Group of Medical Signal (MEDISIG)
Department of Medical Signals

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THEMATIC RESEARCH FOCUS

Research area
– Biomedical engineering
– Signal processing methods
– Software design and development
– Cardiac electrophysiology
– Neuro electrophysiology
– Epileptic seizure localization
– Blood circulation control
– Advanced acquisition technologies

Excellence
– Deep brain electrophysiology – basic neuroscience research regarding the brain activities time-spatial distribution
– Epileptic sources identification and localization, ultra-high frequency oscillations detection
– Blood circulation and hemodynamic control (stroke volume, pulse wave velocity, heart rate and blood pressure variability)
– Heart repolarization abnormalities identification
– Development (in cooperation with academic partners and private companies) of the novel acquisition technologies in neurology and cardiology (the multichannel whole-body bioimpedance monitor, PulseWave software, high frequency and dynamic EEG and ECG recorders)
– High frequency high dynamic range ECG for early diagnostics of heart pathologies
– New software solutions for large data visualization and processing – SignalPlant open access platform

Mission
To contribute to the development of novel diagnostic markers, technologies, protocols and analytical methods that will allow physicians to see more and that improve the quality of life

UP-TO-DATE ACTIVITIES

Research orientation
– Design and verification of methods for identification of epileptic sources within the brain (clinical outcome) and the establishment of functional links between brain structures (basic research outcome)
– Methodology and algorithms for HFOs detection. These are, primarily, identification of the seizure onset zone, irritative zones and remote areas, spikes, ripples, fast-ripple and especially very and ultra-fast ripples(up to 2 kHz) detection, automated detection of HFOs and Welch power spectra analysis. The numerical outputs are statistically evaluated and presented in graphic form
– Design and implementation of new technologies. Includes: high dynamic acquisition system, new software for the analysis of high frequency ECG, interpretation of results and diagnostic applications
– Diagnostic contribution of high frequency ECG
– Analysis of time-spatial distribution of electrical heart activation
– Open access tools of large data visualization and processing
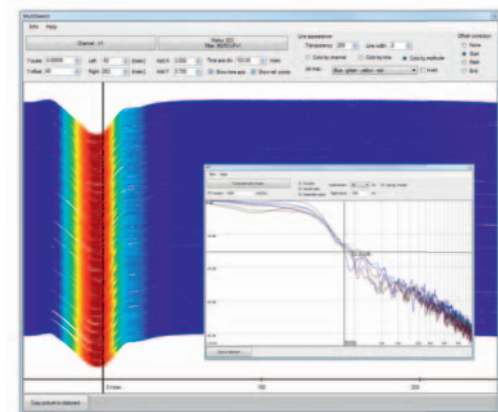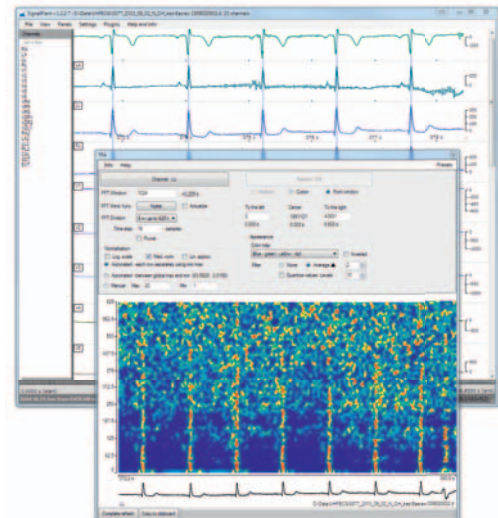
SignalPlant. SignalPlant is free software tool for signal examination, scoring and post-processing. Although it is originally aimed to biological signals, it contains tools useful for any other area of signal processing

Main capabilities
Basic research
– Description of brain region involvement in different mental activities
– Description of brain information transfer and connectivity
– Identification of pathological oscillations properties in intracerebral EEG in epileptic patients, experimental outcomes for clinical medicine
– Distribution of high frequency components during ventricular depolarization period, detection of ventricular dyssynchrony in high temporal resolution
– Dynamic properties of blood circulation parameters

Applied research
– Development and realization of Multichannel PulseWave Monitor – medical device intended for novel non-invasive diagnostics of the state of the arterial system
– High frequency ECG monitor – experimental device for advanced acquisition of multi-lead high frequency and high dynamic electrocardiography
– High frequency ECG methods for identification of ventricular dyssynchorny (patent: https://patents.google.com/patent/WO2015090260A3/en)
– Cardiac Resynchronization Therapy optimization
– SignalPlant – free signal processing and visualization software tools (https://signalplant.codeplex.com/)

Sub-fields of group activities
– Clinical and experimental medicine – neurology
– Clinical end experimental medicine – cardiology
– Biomedical engineering
– Signal acquisition and processing

