Home Care Technologies for Ambient Assisted Living

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Abstract— **Health technology and increased medical knowledge enable accurate diagnostics and effective treatment of a large number of diseases, including those which only a decade ago were not easy to manage and cure. The interest and biomedical research in the modern society is intensively directed on disease prevention, early diagnostic and life quality improvement as well as on development of personalized healthcare especially for those chronically ill, disabled and for the aging population. The aim of the new approach in healthcare is not only to monitor and improve health of individuals, but also to increase their independence, mobility, safety and social contact through increased communication, inclusion and participation using available technologies. A large number of new medical devices for health monitoring, home care, wellness promotion, gerontotechnology, etc. have to be designed, tested and adopted to meet the special needs and demands of different population groups. These new devices for telemonitoring and telediagnostics create large amount of health related information, in most cases from sensors organized into body sensor networks. The information has to be processed, transmitted from the point of care to the healthcare system in a safe way and after managing the information in an appropriate and intelligent manner, decisions related to the persons health are to be made. This paper brings an overview of some solutions presented in literature as well as our own development of intelligent mobile monitoring devices.**

Keywords— **Personalized healthcare, ambient assisted living, body area network, telemonitoring, telediagnostics**

I. Introduction

The average age of the population is increasing considerably, especially in the developed countries. In order to meet the rising demand for health care and other social services for the elderly, the policy makers have decided to encourage a number of research and development projects which combine enabling possibilities of communications, information technology, sensorics and health education.

Due to ageing of population, the prevalence of chronic diseases has increased and at the same time the citizens have extended their demands for the best available health care. The life style, increased stress and workload tend to increase the disease risks in middle aged and younger population and therefore a need for developing disease prediction and early detection programs and devices has risen in order to increase the quality of life and reduce the costs by providing as many as possible services at citizens home [1, 2]. Both, patients and healthy, are prepared to carry different intelligent and networked sensors continuously in order to improve their health and well being. Such wearable devices must comply with many requirements, in addition to their medical functionality and technical specifications: they have to be easy to use, reconfigurable, interoperative [3]. Physiological parameters are measured and processed by body sensor networks often based on e-textiles [4, 5, 6], transmitted to the immediate surrounding such as wristwatch, PDA, or PC [7]. The information may be collected and processed in a medical institution, or at their home. In some cases telemonitoring is covered by global GPS or GIS [8]. The ambient has been adopted by embedding sensors into smart homes in order to provide health monitoring of individuals, and also to increase their independence, mobility, safety and social contact through increased communication, inclusion and participation using available technologies [5, 9, 10]. Smart homes require integration of a large number of sensors and device monitoring with a set of processing and decision making devices resulting with a large number of different applications [11].

The concept of *ambient assisted living* has been created within EU FP6 as a program for funding research and development with outcomes that enhance the life quality of the elderly and of the old primarily by using ICT innovations and by providing remote services. This program shall be continued until at least 2013. The citizens' acceptability of e-Health services is rising worldwide and e.g. the expectations for the EU are that by 2010 up to 5% of the health budget will be spent on these services [12].

II. From home care to personalized health care

Patients do not any longer receive care only in medical facilities. The health care services have spread first to their home and then also to other spaces they reach, and finally there is a tendency to offer the services universally. Also the number of users and potential users has increased since in addition to the need for monitoring either vital functions of patients or their general health status, the wish for continuous information on health status and potential health risks have developed in healthy population also. Health care technology research and development have followed these

needs but there is still a need for further steps in order to cover all applications, from disease and health management, disease prevention and possibly prediction. These efforts are intended for a not static citizen, moving across the borders, at any time, but also under non uniform legal framework, unclear reimbursement policy and high requirements for reliability,security and privacy.

A. Home care

Medical devices and services for home care first developed out of the need to extend patient monitoring after medical interventions, using minimally or non-invasive methods allowing early patient release from the clinical facilities. Currently, the home care devices can be divided into several groups:

- Stationary medical devices used at home to measure particular physiological parameters, transmit them to the center of care within a regular schedule,
- Devices embedded into the home in order to raise alarm in case of a medical need or accident,
- Wearable sensors and sensor networks that continuously monitor several physiological parameters.

