

# **3<sup>rd</sup> Signal Processing and Monitoring (SPaM) in Labour Workshop**

**Porto, Portugal**

**28-30 October 2019**

## **Speakers**

Ana Alarcon, St Joan De Deu Barcelona Children's Hospital, Spain

Rodrigo Aviles-Espinosa, University of Sussex, UK

DIOGO AYRES-DE-CAMPOS, University of Lisbon

João Bernardes, Faculty of Medicine of the University of Porto (FMUP), Portugal

Samuel Boudet, Catholic University of Lille, France

Petar M. Djurić, Stony Brook University, USA

William Fifer, Columbia University, USA

Martin Frasch, University of Washington, USA

Antoniya Georgieva, University of Oxford, UK

Hernâni Gonçalves, University of Porto, Portugal

Malin Holzmänn, Karolinska Institutet, Stockholm, Sweden

Solveig Haukås Haaland, Laerdal Medical AS, Norway

Tomoaki Ikeda, Mie University of Graduate School of Medicine, Japan

Ines Nunes, University of Porto, Portugal

Gerald Quirk, Stony Brook University, U.S.A

Elizabeth Rendon-Morales, University of Sussex, UK

Massimo Rivolta, Università degli Studi di Milano, Italy

Stephane G. Roux, ENS Lyon, France

Barry Schifrin, bpm, Inc. USA

Maria Gabriella Signorini, Politecnico di Milano, Italy

Austin Ugwumadu, St George's University of London, UK

R. Vullings, Eindhoven University of Technology, The Netherlands

Philip Warrick, PeriGen, Canada

Hau-tieng Wu, Duke University, USA

### **Ana Alarcon, St Joan De Deu Barcelona Children's Hospital, Spain**

Dr Ana Alarcon is a neonatologist with a particular interest in the developing brain. She specialised in neonatology at the Hospital La Paz de Madrid and completed her training in the San Joan De Deu Barcelona Children's Hospital, where she later started to work as a Pediatrician-Neonatologist. In 2013 she went to England to work as a Consultant Neonatologist in the University of Oxford Hospital. She returned to the SJD Barcelona Children's Hospital in 2018. She remains academically linked to the University of Oxford through a Clinical Research Fellowship. Dr Alarcon's particular area of interest is Neonatal Neurology. Her research work is primarily based on perinatal cerebral damage secondary to infection/inflammation or of hypoxic-ischaemic origin. Dr Alarcon obtained a Degree in Medicine and Surgery, Universidad Complutense, Madrid in 1998 and a PhD in Medicine, Universitat de Barcelona, Department of Pediatrics, 2011.

### **Rodrigo Aviles-Espinosa, University of Sussex, UK**

Dr. Rodrigo Aviles-Espinosa has combined industry and academic experience focused on the development of biomedical tools. Recently, he moved from the industry to the Department of Engineering and Design at the University of Sussex as a lecturer in Optoelectronics and Bio-Engineering. His research interests are focused on designing the next generation ECG monitoring devices covering micro and macro scales. Applications of his research in the micro scale include the use of photonics and electronics to study the functional and morphological development of model organisms for drug discovery applications. In the macro scale, he is developing the next generation sensing devices to monitor the ECG of foetuses and neonates non-invasively.

### **Diogo Ayres-de-Campos, University of Lisbon**

DIOGO AYRES-DE-CAMPOS is currently Associate Professor at the Medical School - University of Lisbon, Portugal, and Chair of the Obstetrics Department at the Santa Maria University Hospital, Lisbon. His main scientific areas of interest are intrapartum fetal monitoring and obstetric simulation. He is a co-inventor of the "SisPorto®" program for computer analysis of fetal monitoring signals (Speculum, Lisbon, Portugal, 2006), the clinical record database Obscare (Virtualcare, Porto, Portugal), and was the medical consultant for the development of the "Lucina®" obstetric simulator (CAE Healthcare, Montreal, Canada, 2014). He has published 127 papers in international Medline-indexed journals, edited 4 books, authored 17 international book chapters, written 1 international book, and has given 193 invited lectures at international scientific meetings.

