

University of Ljubljana :: Faculty of Electrical Engineering...
[LDOS] :: Laboratory for digital signal processing...



Mobile users ECG signal processing

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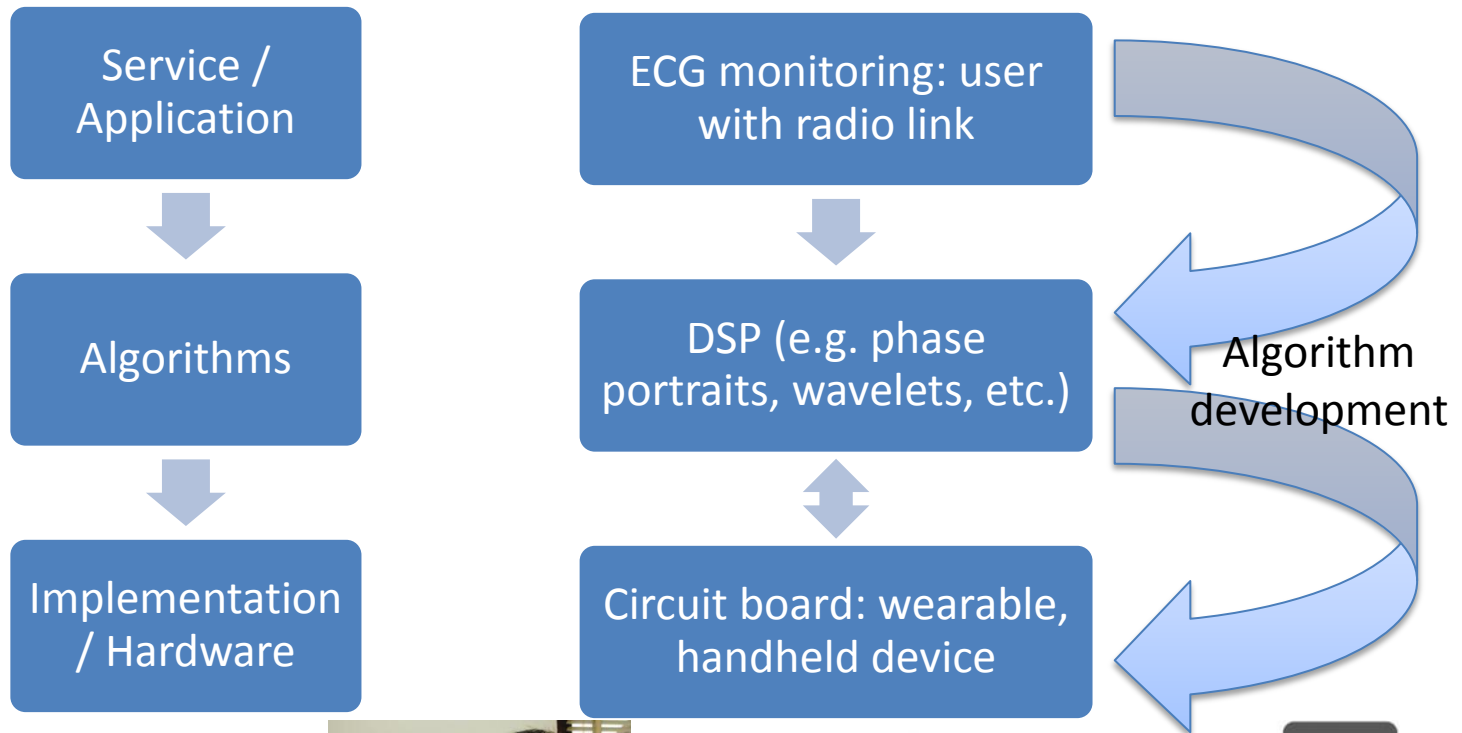
ICT Innovations 2012
Ohrid, 12. – 15. September 2012

