SENSECARE
Real-time Location-based Health Monitoring System

Gerardo Reveriego, Javier Tellez, Cristina Urdiales and Francisco Sandoval
Departamento de Tecnologia Electronica, Universidad de Malaga
E.T.S.I. Telecomunicacion, Campus de Teatinos S/N, Malaga, Spain

Keywords: Telehealth, Physiological parameters, Biotelemetry, GIS.

Abstract: This paper presents an application capable of monitoring the activity of a user in real time. Our work relies on a mobile phone since most users already have one and usually take it with them everywhere they go. Our system makes use of a pulse oximeter connected to the phone to register physiological parameters and sends them to a coordination centre. Other users, such as doctors or carers, can download health data from the coordination center. The result is a report on the route followed by the user with geo-referenced physiological parameters shown in real time. A Geographic Information System (GIS) was used as support. This standard-based report can be visualized with various compatible GIS. We have used Google Earth due to its public and free accessibility.

1 INTRODUCTION

It has been estimated that just in the USA, the health care system could reduce costs by nearly $ 200 billion during the next 25 years if remote patient monitoring tools were delivered for the most prevalent diseases, such as congestive heart failure, COPD (Chronic Obstructive Pulmonary Disease), diabetes, chronic wounds or skin ulcers (Litan, 2008).

In the field of telehealth, remote monitoring or telemonitoring is a broad area that has usually involved the deployment on the user's home of one or various kind of sensors that will measure specific vital signs. Hitherto, many countries and health providers have focused on applications, such as basic videoconference tools or monitoring devices. Many of these home-based telemonitoring solutions are basically a deployment of a single or several medical devices: spirometers, heart monitors, blood pressure cuffs and so on. Commercial examples of home health monitoring devices are: Health Buddy, Ideal LIFE Pod, Genesis DM, Intel's Health Guide, LifeView.

A small number of products can use a mobile device as a communication gateway, like Telestation or HealthAnywhere. This feature, have been proposed in (Pandian, 2008), (Romero et al., 2008), (Jones, 2006a), (Jones, 2006b). Our system comprises a wireless pulse oximeter and a mobile phone that collects the data from the sensor and forwards data to the coordination center. Some research was performed, in order to find an easily wearable device while walking or running, and able to transmit its data using Bluetooth to a mobile device. In that sense, it was also of vital importance the availability of the data protocol from the vendor. It was necessary to connect and decode the stream of information coming from the device's Bluetooth interface. The selected device was a Nonin 4100 pulse oximeter.

A mobile phone with Android Operating System was selected because of its openness and growing acceptance. The only requirements were to include a Bluetooth module and GPS hardware in order to geographically locate the mobile user. For that purpose, a mid-range phone, the HTC G1 was selected.

The objectives of this approach are presented in section 2. In order to fulfill them, the system structure of section 3 and the functional visualization in section 4 are proposed. Experimental results are shown in section 5. Finally, conclusions and future work are presented in section 6.

2 OBJECTIVES

The System's midterm objective is to proof the viability of a mid-high range cellular phone in order to monitor some of the user's physiological parameters. Our target user will be someone with a cell phone capa-

Reveriego G., Tellez J., Urdiales C. and Sandoval F..
SENSECARE - Real-time Location-based Health Monitoring System.
DOI: 10.5220/0003160903740377
In *Proceedings of the International Conference on Biomedical Electronics and Devices* (BIODEVICES-2011), pages 374-377
ISBN: 978-989-8425-37-9

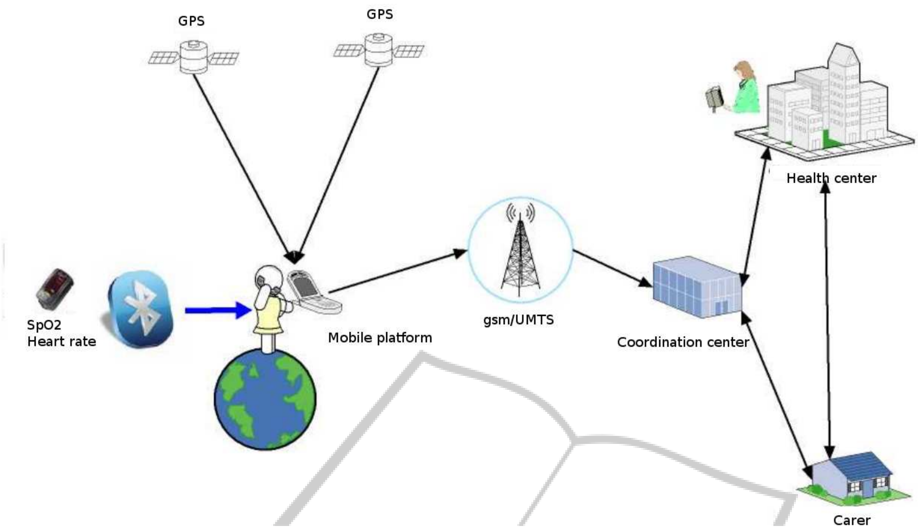

Figure 1: System global structure.

ble of interacting with the environment and be aware of the context. This system aims to provide the cell phone with a new dimension of awareness, so that it is capable of interact and monitor the user's physiological parameters such as heart and respiratory rate, oxygen saturation, etc.