Stationary medical devices are used to measure physiological parameters which do not need to be monitored continuously or the measurement cannot be performed in such a way. A typical parameter in this category is blood pressure, still considered difficult to determine by users themselves. New developments resulted in a more suitable device for home use, which measures ECG and photolethysmographic (PPG) signal as well [13]. Other systems are based on personal computers as base stations for raw data acquisition where multiple parameters (e.g. HR, RR, ECG, SpO2) are collected and processed to produce decision supportive information, while the data is stored in the computer or transmitted to a medical center [14]. Health smart home (HSH) was designed to follow elderly and disabled people in order to avoid hospitalization. Several modalities of monitoring have been introduced: automatic measurements of physiological parameters, activity measurement and disease specific measurements, allowing monitoring of patient's daily activity within his home [15]. However, the intention is to minimize the interventions in the infrastructure. Thus, the design of existing devices has to be added with medical functionality. Wireless LAN, environmental sensor network for temperature, humidity and carbon dioxide monitoring are interfaced to devices for physiological measurements [16].

Embedded devices certainly provide more comfort to users than wearable devices. Since development of the home care concept is related to care for elderly people, highly accurate automatic fall detectors are important for their care. In addition to devices which require the user to wear and activate them, passive and unobtrusive devices based on floor vibration- detectors have been proposed [17]. Sensors are incorporated into furniture, e.g. into beds in order to follow parameters during sleep [18]. However, such build in devices can produce data on a very limited number of patient related information and therefore can be taken only as a part of intelligent environment.

Wearable devices present the vast majority of devices used for home monitoring. However, there are several modalities of monitoring devices and concepts:

- Biotelemetry, as a classical form of data acquisition and transmission, where at the side of the moving transmitter (i.e. patient) only a limited number of parameters is measured and only limited processing is performed, usually in order to compress the data and reduce the power consumption necessary for raw data transmission [19].
- Portable medical devices, personal medical assistants, intended for use at home to facilitate patient centered care and to enable communication with a medical center through wired services as a part of telematic network.
- Body area network (BAN), which enables wireless communication of a central data storage device with numerous sensors attached to the (patient's) body. Miniature integrated circuits allow measurement and communication at ultra low power and low weight [17]. The aim of introducing these networks is extracting, intelligent processing and transmitting information to devices which communicate with national healthcare information systems. BANs have facilitated research of numerous new miniaturized sensors for physiological data measurement such as ear worn sensors [20] or different types of dry electrodes [21]. BANs should be designed so that they do not reduce the mobility of the persons wearing them.
- Intra-body communication networks or personal area networks have also been proposed for data communication between sensors within or in the near vicinity of the body surface [22].

B. System Integration

Body area networks produce a large amount of data which has to be reliably transferred to the base station and/or server. The majority of signal processing is preferably performed within the wearable unit using embedded intelligence [23, 24, 25]. There are many technical constrains, e.g. limited band, power consumption, interference

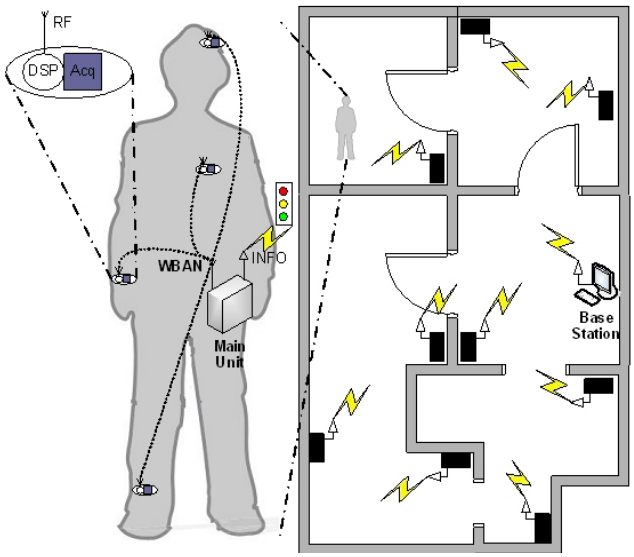

Fig. 1 Body area network for monitoring physiological parameters. Each intelligent sensor is comprised of an acquisition unit (Acq), processing unit (DSP) and a radio frequency transmitter (RF) connected wirelessly into a WBAN. Main unit communicates with the base station in an intelligent ambient.

between different networks – objects. Challenging issues that have also to be resolved are system configuration, customization and integration, standardization of communication protocols, use of off-the-shelf components, as well as security and privacy issues.

