ANALYSIS OF FINGER AND TOE PHOTOPLETHYSMOGRAM SIGNALS: CLINICAL ARTERIAL ELASTICITY MEASUREMENTS BY PPG

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Early rise of arterial elasticity is an independent risk factor causing cardiovascular diseases. Elasticity can be assessed by photoplethysmographic technique (PPG). In PPG sensors there are used red (640 nm wavelength) and near-infrared (910 nm) LEDs to non-invasively monitor absorption changes, .e.g., blood pulsations, heart rate, and arterial wall oscillations inside of a finger and toe tissue. These wavelengths are selectively absorbed by oxyhemoglobin and deoxyhemoglobin in tissue. The PPG sensors have become popular because of their convenience to use for infinite times compared with the ECG electrodes. Simple, cheap, and patient-friendly optical and mechanical non-invasive devices would be needed in the future for commercial biomedical diagnose. PPG measurements collect simultaneously blood pulsation and autonomic waving from periphery unlike ECG. The pulse waveforms with envelopes can reveal different, e.g., blood vessel diseases.
The lab-made PPG device monitors thermoregulations, baroreflex sensitivity, psychophysiological conditions, and breath rhythms. Our PPG device is based on phase sensitive detection and the other mechanical force sensor is based on electromechnical film (EMFi) and were developed and used in parallel with collaboration of Tampere Technical University (TUT) and Oulu University (OU).
The computational analysis method for arterial elasticity determination were carried out within young, and elderly volunteers. Clinical measurements were carried out under the supervision of medical doctors on the patients suffering from many arterial diseases, e.g. arteriosclerosis, and on cohort healthy control groups in the same reception room of the blood vessel surgery clinic of Oulu University Hospital (OUH), and that of Tampere University Hospital (TUH). The biosignal analysis have been carried out according to the research plan, and the regulations given by the authorities (VALVIRA). The measurements succeeded excellently. However, PPG and EMFi signal analysis were challenging. EMFi and PPG sensor signals analysis were studies firstly filtering, then enveloping the clean pulse waveforms (PW), after that normalized 0 to 1. The PWs were differentiated, pulse interval times determined, and twenty PWs were afterwards decomposed into the 5 components. The decomposed waves represent the percussion wave and four reflected wave components in each single pulse wave envelope. The decomposition parameters are a function of increase in vascular elasticity caused by, e.g., arteriosclerosis, or too early ageing.

[1] V. Jeyhani, S. Mahdiani, M. Peltokangas, A. Vehkaoja: Comparison of HRV parameters derived from photoplethysmography and electrocardiography signals, EMBC, 2015 37th Annual International Conference of the IEEE.