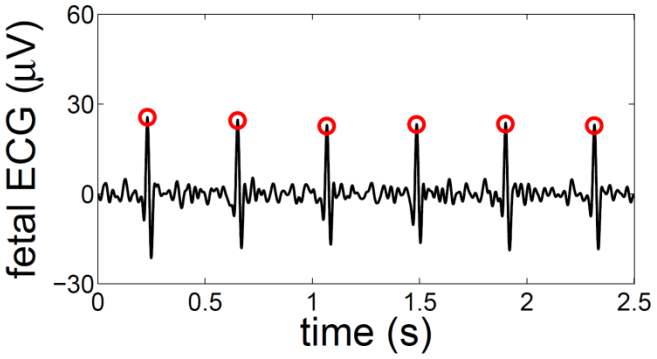
1. Raw signal



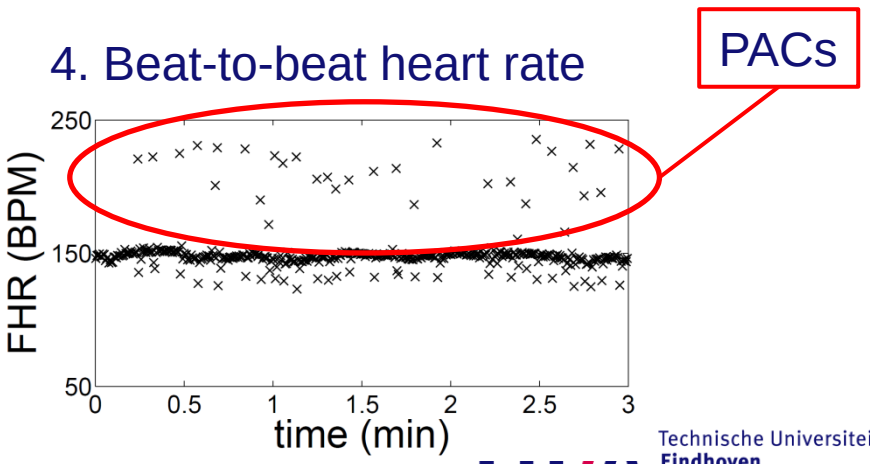
2. Fetal ECG



3. Enhanced fetal ECG



4. Beat-to-beat heart rate



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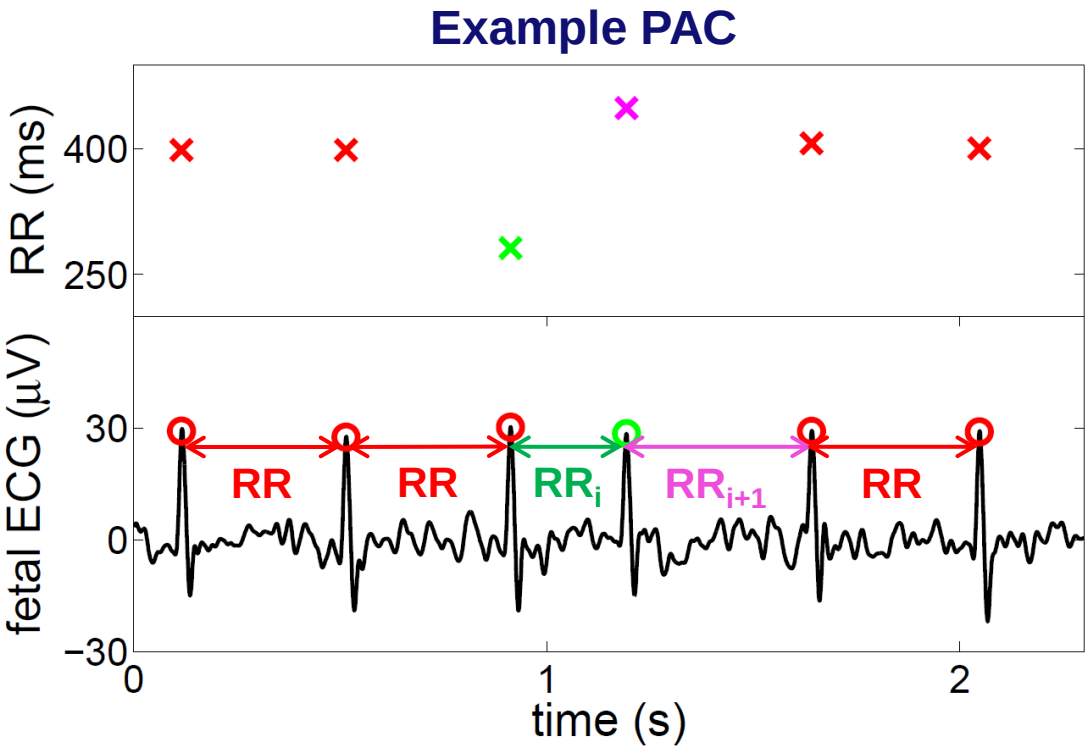
Heart rate based PAC detection