Introduction

- LDOS Research oriented on
 - User services and users (user interfaces, communication, recommendations, etc.)
 - DSP problems (analysis of 1D, 2D, 3D signals)
- Our research:
 - algorithm engineering: bridge between electronics and telecommunications
 - Emphasis on developing efficient ECG processing algorithms for use in mobile applications.
 - Study of ECG digital signal processing challenges that arise in the mobile world, examination of their influence on the signal and analysis of possible solutions
 - Motives and goals:
 - Fast, efficient DSP algorithms for mobile devices in WSN networks
 - Reliable detection of ECG characteristic points for feature extraction and classification purposes even in difficult, noisy circumstances

Algorithm engineering

Example



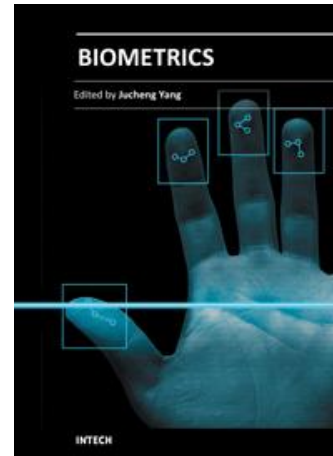
Edwards, J.; , "Wireless Sensors Relay Medical Insight to Patients and Caregivers [Special Reports]," *Signal Processing Magazine, IEEE* , vol.29, no.3, pp.8-12, May 2012



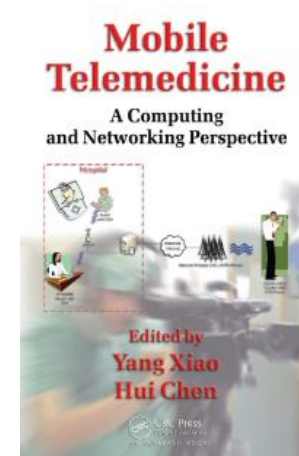
Example applications



M. Walter, B. Eilebrecht, T. Wartzek, and S. Leonhardt, "The smart car seat: personalized monitoring of vital signs in automotive applications," *Pers. Ubiquitous Comput.*, vol. 15, no. 7, pp. 707–715, Oct. 2011.



J. Yang, Ed., *Biometrics*. RI, Croatia: InTech, 2011.



Y. Xiao and H. Chen, Eds., *Mobile Telemedicine: A Computing and Networking Perspective*, 1st ed. FL, USA: Auerbach Publications, 2008.

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Mobile user

- Mobile user – non-clinical applications and services running on mobile devices (phones, tablets, etc.), embedded systems
- Mobility → [single lead ECG](#) is more appropriate for acquisition and analysis
- Existing mobile devices – use of ECG only for R-R interval extraction
- Rarely: information about other characteristic points – P-Q-R-S-T and Q-R-S
- Why do we need all points?
 - New fields and methods of ECG usage: biometrics, remote monitoring, sport training support etc. – penetration of clinical usage
 - More powerful, energy efficient, inexpensive devices with larger color screens enabling implementation of more complex algorithms



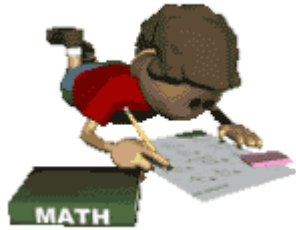
CardioDefender

CardioDefender is the first system to deliver mobile, real-time, beat-by-beat, and quantitative heart monitoring and automated reporting by combining patented analytical smartphone software with a [wireless](#) device and electrodes.



