Selected Practical Aspects of Automated FHR Analysis

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v.1.0 TU/E
Latest revision: 19.03.2015

One slide about our lab

Czech Institute of Informatics, Robotics and Cybernetics

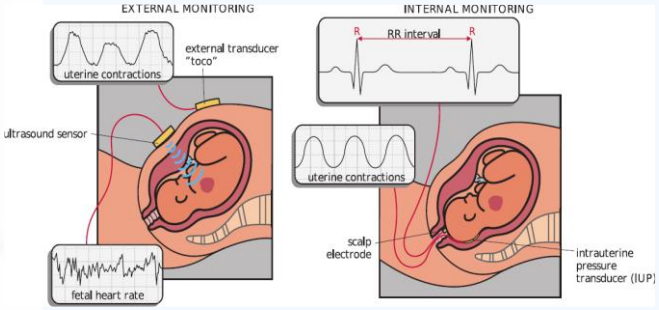
- Cyber-physical systems
- Intelligent systems
- Industrial informatics
- Robotics and machine perception
- Industrial production and automation
- Cognitive systems and neurosciences
- Biomedical and assistive technologies

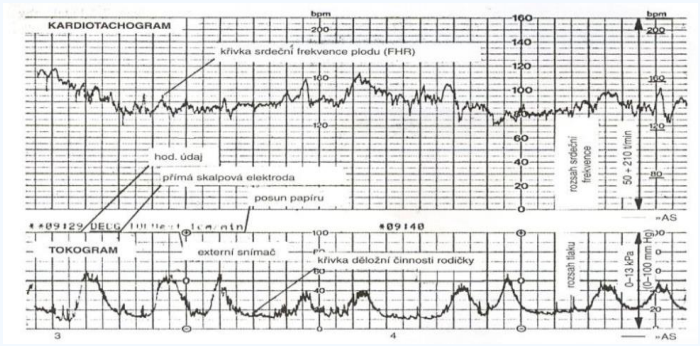
CTG analysis group (http://bio.felk.cvut.cz/ctg)

- **Václav Chudáček, Jiří Spilka** – automated CTG analysis, AI for FHR processing
- Michal Huptych, Miroslav Burša (FEE, CTU) – data collection systems, clinical inf.
- Petr Janků, Lukáš Hruban (FN Brno) – obstetricians at the University hospital in Brno

Context of the work

Intro: Current state of evaluation

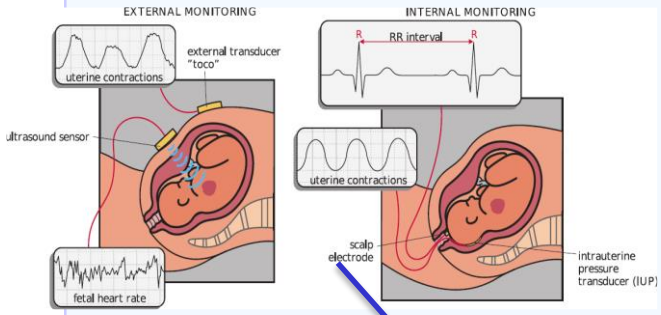


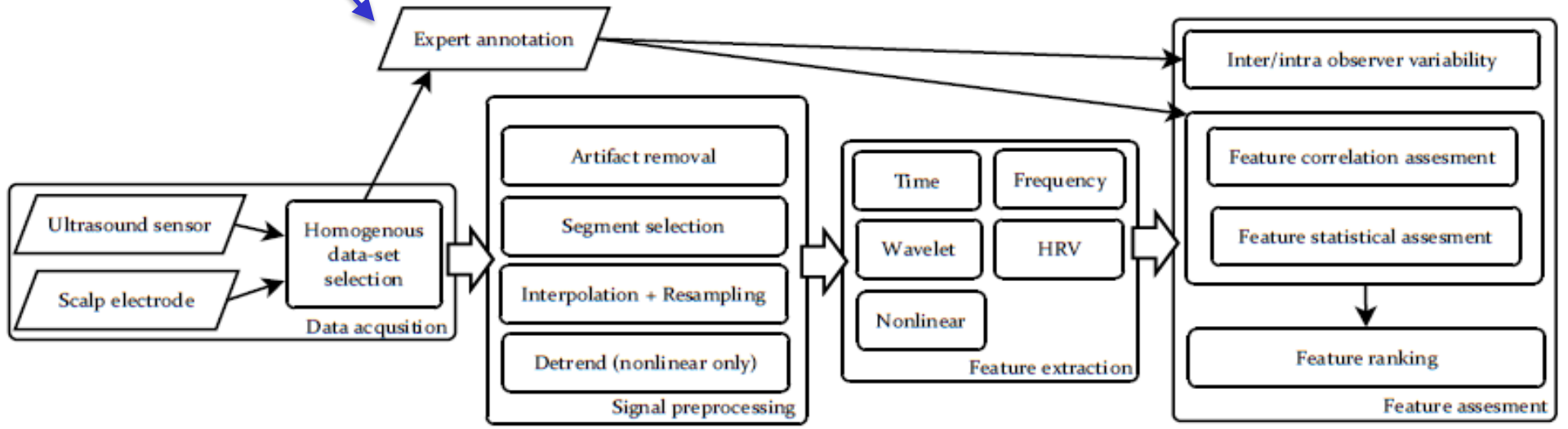


- FHR is measured by US or fECG
- Signs of hypoxia are sought for
- Decision are made based on FHR and clinical data

- Outcomes:
  - Healthy babies
  - Caesarean sections (20-50% in CZ)
  - Pathological pH (1-3%) –> severe cases may result in neurological damage such as cerebral palsy etc.

Intro: Automated analysis?





- Machine representation of FHR is used

Sources of motivation and frustration

"Wisdom comes from experience. Experience is often a result of lack of wisdom."
- Terry Pratchett

General

- Automated analysis?
- Ill defined inputs
  - Databases in general – small, and very difficult to compare
  - CTG segment used for evaluation – how long, how far, which stage
  - Other inputs – e.g. clinical, technical, etc.
- Ill defined outputs
  - What type of outcome do we use as an indicator of CTG/FHR class
    - pH+BDecf (reason: Cerebral palsy – objective/statistical sound outcome measure): not very useful (very few cases)
    - Apgar5 (reason: ? – current CPR techniques are able to get over 7 in 5th minute in most cases): unreliable (subjective, not necessary related to hypoxia)
    - pH alone (reason: it is easy): best (it does not relate to the long-term outcome, about 20% of measurements are wrong, no clear threshold)
    - Expert evaluation (reason: that is how it is done in the hospital): - (large variability, increased defensiveness in evaluation)

Clinical

- Hard to assess real-life CTG evaluation
  - Interventions due to multiple factors
  - CS with normal objective outcome (how often was it necessary?)
  - Low-risk pregnancies not monitored
  - Bad outcomes often related to very low quality or missing recordings
- Guidelines in intrapartum CTG not very good regarding:
  - Clear explanation of reasoning
  - Consistency, Repeatability
  - Reasons for use (cf. history of the CTG introduction)
- Increase of CS without impact on # of hypoxic babies
- Existence of many related confounding factors
- Variability among fetuses (e.g. male vs. female)

Technical

- Majority of works done on static evaluation only
  - One window (usually length < 40min, sleep episodes not considered)
  - Often no prediction (evaluation of full data)
- Limits of technical methods not advertised
  - Ultrasound or STAN recordings – huge difference in terms of quality
  - Some methods need certain length of recording without noise
  - Tocographic data – hardly usable
- Lack of pathological cases
- Preprocessing of the data is feature-dependant
- Almost none of the other information available in the hospital is not considered

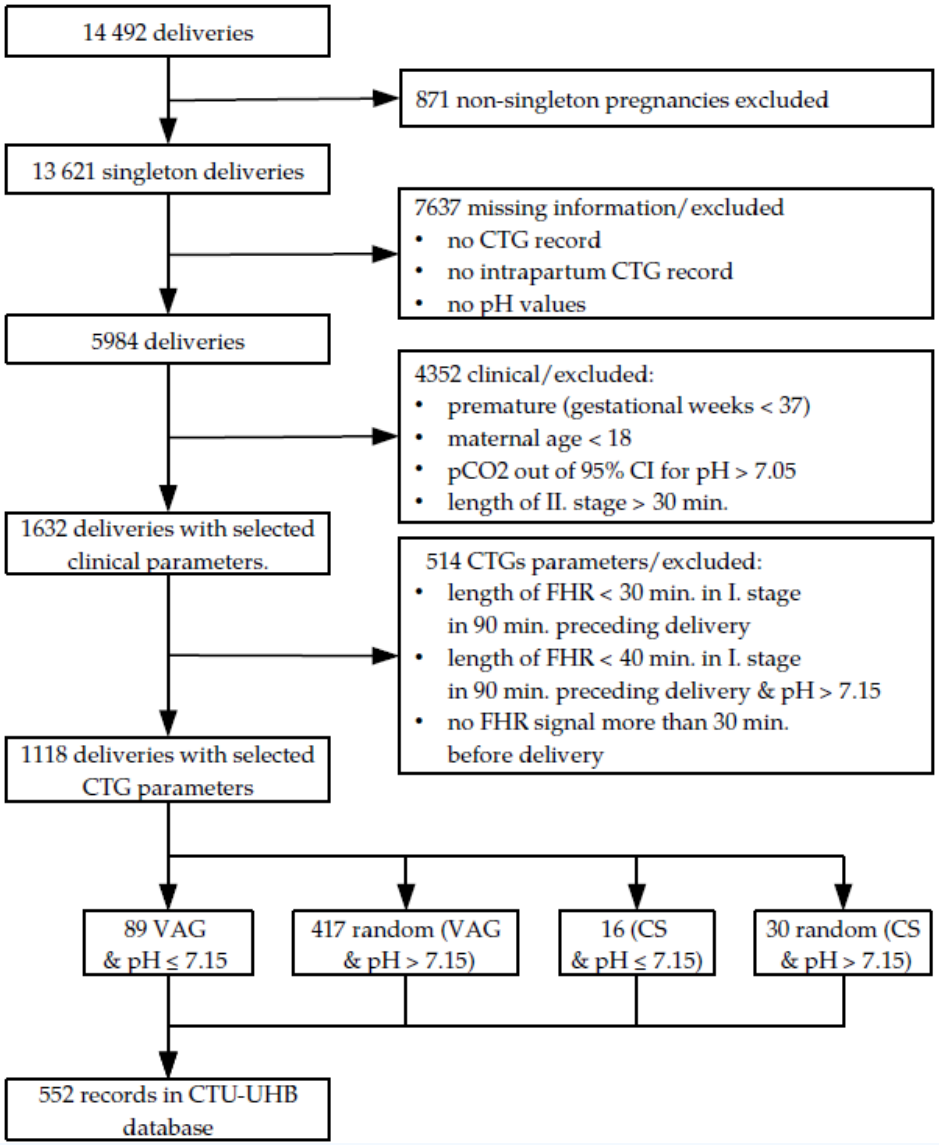
Pieces of our work

(addressing in part the general problems above)

Database

CTU-UHB cardiotocograpic database

CTU-UHB database

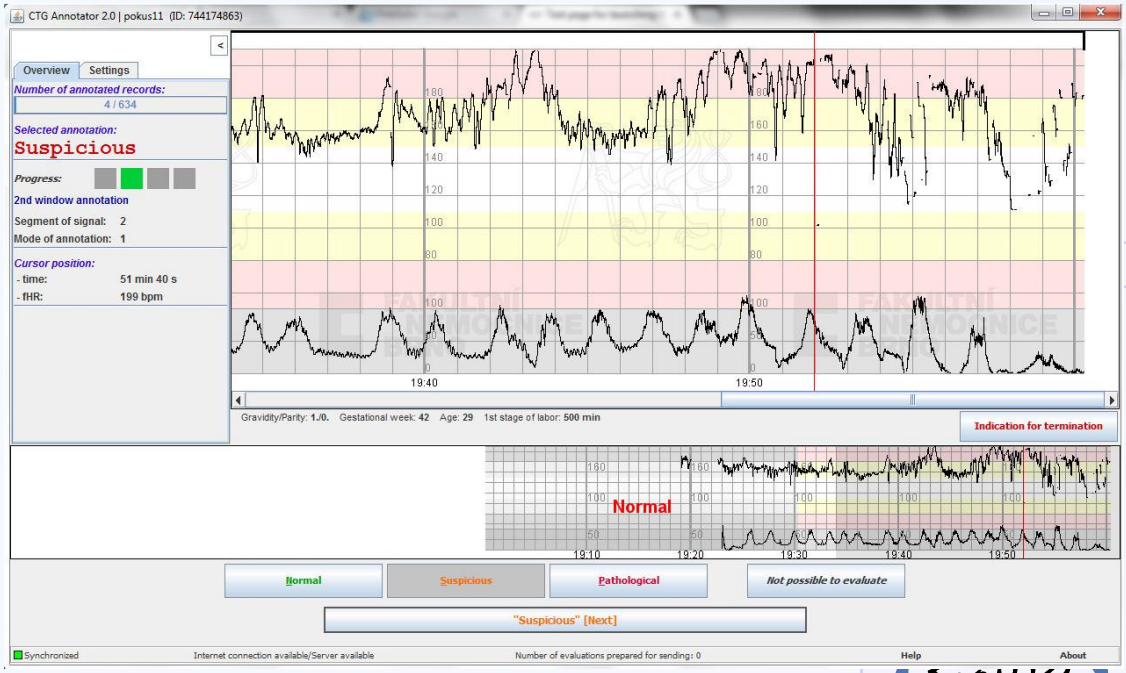


- Collaboration with Ob&Gyn clinic in Brno
- USG and STAN data
- Only mature fetuses
- First open-access CTG database
- Common ground for algorithm comparison
- Available at Physionet

Chudáček et al. Open access intrapartum CTG database, BMC Pregnancy and Childbirth, 2014

Outcome measures for CTU-UHB

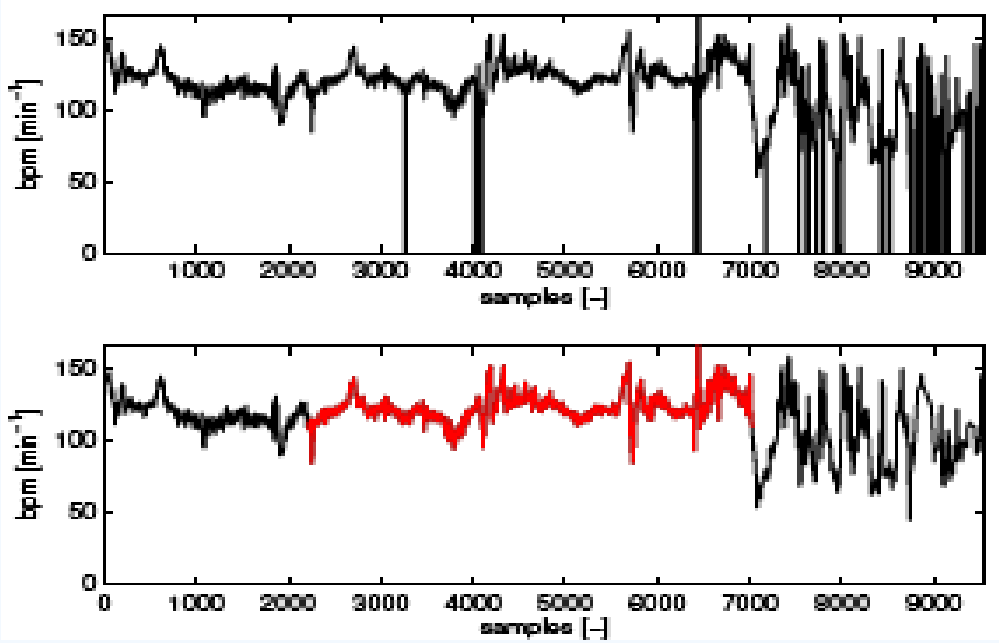
- Subjective – expert evaluation
  - Annotations acquired via CTG Annotator
  - Majority voting, Latent class model based on 9 experts
  - Apgar score
- Objective
  - pH, pCO_2, BDecf, BE
- Mixture
  - Majority, LCMs



FHR Signal processing

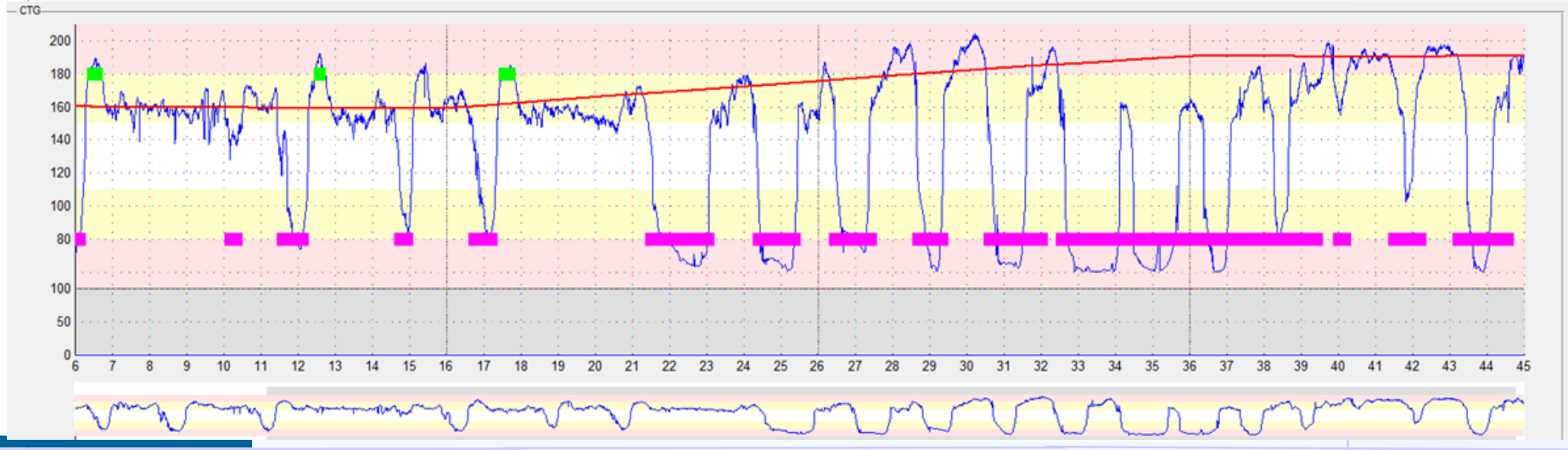
Signal pre-processing

- Gap & Artefact detection
  - Gap removal (< 15s)
  - Artefact rejection
  - Bernardes inspired thresholds
  - Adapted to 4Hz from beat to beat



FIGO features

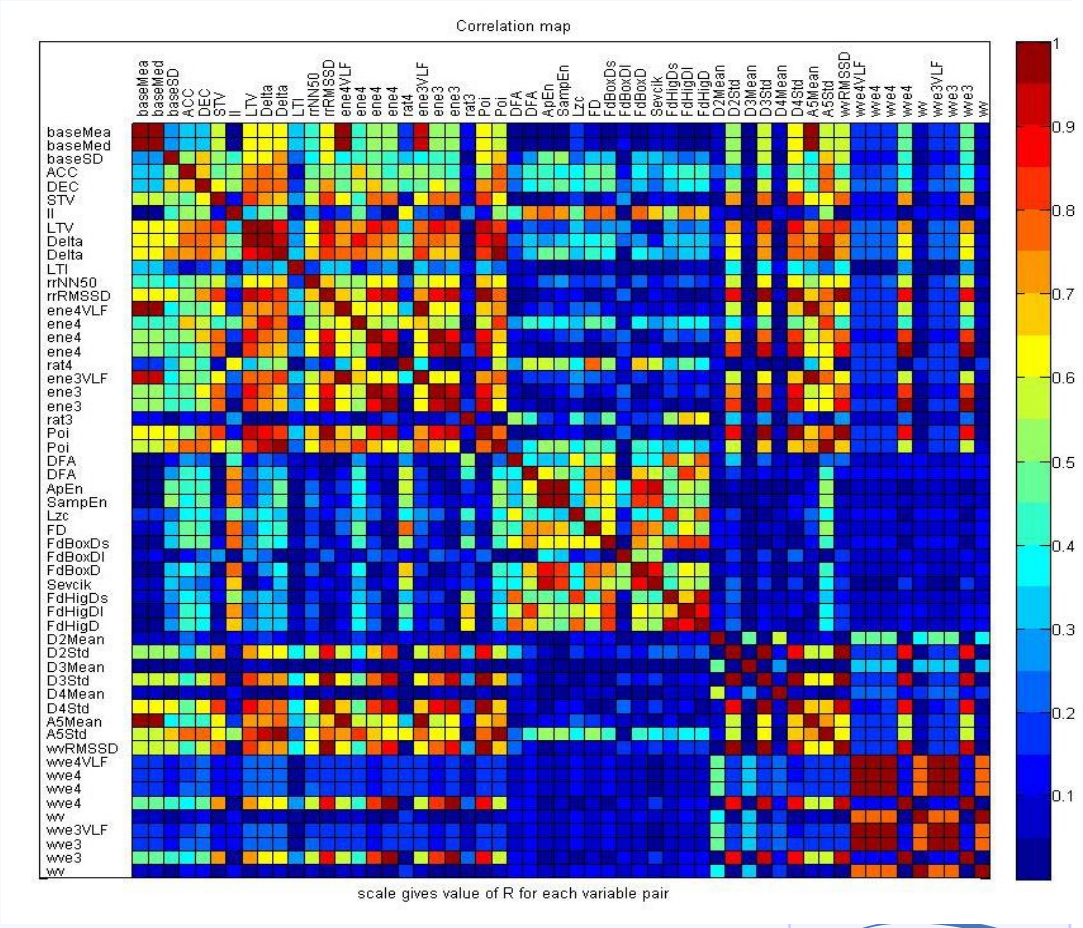
- Official obstetrics guidelines for CTG evaluation
- Circular definition of Acceleration/Deceleration
- Baseline detection based on histogram assessment