PAC classification

1. Instantaneous RR (RR_i) < 85% of average RR
2. Next RR (RR_{i+1}) >115% of RR_i



RR = time between R-peaks, not BPM!

Results case study

Case:

Recording 45 minutes, gestational age: 24+1

Annotation:

- # 6376 ECG complexes
- # 371 PACs

Performance algorithm

Sensitivity (Se):

$$Se = \frac{TP}{TP + FN} 100\%$$

TP = # True-Positives
FN = # False-Negatives
FP = # False-Positives

Positive-Predictive-Value (PPV):

$$PPV = \frac{TP}{TP + FP} 100\%$$

Results

- Sensitivity: **91%**
  - Most PACs are detected
- Positive-Predictive-Value: **92%**
  - Only a few ECG complexes are misclassified as a PAC

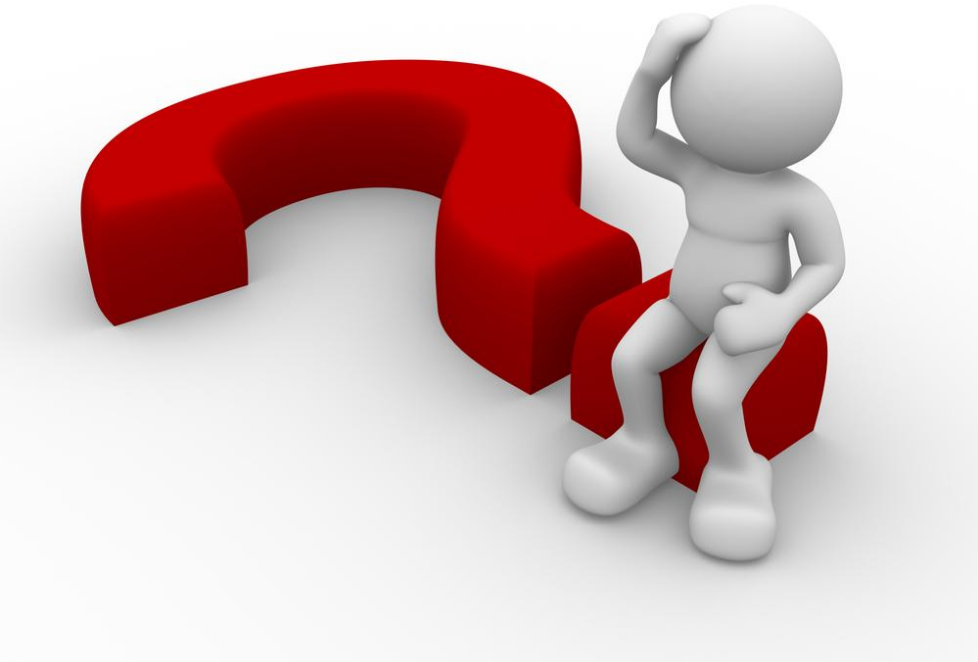
Discussion & conclusions

Case study

- The non-invasive fetal ECG can be used for detection of fetal arrhythmia
- Reduced performance near artifacts

To do

- Further validation of PAC detection
- Extent to different types of arrhythmias
- Use ECG-waveform information



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