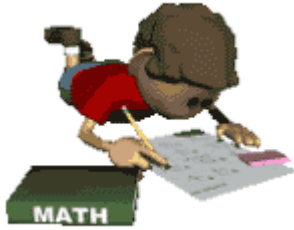
<http://www.everistgenomics.com/content/cardiodefender/summary.htm>

Mobile users ECG



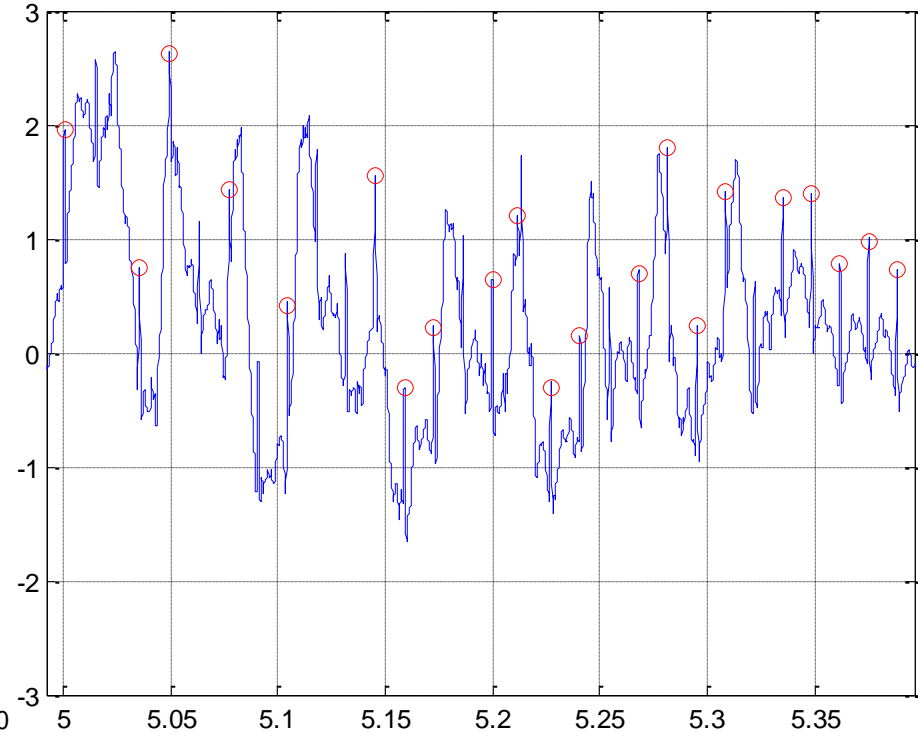
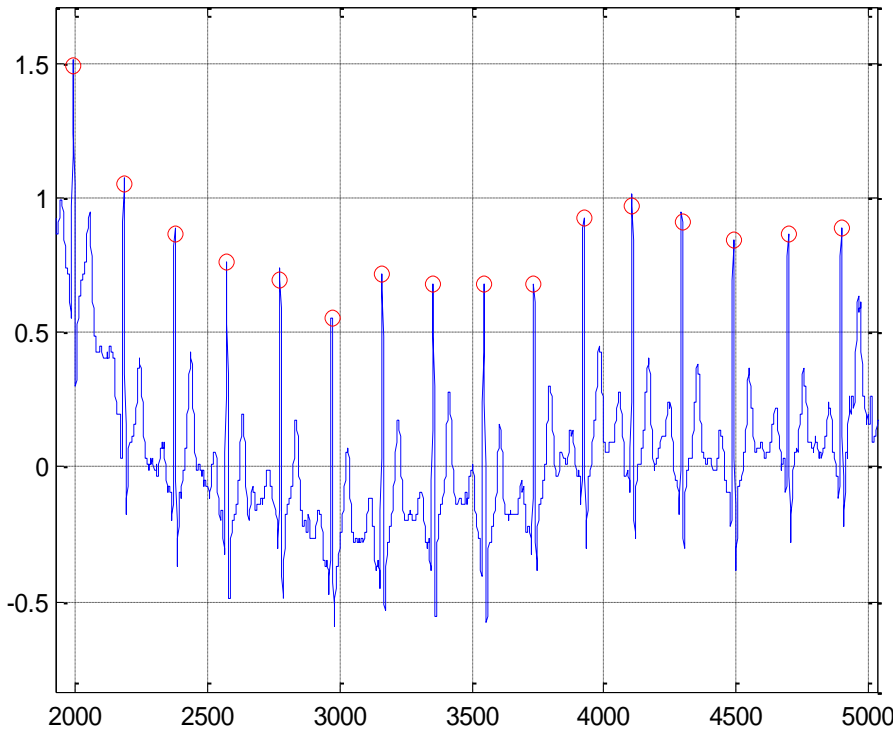
- Why is analysis difficult?
 - Low ECG signal amplitudes
 - High sensitivity to noise
 - Signal variability – different sorts of heart beats
 - Importance of detailed parts of the signal (specific intervals, slopes, amplitude levels, etc.) which are easily distorted by noise
- Problem source:
 - Person movement : muscle contraction causes QRS-like artifacts
 - Electrode movement, lack of contact: changes in electrode-skin impedance (capacitance) cause voltage fluctuations