Body area network for monitoring physiological parameters typically comprises of a number of intelligent sensors which in turn have an acquisition unit (Acq), processing unit (DSP) and a radio frequency transmitter (RF) in order to wirelessly connect all of them into a WBAN. Fig. 1 shows a system being developed at the University of Zagreb. The main unit processes information obtained from all sensors and communicates with the base station, positioned in this case in a smart home, either directly or through a network of simple auxiliary transceivers. A "traffic light" communication between the main unit and the ambient has three levels: a) alert, in case information processing showed unhealthy condition of a patient in need of immediate attention, b) warning, in case the processing showed suspicious information or trends and c) normal condition, when only short messages are exchanged in order to maintain the communication and acquire the position of the patient. The signal and information processing algorithms enable data compression suitable for communication. Fig. 2 presents how from complex signal processing i.e. from a spectrogram obtained from an asthmatic patient (a), the critical parameter – wheezing is extracted (b) and reduced to a one dimensional information, i.e. presence of wheezing in continuously monitored patient record (c) [24]. The messages to the base station from the main mobile patient unit contain an identification part and a set of physiological parameters individually set for the needs of monitoring of each patient.

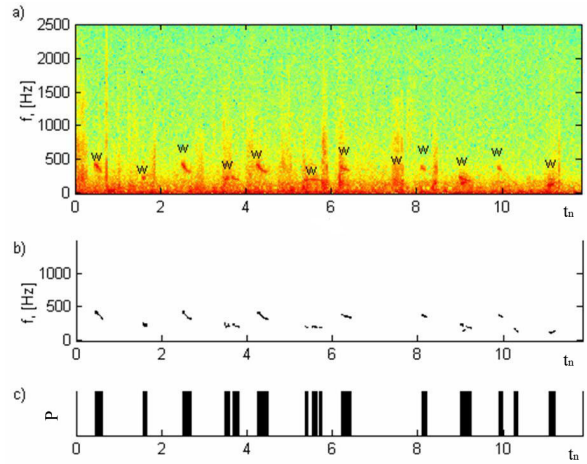

Fig. 2 Results of the wheeze detection in one of the recorded respiratory signals a) spectrogram with marked wheezes (w), b) extraction using connected components, c) detected wheezes in time

E-textiles enable structures which integrate electronic components with textiles, while the term i-textiles designates interactive structure beyond just passive incorporation of electronics and textiles [6]. Smart shirts, also called "wearable motherboards" form wearable infrastructure consisting of a number of sensors integrated into a textile which is as comfortable as traditional clothes [4]. Cellular phones are often used as a platform for communication with the base station. Physiological data is processed and summarized to enable transmission to a remote server in regular time intervals by SMS [26] or the system is configured as an alert system targeting alert message receiving from high-risk patients. The alert system includes continuous collection and evaluation of multiple vital signs and detection of emergency [27].

C. Personalised Care

Innovative systems based on wearable and portable systems will soon include personalized health status monitoring, enabling early diagnosis of disease based on monitoring and analysis of physiological parameters and guidelines for appropriate treatment. The alerting systems will incorporate new algorithms for prediction, detection of symptoms and extraction of adverse events [28, 29, 30]. The knowledge will incorporate results of data mining of existing medical

and scientific databases and blind separation methods for handling large amounts of clinical data. Our environment will become, consciously or unconsciously, a part of ambient assisted living enabling predictive, personalized health care based on patient-specific modelling and simulation.

III. Discussion and conclusions

Health monitoring will in future include monitoring of patients and healthy persons and it will consist dominantly of body sensor networks, either implanted or surface sensors and a personalized, powerful computational unit with embedded intelligence, designed to recognize changes in person's health and context. This personalized unit will enable ubiquitous presence within the health care system. Accordingly, it will be reconfigurable, it will communicate with the ambient to assist changes in regard to living conditions and also activate devices e.g. within rehabilitation program or for drug delivery.

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