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Beth Jelfs

My research career to date has focussed on adaptive signal processing especially statistical signal processing and signal characterisation. In particular I am interested in the intersection of signal processing and machine learning. At the core of all my research is the belief that understanding more about the nature of signal generation mechanisms can aid and inform our choice of machine learning algorithms. I have worked on the theoretical foundations of this approach creating new adaptive algorithms which can track signals in real-time and developing machine learning techniques which take advantage of this information. I have a specific interest in how these techniques can be applied to multichannel and multimodal data. My work highly multi-disciplinary and has been applied to a wide range of problems particularly with reference to biomedical and neural applications.

Education

PhD Electrical & Electronic Engineering
Imperial College London, UK
April 2010

Thesis: Collaborative Adaptive Filtering for Machine Learning

Awarded Engineering & Physical Sciences Research Council Doctoral Training Award

MEng Electronic & Software Engineering
University of Leicester, UK
July 2005

1st Class Honours

Awarded British Computer Society's prize for best graduating student

Research Experience

Vice-Chancellor's Research Fellow
School of Engineering, RMIT University, Australia
March 2017 – Present

My fellowship research is on adaptive signal processing algorithms for signal characterisation and machine learning, projects include:

- Development of time-varying delay estimation algorithms;
- Integration of image processing & machine learning for tracking cellular & tissue responses
- Simulation platform for prediction of station-keeping for high-altitude balloons.

Research Fellow
Dept. Electronic Engineering, City University of Hong Kong, Hong Kong
August 2013 – October 2016

Coordinated the project "Fingers Working in Coordination: Hierarchy of EEG, EMG and Kinematics" funded by the Hong Kong Research Grant Council.
Simultaneously developed a project as part of the Centre for Biosystems, Neuroscience, and Nanotechnology on computational methods for neural synchronization and information transfer.

Postdoctoral Research Associate
Dept. Medical Physics & Bioengineering, University College London, UK
June 2011 – June 2013

Responsible for designing the signal processing aspects of project "Integrating monitoring & modelling for real time tracking of cerebral circulation & metabolism" funded by Wellcome Trust Project Grant.

Postdoctoral Research Assistant
Dept. Chemistry & Dept. Physics, University of Oxford, UK
June 2010 – June 2011

Developed statistical signal processing techniques to study nanopore technology and the accuracy of classification for DNA sequencing.

Select Publications

Impairment of Cognitive Function by Chemotherapy: Association with the Disruption of Phase-Locking and Synchronization in Anterior Cingulate Cortex
L. Mu J. Wang, B. Cao, **B. Jelfs**, R.H.M. Chan, X. Xu *et al.*
Molecular Brain
2015, vol. 8, no. 32 pp. 200–210.

- This paper highlights how computational techniques can provide both assessment of biological data and also aid our understanding of neurology.
- Part of a collaboration with biologists to investigate novel methods to analyse the relationship between neural spiking and local field potentials (LFP) in electrophysiology data.
- To understand how different regions in the brain interact the relationship between the LFP in different regions was studied.
- Results present statistics of the relationship between the neural spike train and the phase of the LFP time series.

Modelling Noninvasively Measured Cerebral Signals During a Hypoxemia Challenge: Steps Towards Individualised Modelling
B. Jelfs, M. Banaji, I. Tachtsidis, C.E. Cooper and C.E. Elwell
PLoS One
2012, vol. 7, no. 6:e38297.

- This paper investigates the use of mathematical modelling for interpretation of physiological data and how differences between data and model can raise questions regarding physiology and the reliability and meaning of signals.
- Results show how individualised model optimisation can increase the model predictive power and provide confidence intervals on model parameters.
- Optimisation was informed by discussion with clinical collaborators in order to determine the parameters of most clinical significance.

An Adaptive Approach for the Identification of Improper Complex Signals
B. Jelfs, D. Mandic and S. Douglas
Signal Processing
2012, vol. 92, no. 2, pp. 335–344.

- This paper presents an adaptive method for identification of improper complex signals in real time and the existence and uniqueness of the solution is supported by convergence analysis.
- Complex data occurs in a wide range of real world situations and understanding the nature of this data allows us to select appropriate modelling/machine learning techniques.
- To highlight the need for the full second order statistics an overview of second order noncircularity (improperness) and widely linear autoregressive modelling is provided.