Features

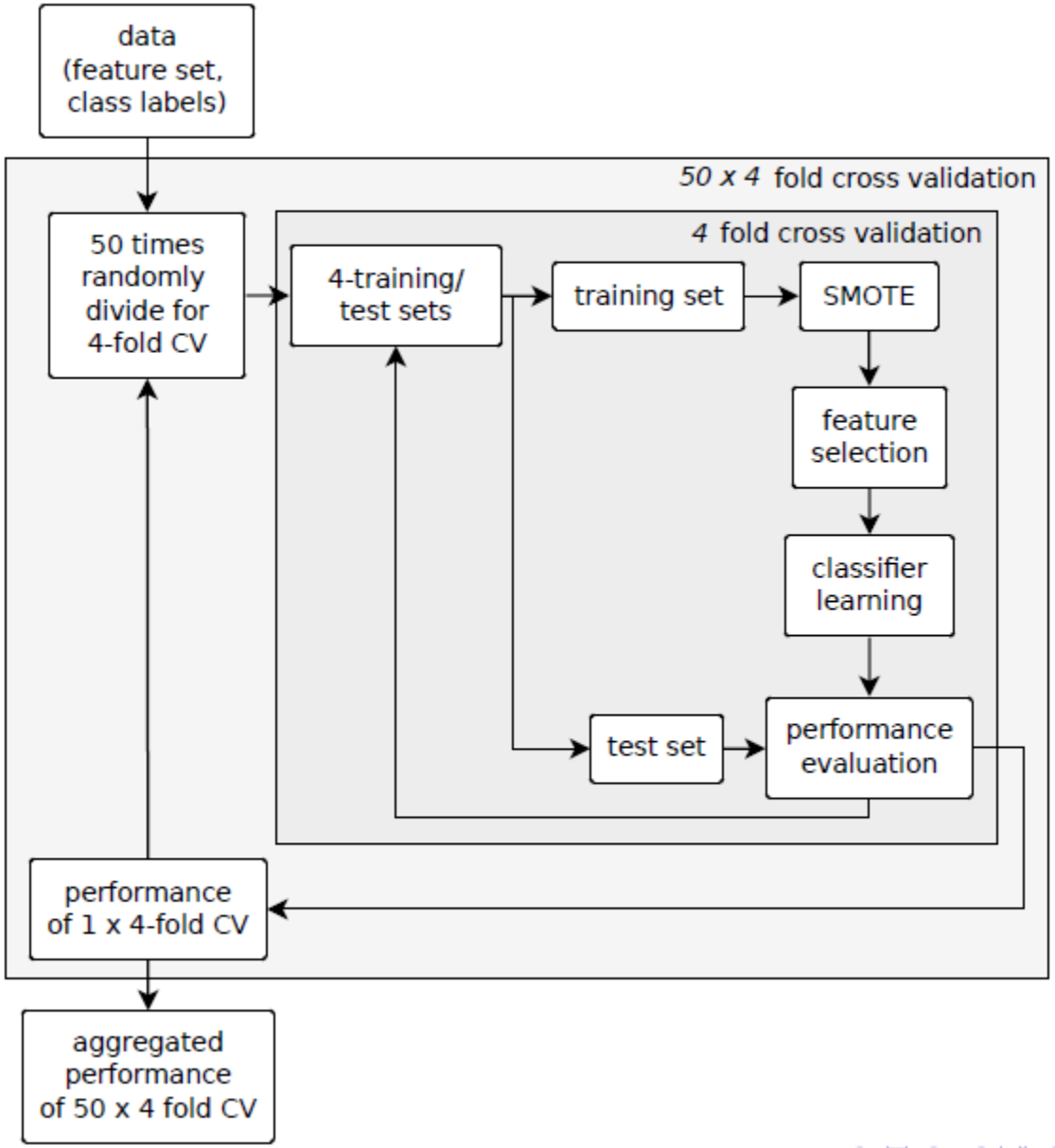
- Morphological features (FIGO) (5)
- Time-domain (6)
- Freq.-domain (13)
- HRV (4)
- Wavelet (15)
- Nonlinear (12)

- In total 55 features



Classification

Classification

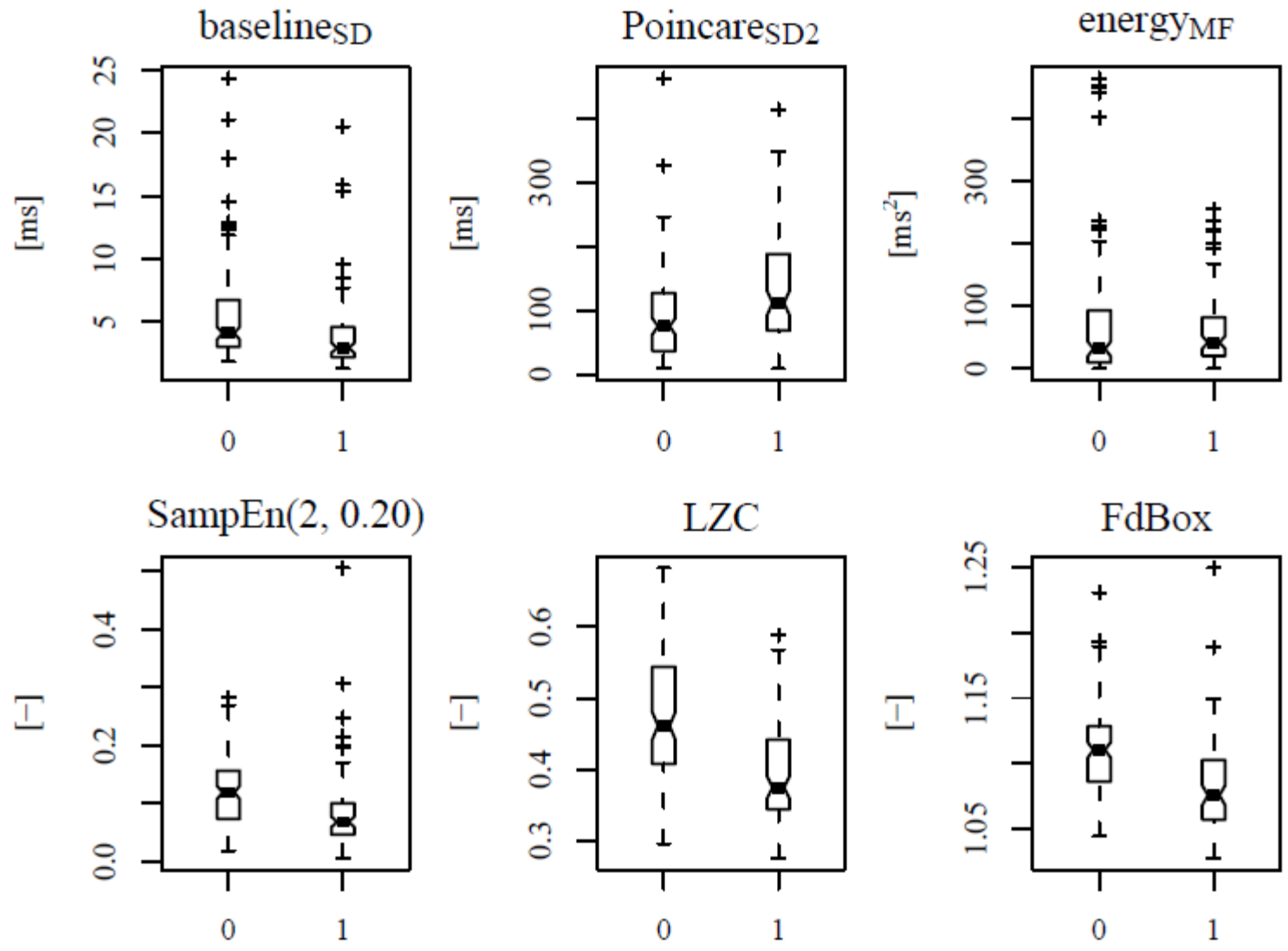


Classification (3)

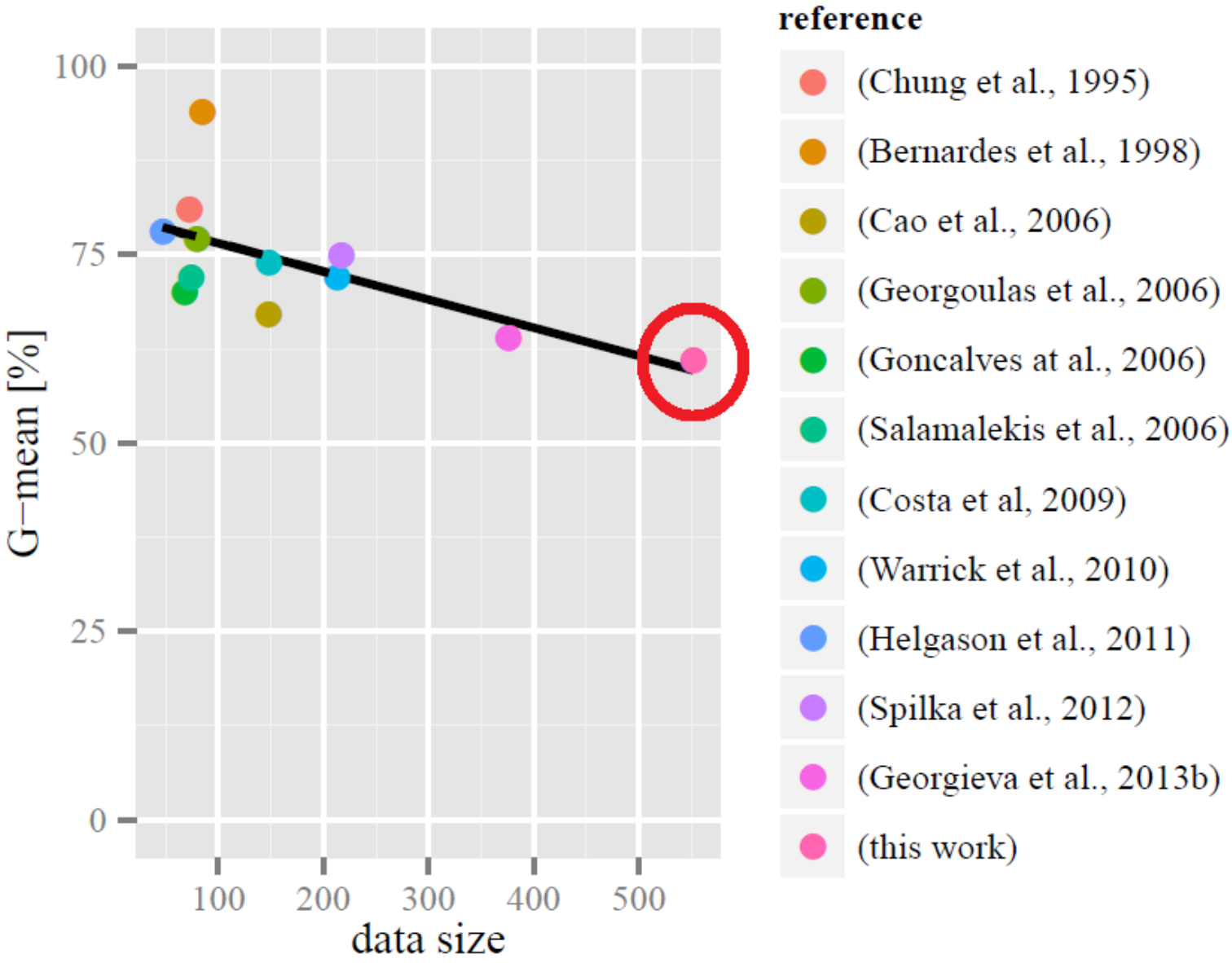
- Selected features
  - Low spectral bands
  - Decelerations
  - Poincare plot SD2

	Naive Bayes	SVM
sensitivity	60 (53–67)	53 (47–60)
specificity	75 (72–77)	78 (75–80)
precision	23 (20–25)	23 (20–26)
F-measure	33 (29–36)	33 (28–37)

Results – obj. annotation (2)



Comparison of results



Shared database of path. cases

- We need a common ground to compare
- Getting the data is cumbersome and unrewarding job
- But most hospitals now have electronic CTG records
- There is no „perfect database“ yet

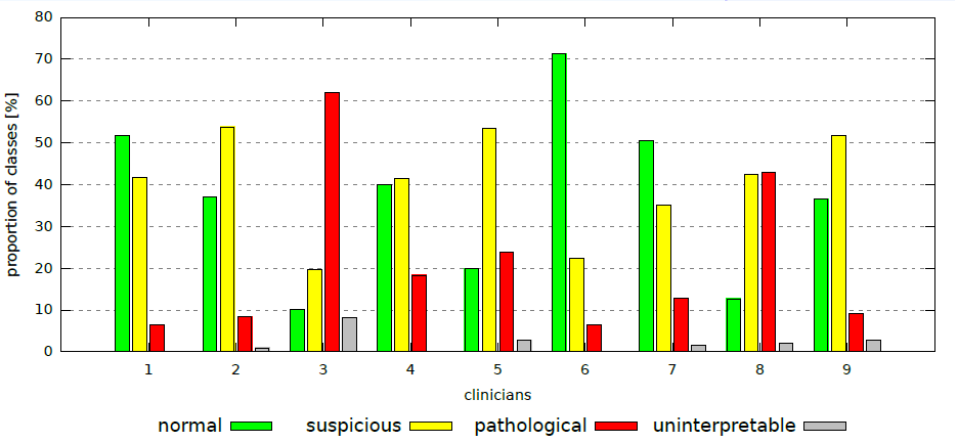
- Experience shows that joining different approaches brings improvement across the board (kaggle.com)
- Individual phase followed by joint effort phase
- Could we build one together?

Outcome measures

Man-machine comparison

Clinical evaluation vs. pH

- Real-life CTG evaluation comparison vs. pH
- Variability
- Overall poor sensitivity
- Sensitivity drops Step3 -> Step4
- Why?



Annotation	Objective	Step 1		Step 2		Step 3		Step 4	
		SE	SP	SE	SP	SE	SP	SE	SP
majority voting	pH ≤ 7.05	29 (12-54)	92 (88-95)	41 (20-65)	86 (81-90)	**86 (45-99)**	**86 (79-90)**	**38 (18-63)**	**94 (91-97)**
	BD ≥ 12	30 (9-62)	92 (87-95)	50 (22-78)	86 (81-90)	**50 (3-94)**	**83 (76-88)**	**22 (4-56)**	**93 (89-96)**
	Apgar < 7	50 (10-90)	91 (87-94)	50 (10-90)	85 (80-89)	**100 (5-100)**	**83 (76-89)**	**75 (25-99)**	**93 (90-96)**
hospital records	pH ≤ 7.05	41 (20-65)	94 (91-97)	41 (20-65)	94 (90-97)	**40 (15-71)**	**93 (88-96)**	N/A	N/A
	BD ≥ 12	60 (29-85)	94 (91-97)	60 (29-85)	94 (90-96)	**25 (1-75)**	**92 (87-95)**	N/A	N/A
	Apgar < 7	0 (0-53)	92 (88-95)	0 (0-53)	92 (87-95)	**33 (2-86)**	**92 (87-95)**	N/A	N/A

Hruban et al. Agreement on CTG intrapartum recordings between expert-obstetricians, J. of Eval. in Clinical Practice , 2015

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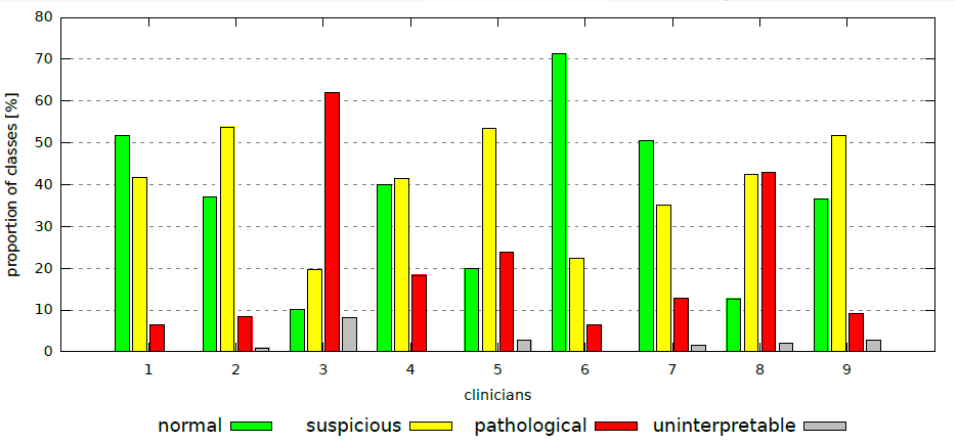

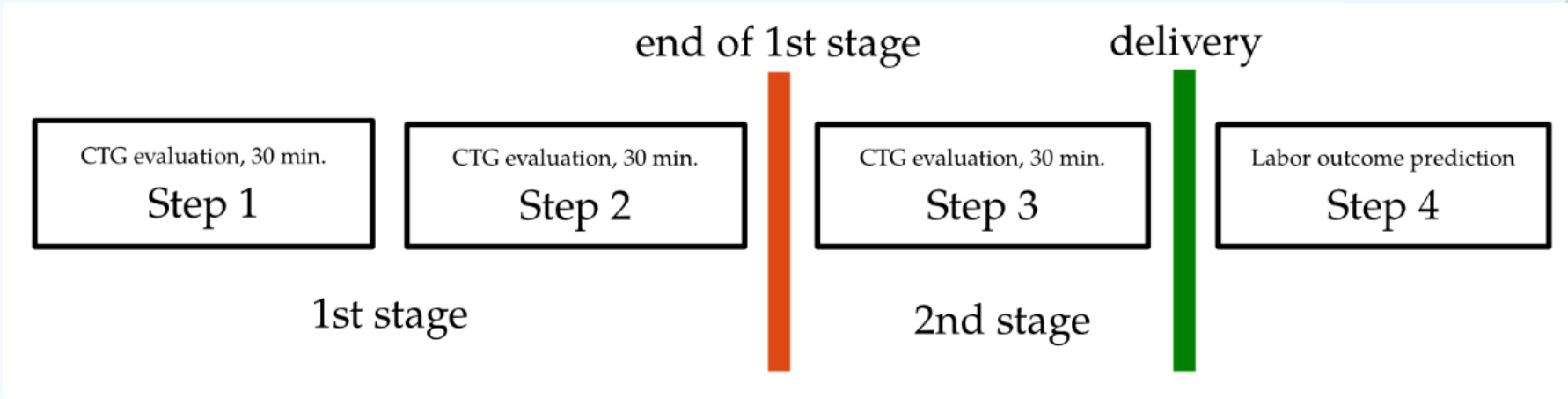

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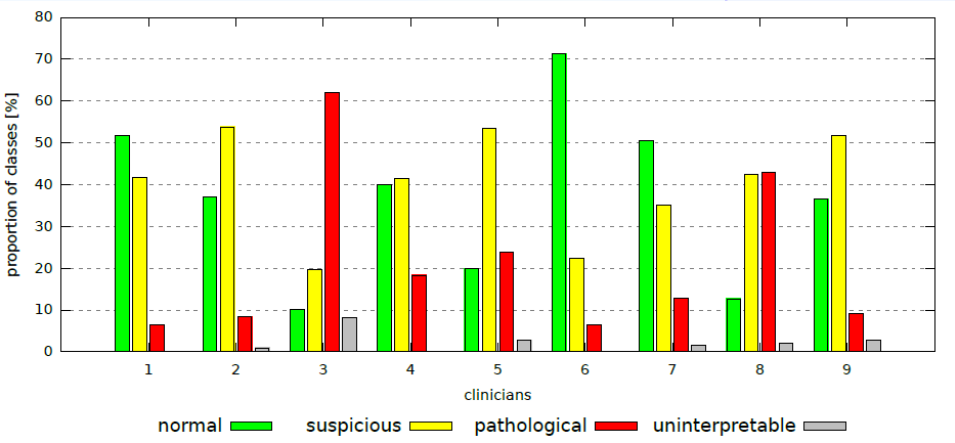

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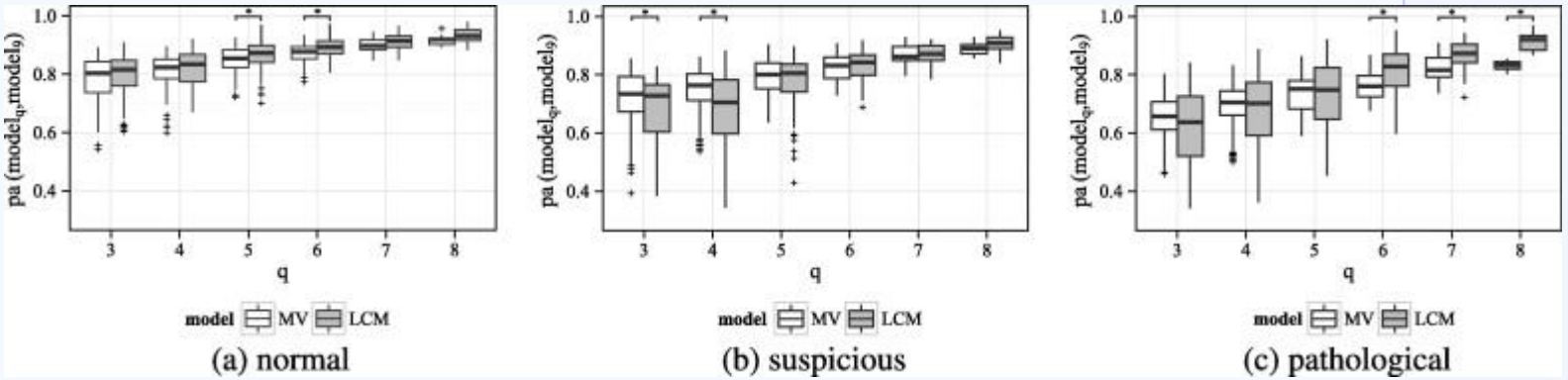
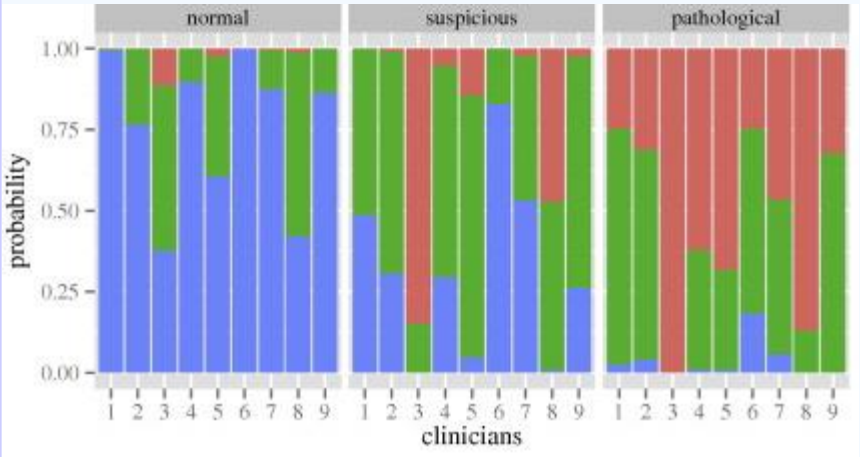
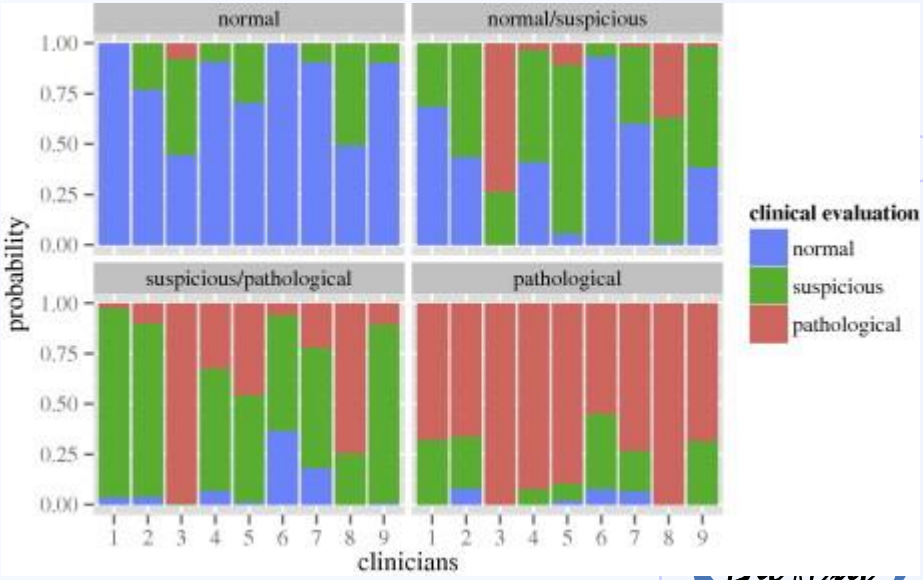
Latent class analysis

- The latent class analysis (LCA) is used to estimate the true (unknown/hidden) evaluation of CTG and to infer weights of individual clinicians' evaluation – the latent class model (LCM).
- The LCM considers clinical evaluation as a finite mixture of multinomial distributions.
- Finite mixture models have fixed number of parameters and the standard method to estimate these parameters is expectation maximization (EM) algorithm.