The system will receive physiological data from sensors placed on the user's body. These sensors will connect to the phone by Bluetooth technology. At present, technology does not allow phones to receive physiological information directly. Commercial off the shell tools and hardware have been used in order to cover the system's requirements.

This system will use the available hardware in order to allow the user and/or his/her carer real time visualization of physiological data while moving. The carer can be described as the actor of the system who needs to manage the user's physiological information. There might be some cases where the user will be the athlete or sportsman/woman who wants to monitor his/her physical progression. A more specialized and attractive use is that given by a health centre, a doctor o even a relative that, for medical reasons, requires monitoring a person with specific needs. The description of those needs goes far beyond the objectives of this paper.

3 SYSTEM STRUCTURE

A near real-time monitoring and control system of a moving user has been developed. Devices for capturing personal physiological data are placed on the user's body. Those sensors connect wirelessly to the mobile phone, that acts as a gateway to the coordination centre. For that purpose, a custom software application has been developed on the HTC G1. The coordination centre gathers the information captured by the cell phone and offers it to any actor who may require it. Vital signs coming from a moving user will be displayed in real time through Google Earth.

Fig. 1 shows the system's global architecture. The following sub-systems can be distinguished:

- **Mobile Platform.** It gathers and manages external data coming from physiological sensors placed on the user's body by means of a Bluetooth technology and location information from Geo-localization systems. The phone stores captured data in an internal database and periodically sends the information to the coordination centre by 3g.
- **Coordination Centre.** The coordination centre can be described as the element in this system in charge of processing and managing the data received from the mobile platform. Its mission is safe storage of user's data. This centre also provides actors/carers with the required information.
- **Carer.** A carer can have access to the information previously processed and managed by the coordination centre and have a graphic display of it. The carer has access to this information, and can act accordingly in case of emergency. On the framework of this system, a graphic interface will be provided so that the carer can see the temporal, geographical and physiological evolution of the user. For this purpose, Google Earth was used, since it allows a 3 dimensional display of georeferenced information where monitored physiological parameters can be shown.

4 FUNCTIONAL VISUALIZATION

Once physiological parameters are available in the coordination center, these data can be used with different purposes. For example, it is posible to detect abnormal patterns that may end in a serious affection and warn the user. However, our purpose is to show the user/actor/carer the information in an easy-to-understand way. It is advisable that the application used to read the resulting report is free and well-known by the user, e. g., Google Earth. The functional visualization described here is based in one designed previously for a vehicle telemetry system (Reveriego et al., 2009). In order to show the user (doctor, carer) someone's activity, there are several parameters that could be of interest such as temperature, heart rate, breath rate, etc. It depends on the application. In this experiment, the shown parameters are the following:

1. Location;
2. Pulse rate;
3. Oxygen Saturation Level;
4. Risk Level.

The representation proposed here consists of a 3-dimensional graph (see Fig. 2). It is composed by a string of prisms. Those prisms are defined using the open standard KML and represent the information showed in Table 1.

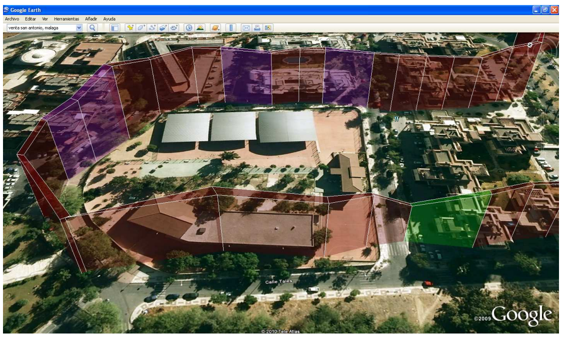

Figure 2: 3-dimensional representation in a middle-distance running.

Table 1: Correspondence between Prism dimension and representing magnitude.

Prism dimension	Representing magnitude
Height	Pulse rate
Width	Oxygen Saturation Level
Color	Risk level

The color of the prisms depends on the risk level. The cooler the color the lower the risk level and the warmer the color the higher the risk level. The level of risk is calculated by simple thresholding of the measured heart rate (Fox et al., 1971). Each prism is a `Polygon` KML object.

5 EXPERIMENTAL RESULTS

Although the system is in an initial stage, positive outcomes can be drawn from each of the three components of the architecture described in section 3. The design of the platform aims to be as transparent as possible to the user, since it intends to be a gateway between the user and the coordination centre. The application must interact with several other systems at the same time seamlessly:

- Visually, with the user in order to display the information sent by the sensors;
- Management of Bluetooth communications with physiological sensor placed on the user;
- Management of user's geo-localization;
- Sending of the information gathered to the coordination centre without the intervention of the user.

