UNIVERSITÀ DEGLI STUDI DI MILANO

DIPARTIMENTO DI INFORMATICA

1st Signal Processing and Monitoring (SPaM) in Labour Workshop

17th March - 19th March 2015

Lyon, France

Acceleration and Deceleration Capacity of Fetal Heart Rate in an In-Vivo Sheep Model

Presenters: Massimo Walter Rivolta, Tamara Stampalija

Research Group

The team is composed by researchers with different **expertise**:

Medical Doctors:

- Enrico Ferrazzi
- Tamara Stampalija
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- Martin Frash

Dept. Of Woman, Mother and Neonate at Buzzi Children's Hospital, Milan, Italy

Dept. of Obstretics-Gynaecology and Neurosciences at Université de Montréal, Montréal, Canada.

Engineers:

- Roberto Sassi
- Massimo W. Rivolta

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Acceleration and Deceleration Capacity of Fetal Heart Rate in an In-Vivo Sheep Model

Massimo W. Rivolta, Tamara Stampalija, Daniela Casati, Bryan S. Richardson, Michael G. Ross, Martin G. Frasch, Axel Bauer, Enrico Ferrazzi, Roberto Sassi

Introduction (1/2)

- Labor exposes the fetus to repetitive transient hypoxic stress

- Identification of hypoxia and pathologic acidemia are crucial

- Fetal heart rate (FHR) analysis (using CTG) is widely used → high sensitivity and low specificity for fetal acidemia

Introduction (2/2)

- Changes in the power spectrum of FHR are associated with fetal hypoxia and acidemia during labo

Phase **R**ectified **S**ignal **A**veraging (Bauer *et al.*):
- PRSA emphasizes quasi-periodicity
- SNR improvement

PRSA also provides:
- Acceleration capacity (AC)
- Deceleration capacity (DC)

Howev

- FHR
  pert

- FHR signals are corrupted by several noisy sources
  (e.g., ventricular ectopic beats, maternal uterine contractions, miss-detected beats and signal losses, etc.)

→ Limits for the applicability of spectral analysis

Objectives & Dataset

Objectives:

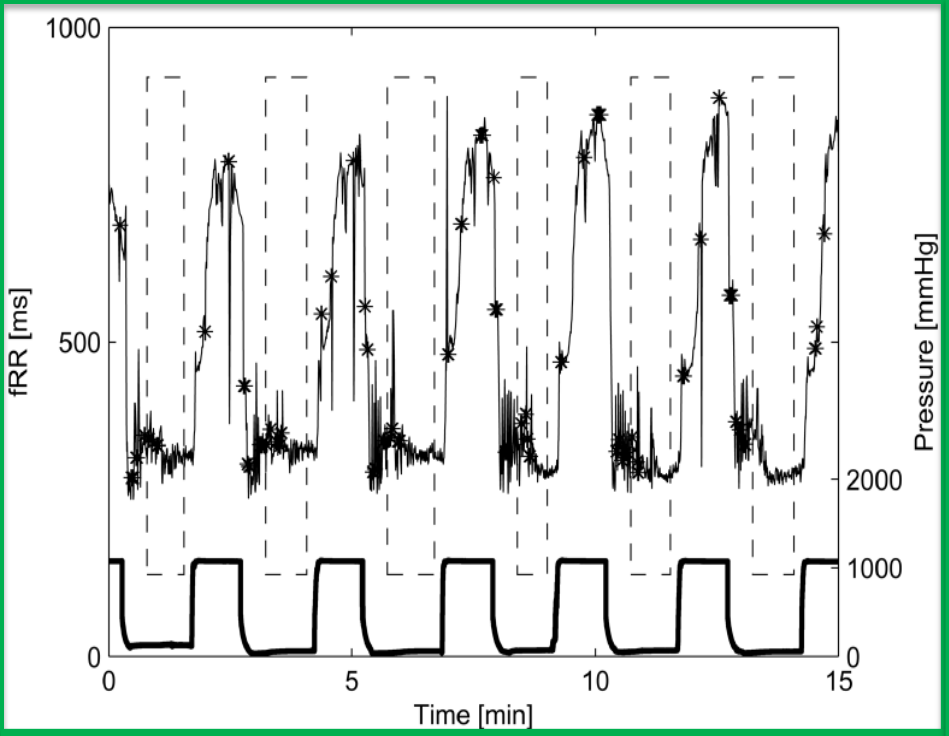
1. Test the sensitivity of AC/DC computed on fRR series to lack of oxygen during labor
2. Evaluate of the influence of the parameters T, s and L on AC/DC

