nano-tera.ch
swiss scientific initiative in health / security / environment systems

ObeSense RTD 2013

FNSNF

Energy Expenditure Estimation by Near-Infrared Spectroscopy

Stefan Kleiser, Nassim Nasseri, Daniel Ostojic, Martin Wolf

Biomedical Optics Research Laboratory, Department of Neonatology, University Hospital Zurich, University of Zurich, 8091 Zurich

BORL Biomedical Optics Research Laboratory University Hospital Zurich | Department of Neonatology

UniversityHospital Zurich Department of Neonatology

University of Zurich UZH

We present a wearable, non-invasive monitoring system to estimate energy expenditure by means of near-infrared spectroscopy (NIRS). A T-shirt with several embedded sensors and a easy-to-use smartphone app will enbable obese patients to track energy expenditure in their daily life.

Method

- Non-invasive and safe NIRS measures oxy- (O_2Hb) and deoxy- (HHb) hemoglobin
- Frequency analysis of O_2Hb and HHb
  - At pulse frequency: arterial oxygen saturation SaO_2: pulse oxymetry
  - At breathing frequency: venous oxygen saturation SvO_2 [2]
- Central SvO_2 by weighted mean of different local SvO_2
- Cardiac output (CO) and Hb concentration (cHb) known
- Fick's principle: Energy_expenditure=CO*cHb*(SaO_2-SvO_2)

Hardware & Software

- Wearable NIRS instrument with 4 wavelengths
- Flexible sensor in biocompatible silicone encasing
- Continuous operation possible (replaceable battery)
- Waterproof charging plug and power switch
- Several sensors integrated into a T-shirt
- Wireless Bluetooth data transmission
- Smartphone computes, displays and stores data

Results

- Hardware designed and production almost completed
- Software development according to plan

Outlook

- Complete production & testing of prototype
- Extension of smartphone app for real application
- Study in adult volunteers to
  - Compare to gold standard and to determine precision of the device
  - Determine number of sensors needed

[1] Scholkmann, F., et al. (2014). "A review on continuous wave functional near-infrared spectroscopy and imaging instrumentation and methodology." Neuroimage 85 Pt 1: 6-27.

[2] Wolf, M., et al. (1997). "Continuous noninvasive measurement of cerebral arterial and venous oxygen saturation at the bedside in mechanically ventilated neonates." Crit Care Med 25(9): 1579-1582.

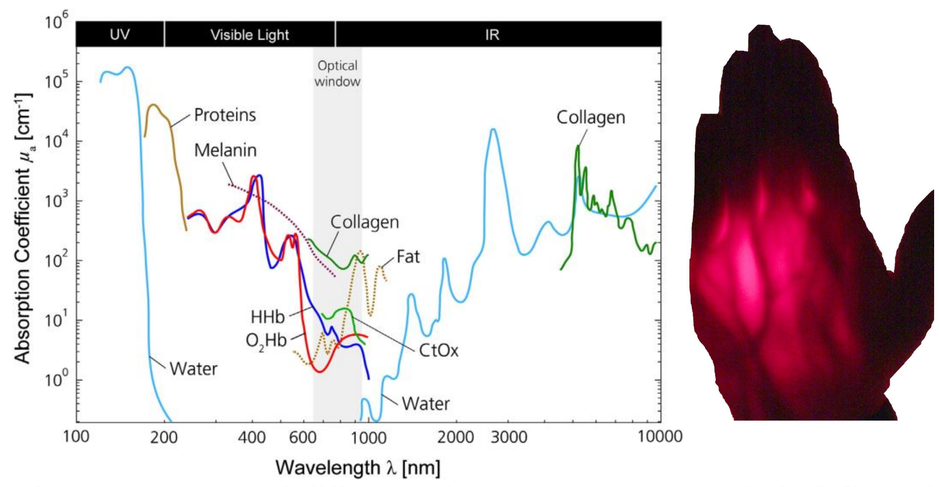

Fig. 1: Spectra of different tissue components (left, [1]) and hand trans-illuminated with photography flash (right).