Mobile users ECG



Low body/muscle activity

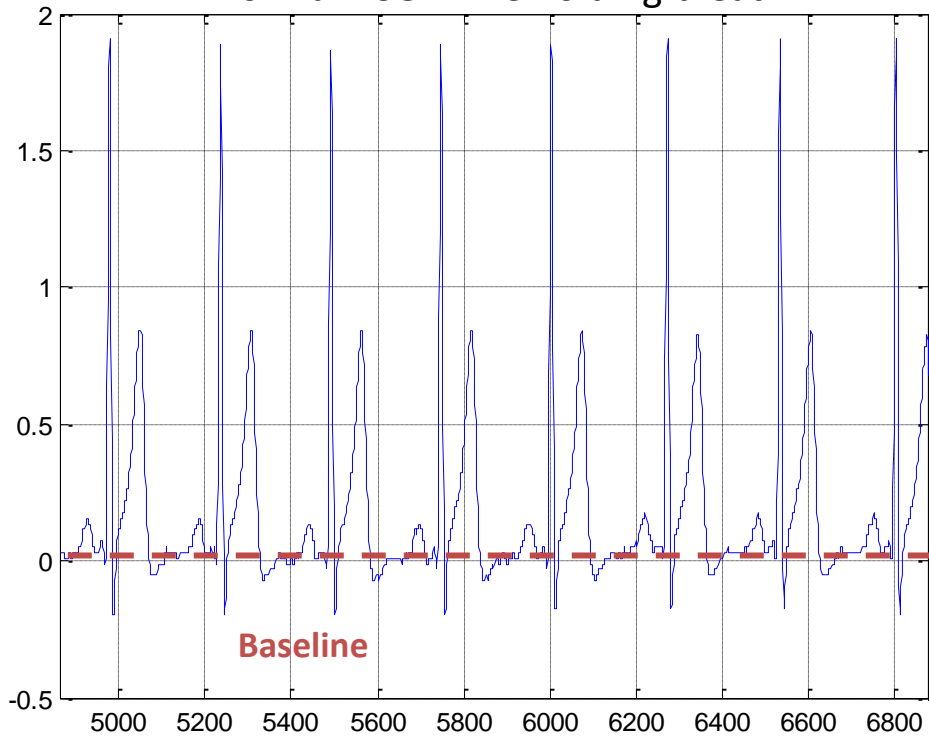
High body/muscle activity



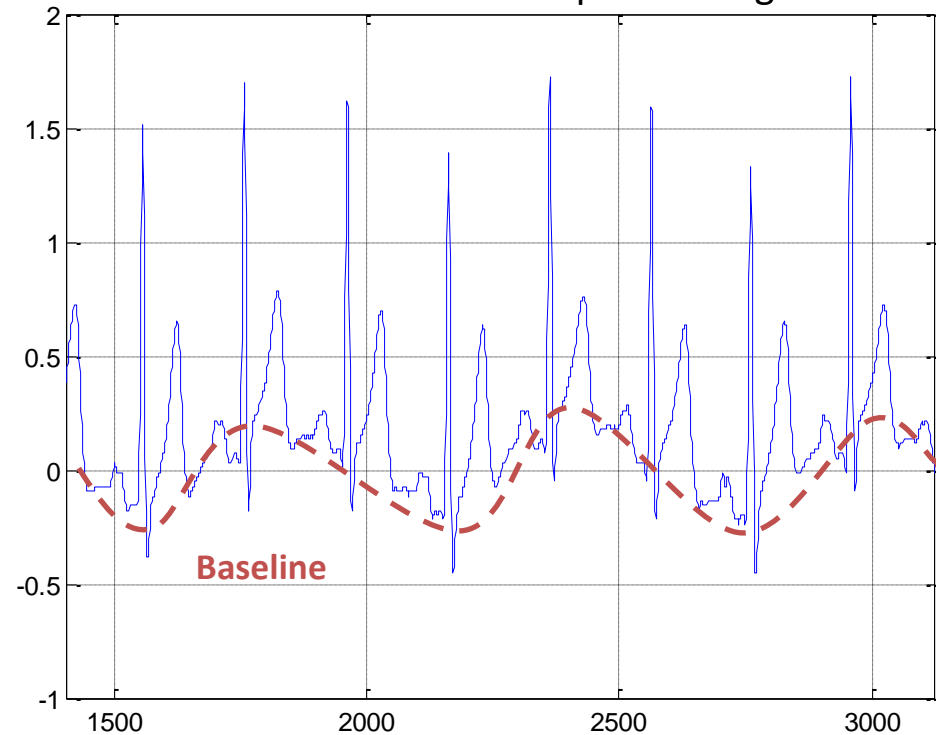
Noise in the mobile users ECG

- Noise classification:
 - Person-electrode motion artifacts
 - Baseline wandering
 - Electromyographic (EMG) noise
 - Power line interference, data collecting device, EMI, etc.