He is the President-Elect of the "European Association of Perinatal Medicine - EAPM", a Council Member of the "European Board and College of Obstetrics and Gynecology - EBCOG", and coordinator of EBCOG Part 2 Exam – Evaluation of clinical skills. From 2010-2018 he integrated the "Safe Motherhood and Newborn Health committee" at the "International Federation of Obstetrics and Gynecology - FIGO", where he co-ordinated the 2015 revision of the "FIGO guidelines on intrapartum fetal monitoring". He participated in the World Health Organisation consensus panels for "Recommendations on antenatal care" and "Intrapartum care and reduction of unnecessary caesarean section" in 2016.

Ayres-de-Campos D, Spong CY, Chandraran E, for the FIGO Intrapartum Fetal Monitoring Expert Consensus Panel. FIGO consensus guidelines on intrapartum fetal monitoring: Cardiotocography. *Int J Gynecol Obstet* 2015;131:13-24

Ayres-de-Campos D, Rei M, Nunes I, Sousa P, Bernardes J. SisPorto 4.0 – computer analysis following the 2015 FIGO guidelines for intrapartum fetal monitoring. *J Mat Fet Neonat Med* 2017;30:62-67.

### **João Bernardes, Faculty of Medicine of the University of Porto (FMUP), Portugal**

Prof João Bernardes graduated and earned his doctoral and aggregation degrees in Medicine at FMUP, where he is full professor of Gynecology and Obstetrics, director of the Department of Gynecology-Obstetrics and Pediatrics and member of the Scientific Council. He was founder and director of the Biomedical Simulation Centre and former director of the PhD Program in Medicine of FMUP.

He also works as Senior Doctor at the University Hospital Centre of S. João, in Porto, where he was director of the Department of Obstetrics and Gynecology. He is president of the Portuguese Board of Gynecologist and Obstetricians and vice-president of the Disciplinary Board of the North Council of the Portuguese Order of Doctors. He was vice-president of the Portuguese Society of Medical Education and secretary of the Portuguese Society of Biomedical Engineering. He is a principal Investigator in the Research Unit CINTESIS and is a former leader of projects of the National Board for Scientific and Technical Research, which gave way to the market model of the system for cardiotocograms' analysis SisPorto. He is member of the Editorial Council of several scientific journals, having authored and co-authored about 200 scientific articles in indexed journals.

### **Samuel Boudet, Catholic University of Lille, France**

Dr Samuel Boudet obtained an Engineering degree in Applied Mathematics from the National Institute of Applied Sciences of Rouen (France) in 2005 and a PhD in Signal Processing from Lille University (France) in 2008. Since 2008, he is a lecturer in the Biomedical Signal Processing Unit of the Faculty of Medicine and Midwifery (Catholic University of Lille, France). His research interests include EEG artefact filtering, iso-electric focusing image analysis, and fetal heart rate computerized analysis. He has developed efficient methods improving significantly the state of art in those three fields. Moreover, Dr Boudet specialized in creating biomedical signal web viewers (FHR, ECG, EEG) having several applications for e-Learning, Tele-medicine and research.

### **Petar M. Djurić, Stony Brook University, USA**

Petar M. Djurić received the B.S. and M.S. degrees in electrical engineering from the University of Belgrade, Belgrade, Yugoslavia, respectively, and the Ph.D. degree in electrical engineering from the University of Rhode Island, Kingston, RI, USA. He is a SUNY Distinguished Professor and currently a Chair of the Department of Electrical and Computer Engineering, Stony Brook University, Stony Brook, NY, USA. His research has been in the area of signal and information processing with primary interests in the theory of signal modeling, detection, and estimation; Monte Carlo-based methods; signal and information processing over networks; machine learning; RFID and the IoT. Recently, his research has been applied to problems related to machine learning methods for intrapartum fetal monitoring. He has been invited to lecture at many universities in the United States and overseas. Prof. Djurić was a recipient of the IEEE Signal Processing Magazine Best Paper Award in 2007 and the EURASIP Technical Achievement Award in 2012. In 2008, he was the Chair of Excellence of Universidad Carlos III de Madrid-Banco de Santander. From 2008 to 2009, he was a Distinguished Lecturer of the IEEE Signal Processing Society. He has been on numerous committees of the IEEE Signal Processing Society and of many professional conferences and workshops. He was Editor-in-Chief of the IEEE Transactions on Signal and Information Processing over Networks. Prof. Djurić is a Fellow of IEEE and EURASIP.