The application meets the above mentioned requirements, although its main limitation lies on batteries autonomy; the simultaneous use of the GPS, the Bluetooth radio and the uploading of the data by 3g, results in considerably high power consumption.

The operation of the coordination centre is adequate and uses open source tools.

By using Google Earth API, the carer can visualize on a real map a 3D representation of the user's physiological activity in real time. To make this possible, the coordination centre shall generate and update the information to be shown on the client Google Earth of the carer when starting. In short, when the carer starts Google Earth, he/she will be able to visualize how the user's physiological and geographical information updates in real time. The carer will also observe how some dynamic polygons of different colors and shapes are drawn on the map.

Fig. 3 shows a screen capture of the carer's interface where a high speed running route made by the monitored person is traced. At first, the the heart rate is slow as the graph is low in height. Probably, the user was staying quiet or just walking. Afterwards, the graph starts to increase rapidly till a higher level and the color of the graph pass from blue, warmer and warmer, to red. Thus, the activity of the user grows in intensity. This is the graph generated by a user that start running fast from a relaxed state.

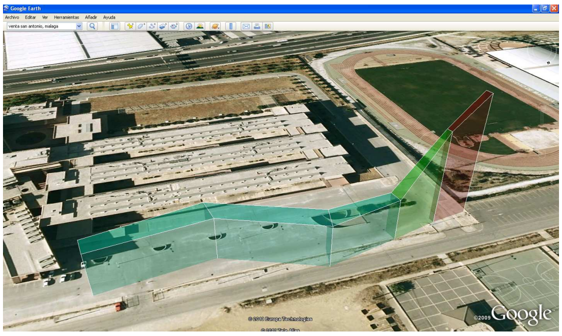

Figure 3: High speed running from relaxed state.

6 CONCLUSIONS AND FUTURE WORKS

A system capable of monitoring physiological parameters in real time has been presented. It is, basically, continuous remote monitoring system comprising:

- A sensor device placed on the user's body that measures physiological data (pulse, Sp02);
- A cellular phone that retrieves data from the sensor device using a short range technology (bluetooth); it collects geographical information (GPS) and it sends it through 3g technology to the coordination centre;
- A coordination centre acting as a server that stores physiological data coming from the cell phone. The coordination centre also receives the demands from the users that wish to visualize physiological data.

It is concluded that the designed visualization system is intuitive and efficient. It is, however, tedious to do a real time monitoring of the patient for a long time. It is very common that neither a physician nor a carer carries out a real time continuous monitoring of the patient. In this case, it seems more useful to implement a system that allows detecting anomalies through data mining, for instance, and alerts doctors, carers or even the patient if abnormalities are detected. This system could be more useful in situations like some kinds of rehabilitation or tests, like stress test for heart disease, when human supervision is advisable. For this purpose, the measurement of more specific vital signs would be a requirement.

Another problem that has to be dealt with is the battery life time of the cell phone. Phone battery life is relatively short (2 hours), since a continuous monitoring implies the use of hardware with high power consumption (GPS, Bluetooth, 3g radio).

Future work will focus on three main lines. First, behavior-based preventive alarms would be interesting to warn users, carers and doctors. Second, it might also be interesting to find transparent, cheap, commercial sensors that could be attached to the mobile phone to improve risk detection and provide additional information. Finally, system software has to be optimized to extend battery life.

ACKNOWLEDGEMENTS

This work has been supported by CENIT-AmIVital, Ingenio 2010 project and by the Spanish Ministerio de Educacion y Ciencia TEC2008-06374-C02-01.

REFERENCES

Fox, S. M., Naughton, J. P., and Haskell, W. (1971). Physical activity and the prevention of coronary heart disease. *Annals of clinical research*, 3(6):404–32.

Jones, V. (2006a). *Mobihealth: mobile health services based on body area networks*. Centre for Telematics and Information Technology University of Twente, Enschede.

Jones, V. (2006b). *Mobihealth: mobile services for health professionals*. Centre for Telematics and Information Technology University of Twente, Enschede.

Litan, R. E. (2008). Vital signs via broadband: Health monitoring transmits savings, enhances lives. *Better Health Care Together*, pages 38–42.

Pandian, P. (2008). Wireless sensor network for wearable physiological monitoring. *Journal of Networks*, 3(5):21–29.

Reveriego, G., Urdiales, C., and Sandoval, F. (2009). Vehicle risks assessment using a nokia n95. In *Intelligent Transportation Systems, 2009. ITSC '09. 12th International IEEE Conference on*, pages 1–6.

Romero, E., Araujo, A., Malagon, P., Vallejo, J. C., Moya, J. M., and Nieto-Taladriz, O. (2008). Patients monitoring system based on a wireless sensor network adaptive platform. In *pHealth. International Workshop on Wearable Micro and Nanosystems for Personalised Health*, Valencia.