Normal ECG while holding breath



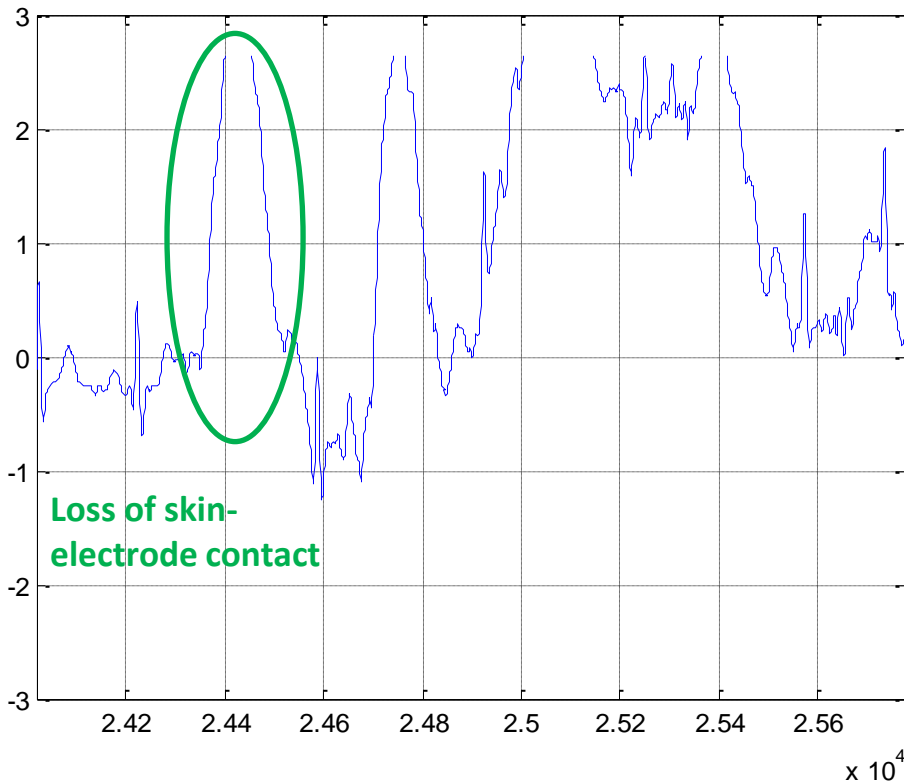
Normal ECG while deep breathing



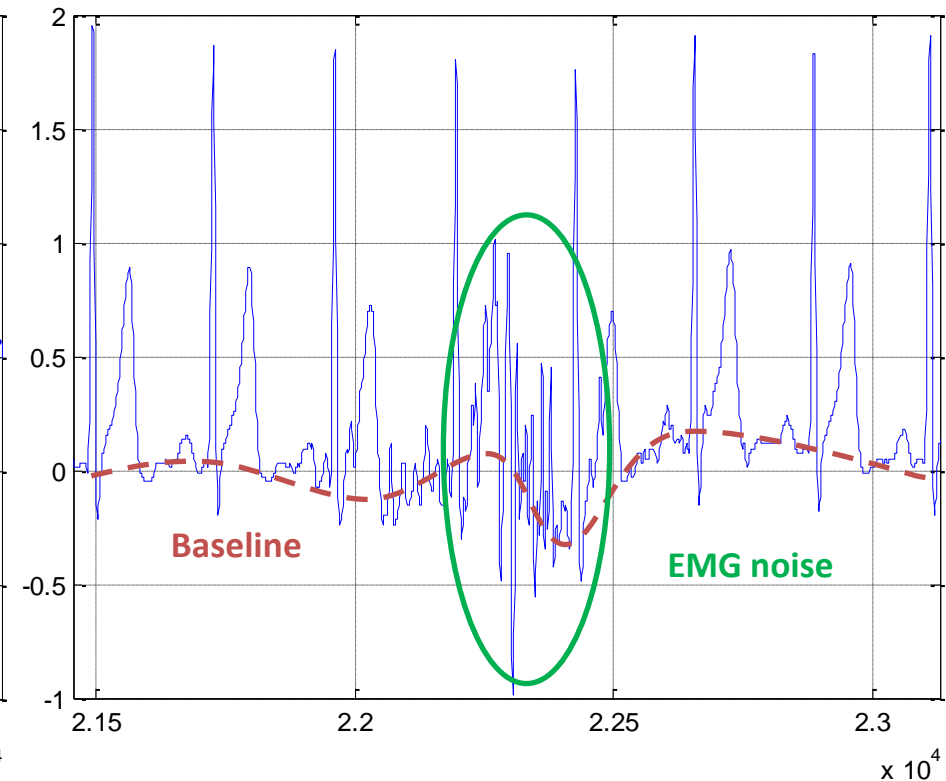
Noise in the mobile users ECG

- Noise classification:
 - Person-electrode motion artifacts
 - Baseline wandering
 - Electromyographic (EMG) noise
 - Power line interference, data collecting device, EMI, etc.

Person-electrode motion artifacts



Normal ECG during movement



Possible solutions (further work)

- Combining different preprocessing techniques:
 - Adaptive filtering
 - Morphological filtering
 - Singular value decomposition (SVD) filtering
 - Wavelet denoising
 - Empirical mode decomposition (EMD)
 - Independent component analysis (ICA)
 - ...

Related research in Europe

- **IMEC Holst Centre:**

- Hamke de Groot, ultra-low-power wireless and digital signal processing (DSP) program director at IMEC/Holst Centre :

“If you develop sensors that measure all kinds of physiological signals—like heart rate, blood pressure, muscle tension and movement, and maybe even brain signals—you can combine this information and send it to a reader device, usually a mobile phone or laptop.”

“If you have a (wireless) electrocardiogram (ECG) patch with a radio link sending all the data to your mobile phone and collecting it, you can be easily be monitored.”