Modelling of Brain Consciousness based on Collaborative Adaptive Filters
L. Li, Y. Xia, **B. Jelfs**, J. Cao and D. Mandic
Neurocomputing
2012, vol. 76, no. 1, pp. 36–43.

- This paper was an invited to a special issue based on the work which won the best student paper award at the International Symposium on Neural Networks.
- The proposed method arises from my PhD research on collaborative adaptive filters and is applied to EEG data to provide a brain consciousness test for coma patients.
- Assessment of consciousness states is achieved via tracking the nonlinearity of EEG signals.
- The test is non-invasive and can potentially avoid unnecessary invasive tests by indicating whether further tests are required.

An Augmented Echo State Network for Nonlinear Adaptive Filtering of Complex Valued Real World Signals
Y. Xia, **B. Jelfs**, M. Van Hulle, J. Principe and D. Mandic
IEEE Transactions on Neural Networks
2011, vol. 22, no. 1, pp. 74–83.

- This paper presents an echo state network architecture produced while working at KU Leuven as part of the FP6 Neuroprobes project.
- By using the full second order statistics of complex data whilst also implementing an adaptive nonlinear output, the network can deal with data with large dynamics and adapt to the nature of the data.
- One major advantage of this method is the ability to process bivariate signals with strong component correlations.

Grants & Awards

Ideation Challenge
SmartSat Cooperative Research Centre
2020

Goal: Development of a vision based attitude estimation system for high altitude platforms.
Role: Successfully lead a project to rapidly conceive and produce a minimum viable product. This has been invited to be developed into a more complete system in a subsequent project.

Project for the Defence Artificial Intelligence Centre
Trusted Autonomous Systems Defence Cooperative Research Centre
2020-2021

Goal: Performance assessment for a self-organising low-cost, high altitude balloon constellation for persistent surveillance and communications.
Role: Development of a simulation platform to allow assessment of performance based on real and simulated data.

Maxwell Eagle Endowment Award
RMIT University
2020

Goal: Using machine-based learning to develop prognostics of CAR T cell outcomes in older patients.
Role: Developing image processing and predictive machine learning algorithms.

Capability Development Fund
RMIT University
2019

Goal: High throughput platform for tracking cellular response.
Role: Creating efficient image processing algorithms for development of high volume machine learning architecture.

Global Connections Fund Bridging Grant
Australian Academy of Technology Sciences and Engineering
2017–2018

Goal: Development of a wireless portable device to monitor muscle fatigue in collaboration with PLUX Wireless Biosignals a Portuguese SME.
Role: Successfully designed new algorithms to assess muscle status in real time.

Scheme for Teaching and Learning Research
RMIT University
2017

Goal: Developing the framework for problem based learning workshop style education.
Role: Design of framework.

Vice-Chancellor's Research Fellowship
RMIT University
2017–2021

Goal: To investigate the use of time-varying algorithms in the assessment of biomedical data for machine learning applications. **Role:** Sole investigator, project design, management and dissemination of results.

Research Exchange Project
BayChina
2015

Collaboration with Neuroscientific Theory Group at TU München.

Best Student Paper Award
International Symposium on Neural Networks
2010

For paper "Modelling of Brain Consciousness based on Collaborative Adaptive Filters".

Academic Research Collaboration Project
British Council and DAAD
2008

Collaboration with TU München and the Max-Planck-Institute for Dynamics and Self-Organization.

International Travel Grant
Royal Academy of Engineering
2007

Awarded to attend IEEE International Conference on Acoustics Speech and Signal Processing.

Teaching Experience

Lecturer, Signals & Systems 1
RMIT University
2019–2020

Offshore course taught at School for Higher and Professional Education, Vocational Training Council, Hong Kong.

Course Coordinator, Biomedical Signal Analysis
RMIT University
2018–2020

Design and delivery of a core 3rd year undergraduate course in biomedical engineering and technical elective for electronic engineering with ~ 40 students.

Guest Lecturer, Brain Machine Interface: Technology, Culture, and Society
City University of Hong Kong
2014–2015

Lecturing on BMI Technology & Neural Computation for a university elective with ~ 200 students.