Feng G, Quirk JG, Djurić PM. Inference about Causality from Cardiotocography Signals Using Gaussian Processes. In ICASSP 2019-2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) 2019 May 12 (pp. 2852-2856). IEEE.

Feng G, Quirk JG, Djurić PM. Supervised and unsupervised learning of fetal heart rate tracings with deep Gaussian processes. In 2018 14th Symposium on Neural Networks and Applications (NEUREL) 2018 Nov 20 (pp. 1-6). IEEE.

### **Martin Frasch, University of Washington, USA**

Dr. Martin Frasch is a member of the Center on Human Development and Disability (CHDD) at the University of Washington in Seattle, USA. He researches the physiologic spatiotemporal structure underlying heart rate variability (HRV), which is a "code" that sheds light on the brain. Martin is passionate about improving health outcomes of pregnant mothers and their babies by monitoring their health non-invasively and providing actionable information to parents and health practitioners. His focus has been fetal heart rate monitoring during pregnancy and labour as well as fetal electroencephalography during labour. Martin's research shows that these technologies may reliably predict the risk for perinatal brain injury, allowing more individualized pregnancy, labour and postnatal health management. For more information, please visit [FraschLab.org](http://FraschLab.org).

Herry CL, Burns P, Desrochers A, Fecteau G, Durosier LD, Cao M, et al. Vagal contributions to fetal heart rate variability: an omics approach. *Physiol Meas*. 2019 Jul 1;40(6):065004.

Herry CL, Cortes M, Wu H-T, Durosier LD, Cao M, Burns P, et al. Temporal Patterns in Sheep Fetal Heart Rate Variability Correlate to Systemic Cytokine Inflammatory Response: A Methodological Exploration of Monitoring Potential Using Complex Signals Bioinformatics. *PLoS One*. 2016 Apr 21;11(4):e0153515.

### **William Fifer, Columbia University, USA**

Professor Fifer is an investigator in the fields of developmental neuroscience and psychobiology, the Chief of the Division of Developmental Neuroscience at the New York State Psychiatric Institute and the Associate Director of the Sackler Institute of Developmental Psychobiology at Columbia University Medical Center. He has active collaborations within the Departments of Psychiatry, Obstetrics, Pediatrics, Behavioral Medicine and Public Health focused on investigations of the role of early experience in shaping fetal/infant physiology and behavior. He and his team investigate the complex interplay of sleep physiology, patterns of brain activity, attention, and autonomic control and how they relate to risk for neurodevelopmental disorders. A major emphasis of his work is to determine how early life experiences, often associated with pre or perinatal exposures, shape the developing brain and later neurodevelopmental outcome. He is currently involved in four large cohort studies with local, national and international colleagues investigating early markers and trajectories of neurodevelopmental disorders and mediators of perinatal autonomic development, early learning and memory, sensory development and brain regulation during sleep. Other current investigations in his laboratory include studies of fetal, newborn and premature infant neurobehavioral responses to environmental stimulation during sleep, early learning and memory, behavioral and cortical activity during environmental challenges, and assessment of risk for neurological disorders including sudden unexplained infant death, autism, and fetal alcohol spectrum disorders.

Shuffrey LC, Myers MM, Odendaal HJ, Elliott AJ, du Plessis C, Groenewald C, Burd L, Angal J, Nugent JD, Isler JR, Fifer WP; PASS Network. Fetal heart rate, heart rate variability, and heart rate/movement coupling in the Safe PassageStudy. *J Perinatol*. 2019 May;39(5):608-618. doi: 10.1038/s41372-019-0342-9.

Zavala JH, Ecklund-Flores L, Myers MM, Fifer WP. Assessment of autonomic function in the late term fetus: The effects of sex and state. *Dev Psychobiol*. 2019 May 24. doi: 10.1002/dev.21865.

