REMOTE MONITORING OF LIFE FUNCTIONS IN HOME ENVIRONMENT AND INFORMATION FUSION NET-WORK FOR ASSISTIVE MEDICAL DECISION MAKING

ASSOC. PROFESSOR IMRE CIKAJLO,
UNIVERSITY REHABILITATION INSTITUTE, SLOVENIA

Healthcare of elderly and people with neuromuscular disorders or diseases after discharge from the hospital has been one of the highest priorities in the last decade. The increasing number of aged population significantly increased the number of outpatient services, interventions and consequently affected the health care budget. Application of novel technologies, e.g. wireless technologies, smart sensors and efficient mathematical algorithms, may contribute to the less frequent outpatient services due to the possible remote monitoring of major life functions such as blood pressure, heart rate, weight, mobility, facial changes, movement patterns and others. Analysis of these major biomedical parameters has been possible with efficient mathematical algorithms and signal processing of measured signals. The measurement technology is nowadays already available on the market and sometimes even off the shelf devices can be applied as assessment tools. More sophisticated sensors can be integrated in the home equipment; oven, bed, floor, mirror, bedding, refrigerator, accessories or even clothes.

Hereby we present a contactless solution for basic health parameter surveillance like heart rate, breathing frequency and movement during resting or sleeping in the bed. Two optical wires were integrated into the bed sheets in a way that the technology was not hindering the person while lying on the bed. The optical fibers were extremely sensitive and could detect any mechanical vibration of the wires caused by sound, movement, etc. Thus the breathing frequency, heart rate (1) and the person's movement could be identified in the post-processed signal. The heat rate was detected from the changes of the interferometric signal, caused by mechanical deformation of the optical fibers placed in the bed mattress. Heartbeats induced the vibro-mechanical deformation and resulted in changes of the optical signal. The heart beat and the heart rate were extracted from the interferometric signal using signal zero-crossings and filter banks. A linear combination over Morlet wavelets at different scales was applied.

The heart rate was defined as sum of wavelets, defined by the criteria of center frequency between 0.8 Hz and 2.8 Hz, where the spacing between the central frequency and the neighboring wavelets was 0.015 Hz (2). Similar wavelets algorithm was applied for the breathing frequency, with different center frequencies between 0.2 Hz in 1 Hz, with 0.006 Hz spacing. Heart rate and breathing frequency detection was tested in 10 healthy volunteers without any dysfunction or disease, and 10 healthy volunteers with heart arrhythmia. Accuracy was more than 95% with negligible standard deviation. Sensitivity at breathing frequency detection was around 84% with standard deviation 11% and accuracy around 82% and with 3% standard deviation. After each assessment the data were transmitted to the database and from there selected data were available via secure user interface world-wide (Fig. 1). A sensor network information and fused information from the relevant database provide the medical experts enough data to decide on the necessity of the outpatient visit or intervention.

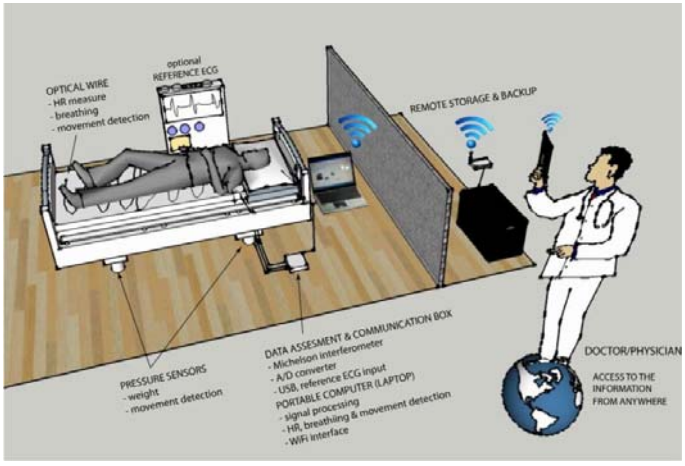

Figure 1. Contactless heart rate, breathing frequency and movement assessment on patient's home and remote monitoring of health parameters.

Imre Cikajlo received his PhD degree in robotics and electrical engineering from the University of Ljubljana, Slovenia in 2003. From 2003 until 2004 he was a post-doc fellow at the Tohoku University, Sendai, Japan and in 2007 a visiting researcher at the University of Tokyo, Japan. Currently he is a Senior Research Associate at the University rehabilitation institute, Ljubljana, Slovenia and an Associate Professor at the University of Nova Gorica, Slovenia. Prof.Cikajlo took part in several EU -FP7 projects (GENTLE/S, MIMICS, CORBYS) and is currently responsible for the Center of Competence Biomedical Engineering at the University rehabilitation Institute, Slovenia. He published 30 journal papers, altogether more than 100 papers, book chapters and books. In 2000 he received the Prešeren Award from Faculty of Electrical Engineering, University of Ljubljana. His research interests include human motion analysis and synthesis, biomechanics, integration of sensory information, control of machine and human movements and rehabilitation robotics. Currently he is involved in the development of rehabilitation devices and procedures that may be used in clinical and/or home environment through application of telerehabilitation techniques and introduction of virtual reality in rehabilitation. He is also a member of ISVR, IFMBE and IEEE.