International Transition Team Graduate Teaching Assistant
City University of Hong Kong
2013–2015

Providing English language support including student tutorials, proofreading of academic papers & preparation of teaching materials.

Tutor, Communications I
Imperial College London
2006–2008

Teaching study groups of ~ 30 students for a core 1st year undergraduate course in electronic engineering.

Service to Field

Steering Committee Member
SmartSat Cooperative Research Centre
2020–Present

AI4Space Research Network: to progress research and development in AI applied to space systems and technologies.

Topic Editor
Entropy
2020–Present
Leading special issues, suggesting new topics, and recommending Guest Editors for these new topics; supervising the editorial process.

Special Session Organiser
APSIPA Annual Summit & Conference, Auckland, New Zealand
2020
Multidimensional Biomedical Signal and Image Processing.

Special Session Organiser
APSIPA Annual Summit & Conference, Honolulu, USA
2018
Emerging Technologies for Healthcare.

Vice-Chancellor's Fellows Advisory Group
RMIT University
2017–2021
Liasing with Research & Innovation Office to provide improved procedures for fellows.
Organising events to promote the fellows' research and collaboration between fellows.

Organising committee
"enGENEious" conference, Oxford, UK
2012
Student & Post-doc lead conference on microbial engineering.

Public Engagement & Invited Talks

Engaging for Impact
RMIT University, Australia
2020
Talk on Tissue Image Processing for Innovation in Healthcare with Precision Medicine session.

Biomedical Engineering Dept.
Shantou University, China
2019
Invited lecture series on biomedical signal processing.

Bioinformatics Network Symposium
RMIT University, Australia
2019
Talk on Machine Learning for High Throughput Cell Imaging.

Pint of Science
London, UK
2013
Event manager for science festival for the general public.

UCL Outreach
University College London, UK
2011–2013
Lead demonstrations and talks with school children for events including:
- Medical Physics Masterclass;
- Women in Engineering Taster Day;
- University Challenge Event.

Doctoral Training Centre
University of Oxford, UK
2011
Talk on DNA Nanopore Sequencing.

Faculty of Computer Science
University of Applied Sciences Schmalkalden, Germany
2008
Talk on Signal Modality Characterisation Using Collaborative Adaptive Filters.

Professional Associations

Asia-Pacific Signal & Information Processing Association (APSIPA)
2018–present

Member
- Member Biomedical Signal Processing & Systems Technical Committee

Institute of Electrical and Electronics Engineers
2006–present

Member
- Affiliate member of Bio Imaging and Signal Processing Technical Committee
- Member of Signal Processing Society
- Member of Engineering in Medicine and Biology Society

Full Publication List

Preprints

[1] **B. Jelfs**, S. Sun, K. Ghorbani, and C. Gilliam. An adaptive all-pass filter for time-varying delay estimation. arXiv:2101.02406

[2] Q. She, **B. Jelfs**, A. S. Charles, and R. H. M. Chan. Network modeling of short over-dispersed spike-counts: A hierarchical parametric empirical bayes framework. arXiv:1605.02869

Journal Articles

[1] W. Li, **B. Jelfs**, A. Kealy, X. Wang, and B. Moran, "Cooperative localization using distance measurements for mobile nodes," *Sensors*, vol. 21, no. 4, p. 1507, 2021. doi:10.3390/s21041507

[2] X. Wang, A. Kealy, W. Li, **B. Jelfs**, C. Gilliam, S. L. May *et al.*, "Toward autonomous UAV localization via aerial image registration," *Electronics*, vol. 10, no. 4, p. 435, 2021. doi:10.3390/electronics10040435

[3] R. Viswanathan, S. P. Arjunan, A. Bingham, **B. Jelfs**, P. Kempster, S. Raghav *et al.*, "Complexity measures of voice recordings as a discriminative tool for Parkinson's disease," *Biosensors*, vol. 10, no. 1:1, 2020. doi:10.3390/bios10010001

[4] D. K. Kumar, **B. Jelfs**, X. Sui, and S. P. Arjunan, "Prosthetic hand control: A multidisciplinary review to identify strengths, shortcomings, and the future," *Biomedical Signal Processing and Control*, vol. 53, no. 101588, 2019. doi:10.1016/j.bspc.2019.101588