### **Antoniya Georgieva, University of Oxford, UK**

Dr Antoniya Georgieva obtained a BSc(Hons) in Applied Mathematics from the Technical University of Sofia (Bulgaria) and a PhD in Computer Science from Portsmouth University. She joined the Nuffield Department of Obstetrics and Gynaecology (Now the Nuffield Department of Women's and Reproductive Health) and the Institute of Biomedical Engineering at Oxford for a post-doctoral position in 2007. In 2012, she co-founded with Prof Chris Redman the Oxford Centre for Fetal Monitoring Technologies, of which Dr Georgieva is the Scientific Director.

Dr Georgieva developed her career in biomedical research, building on her expertise in signal processing, machine learning and mathematical optimisation, but specialising in intrapartum fetal monitoring. She is now leading the Oxford programme to develop evidence-based diagnostics in this clinical field, by working with the world's largest and most complete birth cohort of routine labour data (circa 100,000 births at term). She is also based at the newly opened Big Data Institute at the University of Oxford.

Petrozziello A, Redman CWG, Papageorghiou AT, Jordanov I, Georgieva A, Multimodal Convolutional Neural Networks to Detect Fetal Compromise During Labor and Delivery, IEEE Access 2019 Aug; 7: 112026-112036. [doi: 10.1109/access.2019.2933368](https://doi.org/10.1109/access.2019.2933368)

Georgieva A., Redman CWG, Papageorghiou AT, Computerized data-driven interpretation of the intrapartum cardiotocogram: a cohort study, Acta Obstetrica et Gynecologica Scandinavica 2017; 96: 883–891. <https://doi.org/10.1111/aogs.13136>

### **Hernâni Gonçalves, University of Porto, Portugal**

Hernâni Gonçalves received the B.Sc. degree in Technology Applied Mathematics, the M.Sc. degree in Computational Methods in Science and Engineering, and the Ph.D. degree in Geomatics, from the University of Porto, Porto, Portugal, in 2002, 2004, and 2010, respectively. He worked as a researcher under the scope of a project in biomedical engineering, in the analysis of biomedical signals, from 2002 to 2005. During his Ph.D. (2006-2010), he worked in the automatic registration of satellite images, with a doctoral grant from the Portuguese Science and Technology Foundation (FCT), and between 2011-2017 worked at the Center for Health Technology and Services Research (CINTESIS) in linear/nonlinear analysis of biomedical signals, with a post-doctoral grant also from FCT. Currently he is an assistant professor at the Faculty of Medicine of the University of Porto and the principal investigator of the Signal Processing Applications (SPA) research group at CINTESIS. His research interests include data analysis, biomedical signal analysis and image processing.

### **Malin Holzmann, Karolinska Institutet, Stockholm, Sweden**

Malin Holzmann graduated from Karolinska Institutet in 1996, and started her training in Obstetrics and Gynecology at Karolinska University Hospital, Stockholm in 2002. She still works at Karolinska Hospital, as a consultant since 2008 and senior consultant since 2016. She is study director for the Research School for Clinicians in Epidemiology at Karolinska Institutet since 2018. She obtained her PhD in Medicine in 2014 at Karolinska Institutet, defending her thesis on fetal heart rate patterns and fetal acidemia. In her present research, she continues to focus on electronic fetal monitoring (EFM) and fetal acidemia. She collaborates with researchers at the Royal School of Technology (KTH) in Stockholm in the area of computerized CTG in the antenatal and intrapartum period. Since 2016, she is part of a working group appointed by the Swedish Society for Obstetrics and Gynecology (SFOG) and the Swedish Midwifery Association, updating and developing national guidelines regarding EFM. She holds an expert and editor position at the nationwide Swedish insurance company (LÖF), where she is

responsible for the national web-based education and training program for midwives and obstetricians in EFM. She is a frequent lecturer on the topic EFM for doctors, midwives and students.

Lu K, Holzmann M, Abtahi F, Lindecrantz K, Lindqvist PG, Nordstrom L. Fetal heart rate short term variation during labor in relation to scalp blood lactate concentration. *Acta Obstet Gynecol Scand.* 2018;97(10):1274-80.