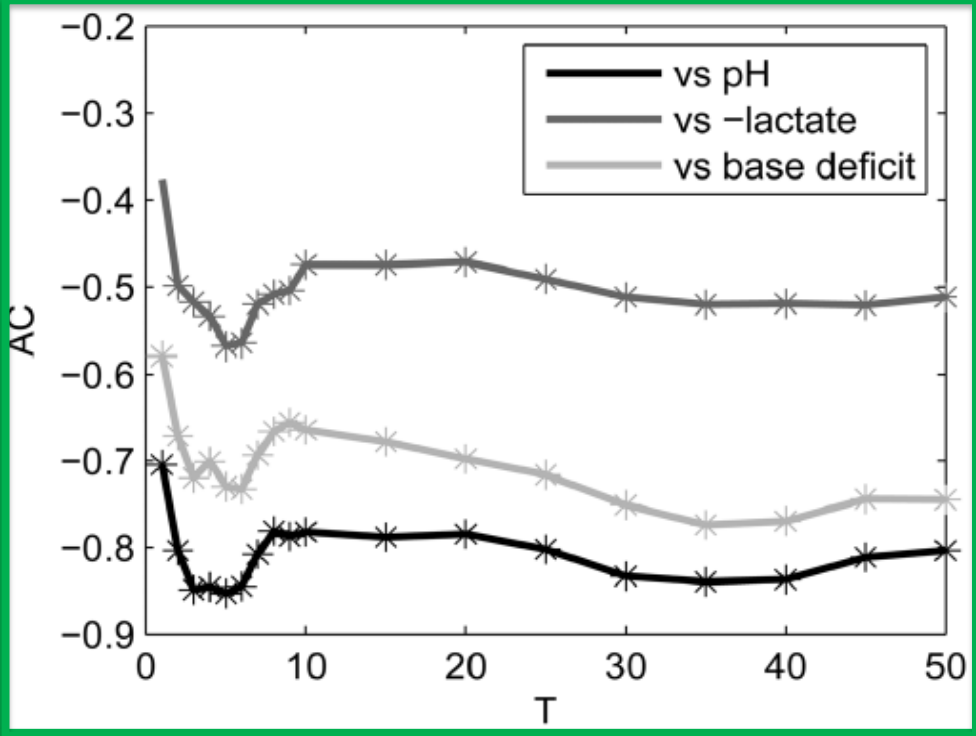
Dataset (retrospectively analyzed)**:**

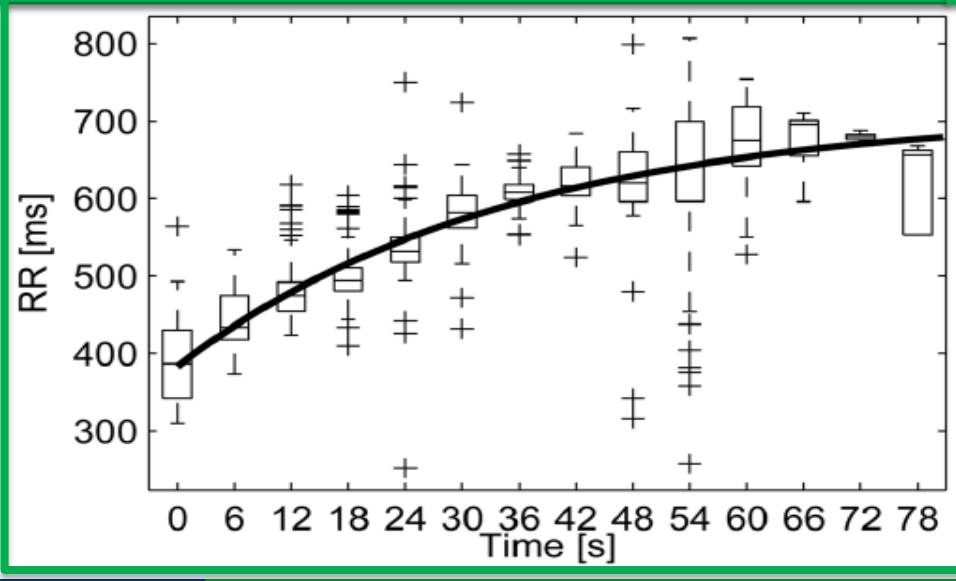
- 7 near-term pregnant sheep model
- Umbilical cord occlusion (UCO) at 4 different strengths (baseline, mild, moderate and severe)
- Biomarkers as pH, base deficit and lactates were collected
- fRR series extracted from fetal ECG

