



ObeSense

MONITORING THE CONSEQUENCES OF OBESITY



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What it's about...

Joining the efforts of research groups in Switzerland involved in the monitoring of physiological markers to combine innovative and non-invasive sensors into single monitoring systems integrated in smart textiles for the long-term monitoring of overweight/obese patients.

Context and project goals

Obesity is a medical condition associated with multiple health problems. Multiple clinical guidelines about the identification, evaluation and treatment of overweight and obesity and its related risks already exist. Importantly, these guidelines recommend the use of long-term monitoring systems that have not been adapted yet to the screening of large-scale populations to efficiently and simultaneously evaluate different physiological markers such as energy expenditure, hypertension, respiratory rate, stroke volume, heart rate and rhythm, etc. Indeed, physiological monitoring systems, if available, present multiple limitations, i.e. invasiveness, poor patient compliance, long-term skin intolerance, non-portable, limited power autonomy and memory, single-physiological marker oriented, sensitivity to motion artifacts, inaccurate estimates, etc.

The goal of the project is to join the efforts of research groups in Switzerland involved in the monitoring of physiological markers to combine innovative and non-invasive sensors into single monitoring systems to completely fulfill the guideline demands. The foreseen advanced sensors and their respective signal analysis algorithms are to be embedded into smart-textiles to provide advanced multi-parametric diagnostic tools for the management of obese patients in the different phases of their health condition: in clinical as well as ambulatory environments in order to improve patient life quality and reduce important health costs related to late prognostics.

How it differentiates from similar projects in the field

The main differentiators are:

- The central role of clearly defined medical application scenarios, driving the user requirements. Those three scenarios address clear medical needs, namely physical activity monitoring (prevention), monitoring at the hospital and post hospitalization monitoring (follow-up),
- The integration of multiple sensors into clinically usable (long-term) monitoring systems.

Quick summary of the project status

The three medical scenarios have been defined in detail, and the corresponding technical requirements have been set.

Monitoring of respiratory rate and volume: transparent flexible polymer-optical fibers have been integrated in a smart T-shirt and have been successfully tested.

Cardiac output: electrical impedance tomography (EIT) is being developed, and the systolic volume balance (SVB) method which requires information that can be extracted by a single pressure waveform, shows promising results.

Energy expenditure: New NIRS sensors with the possibility of being integrated into textile are being developed. Tests to identify the best locations for heart beat and respiration frequency, by applying conventional NIRS sensors are ongoing. An application for cell phones and tablets has been developed, which communicates with the sensors and shows the physiological parameters.

Blood pressure: a non-occlusive sensor setup has been designed. Verification of the prototype and validation over 10 healthy subjects has been completed. Some modifications on the design were required based on bug report.

Smart ECG T-shirts: a new design of comfortable electrodes has been proposed.

Wireless body sensor network: two platforms are being developed, one being in feasibility phase of the ISO 13485 procedure.

ECG analysis: several algorithms have been developed and validated.

Success stories

The coordination between the medical and technical teams, as well as among the technical partners, works perfectly well. The clinical scenarios are entering in an implementation phase.

At the beginning of June, this year's conference about electrical impedance tomography (EIT) was organized by the EIT group at CSEM and held in Neuchâtel. It was a perfect opportunity to exchange ideas, present the current state of research and especially to increase the visibility of CSEM's EIT group.

One of the partners (ASPG, EPFL) got a contract with a startup (Leman Micro Devices SA) for the development of biomedical signal processing algorithms. These algorithms, based on the research work conducted in ObeSense, extract cardiovascular parameters such as instantaneous heart rate and respiration frequency. They are currently ported for iPhone applications.

Presence in the media:

- Swiss TV show "36.9", section "Avis d'expert" and radio show "CQFD": Dr E. Pruvot (CHUV) and Dr M. Bertschi (CSEM) were interviewed on the work in ObeSense
- Newspaper "20minuten": EMPA (L. Scherrer)
- Newspaper EmpaNews – November 2013

Awards:

Fabian Braun (PhD student at EPFL/CSEM), got awarded the best student paper award at the EIT conference for his work about a 4D thorax model for hemodynamic EIT simulations.

