Patient Tracking System

Continuous Monitoring and Location Solution for Ambient Assisted Living Facilities

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***Abstract*—This paper describes a wireless wearable sensing system designed to monitor patients within a building in real-time on a continuous basis. The device automatically provides alarms to caregivers, based on biosignals measured by sensors integrated on a necklace worn by each patient. The device detects heart rate, involuntary falls, and location of the patient within a building. It also has a manual call button. The system is now in its prototype phase and has two main goals: improve the quality of care for the patients; and save care-givers' time.**

Keywords - wearable; monitoring; heart rate; fall; alarm; sensors; hardware; healthcare.

I. Introduction

Population aging is nowadays growing to a worldwide concern. In the U.S. alone, projections of 2008 pointed a 13% population share for senior citizens aged over 65 years in 2010; projections now indicate that this number will increase to 20.2% in 2050 [1]. For the EU, the population forecast is similar: the share of people aged over 65 years in the total population is projected to increase from 17.1% (in 2008) to an impressive 30.0% in 2060 [2].

According to [2], whereas in 2008 in the EU there were 4 people of working age (15-64 years old) for every person aged over 65 years, in 2060, the ratio is expected to be 2 to 1. With this generalized trend, critical issues like the quality of life and healthcare for senior citizens are rapidly arising, thus making way for the development of novel, efficient and cost-effective technologies. In the Era of miniaturization, wireless sensors and computer technologies, one of the most important measures to face these needs is the development of solutions that allow to provide appropriate nursing and healthcare services while keeping patients' independence and comfort.

Pervasive healthcare technologies, such as automated wearable sensor devices are invaluable tools for regular and non-intrusive monitoring of risk population groups, such as the elderly, who face specific needs related with their natural condition, namely involuntary falls, arrhythmia or dementia[3].

In this paper we describe a system designed with the purpose of continuously monitoring health parameters and location of its users inside a building, namely in assisted living facilities. The system is designed to be worn by each patient as a necklace that senses heart rate, involuntary falls and location, automatically generating alarms when some abnormality in these variables is detected. The sensors integrated on the necklace communicate wirelessly to a central monitoring station; which in turn communicates with a portable device that the care-givers wear with them. The ultimate goal of the system is early detection of critical situations and facilitate an early intervention.

II. System Description

The Patient Tracking System is designed for indoor usage. Its general architecture is presented in Fig. 1. It is an integrated system, including a set of end-devices (sensing necklaces for patients and caregiver units), tracking routers (installed at strategic points inside the building) and a base station (coordinator).

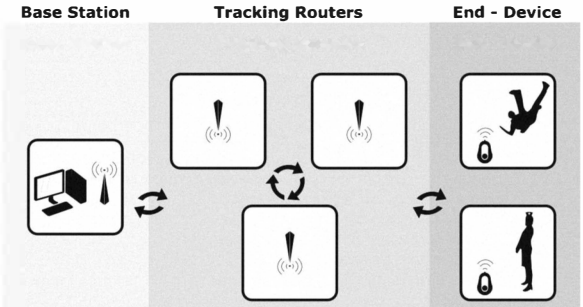

Figure 1. Patient Tracking System architecture.

A. Patient Monitoring Device

The patient monitoring device has the form of a necklace with a pendant, that integrates 3 different sensors: an electrocardiogram (ECG) sensor, a tri-axial accelerometer, and a localization module. Fig. 2(a) presents the form-factor and details of prototype units.

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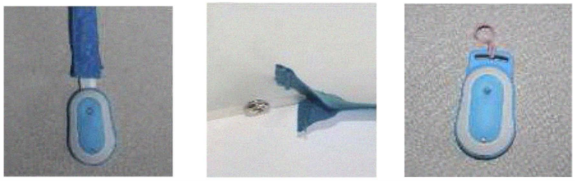

(a) (b) (c)

Figure 2. Images of the prototype units: (a) Patient monitoring device (necklace); (b) Removable cotton sleeve; and (c) Caregiver device.

The device automatically detects signal abnormalities and sends alert events to the care-givers' units. It is also enabled with a manual "call button" that the patient can voluntarily press to issue an alarm event and request assistance.

