Ubiquitous Health Monitoring Systems

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INTRODUCTION

Advances in information technology have made it efficient to send, receive, manipulate, and store vast amounts of data. On the other hand, advances in sensor technology have made it possible to embed different measurements in spaces, objects and even persons while maintaining adequate signal quality. The new health monitoring techniques allow automatic and unobtrusive measurement of biomedical signals and activities of patients – and also other persons who care for their well-being in general. The new integrated sensors and devices provide real-time parameters such as heart and respiration rate. These sensors are used in many new disease management and performance monitoring applications but basic heart and respiration rate monitoring are not enough. The real value of these data is gained only when multiple data channels measured under daily living conditions are processed to form a holistic, systemic health framework.

In comparison to prevalent health care practice, the use of ubiquitous health monitoring offers many advantages. From medical viewpoint, more data with less manual effort are available. This allows for a systemic view to the person's health, leading to early detection of abnormalities and better possibilities for preventive care, supervised rehabilitation, and wellness management (Jovanov & Milenkovic, 2011) rather than just managing the already out-broken disease.

The major possibilities, however, might be for the individual himself. In ubiquitous preventive care the person need not to go to hospital or health center for simple routine tests and the costly time as a patient is minimized. The participation in the monitoring may be a positive experience for a patient and encourage taking care of their health – not to mention the possibility to reverse the trend towards the digital divide (Krishna, Boren, & Balas, 2009). This article sums up the technical concepts, issues, challenges, most promising innovations and opportunities of ubiquitous health monitoring systems.

BACKGROUND

Definitions of Ubiquitous Health Monitoring

Ubiquitous health monitoring systems have emerged as a technology used for ambulatory monitoring. Ubiquitous system design covers engineering fields from microelectronics design to worldwide distributed systems. On the other hand, ubiquitous system design involves also healthcare professionals from a wide range of disciplines. At the moment, ubiquitous monitoring is emerging in diagnostic procedures, chronic condition control, and advanced rehabilitation systems with straight feedback of the patient condition. The

first personal medical monitoring systems have been used only to collect data for off-line processing, as in ambulatory blood pressure or Holter measurements. Ubiquitous approach adds real-time processing and communication; thus allowing prompt actions, such as warnings, drug delivery control, or effective computer assisted rehabilitation.

Ubiquitous health monitoring can be compared with structural health monitoring (SHM) techniques used in the field of engineering. In SHM, a variety of sensing technologies are used to capture, log, and analyze real-time data from mechanical structures such as bridges and dams; buildings; vessels; wind turbines and other large machinery and equipment. The idea is to constantly monitor the functioning of the object, enabling a proactive approach to any deviation of normal function.

For measuring health parameters, three main approaches can be applied: room scale health monitoring; device scale monitoring; and body scale monitoring. In room scale monitoring the monitored person is free to move in a room or apartment and the health parameters are monitored remotely with sensors embedded in walls, floor, ceiling or other structures in the habitat. Obviously, the room scale monitoring is least obstructive but the distance rules out many important parameters like ECG or even weight due to the free movement of the person. However, some health and well-being services are ideal to be realized in room scale, for example, daily life monitoring, fall alarms and other safety services.

Device scale monitoring is carried out by a single device or apparatus which is used by the person, like an automatic blood pressure meter or bathroom scale. The advantage is that the person can be adequately connected to the device and more accurate measurement can be done. However, the measurement is confined to one location and usually demands some cooperation from the monitored person.

Body scale monitoring uses some wearable sensors such as the ECG-strap or the wearable glucose sensor on the body of the monitored person. This type of monitoring has the most possibilities to measure a variety of body functions. However, to be wearable, the size and weight of the device should be minimized. The sensors can also produce some discomfort and the bio-compatibility of materials should be checked.

Examples of Ubiquitous Health Monitoring

Smart Phone and Cell Phone Applications

A variety of simple cell phone-based interventions have been suggested in the literature. Many interventions don't even require sophisticated smart phones and can be effectively used with basic cell phones. Some simple intervention schemes are, for instance, the use of cell phone reminders, treatment advice, and phone support. Benefits of cell phone interventions have been reported in compliance with medicine taking, smoking quit rates, lowering HbA1c, and reducing certain asthma symptoms, for example (Krishna et al., 2009). Also process improvements, such as lower failed appointments and quicker diagnosis and treatment have been reported (Krishna et al., 2009).

There are several phone applications which use smartphones for personal health and fitness monitoring. The available apps most often are just different organizers and guides for healthy life or fitness exercises. There are, however, some applications which use the phone as a ubiquitous measuring device and thus enable the monitoring of at least some health condition. Cardiio, for example, measures and monitors the heart rate. The technique is developed at the MIT Media Lab. The measurement is conducted by recording the picture of one's face by the phone's camera. The frequency of the tiny variations of the facial color tone due to the blood pumped by heart is analyzed from the picture and the pulse is calculated.

Ubiquitous Cardiovascular and General Health Assessment

Ballistocardiography

Ballistocardiography (BCG) is a measurement method where the circulatory reaction forces acting on the whole subject are measured non-invasively. The contribution of Gordon (Gordon, 1877) is often attributed as the origin of the field of BCG. In the mid-20th century, Isaac Starr (Starr, Rawson, Schroeder, & Joseph, 1939) made pioneering work to study the clinical applicability

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