Leila Mirmohamadsadeghi got a best poster award at the Computing in Cardiology (CINC'14) conference.

Main publications

M. Proença, F. Braun, M. Lemay, B. Grychtol, M. Bühner, M. Rapin, P. Krammer, S. Böhm, J. Solà, J.-Ph. Thiran, Understanding the Genesis of Cardiac Signals in Electrical Impedance Tomography, BIOSTEC 2014 Joint International Conference, Angers, France.

J. Solà, M. Proença, D. Ferrerio, J.-A. Porchet, A. Falhi, O. Grossenbacher, Y. Allemann, S. Rimoldi, C. Sartori, Non-invasive and non-occlusive blood pressure estimation via a chest sensor, IEEE Transactions on Biomedical Engineering, vol. 60, no. 12, pp. 3505-3513.

Leila Mirmohamadsadeghi, Jean-Marc Vesin, Respiratory rate estimation from the ECG using an adaptive frequency tracking algorithm, Accepted in Biomedical Signal Processing and Control.

S. Yazdani, J.-M. Vesin, Adaptive Mathematical Morphology for QRS Fiducial Points Detection in the ECG, Computing in Cardiology, vol 41.

L. Mirmohamadsadeghi, J.-M. Vesin, M. Lemay, O. Dériaz, The Respiration Pattern as an Indicator of the Anaerobic Threshold, accepted in the 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society.

M. Rapin, M. Proença, F. Braun, C. Meier, J. Solà, D. Ferrario, O. Grossenbacher, J.-A. Porchet and O. Chételat, Cooperative dry-electrode sensors for multi-lead biopotential and bioimpedance monitoring, Physiological measurement, 36(4), 767, March 2015.

F. Braun, M. Proença, M. Rapin, M. Lemay, A. Adler, B. Grychtol, J. Sola and J.-Ph. Thiran, Aortic blood pressure measured via EIT: investigation of different measurement settings, Physiological measurement, 36(6), 1147, May 2015.

M. Proença, F. Braun, M. Rapin, J. Sola, A. Adler, B. Grychtol, S. Böhm, M. Lemay, and J.-Ph. Thiran., Influence of heart motion on cardiac output estimation by means of electrical impedance tomography: a case study, Physiological measurement, 36(6), 1075, May 2015.

Fabian Braun, Martin Proença, Michael Rapin, Xenia Alba, Karim Lekadir, Mathieu Lemay, Josep Solà, Alejandro F. Frangi and Jean-Philippe Thiran, 4D Heart Model Helps Unveiling Contributors to Cardiac EIT Signal, EIT 2015 International Conference, Neuchâtel, Switzerland.

Andy Adler, Fabian Braun and Josep Solà, Distinguishability as a noise performance metric for EIT algorithms, EIT 2015 International Conference, Neuchâtel, Switzerland.

Michael Rapin, Martin Proença, Fabian Braun, Josep Solà and Olivier Chételat, Cooperative sensors: a new approach towards wearable EIT systems, EIT 2015 International Conference, Neuchâtel, Switzerland.

Martin Proença, Fabian Braun, Michael Rapin, Josep Solà, Mathieu Lemay and Jean-Philippe Thiran, Feasibility of EIT-based pulmonary arterial pressure monitoring, EIT 2015 International Conference, Neuchâtel, Switzerland.

M Padmanabhan, FJ Rincon Vallejos, S Murali, D Atienza Alonso, Energy-Aware Embedded Classifier Design for Real-Time Emotion Analysis, IEEE International Conference of the Engineering in Medicine and Biology Society (EMBC), 2015.

G Surrel, F Rincon, S Murali, D Atienza, Design of ultra-low-power smart wearable systems, Test Symposium (LATS), 2015 16th Latin-American, 1-2, 2015.

G Surrel, F Rincon, S Murali, D Atienza, Real-Time Probabilistic Heart-Beat Classification and Correction for Embedded Systems, Accepted for publication in the Computing in Cardiology conference, 2015.

S Murali, FJ Rincon Vallejos, D Atienza Alonso, A Wearable Device For Physical and Emotional Health Monitoring, Accepted for publication in the Computing in Cardiology conference, 2015.

“Integrated wearable body sensors networks
to monitor obese patients at different stages of the disease”