Latent class models







Spilka et al. Analysis of obstetricians' decision making on CTG recordings, J. of Biomed. Informatics, 2014

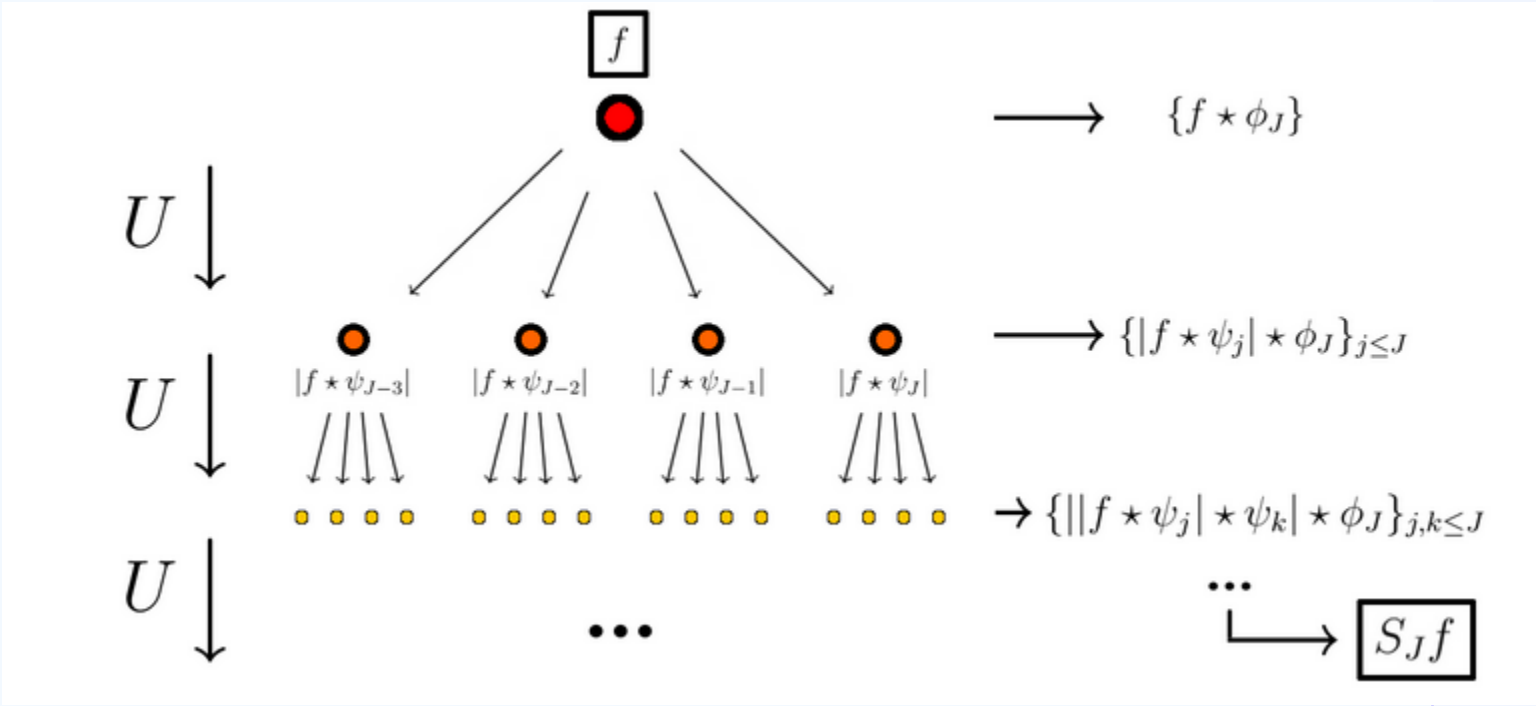
Case studies – different experiments / projects in the field of CTG processing

"Case study " 1:
Scattering transformation

(with
Patrice Abry@ENSL,
Stephane Mallat@ENS)

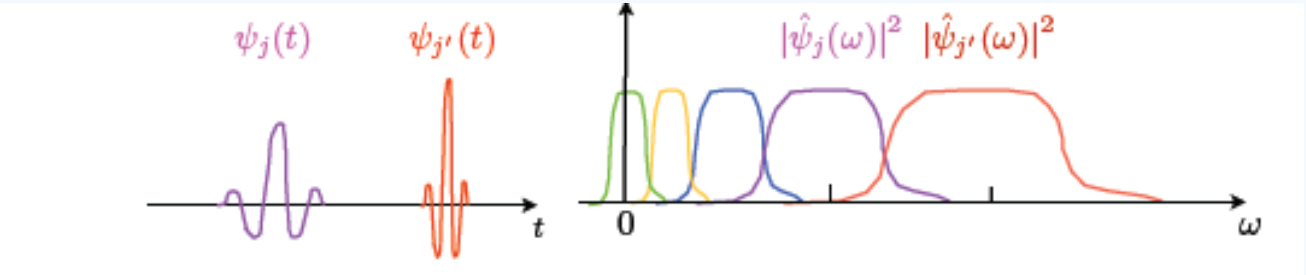
Scattering transform

- Introduced by S. Mallat (http://www.di.ens.fr/data/scattering/)



Scattering transform (2)

- Wavelet transform

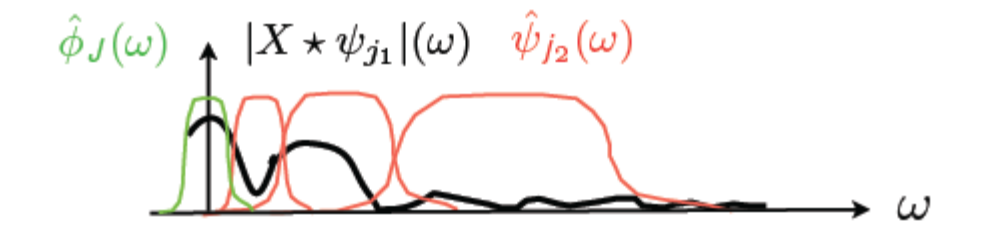


- Complex mother wavelet $\psi(t)$
- Dilated and translated wavelets $\psi_{j,k}(t) = 2^{-j}\psi(2^{-j}(t-k))$
- Wavelet coefficients $X \star \psi_{j,k}$
- First-order coefs: Local time averages of abs. value of wavelet coefs.

$$SX(j,k) = \mathbb{E}\{|X \star \psi_j|\} \approx N^{-1} \sum_{l=k}^{k+N} |X \star \psi_{j,l}|$$

Scattering Transform (3)

- Second order -> beyond Wavelets



- Wavelet transform of absolute values of wavelet coefs.

$$SX(j_1, j_2) = \mathbb{E}\{||X \star \psi_{j_1}| \star \psi_{j_2}|\} \approx N^{-1} \sum_{t=1}^{N} ||X \star \psi_{j_1}| \star \psi_{j_2}(t)|$$

- 2nd order renormalized by the first

$$\tilde{S}X(j_1, j_2) = \frac{SX(j_1, j_2)}{SX(j_1)} \approx \frac{\sum_{t=1}^{2^J} ||X \star \psi_{j_1}| \star \psi_{j_2}(t)|}{\sum_{t=1}^{2^J} |X \star \psi_{j_1}(t)|}$$

- Nonlinear transform:
  - Goes beyond wavelet
  - Explores dependencies beyond correlation (or spectrum)

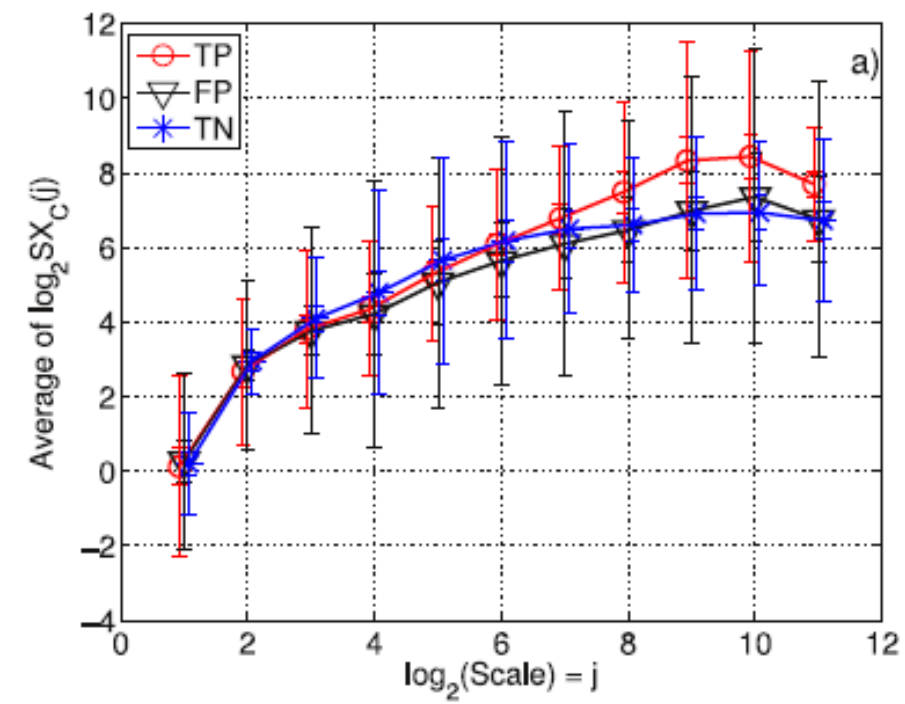
Relation scattering - scaling

- Relation between scattering and scaling $SX(j,k) \sim 2^{jH}$
- H – Hurst exponent
- $z(j_1)$ – scaling exponents that may depart from H

$$\widetilde{S}X(j_1,j_2) \sim 2^{(j_1-j_2)z(j_1)}$$

Fractal Dynamics of FHR

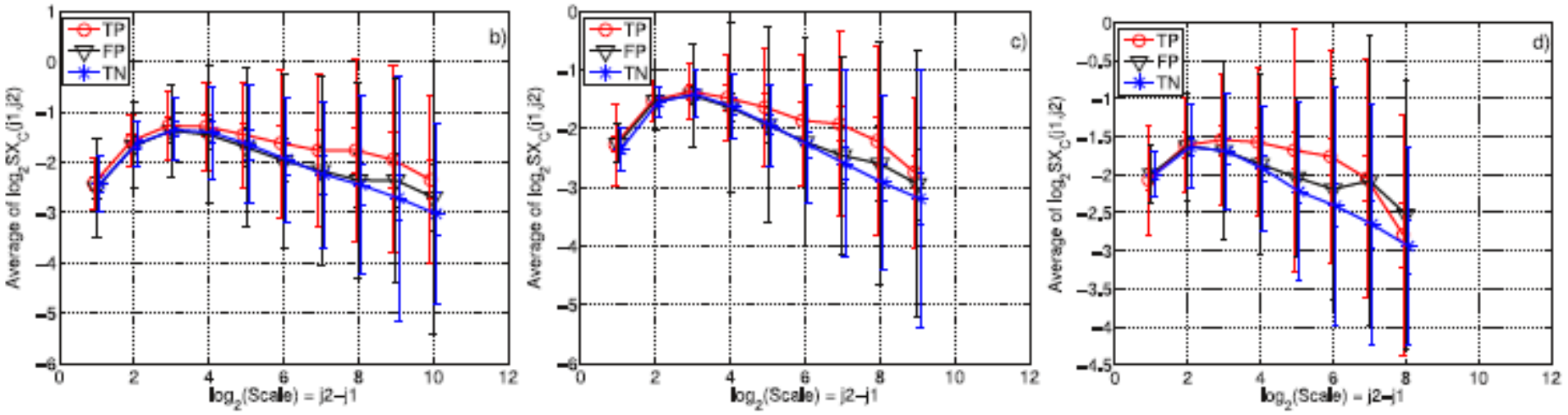
- First order



- Fractal behaviour:
  - Time scales ranging from $4s < a = 2^j < 60s$

Fractal Dynamics of FHR (2)

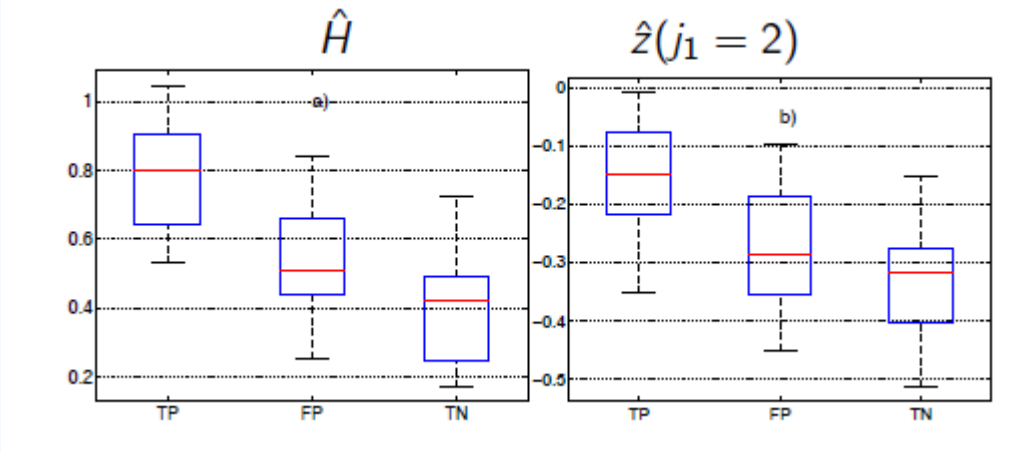
- Second order for j_1= 1, 2, 3.



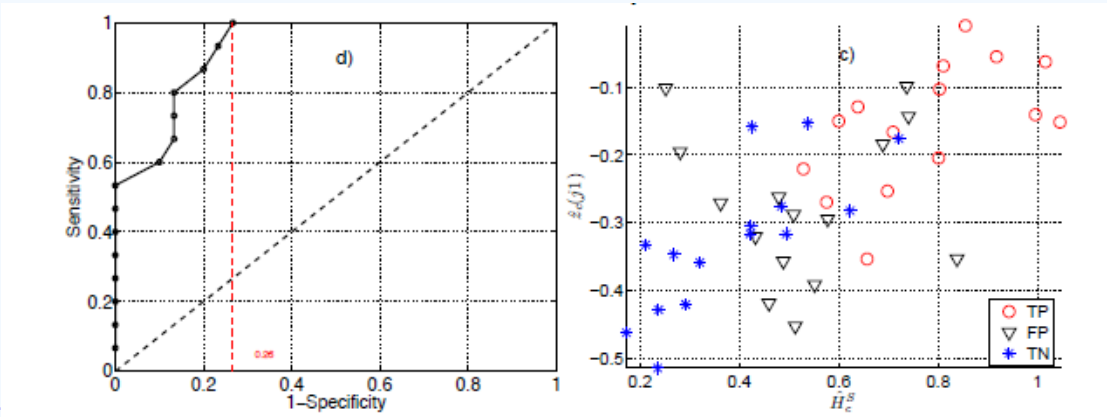
- Fractal behaviour:
  - Time scales ranging from 4s < a = 2^j < 60s

Results

- Discrimination power on SDB (HFME Lyon)



- Performance outcome



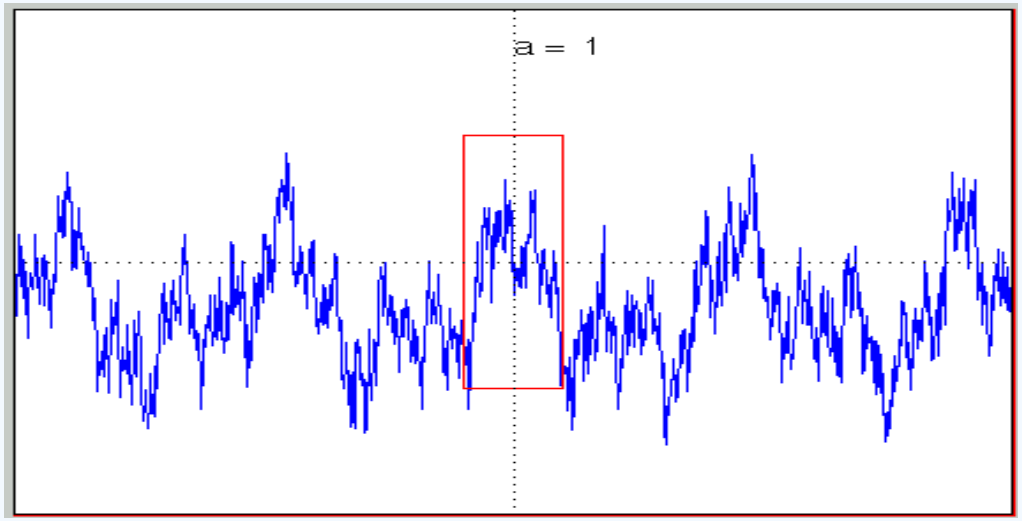
"Case study " 2:
Scaling properties of FHR

(with
Patrice Abry@ENS)

Temporal dynamics

- Classical measures
  - STV – scale of a = 3.75s (antepartum)
  - LTV – scale of a = 60s (intrapartum)
- Why to limit ourselves to these arbitrary intervals?