KEY RESEARCH EQUIPMENT

List of devices
– Computing facilities intended for large data interactive processing (64 core parallel computing, high-speed SSD storages, SW support)
– Equipment for development of high quality signal devices – low noise DC power supply (Kikusui PMR18-1.3TR), arbitrary function generator 50 MHz (Rohde&Schwarz HMF2550), RF signal generator 2 GHz (Anritsu MG3642A)
– Equipment for basic EMC tests – RF spectrum analyser 3.6 GHz (Rohde&Schwarz FSH4), near-field probe set (Rohde&Schwarz HZ-15), electromagnetic field meter, active directional antenna (Rohde&Schwarz HE300)
– Software for FPGA development – signal processing tool (Xilinx System Generator for DSP), logic analyser tool (Xilinx ChipScope Pro)

ACHIEVEMENTS

▌ Awards
– 2014: ESGCO 2014 Award for Technology Transfer, Influence of Tilt Load on Pulse Wave Velocity in Lower Limbs
– 2014: Physionet challenge, Robust Detection of Heart Beats in Multimodal Data, 4th prize (Boston, USA) for QRS multimodal detection algorithm.
– 2015: Physionet challenge (Nice, France), Reducing False Arrhythmia Alarms in the ICU, the 1st and 2nd prize (two different categories) for arrhythmias detection methods.

▌ Publications
– J. Halámek, J.P. Couderc, P. Jurák, V. Vondra, W. Zareba, I. Viščor, P. Leinveber: "*Measure of the QT-RR Dynamic Coupling in Patients with the Long QT Syndrome*", Annals of Noninvasive Electrocardiology **17**, 4, 323-330, 2012

– F. Plešinger, J. Jurco, J. Halámek, P. Jurák: *"SignalPlant: an open signal processing software platform"*, Physiol Meas **37**(7), 38–48, 2016
– M. Pail, J. Halámek, P. Daniel, R. Kuba, I. Tyrlíková, J. Chrastina, P. Jurák, I. Rektor, M. Brázdil: *"Intracerebrally recorded high frequency oscillations: Simple visual assessment versus automated detection"*, Clinical Neurophysiology **124**, 10, 1935-1942, 2013
– M. Brázdil, J. Janeček, P. Klimeš, R. Mareček, R. Roman, P. Jurák, J. Chládek, P. Daniel, I. Rektor, J. Halámek, F. Plešinger, V. Jirsa: *"On the time course of synchronization patterns of neuronal discharges in the human brain during cognitive tasks"*, PLoS ONE. **8**, 5, e63293:1-9, 2013

❚ **US patent: Device for blood flow property measurement and method of its connection**
Patent Number: US 9,167,984 B2
Group Author(s): INSTITUTE OF SCIENTIFIC INSTRUMENTS AS CR, V. V. I
Inventor(s): Vondra V, Jurak P, Halamek J, Viscor I
Official Gazette of the United States Patent and Trademark Office Patents,
Granted: NOV 2015

❚ **PCT patent submission: Electrocardiogram (ECG) signal processing method for heart diagnosing.**
Patent Number: WO2015090260-A2 CZ201301052-A3, 2014
Patent Assignee: USTAV PRISTROJOVE TECHNIKY AVCR; FAKULTNI NEMOCNICE U SV ANNY V BRNE; M & I SPOL SRO
Inventor(s): Jurak P; Halamek J; et al.

❚ **US Patent: Method of ventricular repolarization analysis**
Patent Number: US 8,600,485 B2
Group Author(s): INSTITUTE OF SCIENTIFIC INSTRUMENTS AS CR, V. V. I
Inventor(s): Halamek, J; Jurak, P.
Official Gazette of the United States Patent and Trademark Office Patents,
Granted: DEC 3 2013