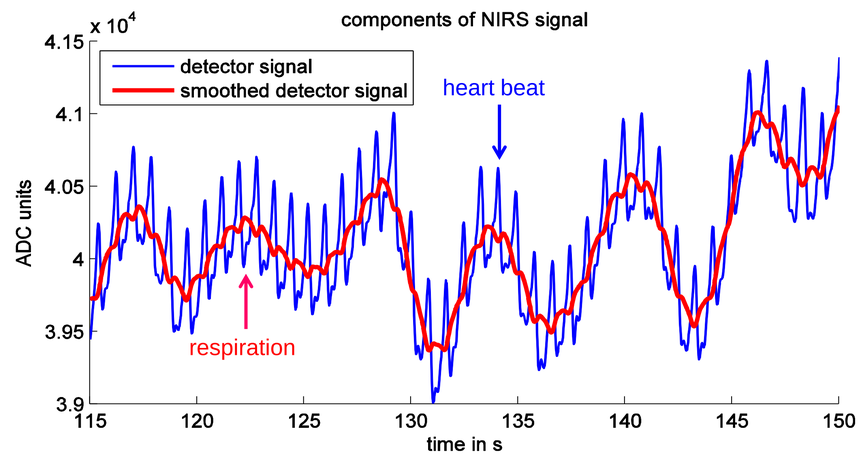

Fig. 2: Typical NIRS signal acquired on the forehead of an adult volunteer showing heart-beat and respiration induced components at a wavelength of 870 nm.

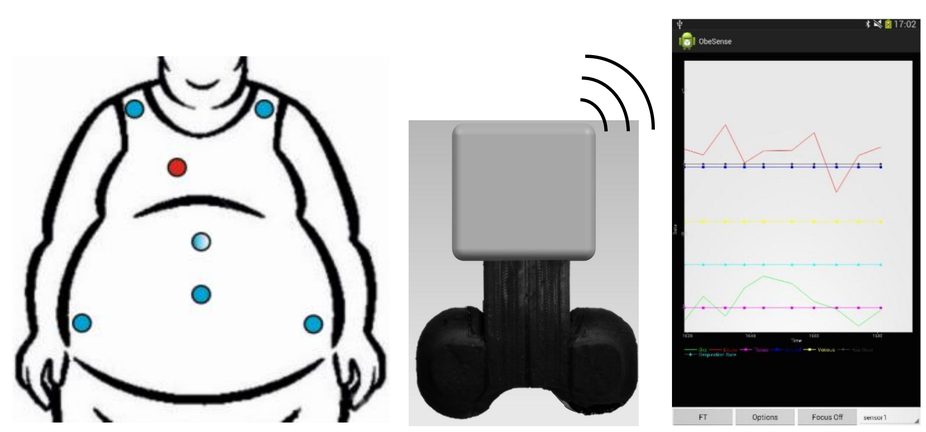

Fig. 3: System overview: multiple NIRS sensors distributed over the upper body transmit signals to a smartphone

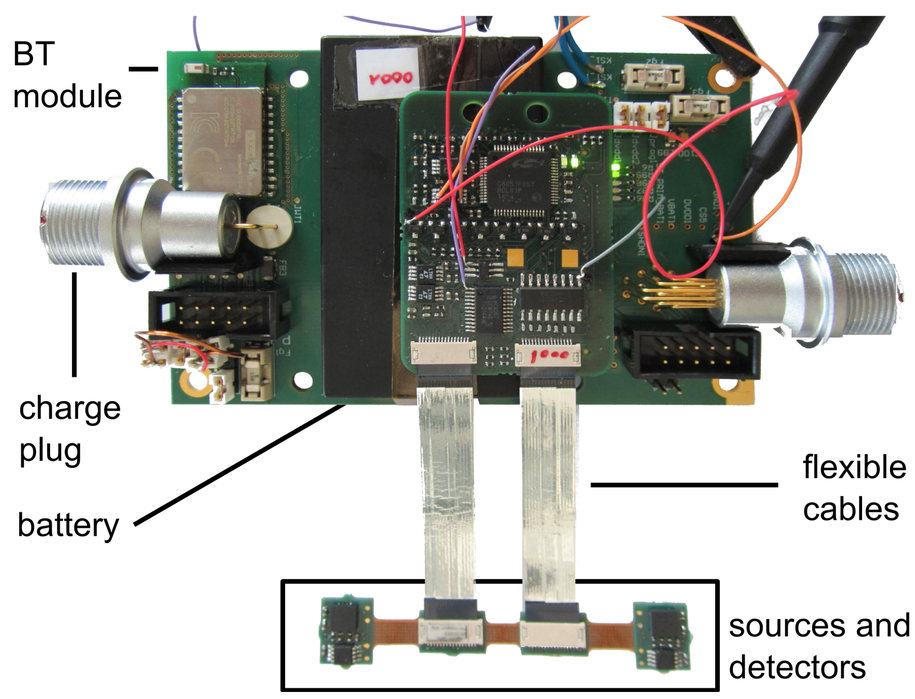

Fig. 4: Printed circuit boards of the new NIRS sensor