Gyllencreutz E, Lu K, Lindecrantz K, Lindqvist PG, Nordstrom L, Holzmann M, et al. Validation of a computerized algorithm to quantify fetal heart rate deceleration area. *Acta Obstet Gynecol Scand.* 2018;97(9):1137-47.

### **Solveig Haukås Haaland, Laerdal Medical AS, Norway**

Solveig Haaland received the M.Sc. degree, in Biophysics and Medical technology, from the Norwegian university of science and technology in 2009. She is also trained as a teacher. Previously she has been working as a medical physicist within radiation therapy and as a high school teacher. Since 2013 she has been employed as a scientist at Laerdal Medical with main focus area of fetal heart rate monitoring. She has played a key role in the development of Moyo fetal heart rate monitor and related training materials. Now she is working with data analysis, research support and product improvements of Moyo.

### **Tomoaki Ikeda, Mie University of Graduate School of Medicine, Japan**

Dr. Tomoaki Ikeda graduated with an MD from Miyazaki Medical College at 1983, entered a 5-year residency at the Department of Obstetrics and Gynecology, Osaka University. He took on a Lecturer position at Department of Obstetrics and Gynecology, Miyazaki Medical College at 1987, starting research on maternal and fetal medicine under Professor Tsuyomu Ikenoue. He studied fetal physiology using sheep fetus at University of California, Irvine with Professor Yuji Murata and Edward Quilligan from 1994 to 1996. He became the Director of Obstetrics and Gynecology in 2005 and Director of Regenerative Medicine in 2009 at National Cardiovascular Center in Osaka. In 2010, he was promoted to Professor and Chairman, Department of Obstetrics and Gynecology, Mie University where he has been since. He established Maternal Death Review Committee in Japan in 2001. His interest is fetal physiology, fetal heart rate monitoring and fetal brain damage.

Parer JT, Ikeda T, A framework for standardized management of intrapartum fetal heart rate patterns. *Am J Obstet Gynecol*, 26.e1-6, 2007.

Magawa S, Tanaka H, Furuhashi F, Maki S, Nii M, Toriyabe K, Kondo E, Ikeda T, Intrapartum cardiotocogram monitoring between obstetricians and computer analysis. *J Matern Fetal Neonatal Med*, May 23:1-7, 2019.

### **Ines Nunes, University of Porto, Portugal**

Ines Nunes, born in Porto, Portugal, in 1983, graduated in Medicine from the University of Porto Medical School in 2007 and started her training in Obstetrics and Gynecology at the S. Joao Hospital-Porto in 2010. Consultant in Obstetrics and Gynecology since 2015, she works in Centro Materno-Infantil do Norte (CMIN) - Centro Hospitalar Universitário do Porto in the field of Maternal (Obesity and Diabetes in Pregnancy) and Fetal Medicine, and she is the Head of the Labour Ward since 2019. She is invited Professor of Obstetrics and Gynecology at ICBAS - Instituto de Ciências Biomédicas Abel Salazar and a researcher in the field of intrapartum fetal monitoring and obstetrical simulation in CINTESIS - Centro de Investigação em Tecnologias e Serviços de Saúde and I3S - Instituto de Investigação e Inovação em Saúde, University of Porto, Portugal. She is Associate Editor of the *Acta*

Obstetrica e Ginecologica Portuguesa since 2016. She is a committee member of the Intrapartum Care Study Group of the European Association of Perinatal Medicine since 2018.

### **J. Gerald Quirk, Stony Brook University, U.S.A**

Dr Quirk received his B.S.(cum laude) degree in Biology from Manhattan College. Thereafter, he received both the M.D. and Ph.D. (Anatomy & Embryology) degrees from SUNY Downstate. He completed a residency in Obstetrics and Gynecology at Columbia Presbyterian Medical Center (Sloane Hospital for Women) followed by a fellowship in Maternal Fetal Medicine at the University of Texas, Southwestern Medical Center. At Southwestern he worked with a distinguished group of clinicians, physiologists and biochemists, supported by a Special Emphasis Research Career Development Award (NIAMD & NICHD) focusing on the ontogeny and regulation of the glycerophospholipid composition of pulmonary surfactant and the effects of maternal diabetes on these processes.