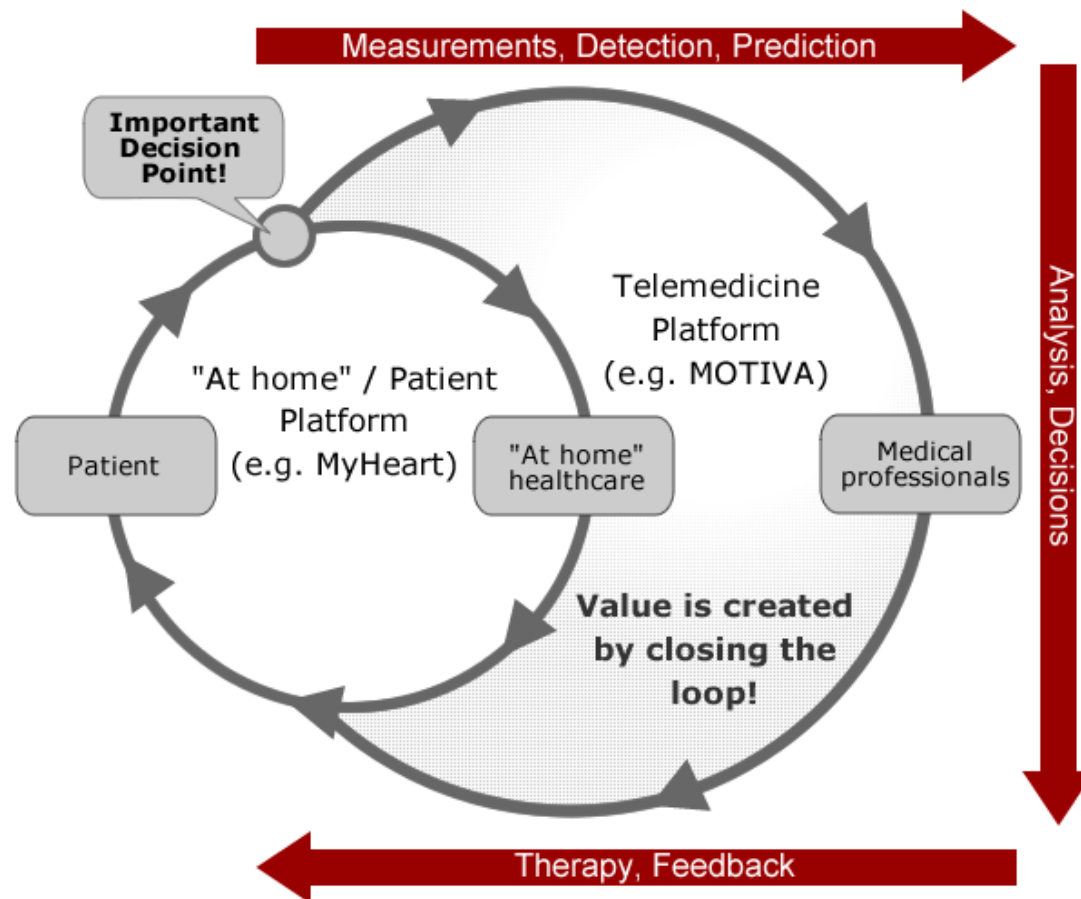


http://www2.imec.be/be_en/press/imec-news/ecgpatch.html

Related research in Europe

- **Philips, CSEM**

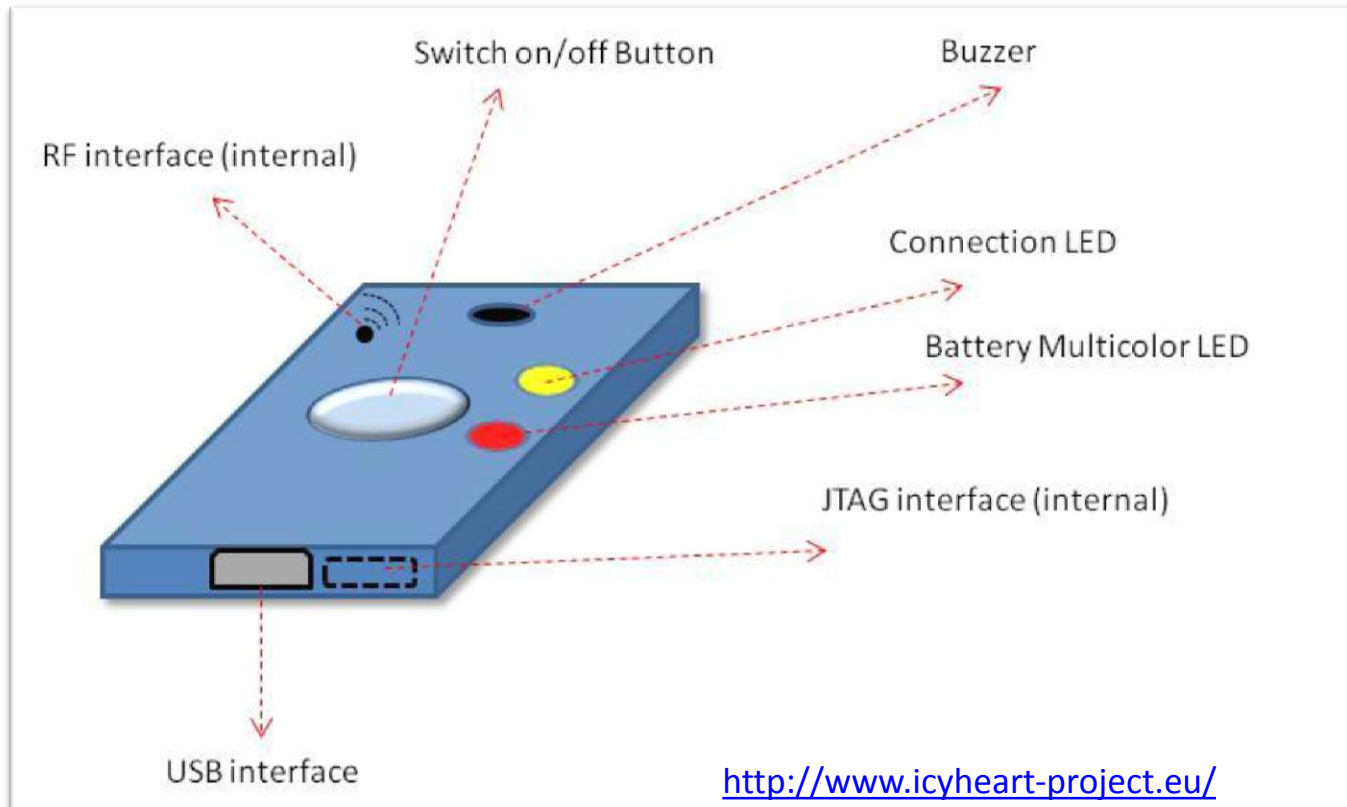
- **Heartcycle** FP7 project : HeartCycle will provide a closed-loop disease management solution being able to serve both Heart Failure (HF) patients and Coronary Heart Disease (CHD) patients, including possible co-morbidities hypertension, diabetes and arrhythmias. This will be achieved by multi-parametric monitoring and analysis of vital signs and other measurements.

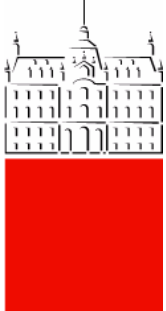


Related research in Europe

- **CSEM**

- **IcyHeart FP7 project:** Highly integrated ultra-low-power SOC solution for unobtrusive and energy efficient cardiac monitoring. Energy efficient signal processing algorithms targeting ECG and similar signals will be embedded and run on the on-chip DSP.





Thank you!