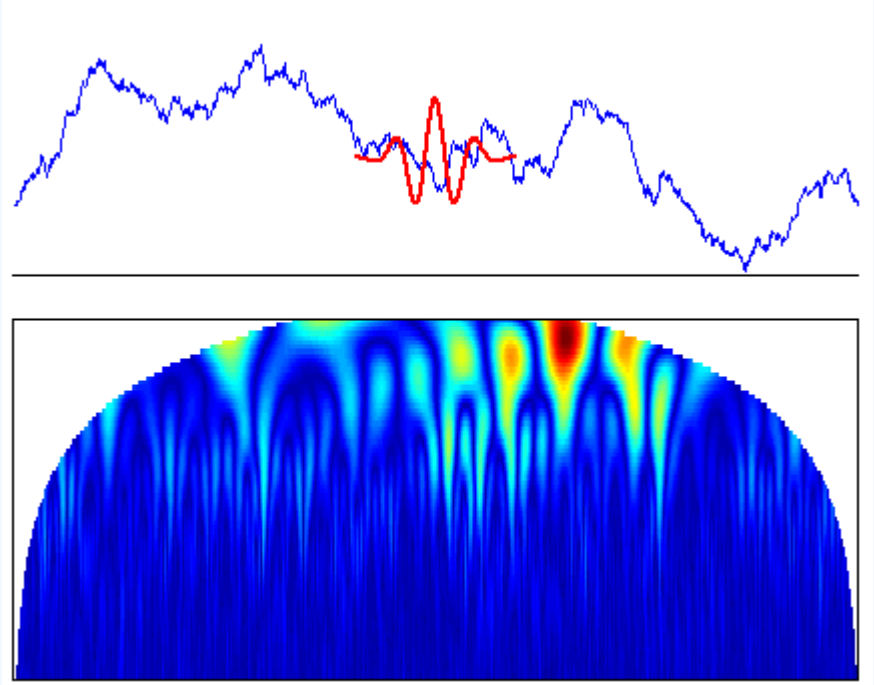
Properties of FHR



"Spectrum" : $\Gamma_X(f) \sim C|f|^{-(2H-1)}, \quad |f| \to 0$

Continuous Wavelet Transform

$$X(t) \rightarrow T_x(a,t) = \langle \frac{1}{a}\psi\left(\frac{u-t}{a}\right) | X \rangle$$



- Joint time and frequency energy content

Fractal exponents

- Oscilations -> wavelet coefs.
- Variability is not characterized by actual value
- Scale invariance is measured instead -> H
- The H computed via wavelet spectrum provides
  - Variability at all scales jointly (not just STV/LTV scale)
  - Gives information of temporal dynamic of HF/LF ratio
- In practice:

$\Rightarrow$ Hurst exponent:

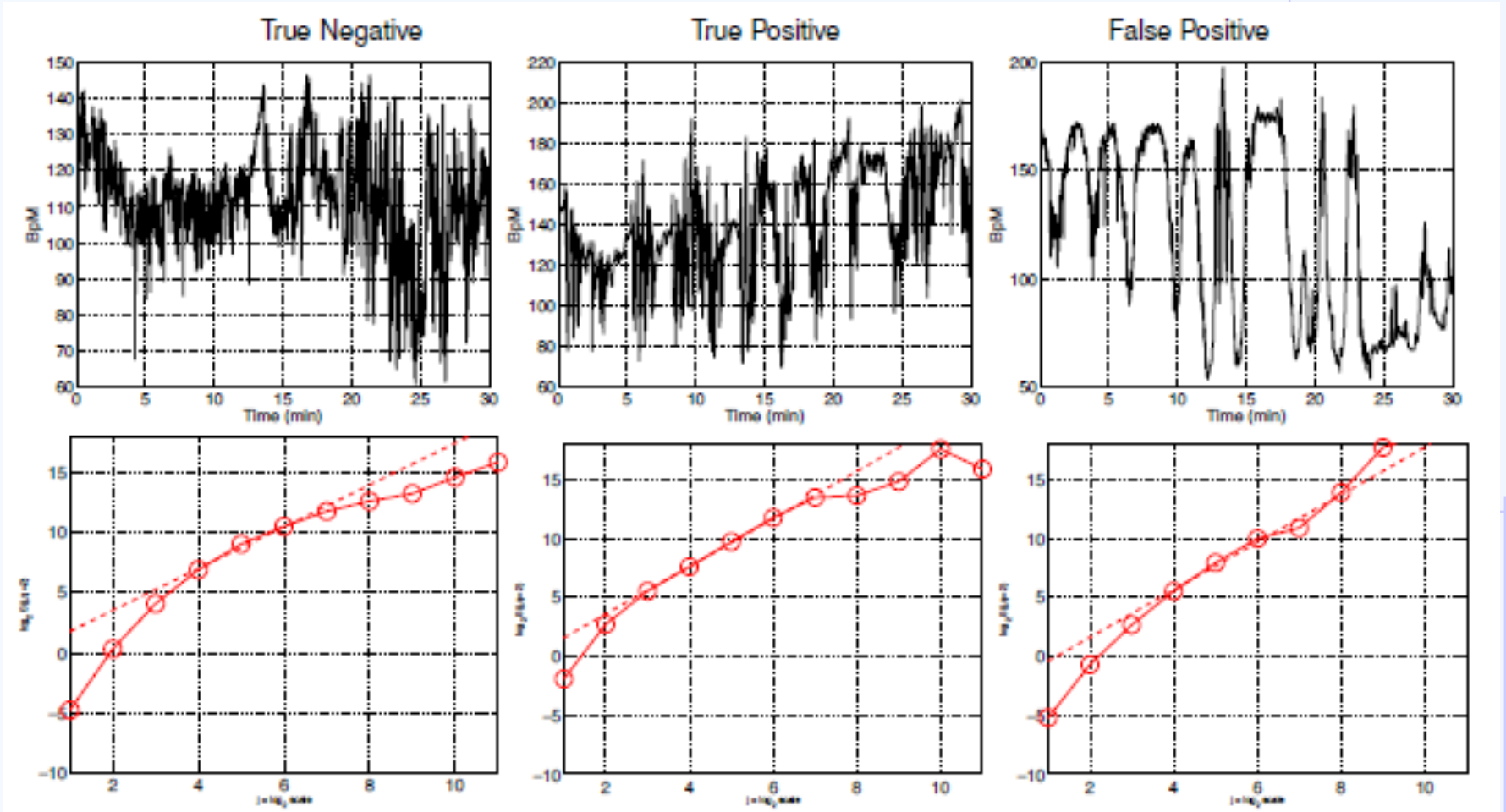
Time averages: $S(a) = 1/n_a \sum_k T_X(a,k)^2$

$\Rightarrow$ Global regularity exponent:

Scale invariance: $|T_X(a,t)| \simeq c(t)a^{h(t)}$

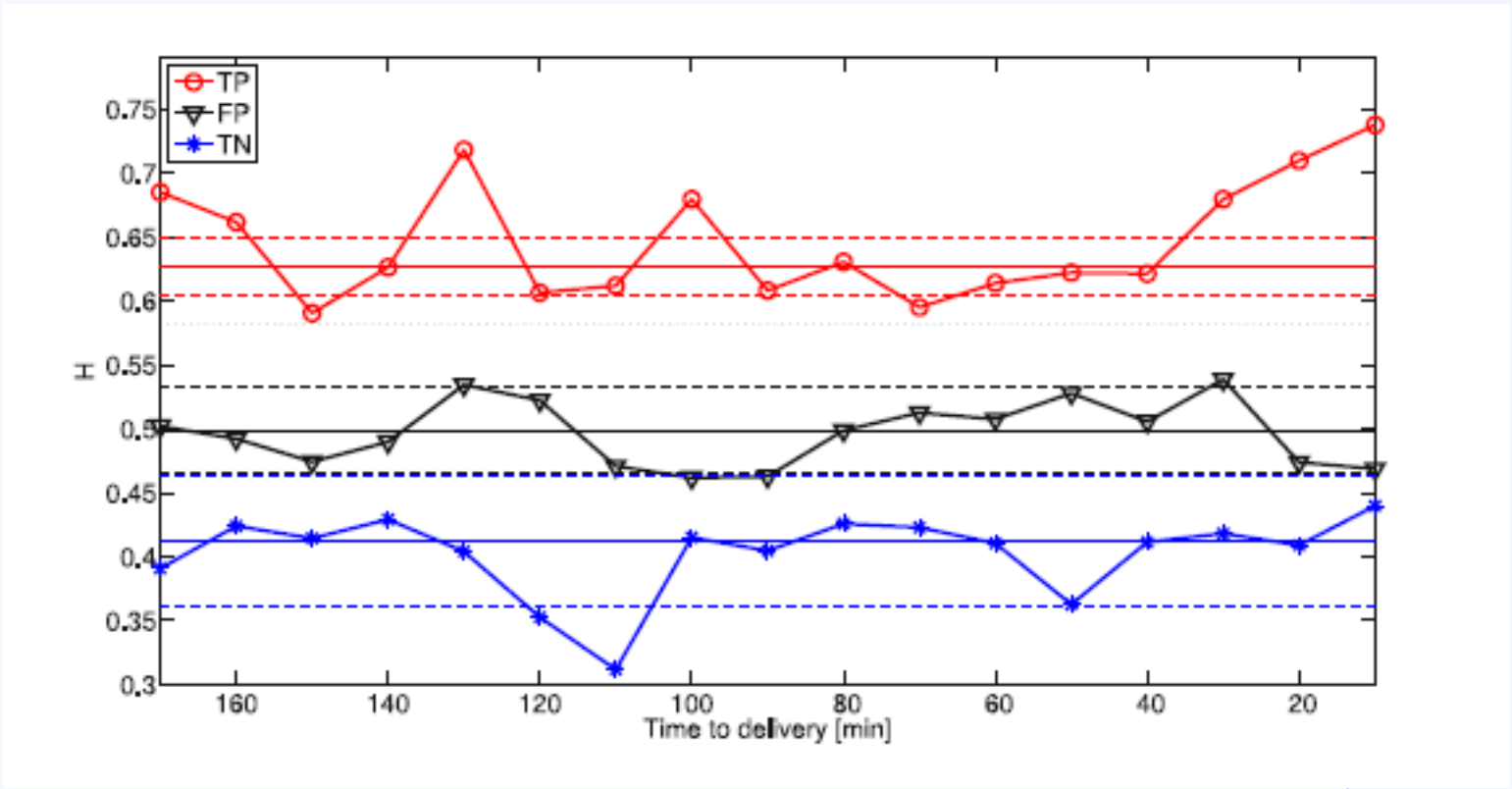
Global regularity: $h_{min} = min_t(h(t))$

Scale invariance in FHR

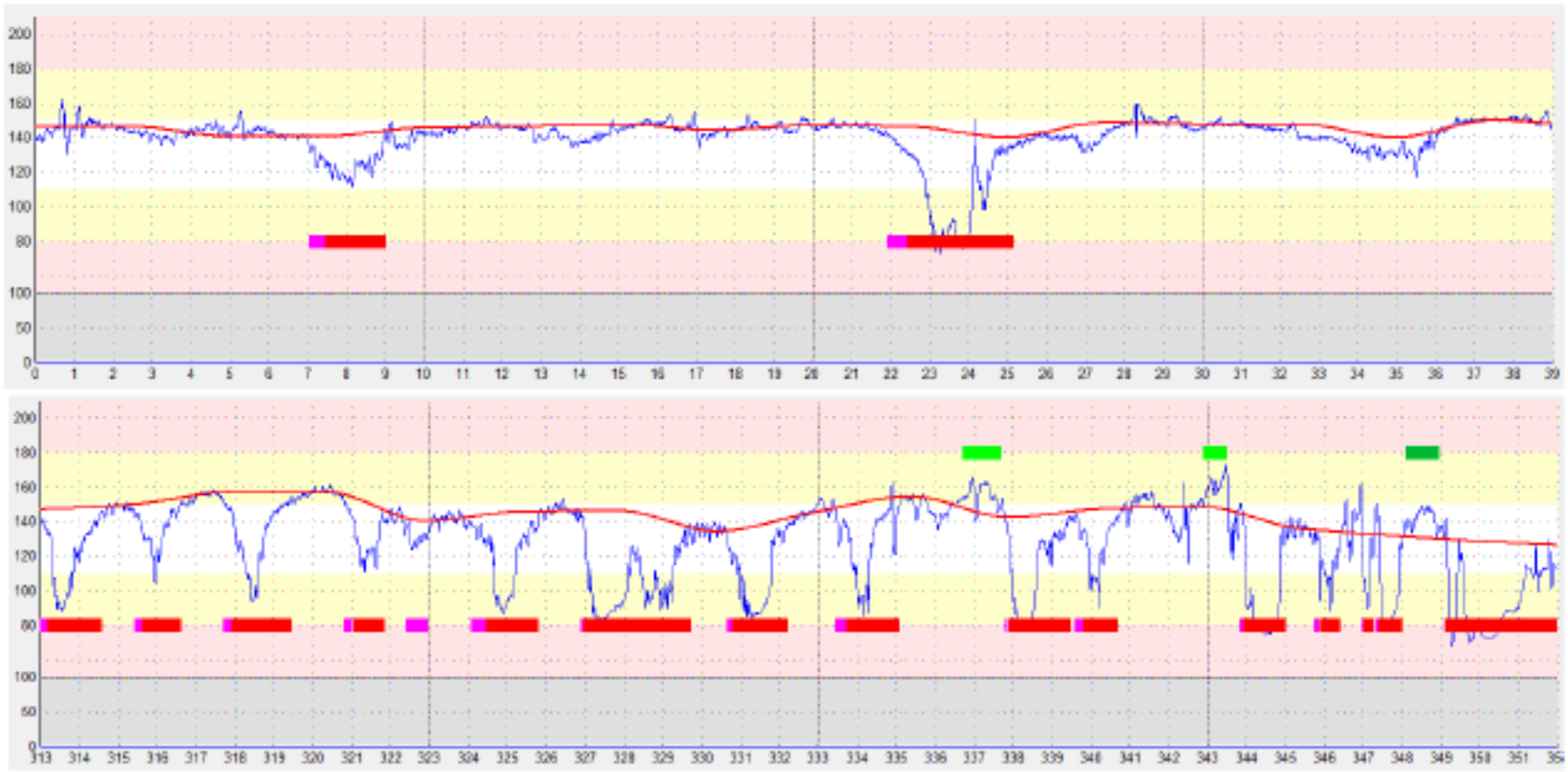


Power Law Behavior: $a_m = 2^3 \leq a \leq a_M = 2^7$

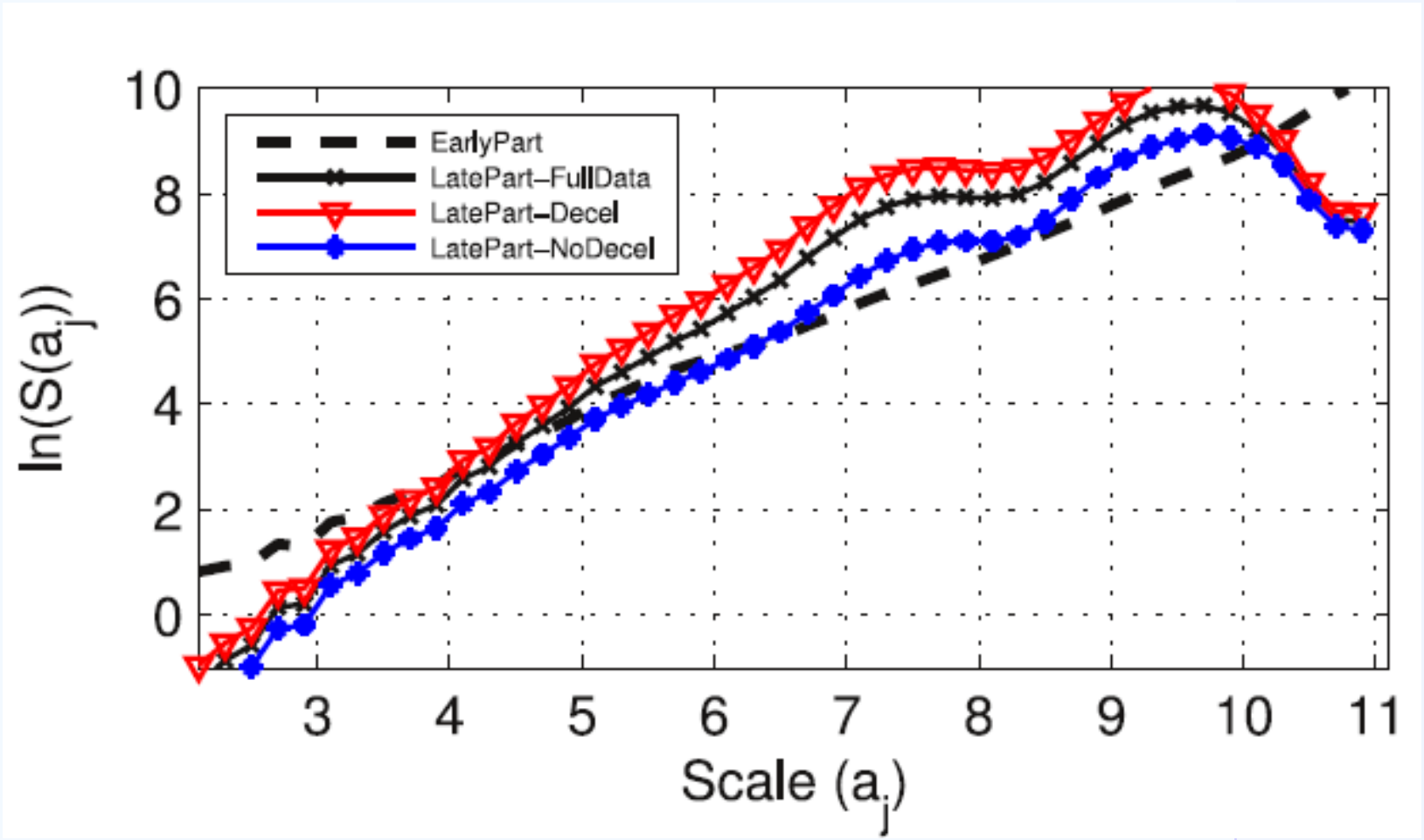
Values of H per class



Influence of decelerations



Influence of decels. on H



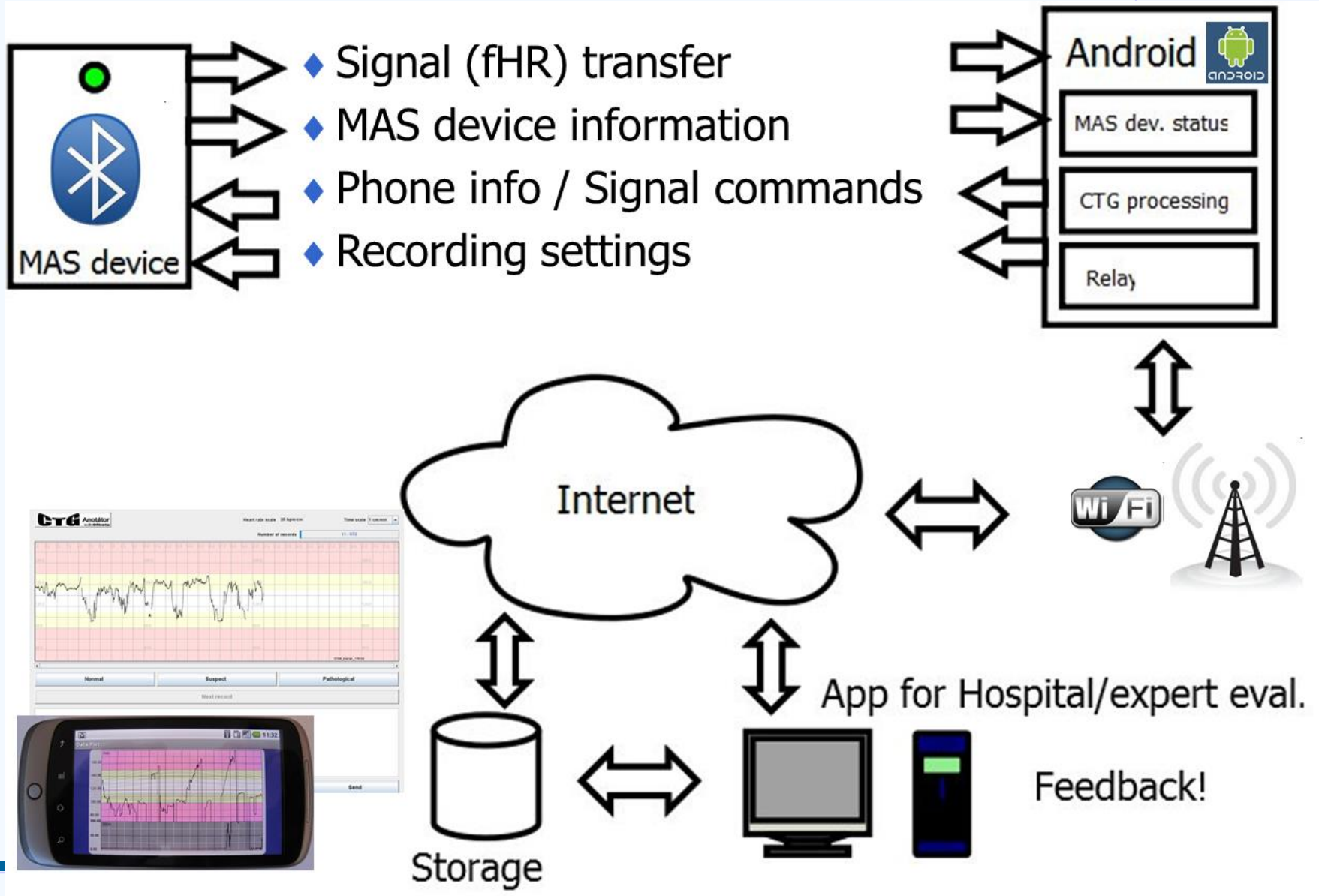
Conclusion

- Hurst exponent
  - Allows representation of time-scale properties of FHR by a single value
  - Measures embraces the Temporal Dynamics as Fractal Variability
  - Gathers time and spectral variabilities of the FHR in one feature
  - Describes temporal dynamics across range of scales rather than for specific scales
  - Simplifies the FHR analysis (in contrast to e.g. FIGO)
- Behaves consistently irrespective to decelerations

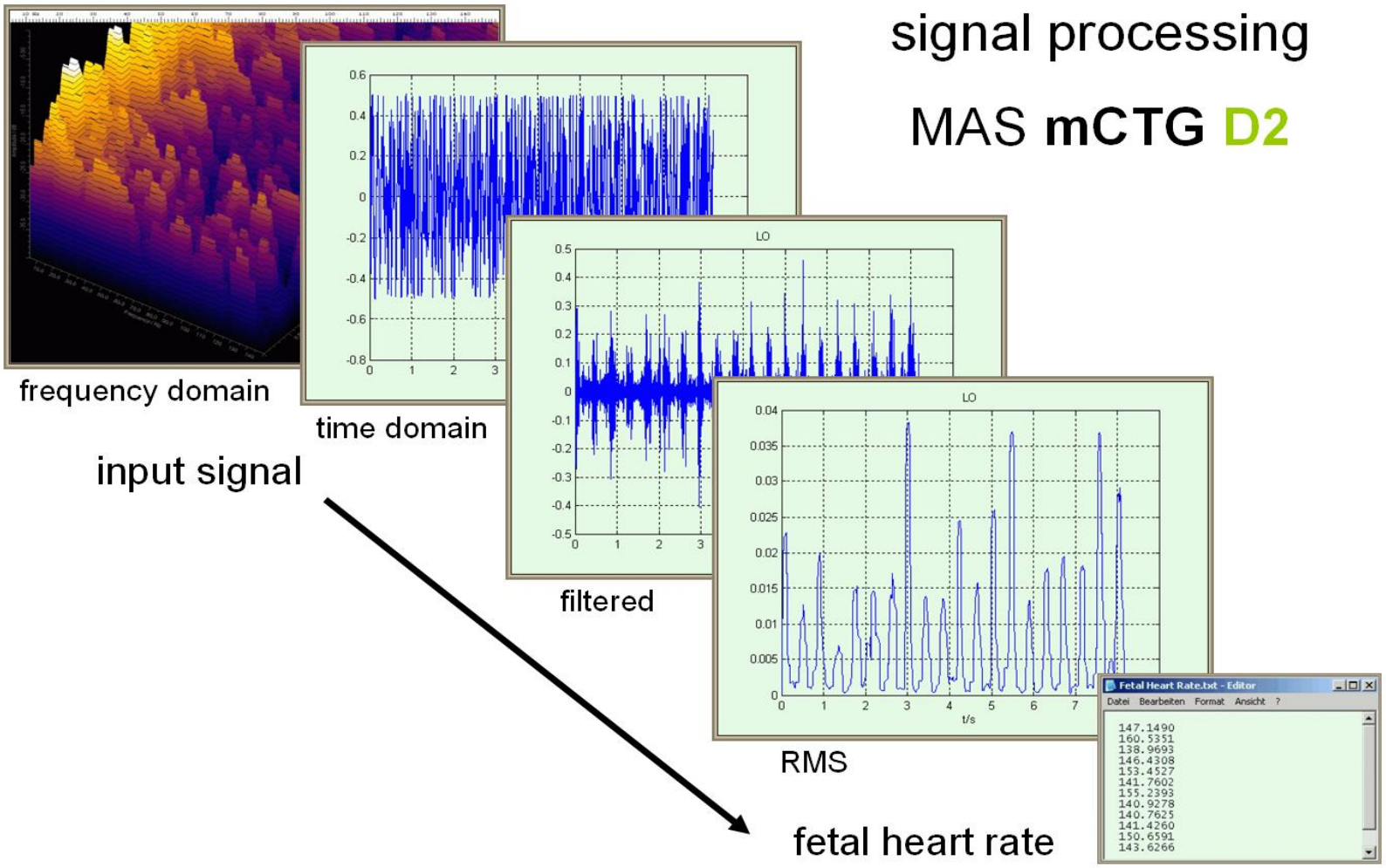
“Case study ” 3:
Mobile CTG

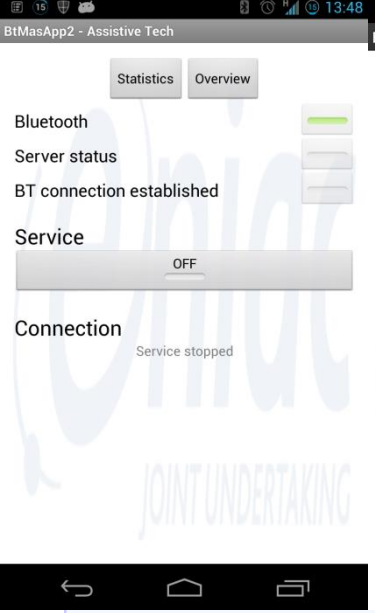
(with Siemens A.G. Austria)