[5] S. M. Keloth, R. Viswanathan, **B. Jelfs**, S. Arjunan, S. Raghav, and D. Kumar, "Which gait parameters and walking patterns show the significant differences between Parkinson's disease and healthy participants?" *Biosensors*, vol. 9, no. 2:59, 2019. doi:10.3390/bios9020059

[6] A. Bingham, S. P. Arjunan, **B. Jelfs**, and D. K. Kumar, "Normalised mutual information of high-density surface electromyography during muscle fatigue," *Entropy*, vol. 19, no. 12, p. 697, 2017. doi:10.3390/e19120697

[7] **B. Jelfs** and R. H. M. Chan, "Directionality indices: Testing information transfer with surrogate correction," *Physical Review E*, vol. 96, no. 5:052220, 2017. doi:10.1103/physreve.96.052220

[8] X. Zhai, **B. Jelfs**, R. H. M. Chan, and C. Tin, "Self-recalibrating surface EMG pattern recognition for neuroprosthesis control based on convolutional neural network," *Frontiers in Neuroscience*, vol. 11, no. 379, 2017. doi:10.3389/fnins.2017.00379

[9] B. Cao, J. Wang, M. Shahed, **B. Jelfs**, R. H. M. Chan, and Y. Li, "Vagus nerve stimulation alters phase synchrony of the anterior cingulate cortex and facilitates decision making in rats," *Scientific Reports*, vol. 6, no. 35135, 2016. doi:10.1038/srep35135

[10] Y. Gao, G. Zhang, **B. Jelfs**, R. Carmer, P. Venkatraman, M. Ghadami *et al.*, "Computational classification of different wild-type zebrafish strains based on their variation in light-induced locomotor response," *Computers in Biology and Medicine*, vol. 69, pp. 1–9, 2016. doi:10.1016/j.compbiomed.2015.11.012

[11] B. Cao, J. Wang, X. Zhang, X. Yang, D. C.-H. Poon, **B. Jelfs** *et al.*, "Impairment of decision making and disruption of synchrony between basolateral amygdala and anterior cingulate cortex in the maternally separated rat," *Neurobiology of Learning and Memory*, vol. 136, pp. 74–85, 2016. doi:10.1016/j.nlm.2016.09.015

[12] J. Wang, B. Cao, T. R. Yu, **B. Jelfs**, J. Yan, R. H. M. Chan *et al.*, "Theta-frequency phase-locking of single anterior cingulate cortex neurons and synchronization with the medial thalamus are

modulated by visceral noxious stimulation in rats," *Neuroscience*, vol. 298, pp. 200–210, 2015. doi:10.1016/j.neuroscience.2015.04.024

[13] L. Mu, J. Wang, B. Cao, **B. Jelfs**, R. H. M. Chan, X. Xu *et al.*, "Impairment of cognitive function by chemotherapy: Association with the disruption of phase-locking and synchronization in anterior cingulate cortex," *Molecular Brain*, vol. 8, no. 32, 2015. doi:10.1186/s13041-015-0125-y

[14] **B. Jelfs** and D. P. Mandic, "A unifying framework for the analysis of proportionate NLMS algorithms," *International Journal of Adaptive Control and Signal Processing*, vol. 29, no. 9, pp. 1073–1085, 2014. doi:10.1002/acs.2518

[15] **B. Jelfs**, M. Banaji, I. Tachtsidis, C. E. Cooper, and C. E. Elwell, "Modelling noninvasively measured cerebral signals during a hypoxemia challenge: Steps towards individualised modelling," *PLoS ONE*, vol. 7, no. 6:e38297, 2012. doi:10.1371/journal.pone.0038297

[16] **B. Jelfs**, D. P. Mandic, and S. C. Douglas, "An adaptive approach for the identification of improper complex signals," *Signal Processing*, vol. 92, no. 2, pp. 335–344, 2012. doi:10.1016/j.sigpro.2011.07.020

[17] L. Li, Y. Xia, **B. Jelfs**, J. Cao, and D. P. Mandic, "Modelling of brain consciousness based on collaborative adaptive filters," *Neurocomputing*, vol. 76, no. 1, pp. 36–43, 2012. doi:10.1016/j.neucom.2011.05.038