Subsequently, Dr Quirk served as Director of Obstetrics (1983- 1990) and Professor & Chair of the Department of Obstetrics & Gynecology at the University of Arkansas (1990-1998). In 1998 he was recruited to the position of Professor & Chair of the Department of Obstetrics, Gynecology & Reproductive Medicine at Stony Brook University School of Medicine. He has conducted research in the area of embryology and the molecular biology of tumor makers. Most recently, Drs Quirk & Djuric and colleagues in the School of Engineering at Stony Brook have developed a research program investigating problems related to machine learning methods for intrapartum fetal monitoring. This effort is supported by the NIH. Dr Quirk has lectured widely and has authored well over 150 research papers, book chapters and reviews.

Yu Kezi, Quirk J.G., Djuric P.M. Dynamic classification of fetal heart rates by hierarchical Dirichlet process mixture models. PLOS One 12 (9): e0185417.

Feng G., Quirk J., Djuric P. Supervised and unsupervised learning of fetal heart rate tracings with deep Gaussian processes. Presented at the 14th Symposium on Neural Networks and Applications (NEUREL), 2018.

### **Elizabeth Rendon-Morales, University of Sussex, UK**

Dr. Elizabeth Rendon-Morales is a lecturer in Electrical and Electronics Engineering in the Department of Engineering and Design at the University of Sussex. The main area of her research is the, design, development and testing of next generation precision tools and medical instrumentation. Her areas of expertise include sensors, electronics, robotics and telemetry systems. Within the sensing area, she is leading the development of advanced sensing devices to monitor electrocardiogram -ECG signals on babies during early pregnancy and throughout labour. On the robotics area, she is leading the development of micron level precision instrumentation tools to achieve linearity and repeatability that could contribute to the next generation surgical robotic systems allowing surgeons to execute minimally invasive surgeries autonomously.

### **Massimo Rivolta, Università degli Studi di Milano, Italy**

Massimo W. Rivolta received B. Sc and M. Sc. degrees in Biomedical Engineering in 2007 and 2011 from the Politecnico di Milano, Italy. In 2015, he obtained a Ph. D. degree in Computer Science at the Università degli Studi di Milano, Italy. Currently, he is a post-doctoral researcher and member of the Biomedical image and Signal Processing Group (BiSP) at the Università degli Studi di Milano, Italy. His research interests include signal processing, feature extraction, computational intelligence and computerized simulations, focused on biomedical applications. The main areas of interest include ECG analysis, HRV and fetal HRV, and movement analysis with wearable sensors.

Rivolta MW, Stampalija T, Frasch MG, Sassi R. Theoretical Value of Deceleration Capacity Points to Deceleration Reserve of Fetal Heart Rate. IEEE Trans Biomed Eng 2019

Rivolta MW, Stampalija T, Casati D, Richardson BS, Ross MG, Frasci MG, Bauer A, Ferrazzi E, Sassi R. Acceleration and Deceleration Capacity of Fetal Heart Rate in an In-Vivo Sheep Model. PLoS ONE 2014;9(8): e104193

### **Stephane G. Roux, ENS Lyon, France**

Stephane G. Roux was born in Montpellier, France in 1967. He graduated at University of Montpellier and completed a Ph.D. in Physics in 1996 at University of Aix-Marseille. Since September 2001, he is associate professor at the Laboratoire de Physique of Ecole Normale Supérieure de Lyon. His research interests include scale invariance, wavelet analysis and their practical applications in physics, neuroscience, art and biology.

### **Barry Schifrin, bpm, Inc. USA**

Dr. Schifrin is a licensed physician in the state of California, USA. After completing medical school at The Chicago Medical School, he interned at Michael Reese Hospital in Chicago, Illinois then pursued residency programs in Obstetrics and Gynecology at New York Medical College then at the Columbia Presbyterian Medical Center in New York. He completed an OB/GYN Fellowship program at the University of Miami School of Medicine in 1967 and 1968 and a second fellowship in Perinatal Biology at Yale University School of Medicine in New Haven, Connecticut between 1968 and 1969 where he was involved in the early study and promulgation of electronic fetal monitoring. He is Board certified in Obstetrics & Gynecology and Maternal-Fetal Medicine.