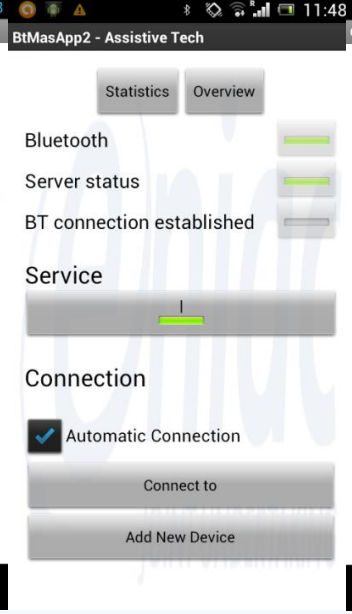
General schema of mCTG

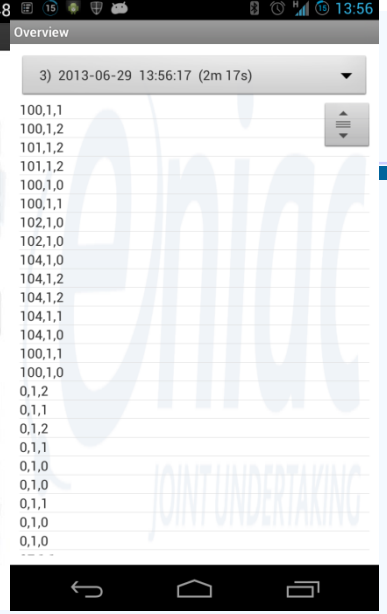


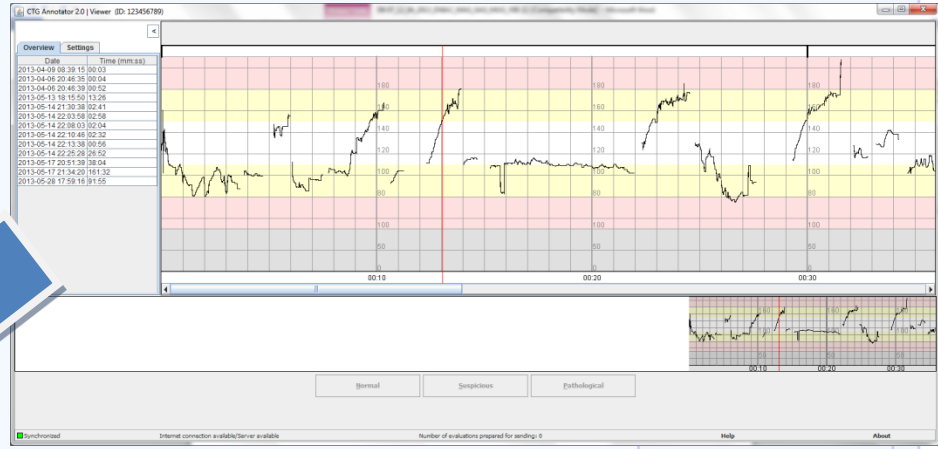
Phonography signal processing

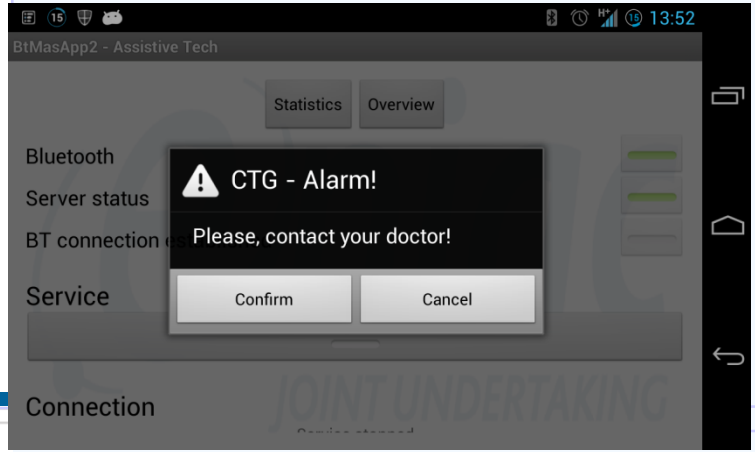



BtMasApp2 - Assistive Tech
Statistics
Overview
Bluetooth
Server status
BT connection established
Service
OFF
Connection
Service stopped


BtMasApp2 - Assistive Tech
Statistics
Overview
Bluetooth
Server status
BT connection established
Service
Connection
Automatic Connection
Connect to
Add New Device


Overview
3) 2013-06-29 13:56:17 (2m 17s)
100,1,1
100,1,2
101,1,2
101,1,2
100,1,0
100,1,1
102,1,0
102,1,0
104,1,0
104,1,2
104,1,2
104,1,1
104,1,0
100,1,1
100,1,0
0,1,2
0,1,1
0,1,2
0,1,1
0,1,0
0,1,0
0,1,1
0,1,0
0,1,0

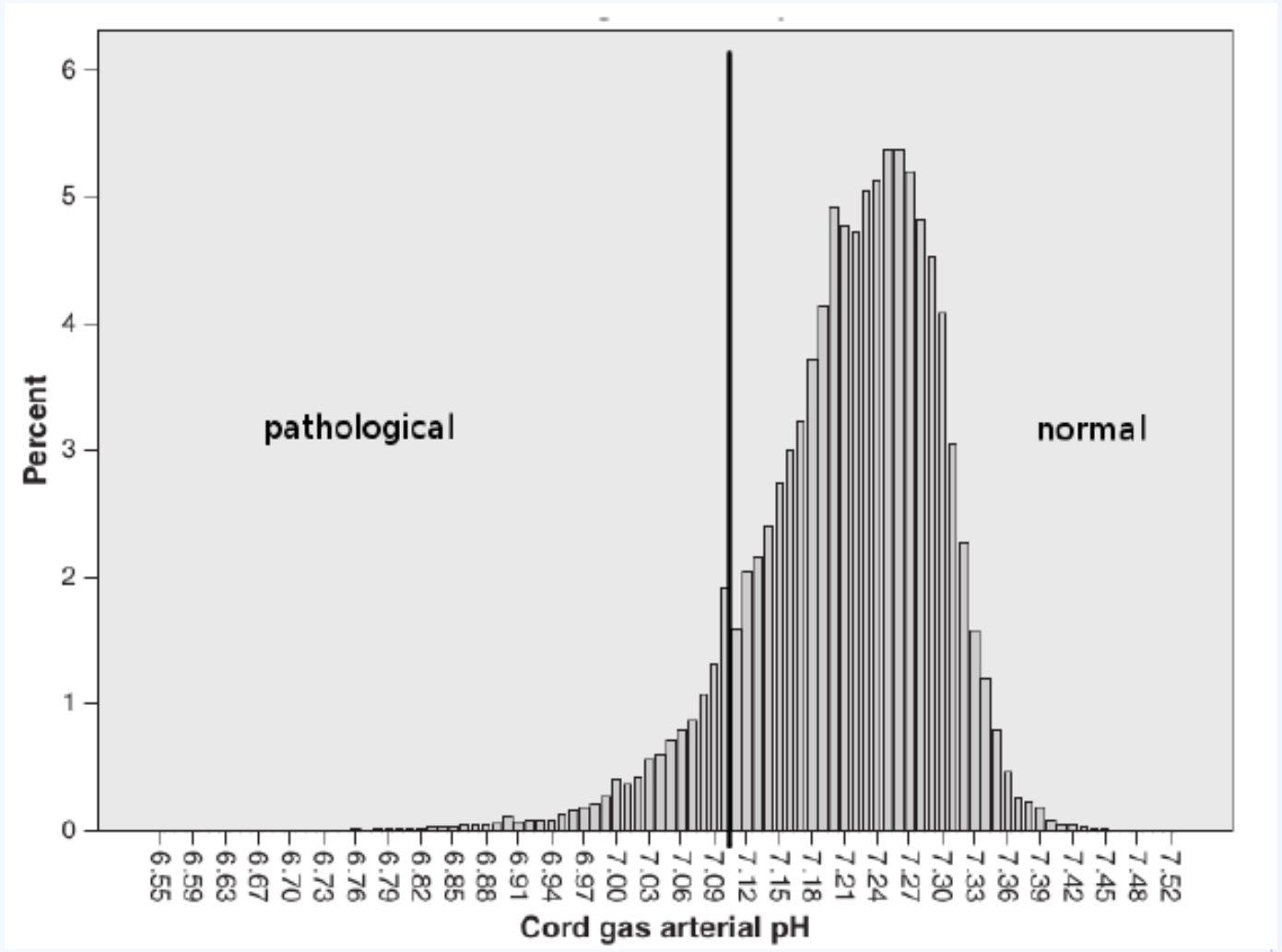



BtMasApp2 - Assistive Tech
Statistics
Overview
Bluetooth
Server status
BT connection
Service
Connection
CTG - Alarm!
Please, contact your doctor!
Confirm
Cancel

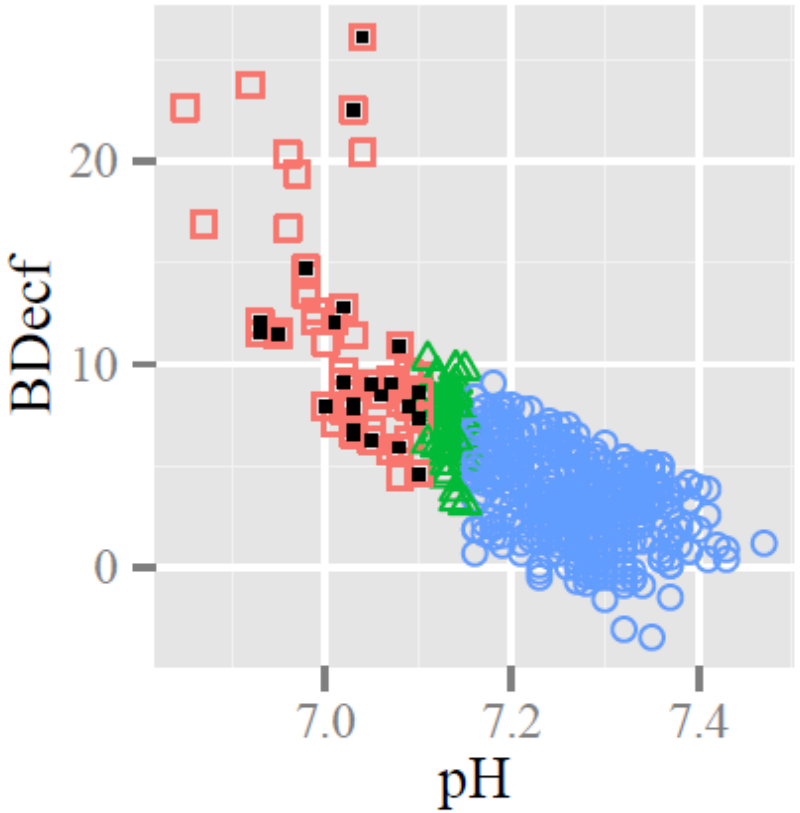
“Case study ” 4:
Latent class model

(by Jiří Spilka@CTU)

Motivation


Percent
6
5
4
3
2
1
0
pathological
normal
6.55
6.59
6.63
6.67
6.70
6.73
6.76
6.79
6.82
6.85
6.88
6.91
6.94
6.97
7.00
7.03
7.06
7.09
7.12
7.15
7.18
7.21
7.24
7.27
7.30
7.33
7.36
7.39
7.42
7.45
7.48
7.52
Cord gas arterial pH

Results on pH

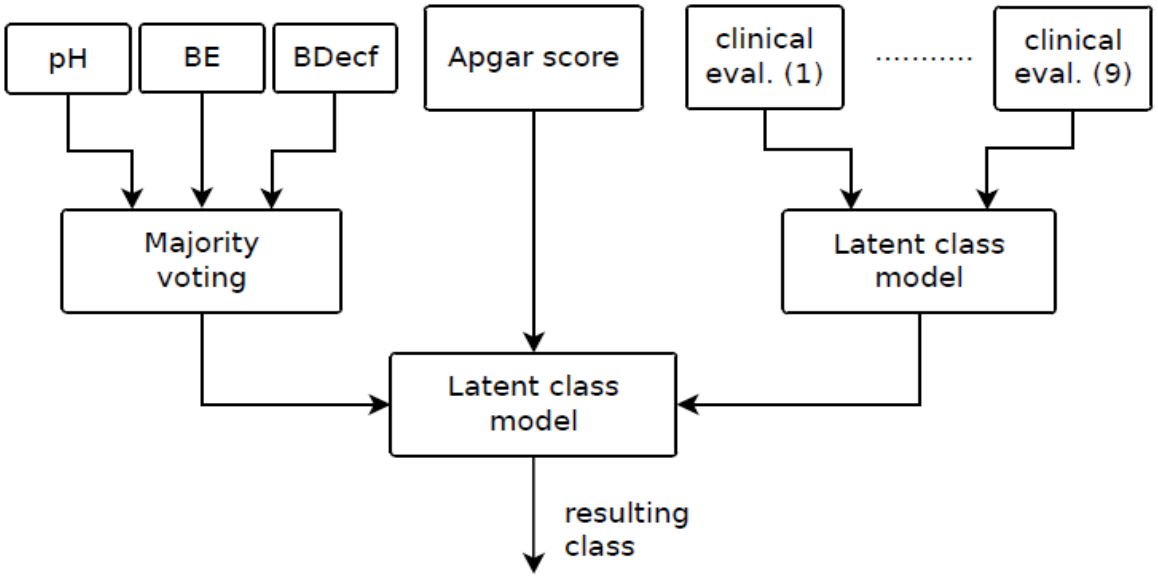


- used 3 class scenario
- black squares – false negatives
- pathological pH ≤ 7.10
- suspicious pH $(7.10, 7.15]$
- normal: pH > 7.15
- misclassification near boundary

- #16 recs. not pathological BDecf
- #11 recs. high Apgar score ≥ 9 (max. value 10)
- #11 recs. for each record ≥ 5 clinicians said FHR is normal

Latent class model

Latent class model (LCM)

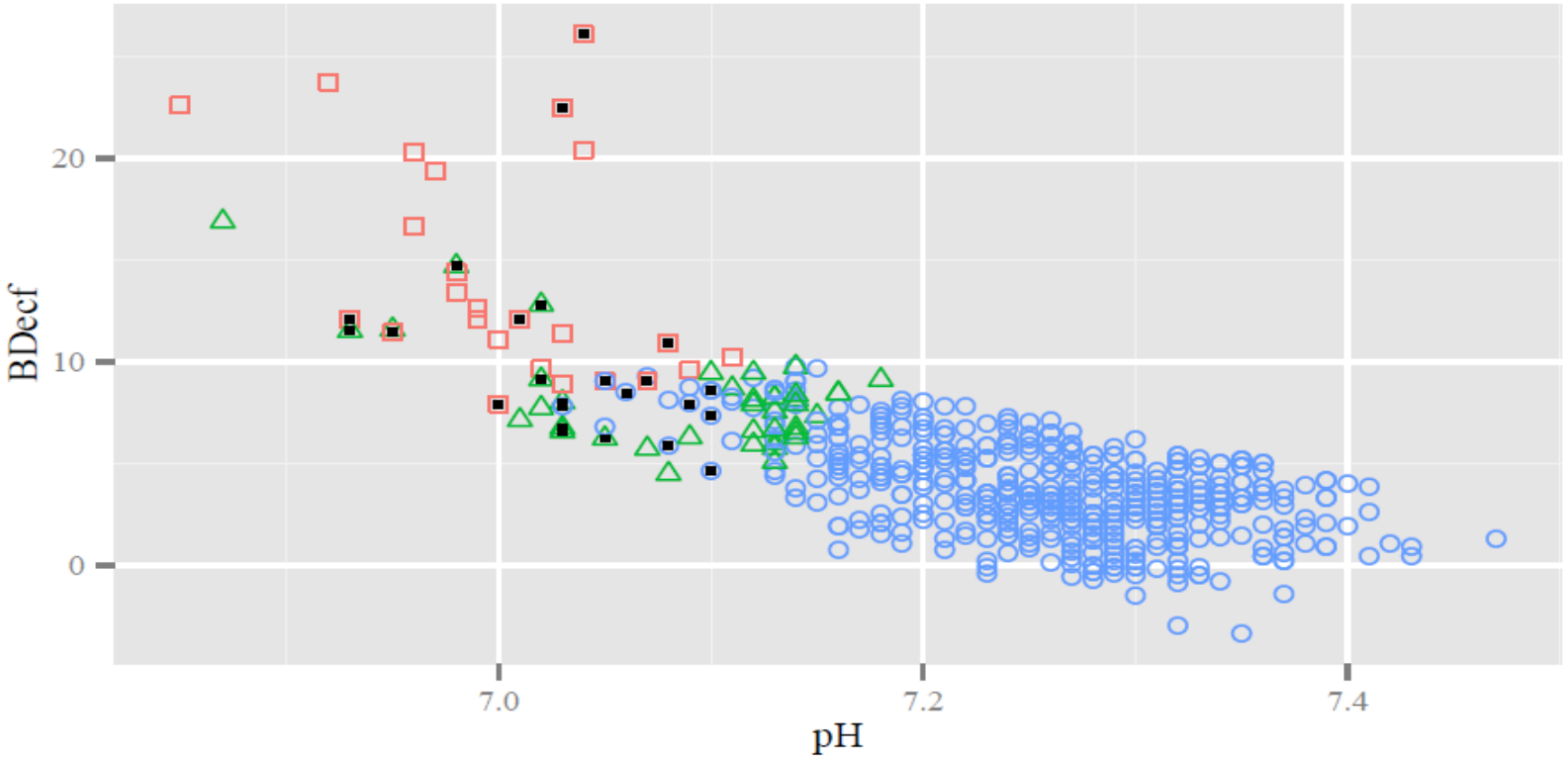


- **Input data**: noisy and imprecise
  - $y_i^j, \quad j = 1, \ldots, J \quad , i = 1, \ldots, N$
- **Goal**: estimate ground (unobserved) truth

$$\Pr[y_i^1, \ldots, y_i^J | \theta] = \prod_{i=1}^{N} \left[\sum_{c=1}^{C} \pi_c \Pr[y_i^1, \ldots, y_i^J | \theta_c] \right]$$

Results on pH with LCM

LCM – false negatives from supervised learning



- no strict boundary: normal ○, suspicious △, pathological □
- false negatives (■) – some explained by BDecf, Apgar score, clinical evaluation

"Case study " 5:
OB information system – The Delivery Book

(by Michal Huptych@CTU)

Electronic delivery book

- The application has been deployed as pilot version.