[18] Y. Xia, **B. Jelfs**, M. M. V. Hulle, J. C. Principe, and D. P. Mandic, "An augmented echo state network for nonlinear adaptive filtering of complex noncircular signals," *IEEE Transactions on Neural Networks*, vol. 22, no. 1, pp. 74–83, 2011. doi:10.1109/tnn.2010.2085444

[19] **B. Jelfs**, S. Javidi, P. Vayanos, and D. Mandic, "Characterisation of signal modality: Exploiting signal nonlinearity in machine learning and signal processing," *Journal of Signal Processing Systems*, vol. 61, no. 1, pp. 105–115, 2010. doi:10.1007/s11265-009-0358-z

Book Chapters

[1] **B. Jelfs**, P. Vayanos, S. Javidi, V. S. L. Goh, and D. Mandic, "Collaborative adaptive filters for online knowledge extraction and information fusion," in *Signal Processing Techniques for Knowledge Extraction and Information Fusion*, D. Mandic et al., Ed. Springer, 2008, pp. 3–21. doi:10.1007/978-0-387-74367-7_1

[2] P. Vayanos, M. Chen, **B. Jelfs**, and D. P. Mandic, "Exploiting nonlinearity in adaptive signal processing," in *Advances in Nonlinear Speech Processing*, M. Chetouani et al., Ed. Springer Berlin Heidelberg, 2007, pp. 57–77. doi:10.1007/978-3-540-77347-4_3

[3] **B. Jelfs**, P. Vayanos, M. Chen, S. L. Goh, C. Boukis, T. Gautama, T. Rutkowski, T. Kuh, and D. Mandic, "An online method for detecting nonlinearity within a signal," in *Knowledge-Based Intelligent Information and Engineering Systems*, B. Gabrys et al., Ed. Springer Berlin Heidelberg, 2006, pp. 1216–1223. doi:10.1007/11893011_154

Peer Reviewed Conference Proceedings

[1] **B. Jelfs** and C. Gilliam, "Application of image processing and circular statistics to 3D cellular alignment," in *Proc. Asia-Pacific Signal and Information Processing Association Annual Summit and Conference*, 2020, pp. 992–1000.

[2] **B. Jelfs** and C. Gilliam, "Fast & efficient delay estimation using local all-pass & Kalman filters," in *Proc. Asia-Pacific Signal and Information Processing Association Annual Summit and Conference*, 2019, pp. 1533–1539. doi:10.1109/APSIPAASC47483.2019.9023238

[3] R. Viswanathan, A. Bingham, S. Raghav, S. P. Arjunan, **B. Jelfs**, P. Kempster *et al.*, "Normalized mutual information of phonetic sound to distinguish the speech of Parkinson's disease," in *Proc.*

Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2019, pp. 3525–3526. doi:10.1109/embc.2019.8857112

[4] C. Gilliam and **B. Jelfs**, "Estimating muscle fibre conduction velocity in the presence of array misalignment," in *Proc. Asia-Pacific Signal and Information Processing Association Annual Summit and Conference*, 2018, pp. 853–860. doi:10.23919/apsipa.2018.8659741

[5] A. Bingham, **B. Jelfs**, S. P. Arjunan, and D. K. Kumar, "Identifying noisy electrodes in high density surface electromyography recordings through analysis of spatial similarities," in *Proc. Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 2018, pp. 2325–2328. doi:10.1109/embc.2018.8512846

[6] C. Gilliam, A. Bingham, T. Blu, and **B. Jelfs**, "Time-varying delay estimation using common local all-pass filters with application to surface electromyography," in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing*, 2018, pp. 841–845. doi:10.1109/icassp.2018.8461390

[7] S. Bhowmik, **B. Jelfs**, S. P. Arjunan, and D. K. Kumar, "Outlier removal in facial surface electromyography through Hampel filtering technique," in *Proc. IEEE Life Sciences Conference*, 2017, pp. 258–261. doi:10.1109/lsc.2017.8268192

[8] Y. Li, **B. Jelfs**, and R. H. Chan, "Entropy of surface EMG reflects object weight in grasp-and-lift task," in *Proc. Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 2017, pp. 2530–2533. doi:10.1109/embc.2017.8037372