Also, the device is fitted with a lock detection mechanism that triggers an event whenever it is opened. This allows caregivers to be informed of cases where device is removed and the user is no longer monitored. The necklace is used around the user's neck, underneath his/her clothing and jewelry.

This device was specially designed for continuous use: the pendant is light-weighted (40g); miniaturized (51x32x13mm); and a washable, replaceable cotton sleeve is fitted to the strap that holds the device around the neck (Fig. 2(b)). The pendant has no sharp edges and it is waterproof, therefore it can be used while the patient is sleeping and also while bathing.

B. Alarms and Events

Automatic alarms are triggered when the system detects deviations from the limits defined by the caregivers in the signals that are being monitored: heart rate, acceleration and location.

Location information is determined by the link between the routers installed in the facilities and the end-devices (necklaces and caregivers). It is possible to define a "safety perimeter", inside of which the monitored patients are allowed to be. The pendant detects permanently the closest tracking router within a certain area to determine the patient location, and interacts with it to send the patient data to the base station. This feature allows the system to know the location of each patient within the "safety perimeter" and to emit alarms when a patient leaves it. Through these notifications, caregivers are able to immediately track the patient and prevent, for example, wandering patients from leaving the facilities. This feature is particularly useful for patients with dementia.

The necklace has 3 integrated metallic leads, which contact the patient's skin at the cervical level, ensuring the proper detection of the ECG signal at the neck. The heart rate is computed and sent wirelessly, in real time, to the base station, via the closest tracking router installed the building. When the heart rate deviates from the bounds defined by the caregivers, an alarm is automatically generated and sent to the care-givers' units through the base station.

Fall events are identified when sudden changes in the magnitude of the acceleration signal are detected. This triggers an alarm, ensuring that adequate assistance is rapidly provided to the patient. The fall detector [4] is included on the pendant part of the device and integrates one ADXL330 ±3G MEMS® tri-axial accelerometer.

C. Caregiver Device

The caregiver devices are attached to their name badges. (Fig. 2(c)). Whenever an alarm is triggered, the caregiver devices produce a noticeable beep to notify the caregiver and events informing the type of alarm and the patient location are produced by the system. This way, the caregiver has is able to rapidly reach the user in response to the alarm, assisting the patient on the early stage of the occurrence.

III. How it Works?

The information workflow and application scenario of the Patient Tracking System will be presented in a live demo at the conference. With the aim of testing the main features of the system, we designed an interactive testing protocol which will allow the public to experiment the wearable devices and check the system's features: a) heart rate detection; b) fall detection; and c) location.

A pilot installation was performed and is currently in operation at an Assisted Residence facility for feasibility tests. For now, 20 elderly people are continuously using the device during its daily activities. The users have shown good acceptance of the system and it has been contributing for an improvement of the wellness and independency within the nursing home facilities.

From the caregivers perspective, the system has been allowing them to optimize their time and enhance the quality of service that they offer to the patients since their availability to assist them has increased.

IV. Conclusions

The development of this prototype system has shows that the current capabilities of miniaturization, low-power wireless transmission, and sensor design, allow the development of integrated solutions for pervasive health monitoring.

These solutions will help to devise new practices in the public health sector, towards a more patient centered in-house diagnostics, therapies and remote follow-up, being the final objective the promotion of a more independent life style, higher quality of life, and more efficient quality of care.

References

[1] U.S. Census Bureau, "2008 National Population Projections", 2008.http://www.census.gov/population/www/projections/2008projections.html

[2] G. Konstantinos, "Ageing Characterises the Demographic Perspectives of the European Societies", in Eurostat Statistics in Focus 72/2008, 2008.

[3] D. Aziz, B. Lo, J. Pansiot, L. Atallah, G. Yang, A. Darzy. "From Computers to Ubiquitous Computing by 2010: Health Care", Phil. Trans. R. Soc. A, vol. 366, pp. 3805–3811, 2008.

[4] H. Silva, F. Silva, H. Gamboa, V. Viegas, "Automatic Fall Detection and Alert System - a Compact GPS/GSM Enabled Unit Based on Accelerometry", Proc. of BIODEVICES 2008, vol 2, Portugal, January 2008.

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