Elektronická porodní kniha v0.99

Nový | Editovat | Hledat | Filtr | Statistiky | Export do PDF | O programu | Předchozí | Stránka 1 / 3 | Následující

č. rok	č. měsíc	č. den	Jméno a příjmení	Příjmení dítěte	Datum	Čas	Pohlaví	Váha	Délka	Číslo nov.	Týden + den
1	1	1	Aa ---		08.01.2014	11:23	---	---	---	---	--- + ---
2	2	1	bbb ---		09.01.2014	13:45	---	---	---	---	--- + ---
3	3	1	cc ---								
4	4	2	Nol Fyhl								
5	5	1	Ert ---								
6	6	2	dd ---								
7	7	3	e e								
8	8	4	Rui Rui								
9	9	5	Fghj Fgj								
10	10	1	Cvb Cvb								
11	11	2	Rut Utr								
12	12	1	Ret Ert								
13	13	2	Vgh Jukl								
14	14	3	Rasd Tery								
15	15	1	Gg ---								
16	16	2	Fasd Hjgk								
17	17	3	H H								
18	18	4	Ff ---								
19	19	5	Vbn Mnb								
20	20	1	Frk Mrk								

Editor

Jméno rodičky: Ert Ret

Rodička / Příjem | Porod | Diagnózy/Operace/Pracovníci | Novorozenec | Neonatologie

Porod

1. Datum porodu (den.měsic.rok) 13.01.2014 Kalendář — Poloha plodu

Čas porodu (hodina:minuta) 11:45 — Výsledek porodu

Týden těhot. (Rozsah 20 - 45) — +Dní (Rozsah 0 - 6) — Krevní ztráta (0 - 5000 ml) — Indukovaný porod

Porodní doby (1.,2.,3., celková) — Patologický porod — Zobraz protokol

Anestezie — Místo porodu — Medikace

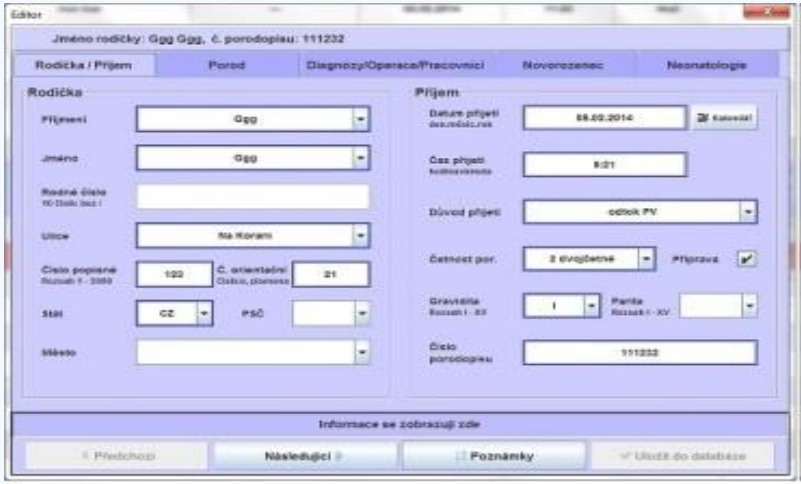
Doprovod u porodu — Poloha matky při porodu

Informace se zobrazují zde

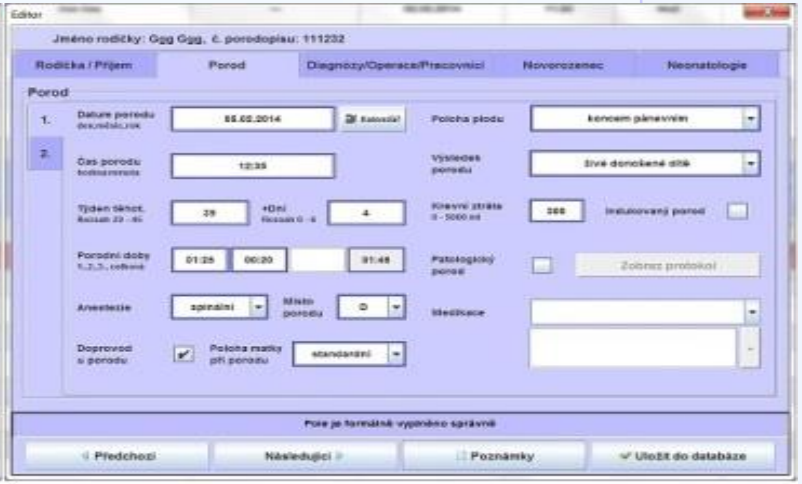
Předchozí | Následující | Poznámky | Uložit do databáze

Přihlášen: as. Lukáš Hruban, FN Brno Obilní trh

Odhlásit | Aktualizovat (Ctrl+R) | Rozšířená tabulka


Editor
Jméno rodičky: Ggg Ggg, č. porodopisu: 111232
Rodička / Příjem
Porod
Diagnózy/Operace/Pracovníci
Novorozenec
Neonatologie
Rodička
Příjmení
Ggg
Jméno
Ggg
Rodné číslo
Ulice
Na Koráni
Číslo popisné
122
Č. orientační
21
Stát
CZ
PSČ
Město
Příjem
Datum přijetí
08.02.2014
Kalendář
Čas přijetí
9:21
Důvod přijetí
odtok FV
Četnost por.
2 dvojčetné
Příprava
Gravidita
1
Parita
Číslo porodopisu
111232
Informace se zobrazují zde
Předchozí
Následující
Poznámky
Uložit do databáze

a)


Editor
Jméno rodičky: Ggg Ggg, č. porodopisu: 111232
Rodička / Příjem
Porod
Diagnózy/Operace/Pracovníci
Novorozenec
Neonatologie
Porod
1.
2.
Datum porodu
08.02.2014
Kalendář
Čas porodu
12:39
Týden těhot.
39
+Dni
4
Porodní doby
01:25
00:20
01:48
Anestezie
spinální
Místo porodu
D
Doprovod u porodu
Poloha matky při porodu
standardní
Poloha plodu
koncem pánevním
Výsledek porodu
živé donošené dítě
Krevní ztráta
300
Instrumentovaný porod
Patologický porod
Zobraz protokol
Medikace
Pole je formálně vyplněno správně
Předchozí
Následující
Poznámky
Uložit do databáze

b)

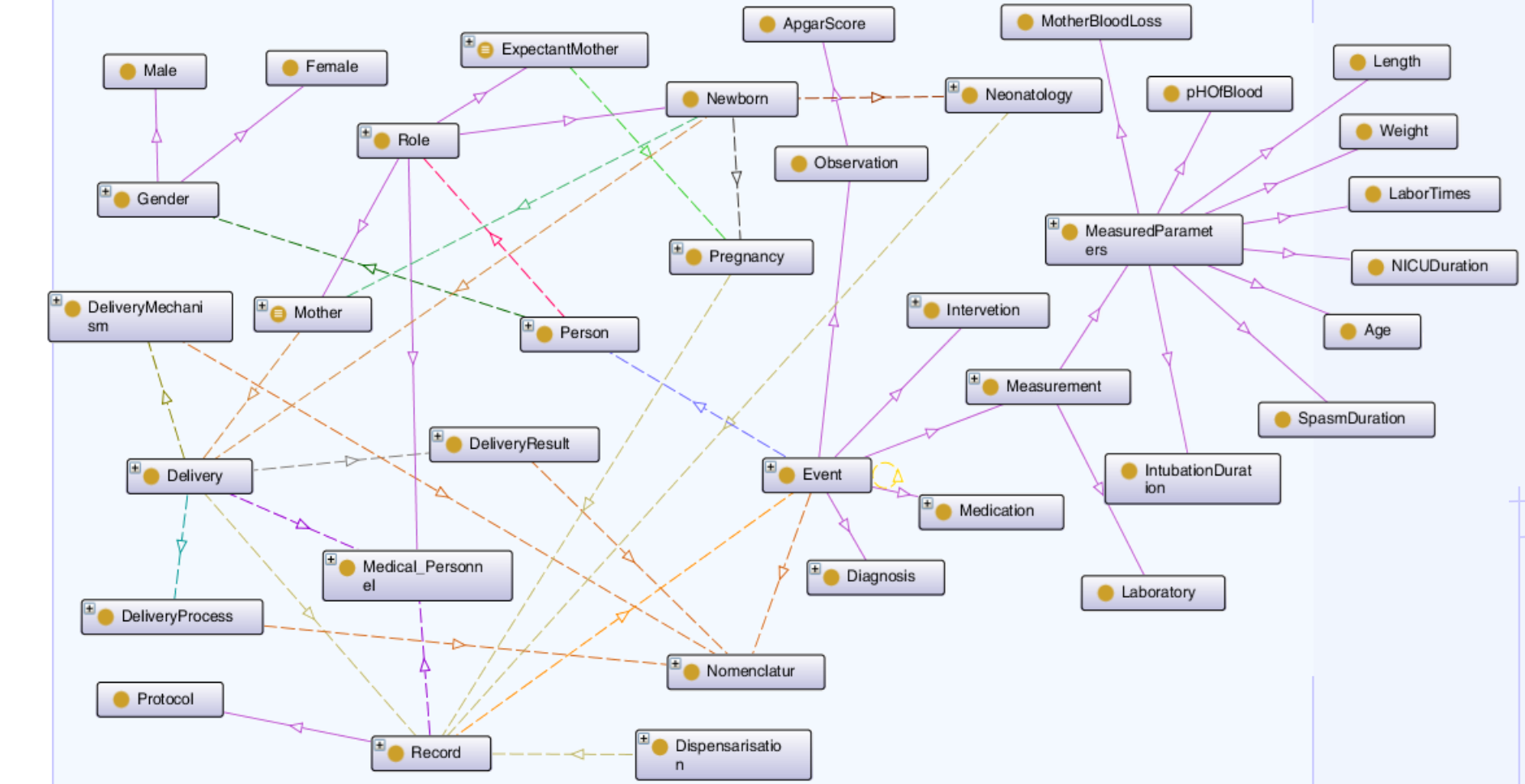

Editor
Jméno rodičky: Ggg Ggg, č. porodopisu: 111232
Rodička / Příjem
Porod
Diagnózy/Operace/Pracovníci
Novorozenec
Neonatologie
Novorozenec
1.
2.
Číslo novor.
002
Pohlaví
žena
Délka
57
Váha
3200
Apgar
9
9
9
pH arteriální
7,21
pH venózní
7,14
BE arteriální
-1,54
BE venózní
-1,67
Příjmení otěhe
Obsah je v pořádku
Předchozí
Následující
Poznámky
Uložit do databáze

c)


Editor
Jméno rodičky: Ggg Ggg, č. porodopisu: 111232
Rodička / Příjem
Porod
Diagnózy/Operace/Pracovníci
Novorozenec
Neonatologie
Neonatologie
1.
2.
Datum přijetí
08.02.2014
Kalendář
Traumatizmus
Diagnózy při propuštění
AV malformace přívod.cév mozku Q280
Aberrantní chromosomů, NS Q999
Propuštěn
08.02.2014
Kalendář
Disponzantzace
Hosp. na JIP
Intubace
Křeče
Doba trvání
12
Umrtí novorozence
Kardiologie
Neurologie
Typ zařízení, ve kterém je prováděno sledování.
Předchozí
Následující
Poznámky
Uložit do databáze

d)

Domain model in obstetrics



"Case study " 6:

DeBo database mining

Epidemiological study of pH

(with
Ibrahim Abou Khashbah@CIIRC)

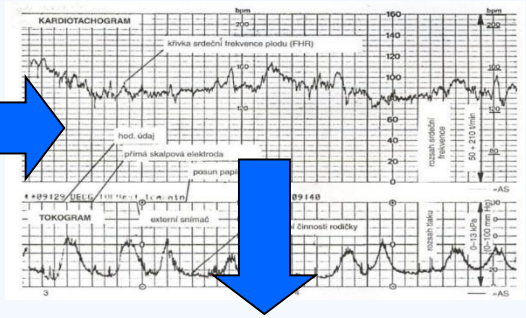
- 12 878 patients from FN Brno
- 99 pH < 7.05, 231 pH <7.1
- 107 features

Feature	n(-)	prct(%)	OR (95% CI)
pH ($\leq$ 7.1)	251	2.36	-
Apgar score 5min ($<$ 8)	203	1.91	12.08 (8.33 - 17.53)
Sectio Caesarea	2110	20.30	1.12 (0.83 - 1.52)
Induced delivery	2198	20.69	1.82 (1.39 - 2.39)
Entonox(medic.)	144	1.36	1.18 (0.43 - 3.22)
Epidural analg.	1915	18.03	1.25 (0.92 - 1.70)
Ist stage ($>$ 360min)	1807	18.40	1.40 (1.04 - 1.89)
IInd stage ($>$ 30min)	884	10.11	2.87 (2.07 - 3.97)
Parity ($<$ 2)	5299	49.99	3.42 (2.54 - 4.59)
Sex (Male)	5468	51.53	0.83 (0.65 - 1.07)
O100 – hypertension	533	5.02	1.30 (0.78 - 2.17)
O140 – preeclampsia	114	1.07	0.74 (0.18 - 3.00)
O365 – IUGR	375	3.53	1.14 (0.60 - 2.16)
O681 – meconium	784	7.38	1.60 (1.07 - 2.38)
D650 – defibrination syndrome	258	2.43	1.33 (0.65 - 2.73)
D695 – secondary thrombocytopenia	36	0.34	3.79 (1.15 - 12.44)

"Case study " 7:
CTG Trainer App for Android and web

(with Petr Stuchlik@PPF)

Clinical practice



CTG Trainer

KTG+ Fyziologie Interpretace KTG Prohlížeč KTG Analýza STAN Databáze záznamů Doporučení ČGPS

Můj účet
Odhlásit

Případy

Dostupný test: - nezáleží - | Má CTG signál: ano | Příjmení | Reset

	Název	Gravidita	Parita	Týden	Datum a čas porodu	IČ chorobopisu	Pat. porod
Prohlížet	Kamila Vašourková	IV	II	40	06.10.2014 - 14:00	1319003	ne
Prohlížet	Iveta Švančarová	V	IV	41	06.10.2014 - 13:25	1318856	ne
Prohlížet	Martina Pospíšilová	IV	II	38	06.10.2014 - 13:15	1318828	ne
Prohlížet	Jana Vachalová	II	II	36	06.10.2014 - 12:45	1318823	ne
Prohlížet	Denisa Bartoňová	I	I	40	06.10.2014 - 12:40	1318961	ne
Prohlížet	Petra Rybníkářová	III	III	40	06.10.2014 - 12:30	1318834	ne
Prohlížet	Dana Doleželová	I	I	41	06.10.2014 - 12:30	1318829	ne
Prohlížet	Darina Magdová	III	II	37	06.10.2014 - 10:50	1316169	ano
Prohlížet	Kateřina Slováková	II	II	40	06.10.2014 - 10:45	1318808	ne
Prohlížet	Monika Štodrová	II	II	39	06.10.2014 - 09:55	1318830	ne
Prohlížet	Monika Peloušková	I	I	38	06.10.2014 - 09:00	1318825	ne
Prohlížet	Petra Slavíková	I	I	37	06.10.2014 - 05:20	1318817	ne
Prohlížet	Valeria Matyáš	I	I	39	06.10.2014 - 04:55	1318718	ne
Prohlížet	Veronika Jínová	II	II	39	06.10.2014 - 04:35	1318820	ne
Prohlížet	Markéta Matušková	II	II	40	05.10.2014 - 18:30	1318791	ne
Prohlížet	Ivana Horňáková	II	I	40	05.10.2014 - 18:00	1318772	ne
Prohlížet	Iveta Šččánková	I	I	39	05.10.2014 - 17:15	1318734	ne
Prohlížet	Hanna Krychtof	I	I	40	05.10.2014 - 17:10	1318730	ne
Prohlížet	Lenka Havlíčková	I		40	05.10.2014 - 16:00	1318487	ne
Prohlížet	Martina Houdková	II	I	38	05.10.2014 - 14:05	1318688	ne

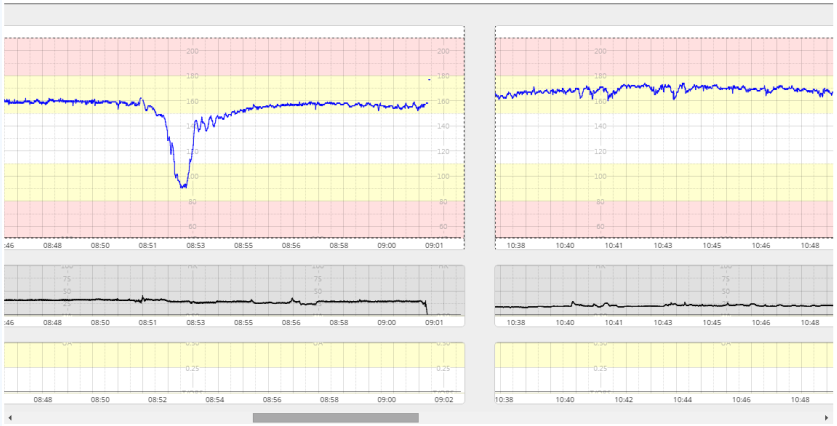
KTG+ Fyziologie Interpretace KTG Prohlížeč KTG Analýza STAN Databáze záznamů Doporučení ČGPS

KTG+ Viewer

CTG Viewer demo I. (1308098)

Naměřené hodnoty

Věk: 32, GRAV: II, PARA: I, týden: 32 + 1, indukovaný porod: ne



KTG+ Fyziologie Interpretace KTG Prohlížeč KTG Analýza STAN Databáze záznamů Doporučení ČGPS

KTG+ Viewer

Průběh porodu

(1294463)

Příznaky z automatické fígoanalýzy

Naměřené hodnoty

Věk: 25, GRAV: I, PARA: I, týden: 40 + 5, indukovaný porod: ne

9/6/2014 _04:00 Spont. odtok plodové vody _21:45 CS=8; 5ml penicilinu ve 100ml FR i.v. _10/6/2014 _02:00 2,5ml PNC ve 100ml FR i.v._ 04:00 Epidural _05:00 Epidural _06:00 2,5ml PNC ve 100 ml FR i.v.

06:00 - 06:30 Progres = 3cm

06:50 - 07:20 Progres = 4cm

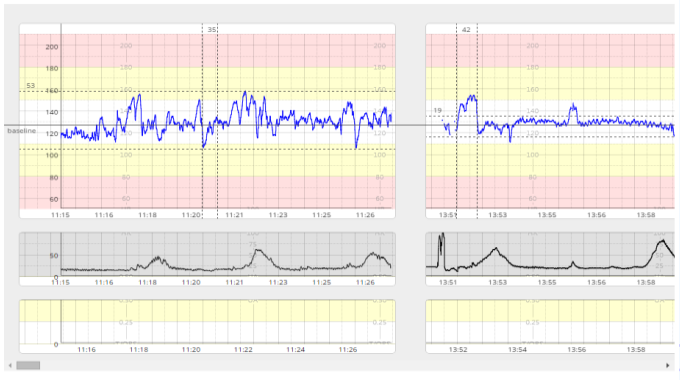
_08:30 500ml FR+5j Oxytocin _08:45 Epidural

08:50 - 09:20 Progres = 5cm

_09:30 Epidural

10:10 - 10:40 Progres = 8cm

10:40 - 11:10 Progres = LEM



KTG+ Fyziologie Interpretace KTG Prohlížeč KTG Analýza STAN Databáze záznamů Doporučení ČGPS

KTG+ Viewer

Průběh porodu

(1294463)

Příznaky z automatické fígoanalýzy

Naměřené hodnoty

Věk: 25, GRAV: I, PARA: I, týden: 40 + 5, indukovaný porod: ne

9/6/2014 _04:00_ Spont. odtok plodové vody _21:45_ CS=8; 5ml penicilinu ve 100ml FR i.v. 10/6/2014 _02:00_ 2,5ml PNC ve 100ml FR i.v. _04:00_ Epidural _05:00_ Epidural _06:00_ 2,5ml PNC ve 100 ml FR i.v.

06:00 - 06:30 Progres CS=3

06:50 - 07:20 Progres CS=4

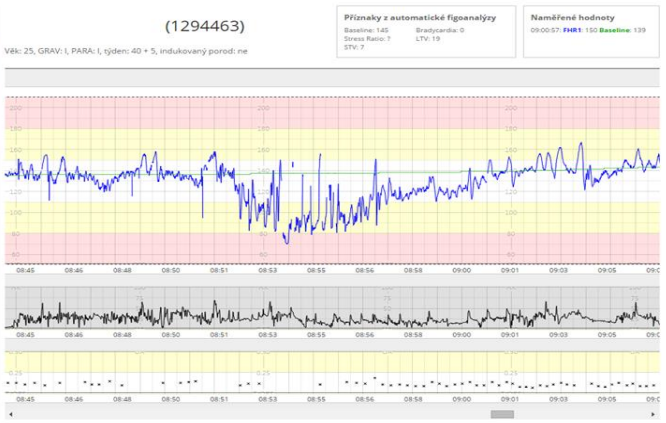
_08:30_ 500ml FR+5j Oxytocin _08:45_ Epidural

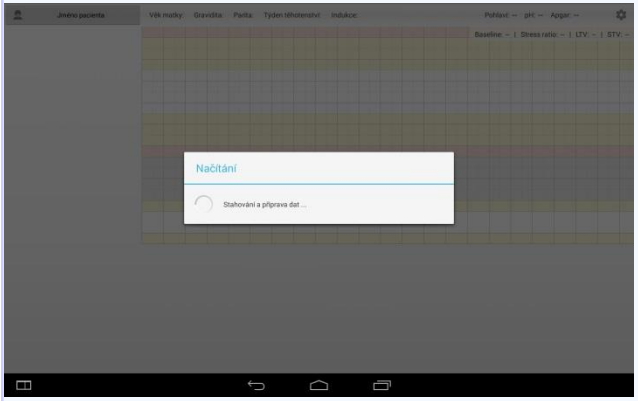
08:50 - 09:20 Progres CS=5

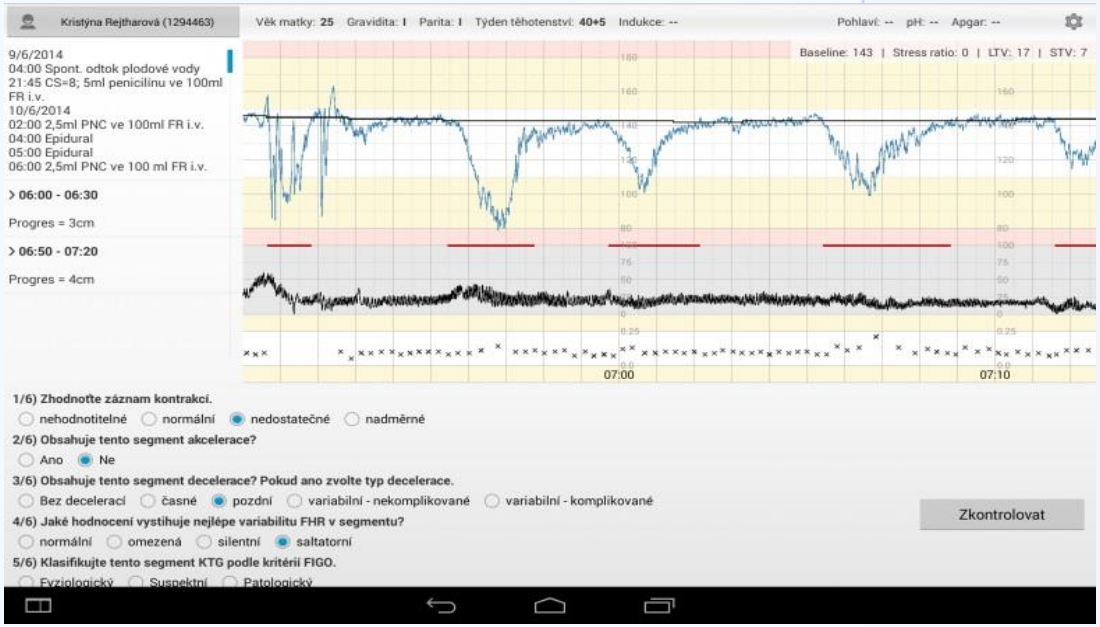
_09:30_ Epidural

10:10 - 10:40 Progres CS=8

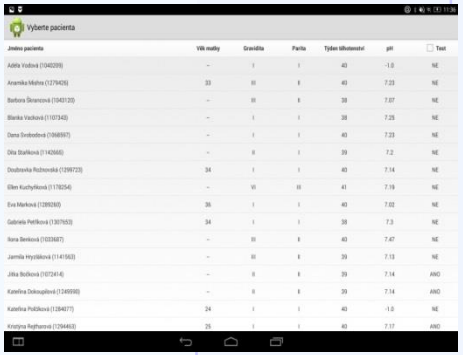
10:40 - 11:10 Progres CS=LEM




Načítání
Stahování a příprava dat ...