[9] W. K. Y. So, L. Yang, **B. Jelfs**, Q. She, S. W. H. Wong, J. N. Mak *et al.*, "Cross-frequency information transfer from EEG to EMG in grasping," in *Proc. Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 2016, pp. 4531–4534. doi:10.1109/embc.2016.7591735

[10] X. Zhai, **B. Jelfs**, R. H. M. Chan, and C. Tin, "Short latency hand movement classification based on surface EMG spectrogram with PCA," in *Proc. Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2016, pp. 327–330. doi:10.1109/embc.2016.7590706

[11] **B. Jelfs**, L. Li, C. Tin, and R. H. M. Chan, "Fuzzy entropy based nonnegative matrix factorization for muscle synergy extraction," in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing*, 2016, pp. 739–743. doi:10.1109/icassp.2016.7471773

[12] **B. Jelfs**, S. Zhou, B. K. Y. Wong, C. Tin, and R. H. M. Chan, "Recruitment of small synergistic movement makes a good pianist," in *Proc. Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 2015, pp. 242–245. doi:10.1109/embc.2015.7318345

[13] **B. Jelfs**, J. Panovska-Griffiths, I. Tachtsidis, M. Banaji, and C. Elwell, "Individualised optimisation of modelled cerebral oxygenation near-infrared spectroscopy signals," in *Biomedical Optics and 3-D Imaging*, no. JM3A.32, 2012. doi:10.1364/biomed.2012.jm3a.32

[14] S. Javidi, **B. Jelfs**, and D. P. Mandic, "Blind extraction of noncircular complex signals using a widely linear predictor," in *Proc. IEEE Workshop on Statistical Signal Processing*, 2009, pp. 501–504. doi:10.1109/ssp.2009.5278530

[15] **B. Jelfs**, Y. Xia, D. P. Mandic, and S. C. Douglas, "Collaborative adaptive filtering in the complex domain," in *Proc. IEEE Workshop on Machine Learning for Signal Processing*, 2008, pp. 421–425. doi:10.1109/mlsp.2008.4685517

[16] **B. Jelfs** and D. Mandic, "Signal modality characterisation using collaborative adaptive filters," in *Proc. IAPR Workshop on Cognitive Information Processing*, 2008.

[17] D. P. Mandic, P. Vayanos, S. Javidi, **B. Jelfs**, and K. Aihara, "Online tracking of the degree of nonlinearity within complex signals," in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing*, 2008, pp. 2061–2064. doi:10.1109/icassp.2008.4518046

[18] **B. Jelfs**, D. P. Mandic, and A. Cichocki, "A unifying approach to the derivation of the class of PNLMS algorithms," in *Proc. International Conference on Digital Signal Processing*, 2007, pp. 35–38. doi:10.1109/icdsp.2007.4288512

[19] **B. Jelfs**, D. P. Mandic, and J. Benesty, "A class of adaptively regularised PNLMS algorithms," in *Proc. International Conference on Digital Signal Processing*, 2007, pp. 19–22. doi:10.1109/icdsp.2007.4288508

[20] D. Mandic, P. Vayanos, C. Boukis, **B. Jelfs**, S. L. Goh, T. Gautama *et al.*, "Collaborative adaptive learning using hybrid filters," in *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing*, 2007, pp. 921–924. doi:10.1109/icassp.2007.366831

[21] M. Chen, T. Rutkowski, **B. Jelfs**, G. Souretis, J. Cao, and D. Mandic, "Assessment of nonlinearity in brain electrical activity: A DVV approach," in *Proc. RISP International Workshop on Nonlinear Circuits and Signal Processing*, 2007, pp. 461–464.

[22] **B. Jelfs** and D. Mandic, "Towards online monitorying of the changes in signal modality: The degree of sparsity," in *Proc. IMA International Conference on Mathematics in Signal Processing*, 2006, pp. 29–32.

[23] F. Schlindwein, A. Boardman, S. Vali, N. Wright, **B. Jelfs**, S. Mauger *et al.*, "Noninvasive determination of fetal heart rate and short term heart rate variability using solely doppler ultrasound with autocorrelation," in *Proc. International Conference on Medical Signal & Information Processing*, 2004.