Intracerebral EEG recordings and analysis – brain structures involvement in cognition process, pathological and functional connectivity
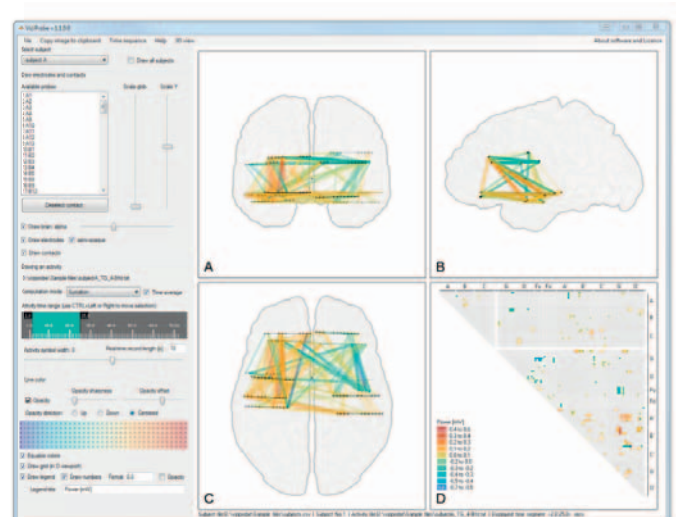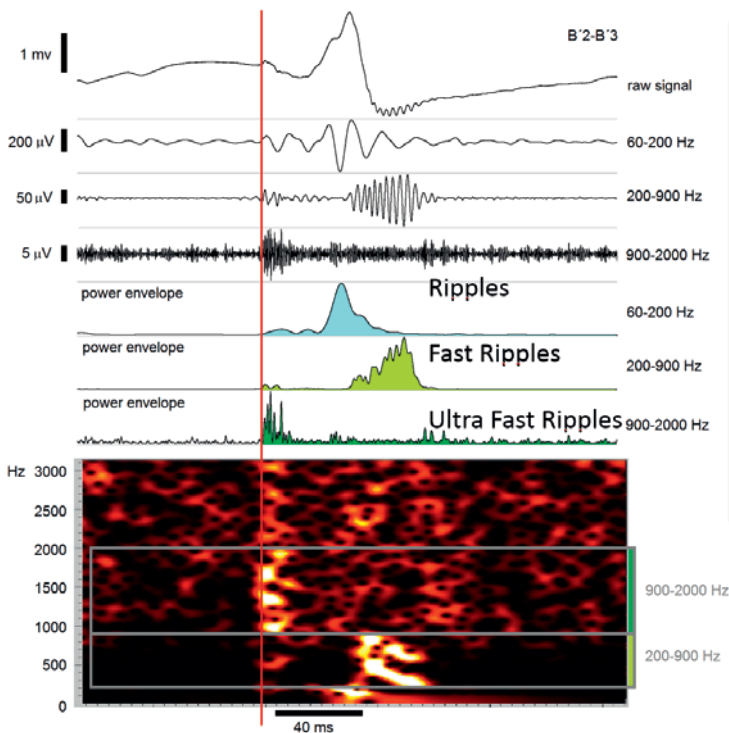
▮ US and EU submitted patent: Method of EKG signal processing and apparatus for performing the method
Inventor(s): Jurak, P. et al.
https://patents.google.com/patent/WO2015090260A3/en

MAIN COLLABORATING PARTNERS

Collaboration with academic partners
Mayo Clinic, Rochester (MN, USA)
University of Rochester (Rochester, NY, USA)
Imperial College London (London, UK)
International Clinical Research Centre (St. Anne's University Hospital, Brno, CZ)
Brno University of Technology (Brno, CZ)
Masaryk University (Brno, CZ)
Institute for Clinical and Experimental Medicine (Prague, CZ)
National Institute of Mental Health (Klecany, CZ)

Collaboration with companies
M&I (Prague, CZ)
Cardion (Brno, CZ)
AMV medical (Brno, CZ)
MDT – medical data transfer (Brno, CZ)

EXPECTATIONS

Offers
We offer collaboration in the areas of our expertise:
– Biomedical signal acquisition and analysis
– Development of diagnostic technologies and data processing methods
– Cooperation in clinical evaluation of new technologies
– Partnership in international scientific and technology-transfer projects

Requirements
We look for cooperation with academic partners as well as companies in the fields of signal processing and application of new analysis and technologies especially in neurology and cardiology.
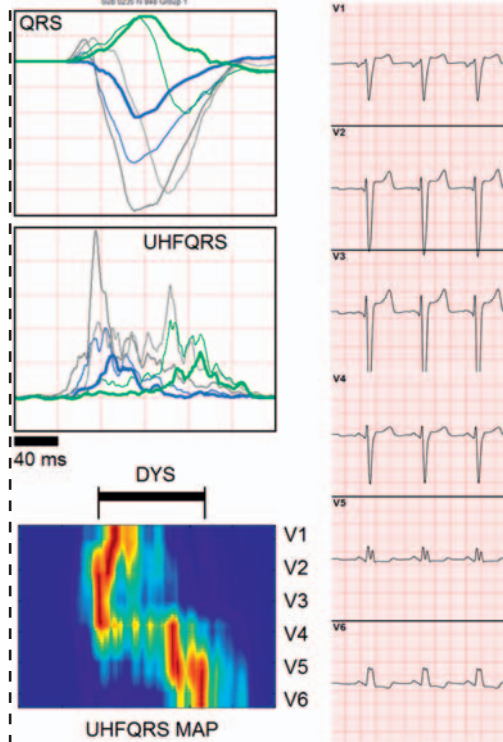
Ultra-high frequency ECG technology. Measurement of ventricular depolarization distribution and identification of dyssynchrony

The multichannel whole-body impedance monitor