Kristýna Rejtharová (1294463)
Věk matky: 25 Gravidita: I Parita: I Týden těhotenství: 40+5 Indukce: --
Pohlaví: -- pH: -- Apgar: --
9/6/2014
04:00 Spont. odtok plodové vody
21:45 CS=8; 5ml penicilínu ve 100ml FR i.v.
10/6/2014
02:00 2,5ml PNC ve 100ml FR i.v.
04:00 Epidural
05:00 Epidural
06:00 2,5ml PNC ve 100 ml FR i.v.
> 06:00 - 06:30
Progres = 3cm
> 06:50 - 07:20
Progres = 4cm
Baseline: 143 | Stress ratio: 0 | LTV: 17 | STV: 7
07:00
07:10
1/6) Zhodnoťte záznam kontrakcí.
nehodnotitelné normální nedostatečné nadměrné
2/6) Obsahuje tento segment akcelerace?
Ano Ne
3/6) Obsahuje tento segment decelerace? Pokud ano zvolte typ decelerace.
Bez decelerací časné pozdní variabilní - nekomplikované variabilní - komplikované
4/6) Jaké hodnocení vystihuje nejlépe variabilitu FHR v segmentu?
normální omezená silentní saltatorní
5/6) Klasifikujte tento segment KTG podle kritérií FIGO.
Fyziologický Suspektní Patologický
Zkontrolovat


Kristýna Rejtharová (1294463)
Věk matky: 25 Gravidita: I Parita: I Týden těhotenství: 40+5 Indukce: --
Pohlaví: -- pH: -- Apgar: --
9/6/2014
04:00 Spont. odtok plodové vody
21:45 CS=8; 5ml penicilínu ve 100ml FR i.v.
10/6/2014
02:00 2,5ml PNC ve 100ml FR i.v.
04:00 Epidural
05:00 Epidural
06:00 2,5ml PNC ve 100 ml FR i.v.
> 06:00 - 06:30
Progres = 3cm
Baseline: 145 | Stress ratio: 0 | LTV: 19 | STV: 7
06:10
06:20
Bez decelerací časné pozdní variabilní - nekomplikované variabilní - komplikované
2/6) Obsahuje tento segment akcelerace?
Ano Ne
3/6) Jaká je průměrná hodnota isolinie v segmentu? (Vysvětlení: Dobře hodnotitelný, fyziologický záznam)
Nedefinovatelná Hodnotitelná Průměrná hodnota v bpm: 145
4/6) Zhodnoťte záznam kontrakcí.
nehodnotitelné normální nedostatečné nadměrné
5/6) Jaké hodnocení vystihuje nejlépe variabilitu FHR v segmentu?
normální omezená silentní saltatorní
Další

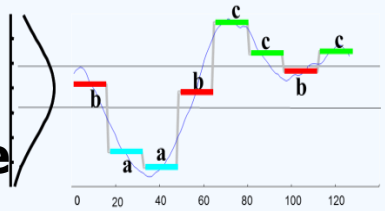

Výběr pacienta

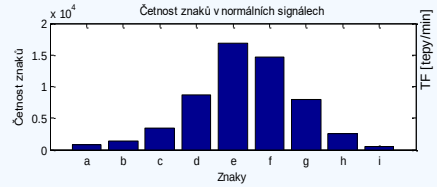
"Case study " 8:
Clustering of FHR using SAX

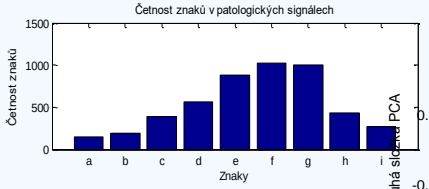
(with
Helen Drosou@TEI of Athens)

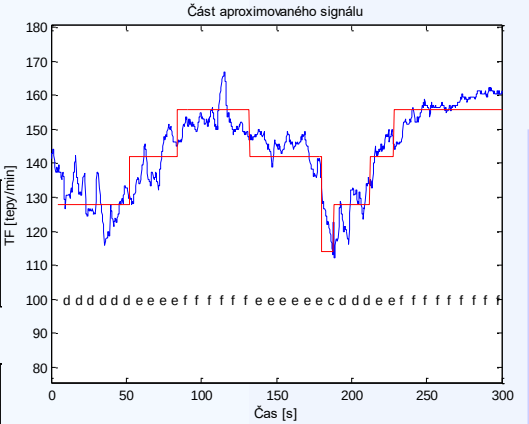
- **Can we get by without those anoying features?**

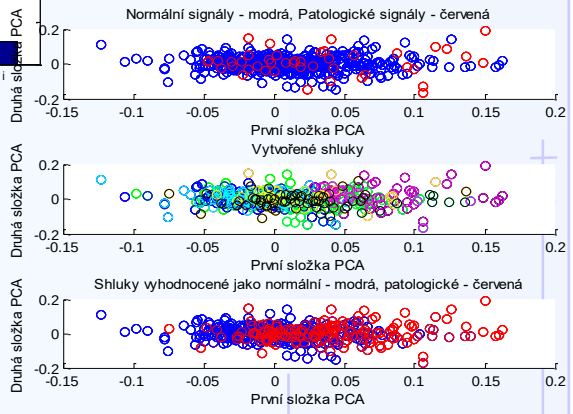
- SAX – symbolic approximation
- Based on piecewise agregate approximation
- Simple k-means algorithm is used for clustering
- Preliminary results very promising given there are no “classical” features involved











	ClassN	ClassP
Normal	361	147
Pathological	16	28

"Case study " 9:
Embedding & graph of graphs

(with
Patrice Abry@ENS,
Ronen Talmon@Technion)

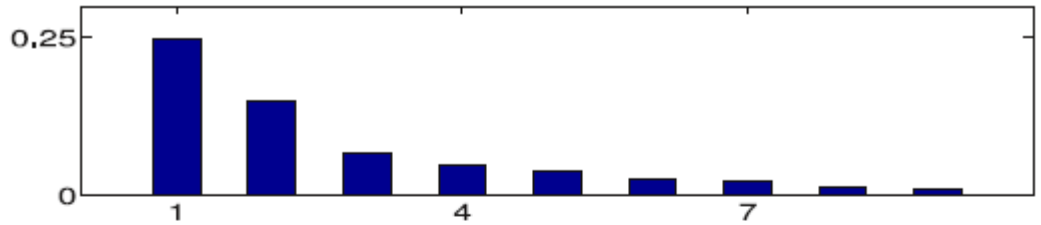
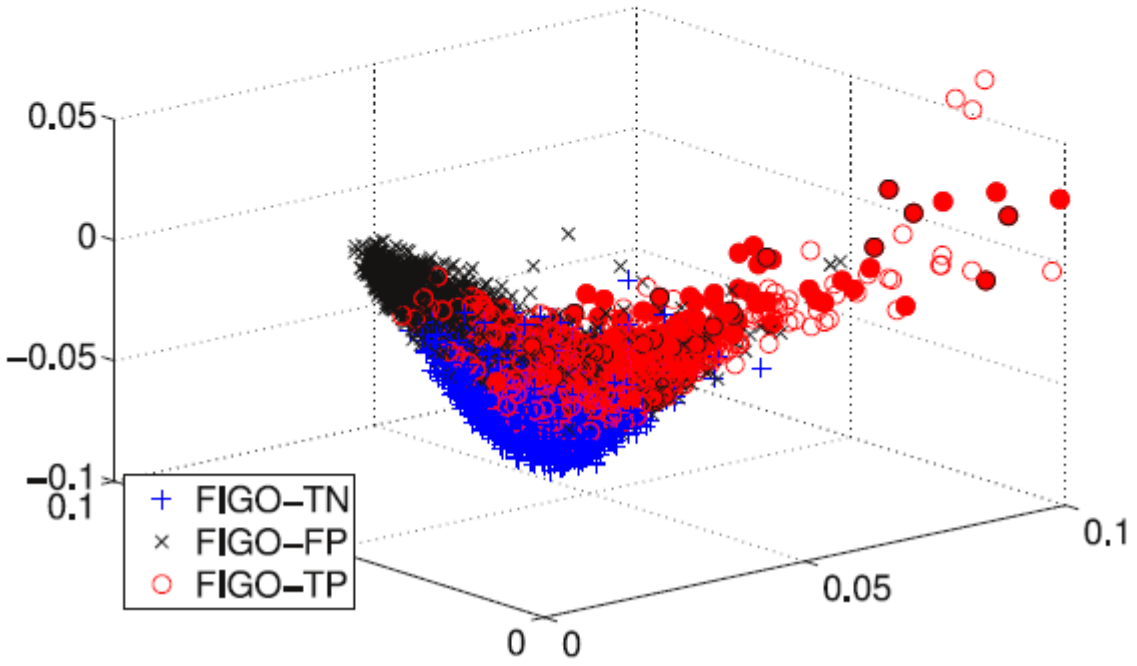


Fig. 1. Decay of sorted embedding eigenvalues.



"Case study " 10:
New biochemical markers

(with Laboratory of Molecular Diagnostics FN Brno)

New markers

- mRNA
  - **Messenger RNA** (**mRNA**) is a large family of RNA molecules that convey genetic information from DNA to the ribosome, where they specify the amino acid sequence of the protein products of gene expression.
- miRNA
  - A **microRNA** (abbreviated **miRNA**) is a small non-coding RNA molecule (containing about 22 nucleotides) found in plants, animals, and some viruses, which functions in RNA silencing and post-transcriptional regulation of gene expression
  - The human genome may encode over 1000 miRNAs, which are abundant in many mammalian cell types and appear to target about 60% of the genes of humans and other mammals.

Acknowledgments

- **Lenka Lhotská** (CTU PhD supervisor)
- **Patrice Abry** (ENS post-doc supervisor)
- Jiří Spilka – main coinvestigator
- Michal Huptych – delivery book developer
- Miroslav Burša – database guy
- Lukáš Zach, Petr Stuchlík – BSc./MSc. students, programmers
- Petr Janků
  - Chief obstetrician in FH Brno
  - IGA grant with Faculty Hospital in Brno
- Lukáš Hruban, Martin Huser
  - Part of the IGA team in FH Brno
- Michal Koucký
  - Obstetrician, 1st Medical Faculty Charles University in Prague.
  - First contact with the topic (2008)

Thank you for your attention!

Variability & HF/LF features united

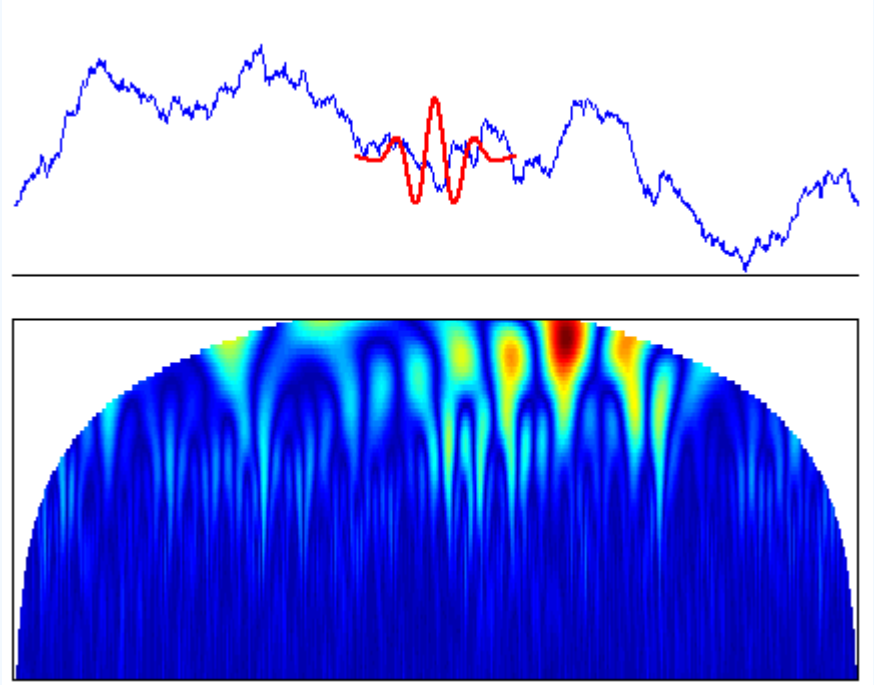
Scaling properties of FHR

Temporal dynamics

- Classical measures
  - STV – scale of a = 3.75s (antepartum)
  - LTV – scale of a = 60s (intrapartum)
- Why to limit ourselves to these arbitrary intervals?

Continuous Wavelet Transform

$$X(t) \rightarrow T_x(a,t) = \langle \frac{1}{a}\psi\left(\frac{u-t}{a}\right) | X \rangle$$



- Joint time and frequency energy content

Fractal exponents

- Oscilations -> wavelet coefs.
- Variability is not characterized by actual value
- Scale invariance is measured instead -> H
- The H computed via wavelet spectrum provides
  - Variability at all scales jointly (not just STV/LTV scale)
  - Gives information of temporal dynamic of HF/LF ratio
- In practice:

$\Rightarrow$ Hurst exponent:

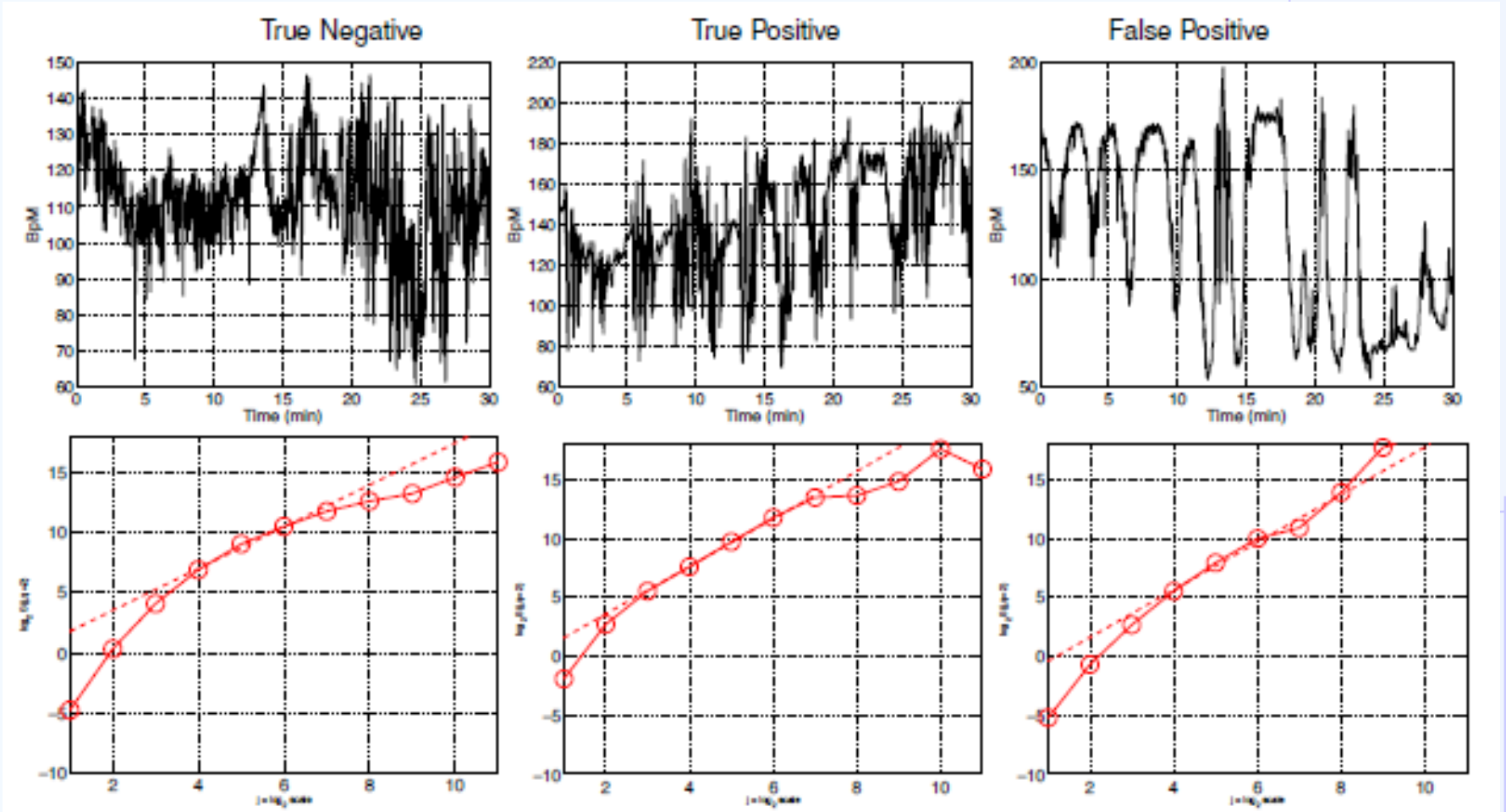
Time averages: $S(a) = 1/n_a \sum_k T_X(a,k)^2$

$\Rightarrow$ Global regularity exponent:

Scale invariance: $|T_X(a,t)| \simeq c(t)a^{h(t)}$

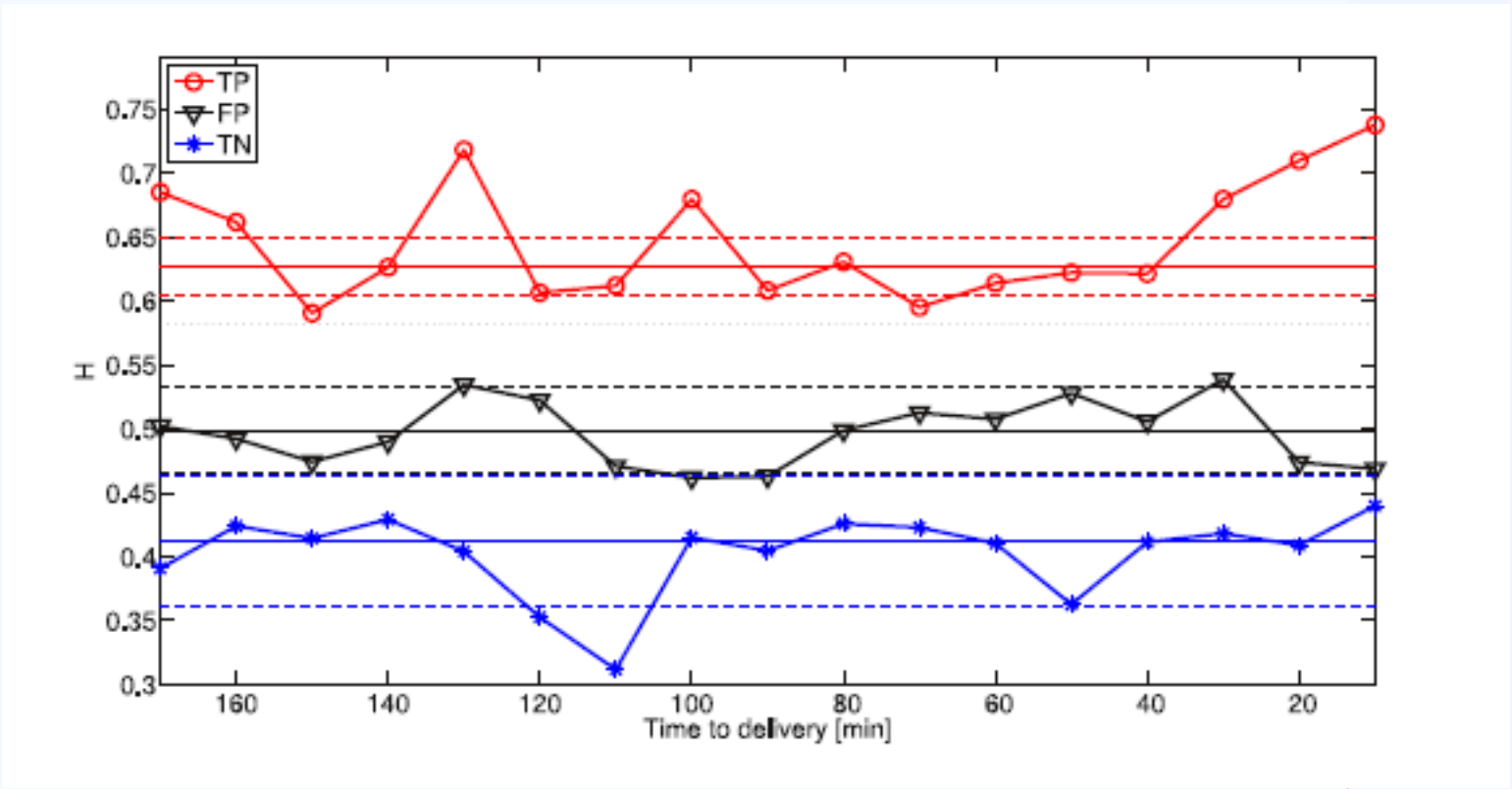
Global regularity: $h_{min} = min_t(h(t))$