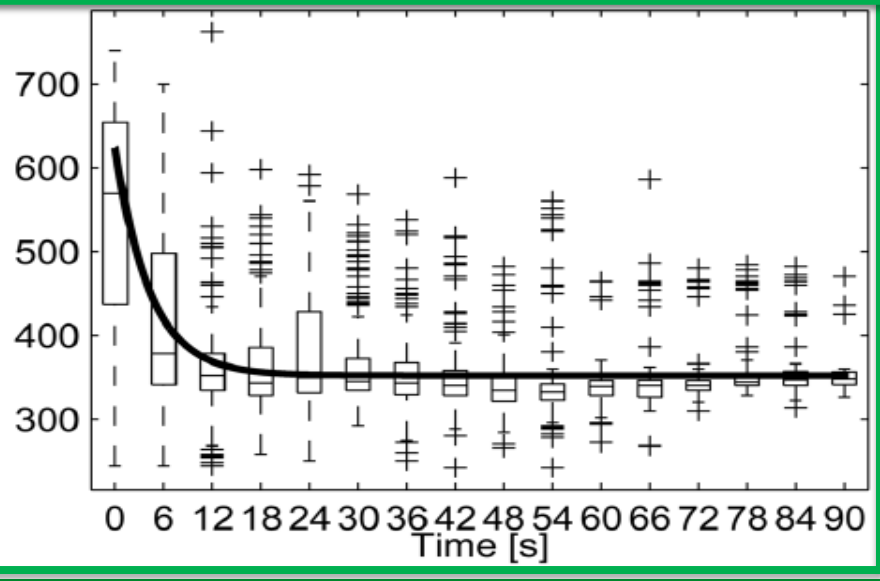
Objective evaluations:

- Computation of the correlation between AC/DC and the biomarkers
- Evaluation of the average rate of FHR response to UCOs


1000
500
0
fRR [ms]
2000
1000
0
Pressure [mmHg]
0
5
10
15
Time [min]


−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
AC
vs pH
vs −lactate
vs base deficit
0
10
20
30
40
50
T


800
700
600
500
400
300
RR [ms]
0 6 12 18 24 30 36 42 48 54 60 66 72 78
Time [s]


700
600
500
400
300
0 6 12 18 24 30 36 42 48 54 60 66 72 78 84 90
Time [s]

