Abstract

Ubiquitous computing provides an environment that discretely integrates digital and physical devices, and thus enables users to access data and environment applications as easily as accessing data from their computers. These advances have provided a different perspective on how to work in healthcare. Thus, this paper sets out the project of an ubiquitous system in health that aims to provide information for professionals as well as to have a positive impact on the quality of life. The proposed system allows continuous monitoring of any active signs that people are in need of care, either because they are elderly or suffer from a disease. The architecture allows mobile devices to carry out the collection of data from sensors coupled to the environment or to the individual and make available the information, after it has been processed, by means of web services for use by other applications. What will be examined is the proposed architecture and resources in terms of communication and integration of technologies.

1. Introduction

Ubiquitous computing provides an environment for integrated, discrete, digital and physical devices. Thus, users can access data and applications from the environment as easily as accessing data from their computers. The proposal made by Weiser in 1991, was for a computer that helps users in a way they do not allow them to perceive it [1]. This has stimulated research among the scientific community in this field and today some progress has already been observed in attempts made to optimize interaction in the user-environment.

The advances achieved in technology have led to different perspectives on how to work in healthcare. This area has attracted a good deal of attention in research projects as it affects human lives and in many cases, involves critical applications. The purpose of developing ubiquitous systems in this area is to provide more information at a reasonable cost, and have a positive impact on the quality of life.

However, it is necessary to plan a set of solutions for the challenges that arise in the area of health, which include the following: high costs of treatment and cure, especially given the increasing number of elderly people, the large number of hospitalized patients, the increase in chronic diseases related to different lifestyles, the growing demand for new medical treatment and technology, and the reduction in the number of professionals compared to the growth in population [2].

Several studies have been carried out in the search for effective results from new systems of healthcare, which have brought benefits in several areas, for example: support for health professionals through the introduction of systems that allow a faster and more accurate diagnosis, systems that assist in a life-saving more agile service, systems that provide greater autonomy for people with illnesses that require constant monitoring, better control of information to maintain privacy and data security, access to information anytime and anywhere by authorized persons; and systems to help in the prevention of diseases [3] [4] [5] [6] [7] [8].

The integration of health with the potential characteristics of ubiquitous computing requires the following: system designs that take full account of the large amount of information that needs to be stored safely, a high availability system, different hardware resources (especially sensors and the mobile devices of different platforms), different types of communication, possible interoperability with other systems, different environments, and different profiles of system users (professionals, patients, family members, and carers).

To meet these needs, this work proposes a system of
continuous monitoring of people, based on data from ECG (electrocardiogram) which can make information available for professionals and families. Furthermore, the system reacts to changes in the standard ECG monitoring service for generating warning signals.

In Section 2, there is an introduction to pervasive Healthcare. Following this, there is a simplified account of the monitoring system that is proposed and in the last chapter, there are some final considerations.

2. Pervasive Healthcare

According to [9] Pervasive Healthcare can be defined from two perspectives: i) the application of pervasive computing technologies in health and other areas ii) the way health care can be made available anywhere, anytime, to anyone. According to the authors, Pervasive Healthcare is closely related to: biomedical engineering (biomedical engineering - BME), medical informatics (medical informatics - MI) and ubiquitous computing (ubicomp). These three approaches can be defined as follows:

- BME: combines engineering expertise with biomedical science to improve the diagnosis, treatment and monitoring (prostheses, diagnostic devices, equipment, drugs).
- MI: processes large amounts of health data to optimize the use of health information (the electronic records of patients).
- Ubicomp: develops and evaluates the use of pervasive sensorized new systems deployed on a large scale.

While BME and MI mainly focus on technology to improve the existing model of health care, pervasive healthcare is opposed to attempts to change the model of health care. As a result, the goal of Pervasive Healthcare is to become a means of achieving health in an ubiquitous way (i.e. anywhere and anytime).

According to [9], Pervasive Healthcare can provide new opportunities for both healthcare professionals and patients. On the one hand, health professionals benefit from the new diagnostic prospects that go far beyond what is possible with today’s routine examinations. They may have access to a history of physiological data measured continuously in the real environment for a long time, including the patient’s activities and the situations which he/she was exposed to. In the other part, patients have the opportunity to play a more active role in managing personal health and prevention. Thus, from the feedback obtained, a patient can be helped to adjust his/her lifestyle and be given a higher quality of healthcare. The authors note that research should be focus on the following areas:

a) pervasive monitoring systems that are long-term, continuous and reliable; b) systems that regard prevention as the key feature to maintain well-being and long life, and c) design and evaluation methods for pervasive, patient-centered technologies.