Dr. Schifrin has held numerous clinical and academic appointments in Obstetrics & Gynecology in Medical Schools at Harvard University, the University of Southern California School and Loma Linda University. He has held the position of Director of Maternal-Fetal Medicine in a number of California hospitals including among others, Cedars-Sinai Medical Center in Los Angeles; Encino-Tarzana Regional Medical Center in Thousand Oaks; Los Robles Medical Center in Thousand Oaks; Antelope Valley Medical Center in Lancaster; and Glendale Adventist Medical Center in Glendale, where he was the Director of the OB/GYN Residency training program. He has lectured widely to medical and legal audiences about a wide range of obstetrical subjects, but most often related to obstetrical safety, fetal surveillance in labor and the relationship of obstetrical care to subsequent neurological injury. He is the author of over 200 contributions to medical literature. He has also participated as an expert witness in numerous legal cases involving his areas of interest.

### **Maria Gabriella Signorini, Politecnico di Milano, Italy**

Maria G. Signorini is Associate Professor at the Department of Electronic, Information and Bioengineering, Politecnico di Milano since 2003. At the same University, she obtained the Ph.D. in Biomedical Engineering in 1995. After a Post Doc fellowship (1996-98) she became Research Assistant (1999). She served as Coordinator of the Biomedical Engineering PhD track at the Doctorate School of the Politecnico di Milano (2004-2014). 2014-2016 she has been charged by the Italian Government as one of the nine members of the national Committee of Experts for the Policy of the Research (CEPR) at the Ministry of the University and Research (MIUR) where she is collaborating as Member of Commissions. Her main research field is focused on improving healthcare paths and medical devices by introducing both new methodological approaches and technological solutions based on biomedical signal processing. She developed application of nonlinear analysis to biomedical time series. Her activity is devoted to fetal heart rate monitoring through analysis and classification by data analytics and machine learning techniques. She developed multiparameter approaches integrating linear and nonlinear parameters towards the prediction of risk in antepartum fetal monitoring, premature babies, dialysis patients and others cardiovascular diseases. Research results have been translated into technological solutions with modification of existing biomedical devices (Cardiotocography, Dialysis) or design of new instrumentation (wearable fetal HR monitoring).



Maria G. Signorini is investigator and co-investigator in research projects. She is reviewer for several Scientific Journals (IEEE-EMBS Trans., Physiol. Measur, Chaos, Biom Eng &Comp, ...). Since 2007 she is Associate Editor for the IEEE-EMBS Conference, Theme: Biomedical Signal Processing.

### **Austin Ugwumadu, St George's University of London, UK**

Austin is a Consultant Obstetrician & Gynaecologist, and currently the Clinical Director of Women's Services at St George's University Hospital in London. His clinical and research interests include subclinical perinatal infections, intrapartum fetal heart rate monitoring, synergistic inflammation-hypoxia interactions, and fetal brain injury. He has published 150 refereed papers, reviews, commentaries, book chapters and books, and conference abstracts. He is scientific editor for British Journal of Obstetrics and Gynaecology, Infectious Diseases in Obstetrics and Gynaecology, and Section Editor (Infections) for Global Library of Women's Medicine. He is also a member of the Intrapartum Fetal Monitoring Group, and ex-President of the European Society for Infectious Diseases in Obstetrics & Gynaecology (ESIDOG), (UK).

Amer-Wählin I, Ugwumadu A, Yli BM, Kwee A, Timonen S, Cole V, Ayres-de-Campos D, Roth GE, Schwarz C, Ramenghi LA, Todros T, Ehlinger V, Vayssiere C; Study Group of Intrapartum Fetal Monitoring (European Association of Perinatal Medicine). Fetal electrocardiography ST-segment analysis for intrapartum monitoring: a critical appraisal of conflicting evidence and a way forward. *Am J Obstet Gynecol.* 2019 Apr 10

Lear CA, Westgate JA, Ugwumadu A, Nijhuis JG, Stone PR, Georgieva A, Ikeda T, Wassink G, Bennet L, Gunn AJ. Understanding Fetal Heart Rate Patterns That May Predict Antenatal and Intrapartum Neural Injury *Semin Pediatr Neurol.* 2018;28:3 - 16.