Scale invariance in FHR

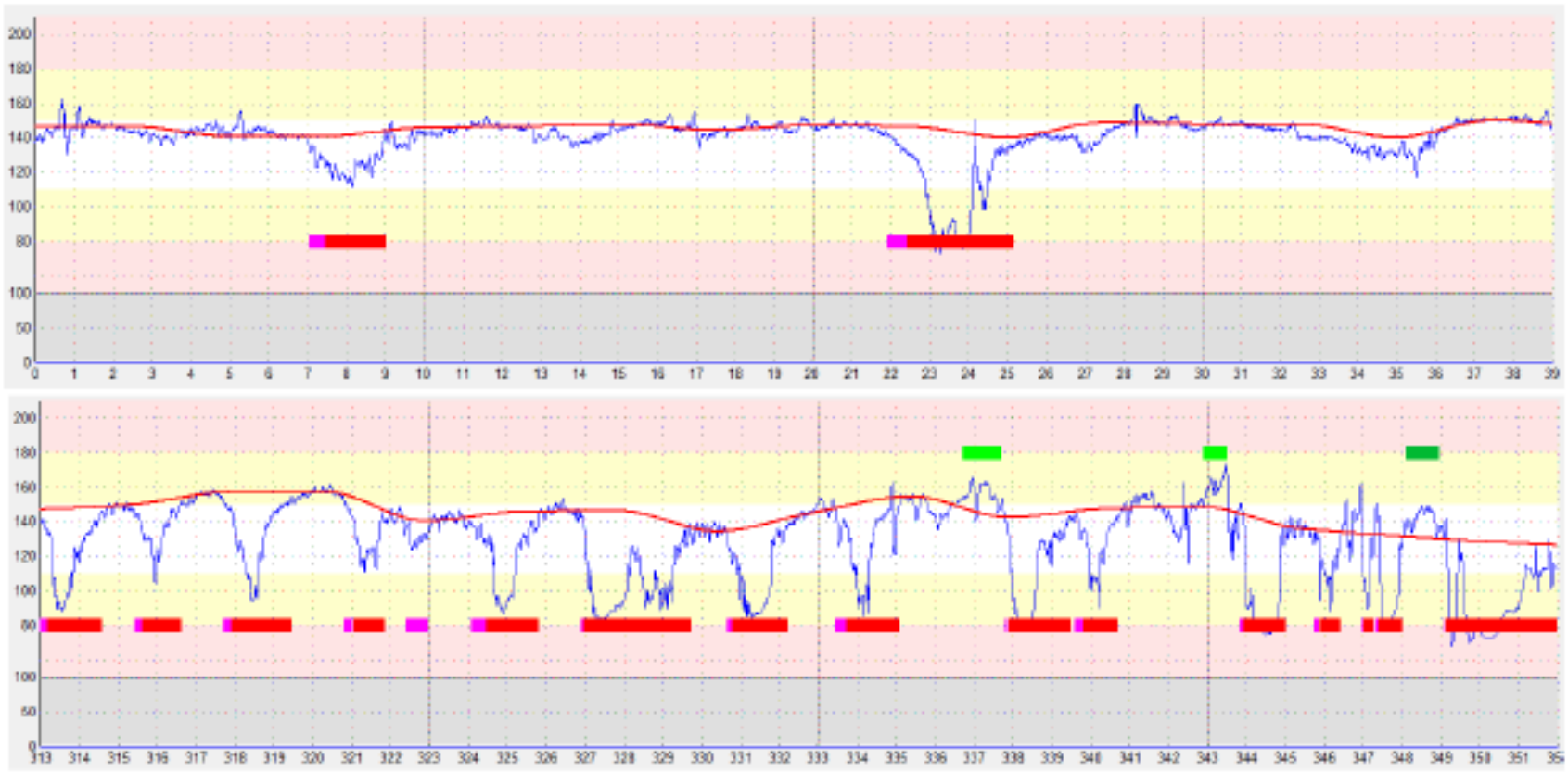


Power Law Behavior: $a_m = 2^3 \leq a \leq a_M = 2^7$

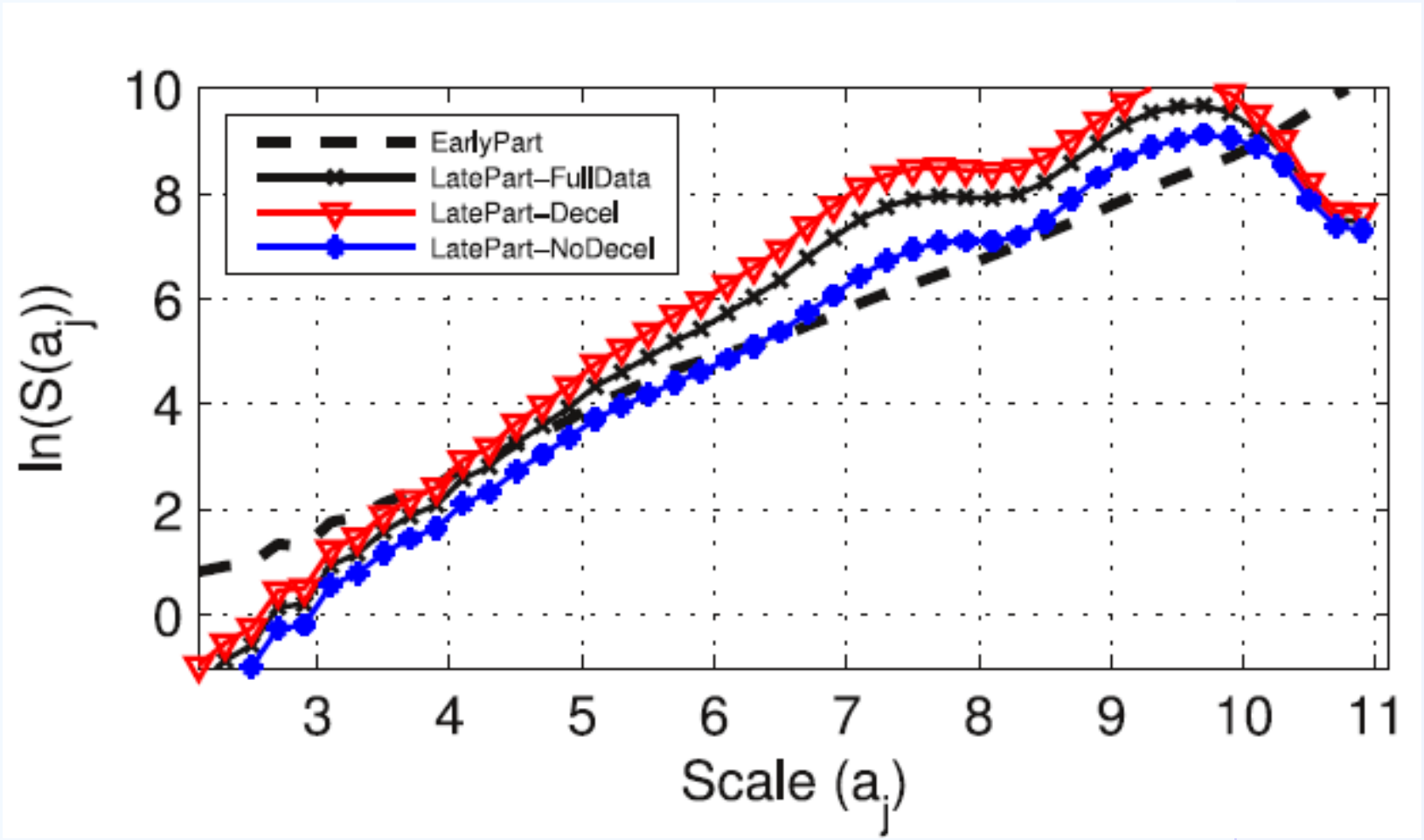
Values of H per class



Influence of decelerations



Influence of decels. on H



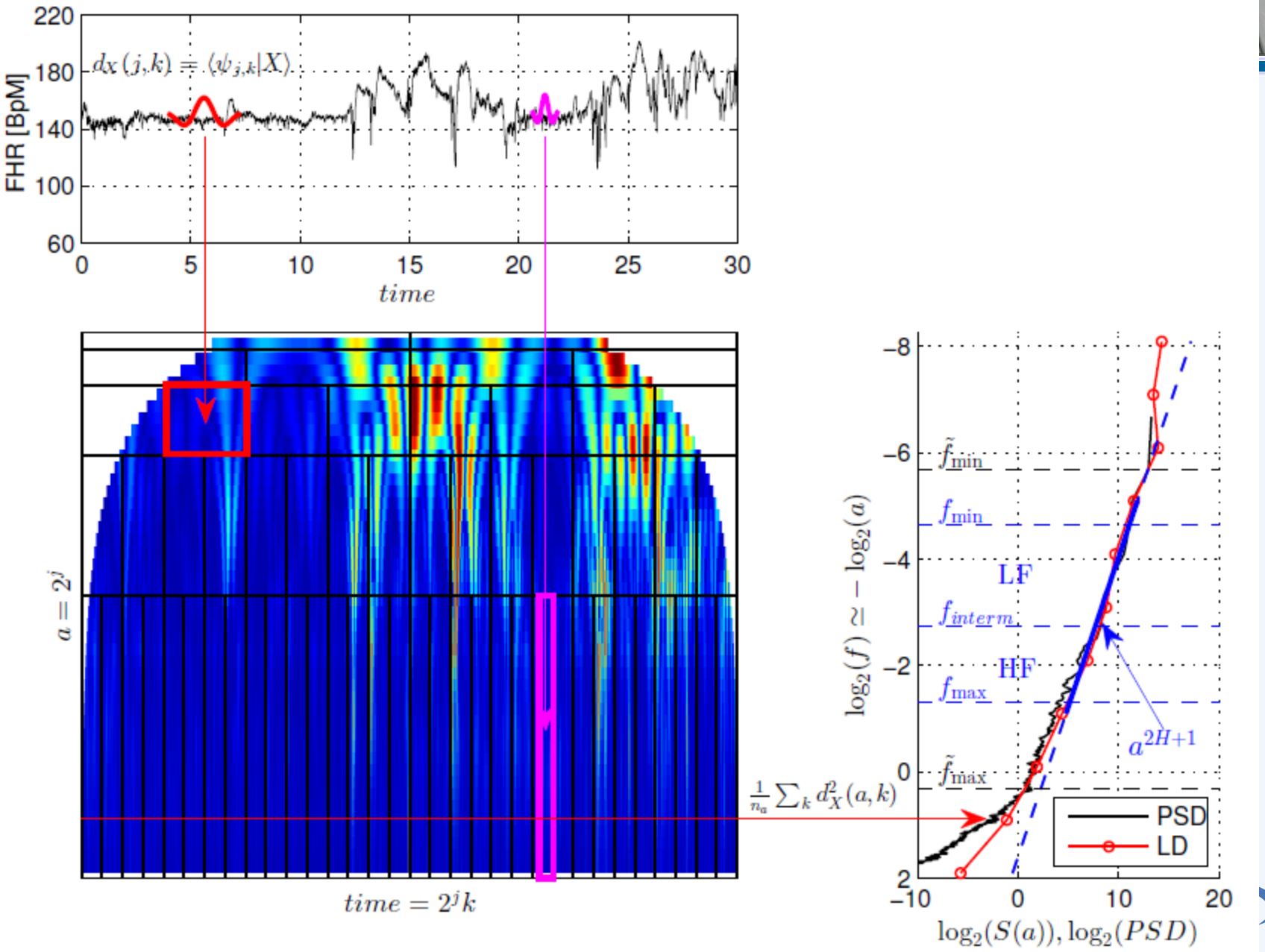
Conclusion

- Hurst exponent
  - Allows representation of time-scale properties of FHR by a single value
  - Measures embraces the Temporal Dynamics as Fractal Variability
  - Gathers time and spectral variabilities of the FHR in one feature
  - Describes temporal dynamics across range of scales rather than for specific scales
  - Simplifies the FHR analysis (in contrast to e.g. FIGO)
- Behaves consistently irrespective to decelerations

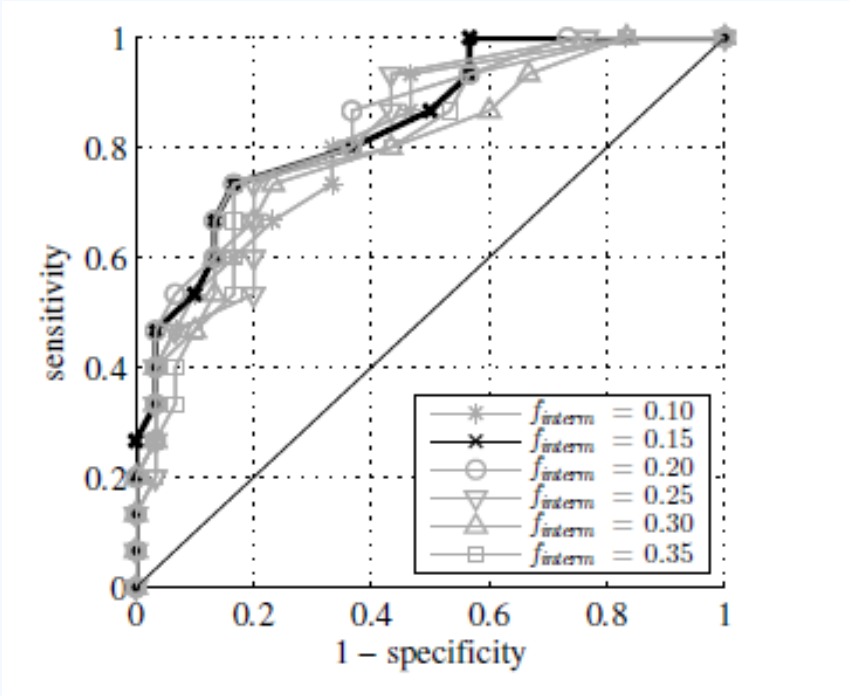
HF/LF

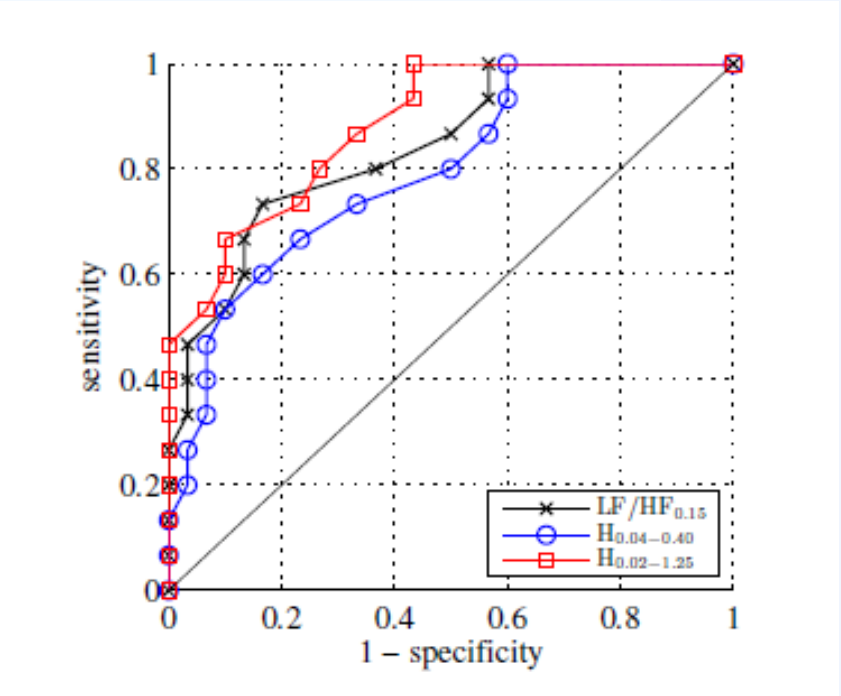
- HF and LF bands set-up taken from adults
- No evidence proved the threshold to be universal
- Could we use other thresholds?
- Is the band splitting relevant, then?
- H can be robust alternative to HF/LF

f_{interm}	AUC	p-value
0.10	0.79 (0.08)	< 0.05
0.15	**0.82 (0.07)**	< 0.05
0.20	0.82 (0.07)	< 0.05
0.25	0.80 (0.07)	< 0.05
0.30	0.77 (0.08)	< 0.05
0.35	0.78 (0.08)	< 0.05

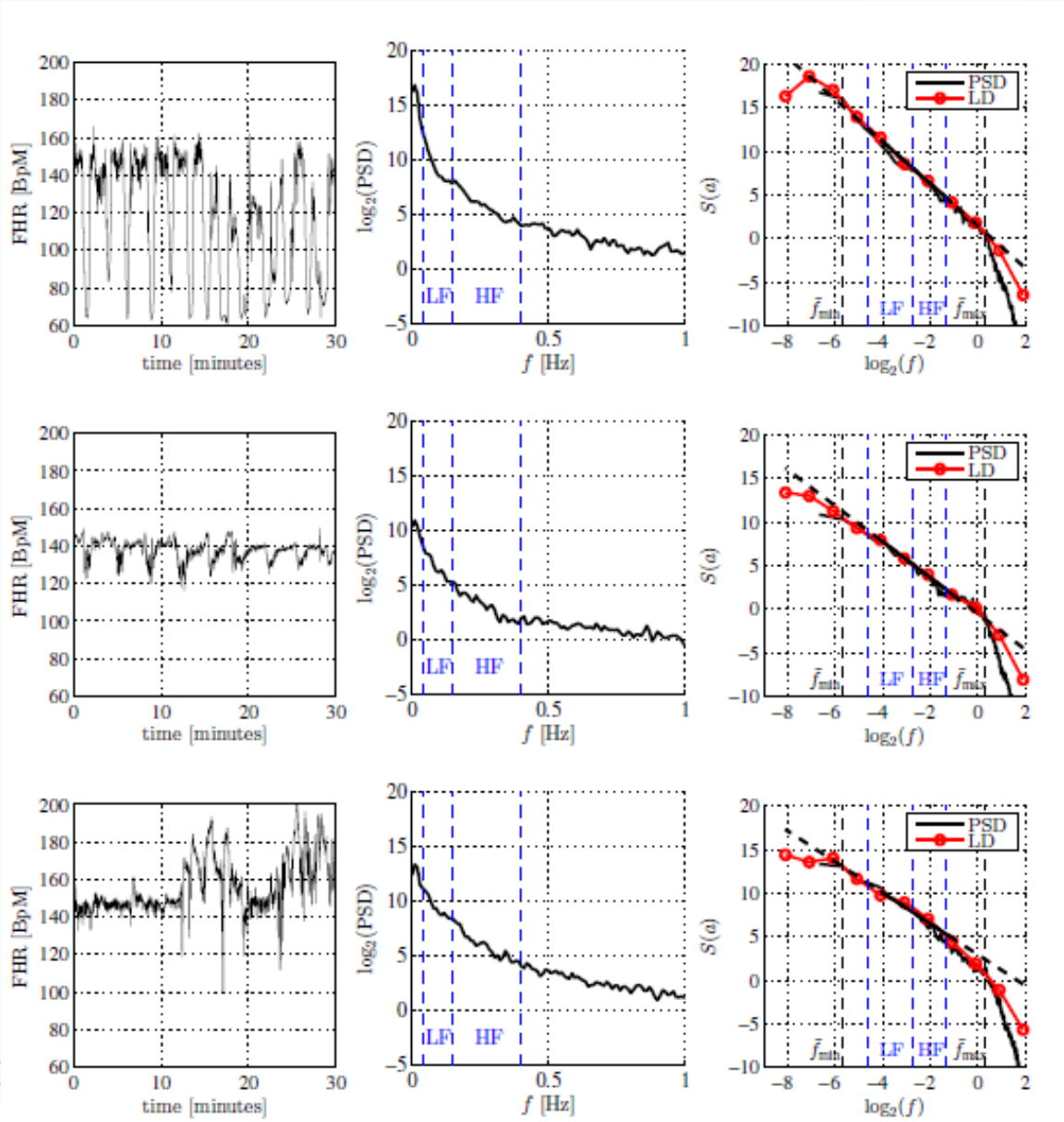

FHR [BpM]
time
$d_X(j,k) = \langle \psi_{j,k} | X \rangle$
$a = 2^j$
$time = 2^j k$
$\frac{1}{n_a} \sum_k d_X^2(a,k)$
$\log_2(f) - \log_2(a)$
$\log_2(S(a)), \log_2(PSD)$
$\tilde{f}_{\min}$
$f_{\min}$
f_{interm}
$f_{\max}$
$\tilde{f}_{\max}$
LF
HF
a^{2H+1}
PSD
LD

ROC curves for band split and H



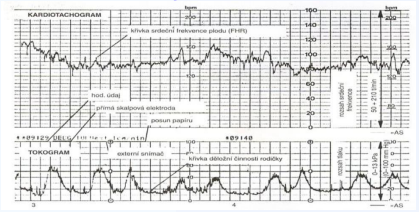


Power law behaviour on classes



What is the goal?

- CTG-centric: Related mainly to CTG
  - Correctly classified CTG (based on guidelines)
  - Detection of abnormal CTG => outlier detection
  - Classification into classes based on data => clustering



- Baby-centric: Related to delivery as a whole
  - Always healthy baby => rate of CS close to 100%
  - "Happy" baby & mother
  - Good pH (or any other "objective") value

- M.D. centric:
  - Decision based on objective rather than subjective indices
  - Less legal trouble for obstetricians

Problems with goals (1)

- CTG-centric: Related mainly to CTG
  - Relation of CTG and outcome (Se is ~40%, Hruban2014 submitted)
- Correctly classified CTG (based on guidelines)
  - Guidelines are flawed and irreproducible (Campos2010)
  - Guidelines are taking over common sense (Ugwumadu2014)
- Detection of abnormal CTG => outlier detection
  - In theory sound idea – yet about 30-50% of pathological cases misclassified (unpublished results on HFMEdb of about 3000 cases)
- Classification into classes based on data => clustering
  - Large db is needed with sufficient number of pathological cases and similar signal quality. Treatment of unbalance sets necessary to achieve results comparable to classification. (Janickova2014)

Problems with goals (2)

- Baby-centric: Related to delivery as a whole
  - Always healthy baby => rate of CS close to 100%?
    - Not a reasonable thing, right? Not everybody can drive a tank…
  - "Happy" baby & mother
    - Ideal, unfortunately very vague – how to define such a state? 1990s with current prenatal treatment/diagnostics? Is it possible?
  - Good pH (or any other "objective") value
    - The objective marker is not very specific when used for delivery outcome assessment. Too many influences from other clinical factors (e.g. sex of the new-born).
- M.D. centric
  - Complementary goals to any above

Our conclusion from the intro qs

- "Happy" baby is our goal
- Related clinical questions
  - To monitor or not to monitor (intensively)?
  - To use SoA supplementary methods e.g. STAN?
  - To simplify guidelines e.g. along 4-rules/states by Schifrin?
  - To find relevant clinical features (and combinations) to the outcome?
- Features from CTG – just one input to more complex system
  - Features focused on are decelerations and **variability – via scaling properties of the signal**
  - **Composite outcome (Latent class modeling)** is decided based on pH, Apgar, and subj. eval. of CTG
  - Based on CTG class – different features will be used for further analysis