[7] mentions that some factors with regard to Pervasive Healthcare that have already been surveyed, have yielded some results, but many others still have a lot of unanswered open questions. The author classifies Pervasive Healthcare systems as a) Monitoring and Body Sensor Networks, b) Pervasive Assistive Technologies, c) Pervasive Computing for Hospitals d) Preventive and Persuasive Technologies.

The monitoring of body sensor networks has been a very active research topic in Pervasive Healthcare and showed a degree of success. A major feature is the monitoring of signs of health, such as blood pressure, ECG, heart rate, skin conductance, and blood glucose. The main challenge has been how to design and develop portable sensors that are reliable and non-intrusive, and which can be used by a layman. The goal is to create a platform for continuous monitoring because clinical evidence suggests that continuous monitoring of clear symptoms can detect the early stages of various chronic diseases like hypertension, heart failure, diabetes, dementia and epilepsy. Thus, a detailed research project in this area involves the need for monitoring and sensor technology to collaborate in a distributed infrastructure. Resilience, network topology, wireless communication protocols and data management in real time are important issues in this field of research. Moreover, there is another strand of research that seeks to develop technologies and approaches for monitoring and recognition of behavioral characteristics of a higher order. An example of this are the detection activities of daily living (ADLs), based on the sensor network and approaches to machine learning. Thus, the goal is to analyze the condition of an individual, and use this information for early warning, safety, prevention and care. For example, tracking the early signs of dementia, involves monitoring older people at home, and helping people with dementia to wash their hands or remember conversations.

3. A Monitoring System

The proposed system provides monitoring of the ECG signal for the elderly or patients requiring special attention due to their health. By employing a textile technology that enables the collection of ECG data, we propose a systems architecture, as shown in Figure 1. For a better understanding of the architecture, we describe the operation, as can be seen in Figure 1. The architecture can provide the user with textile technology (smartshirt) that carries out the collection of data sent by Bluetooth to a mobile device (acquisition unit). This in turn, processes the data and sends it to a remote server (via Web Services). Following this, the operation will be described by dividing it into three components: smartshirt, acquisition unit and Web Services.
3.1. Smartshirt

An ECG signal is bioelectric and registers the electrical activity of the heart as a function of time and is therefore a diagnostic tool for a basic and important evaluation of the heart’s functions. A smartshirt VitalJacket developed at the University of Aveiro, will be used to collect ECG data from the user over a long period of time. \[10\] [11]. The VitalJacket is an example of textile technology and electronics, which allows monitoring of the vital signs of its user. In addition to storing data on an SD card, the smartshirt has the ability to send signals via Bluetooth communication. Currently, the manufacturer only provides software for mobile devices for Windows Mobile platform and allows data to be collected continuously for 72 hours.

3.2. The Acquisition Unit

The acquisition of the data collected by smartshirt, is carried out by a mobile device that is receiving the signals through a Bluetooth connection. The mobile system of the device, developed for the Android platform, will be responsible for the processing of the incoming data and storing it in a local database.

The ECG displays a succession of waves corresponding to cardiac cycles, and the normal cycle is a succession of P waves, QRS complex and T waves. There are several algorithms which can detect the heart rhythm. One of the most widely used, is based on the idea proposed by Pan and Tompkins [12] and is employed in this work.

After the data have been processed, they are stored in the device and its user can view the data directly on the device. Data is sent to a remote Web service within a time interval and by means of an existing connection, using a RESTful.

3.3. Web Services

The objective of providing data on a server is to enable other applications to access the data on the patients. This information is available via Web Services, and other applications on any platform, e.g. a mobile or web.

The use of a RESTful approach to Web services is due to the fact that this structure has a better performance than the SOAP approach [13]. REST (Representation State Transfer) architectural style is software designed for widely distributed systems that exploit the capabilities of HTTP. RESTful is called on when the four methods are used to define, manipulate and transfer the data: PUT/GET/DELETE/POST.

The data received on the server via Web Services will be stored in a PostgreSQL database the structure of which is shown in Figure 2. The diagram shows the tables in the database and their attributes. The Web service accepts incoming data in two different formats: XML and JSON.

4. Conclusions

This work outlined a proposed architecture for monitoring ECG signals of the elderly or patients who require monitoring. The aim of the system is as follows: to provide mechanisms that allow the health status of the patient to be defined, by taking full account of the data collected, to enable professionals to monitor the patient and adjust their plans for care, to provide families with access to information about patients; and report emergency situations to the monitoring center or health care professional. The research was conducted by defining an application for mobile devices on the Android platform which is responsible for receiving the signals, processing them and sending them to the remote server by using web services. The Web Service allows applications that are designed for different platforms, to make the information accessible, while maintaining privacy.
Figure 2. Class diagram corresponding to the persistence layer

References