### **Rik Vullings, Eindhoven University of Technology, The Netherlands**

Rik Vullings received the M.Sc. (Applied Physics) and PhD (Electrical Engineering) degrees from the Eindhoven University of Technology in 2005 and 2010, respectively. During his M.Sc. he worked on monitoring of the uterine activity and fetal heart activity during pregnancy. During his PhD he only focused on the fetal heart activity in terms of non-invasive electrophysiological monitoring of fetal heart rate and fetal electrocardiogram. After completion of his PhD, he stayed at Eindhoven University of Technology (TU/e) as Postdoctoral researcher and currently, after having received a Veni grant in 2012, is part-time member of the permanent staff of the Signal Processing Systems group (Electrical Engineering department) as Assistant Professor. In this capacity, he supervises 10 PhD students, half of which are working on pregnancy monitoring.

In 2009, he co-founded Nemo Healthcare and currently, next to his position at TU/e, he works as Chief Scientific Officer at Nemo Healthcare, leading the team responsible for the development of signal processing and signal interpretation methods. His research interests include biomedical signal processing and modelling, machine learning – including deep neural networks and pattern recognition, with a special interest in pregnancy monitoring. He has (co)authored 9 patents and/or patent applications and more than 40 peer-reviewed journal papers, mainly about pregnancy monitoring.

Noben L, Clur SA, Van Laar J, Vullings R. Prenatal diagnosis of a bundle branch block based on the fetal electrocardiogram. *BMJ Case Reports* 2019;12(7):e229998.

Hamelmann P, Mischi M, Kolen AF, Van Laar JOEH, Vullings R, Bergmans JWM. Fetal heart rate monitoring implemented by dynamic adaptation of transmission power of a flexible ultrasound transducer array. *Sensors (Basel).* 2019;19(5):E1195.

### **Philip Warrick, PeriGen, Canada**

Dr. Philip A. Warrick obtained a B.A.Sc. (Electrical Engineering) from the University of Waterloo (Waterloo, Canada), and a M.Eng. (Electrical Engineering) and Ph.D. (Biomedical Engineering) from McGill University (Montreal, Canada). His research interests lie in the fields of systems modelling, statistical signal processing, machine learning (including deep learning), decision support systems, obstetrics and cardiology. His interest in novel intra-partum signal modelling and associated diagnostic tools has exposed areas of improvement for current clinical data acquisition (ultrasound for fetal heart rate and tocography for maternal uterine pressure) that new sensor research and technology has begun to address by providing surface electrode acquisition of both fetal ECG and maternal uterine pressure as electrohysterography (EHG). These developments facilitate research into higher quality models, in terms of signal-to-noise ratio and information extraction, to improve intrapartum diagnosis of the fetal state. Many aspects of fetal heart rate interpretation share commonality with other biomedical signals, especially with other currently challenging issues in cardiology. He has directed successful projects involving fetal ECG detection from abdominal sensors, adult electrocardiogram (ECG), phonocardiogram classification for early diagnosis of arrhythmias and arousal detection from polysomnography.

### **Hau-tieng Wu, Duke University, USA**

Dr Wu studies focus on the mathematical and statistical foundation of machine learning tools aiming for analyzing multimodal physiological waveform signals and providing solutions to medical challenges. During his medical training and subsequent clinical practice, Dr Wu realized that physicians take mainly “snapshot” information into account to make clinical decisions, even though there are a lot of physiological waveform signals containing complimentary information that are rarely analyzed in clinics. In 2015, his research was recognized and awarded the prestigious Sloan research fellowship. In 2017, Dr Wu obtained the early career award from CAIMS/PIMS. To date, his research has accumulated more than 2,800 citations and his H-index is 23 according to Google Scholar.

Starting from 2016, Dr Wu participated in inter-continental research with a clinical trial carried out in Germany to study fetal ECG, fetal heart rate variability, and maternal stress. In this clinical trial, he designed algorithms to extract fetal ECG from the single lead trans-abdominal ECG signal, and developed a new fetal fetal heart rate variability index for maternal stress detection. ß