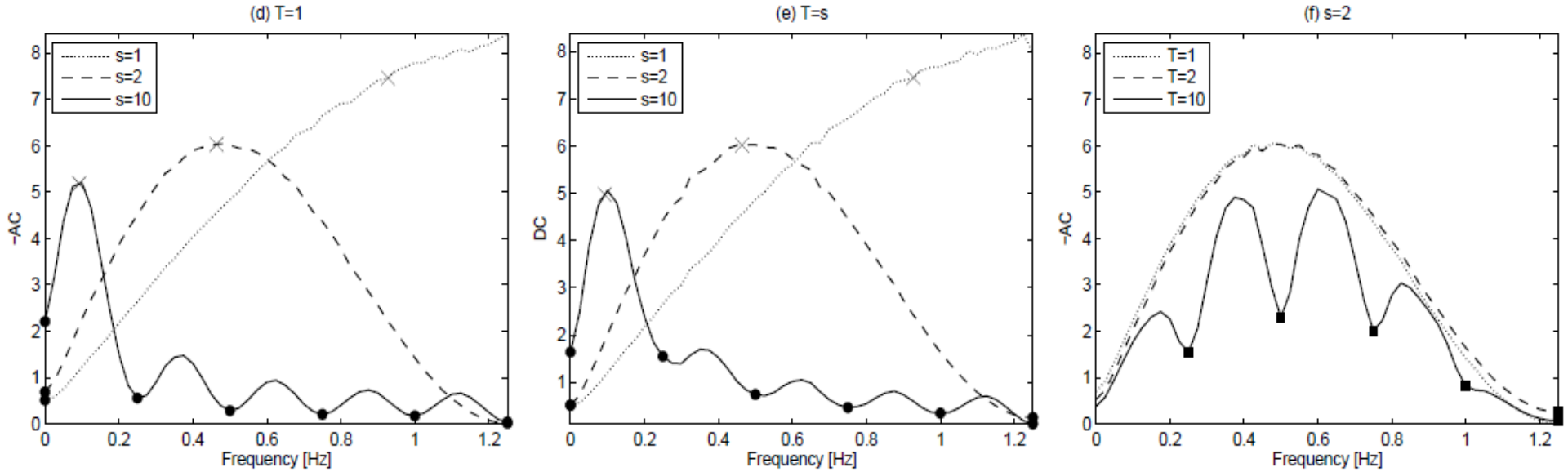
Results & Further Investigations

- FHR accelerations and decelerations have a different change rate
- The rate to return at baseline after UCO is faster
- AC/DC are correlated with biomarkers when T (=s) is in the range 2 to 6
- The higher the lack of oxygen the higher the AC and DC values (acute insult)

Further investigations on synthetic data:

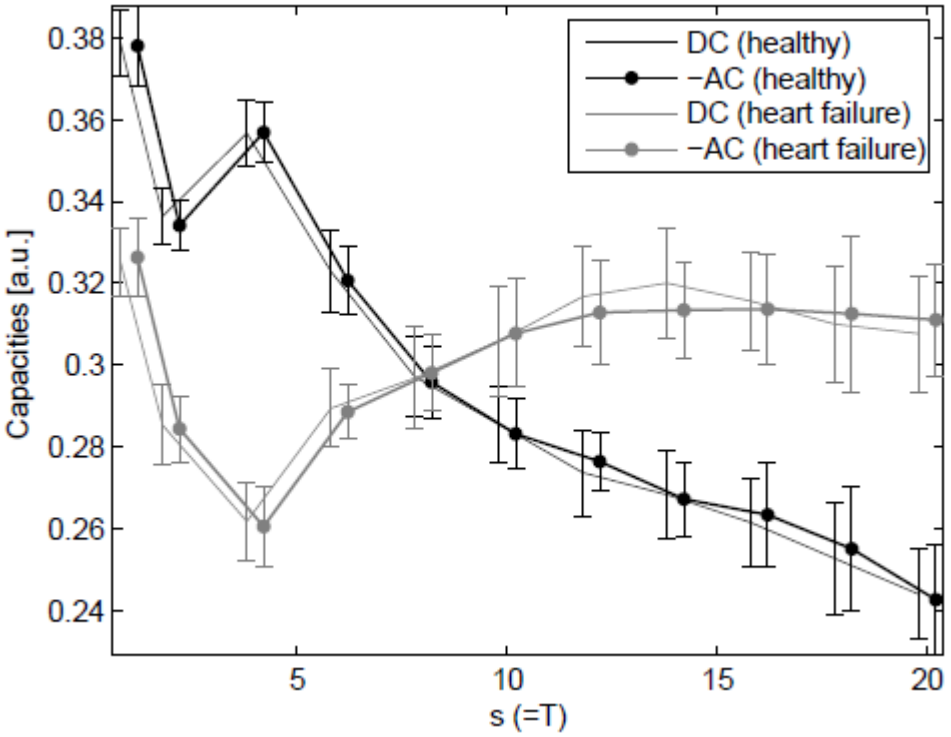
- What's the theoretical effect of varying the parameters s and T on AC and DC? How they related to the well known Spectral Analisys?
- Do AC and DC represent the typical information associated by spectral analysis to symphatetic and vagal activities, respectively?

Simulation results (1/2)



- AC and DC were computed for autoregressive process with a single dominant oscillatory component, which was varied to different frequencies
- T acts as a low pass filter (but is ONLY involved in the selection of anchor points, it does not act directly on PRSA)
- s acts as a high pass filter on the PRSA series (directly)

Simulation results (2/2)



- More realistic scenarios: RR series generated via AR models fitted on a healthy and a heart failure subject (different ANS regulation)
- AC/DC were statistically different between the healthy and the heart failure subject for many T values
- AC and DC are substantially identical for series generated by a single AR model (time-reversal symmetry)

→ AC and DC do not simply represent the same information collected by Spectral Analysis on the symphatetic and vagal activity (they capture lack of time symmetry)

Conclusions

The main results are:

- Robustness of AC and DC to noise on real data
- Correlation of AC/DC with lack of oxygen during labor
- The parameters T and s play as frequency band selectors

Thanks

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