e-Health Control and Location Services for Wandering Patients through Cloud-based Analysis

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***Abstract*— This paper presents work in progress towards a platform system aimed at providing support in e-health control and provision of location services for wandering patients through real-time medical and mobility information analysis. These critical aspects are pivotal for the PAVISALE project whose core ideas are presented in this paper. The PAVISALE platform provides services for patients, caregivers and for e-health service operators. Patients are enabled to receive notifications and suggestions in response to emergency, contingency situations or deviations from health and mobility patterns. Caregivers receive such notifications as well for further assistance and they are also enabled to analyse health information and mobility behaviour of patients during time scales and territorial scopes. E-Health service operators are enabled to program e-health and mobility control guidelines according to specific needs of wandering patients. A platform system for e-health control and mobility for wandering patients is possible if and only if efficient and robust wearable devices are designed and they are integrated into a holistic analysis system that can monitor, analyse and store medical information in run-time aligned to the needs of wandering patients' health control and mobility constraints.**

Keywords-wandering patients`; Location-based services; medical information processing; cloud.

I. INTRODUCTION

Dementia refers to the loss of cognitive functioning. People suffering from dementia are affected in their ability to think, remember and reason. There are a number of conditions that cause symptoms of dementia. The most common causes are Alzheimer's disease, vascular dementia or multi-infarct dementia with Lewy bodies and frontotemporal dementia [1]. Although vascular dementia covers 20% to 30% of all cases of dementia, Alzheimer's disease is the most common cause of dementia covering 50% to 75% of cases. It destroys brain cells and nerves, affecting the transmitters that send messages to the brain, particularly those responsible for storing memories.

As mentioned by León-Ortíz et al. [2], the age is the most important risk factor for developing a dementia syndrome. It is expected that by 2030, 60 countries will have more than 2 million elderly persons over 65 years. This will have great impact on public health in several countries because dementia is the leading cause of disability in elderly people, accounting for 11.9% of years lived with disability from non-communicable diseases. Symptoms of Alzheimer's disease are the sudden loss of memory, confusion in everyday activities, adoption of disturbing behaviour like getting up in the middle of the night or wander errantly and getting lost [1].

People with dementia are at constant risk of wandering away, being exposed to suffer physical, emotional damage and even death. In addition, wandering patients, mostly elderly people, frequently have other diseases that could demand additional health control processes (e.g., taking pills, blood pressure and temperature checkups, etc.), which in turn could be jeopardized due to their wandering behavior.

This paper presents our work in progress towards a cloud-based platform that supports e-health and location services for wandering patients. We present our initial ideas towards a system that would allow monitor specific biomedical parameters, produce alerts in case of abnormal biomedical behavior or unknown location of wandering patients, and also, to produce suggestions from the system to control the health of the patients, all in all, to increase the quality of life of wandering patients. The novelty of this platform relies on the improvement of the capabilities of e-wearable devices, and its integration with a novel intelligent system, which both together can be exploited to produce comprehensive tracking, monitoring and control of healthy life in wandering patients with specific needs. The system will exploit cloud services to enable intelligent storage and processing of information in real time, in favour of scalable e-health services. The system will allow monitor, locate, detect patterns of behaviour and mobility, and follow up of medical treatments using smart technology for a large number of patients. The proposed system is the target of the PAVISALE project, which is a research and innovation project targeting a platform for assistance of healthy life control and location of wandering patients.

After this introduction, Section II presents the state of the art. Section III presents the conceptual framework of the platform system. Section IV presents the technological impact of the proposed solution, and finally Section V concludes the paper.

II. STATE OF THE ART

The last decade has seen a tremendous interest for all aspects of e-health. As a comprehensive survey would require more than a single paper, this section describes selected work related to the system subject of our study.

Intercom Sick-nurse Systems [3] provides support to have the information and patient's alarms in one centralized system.

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It includes breathing equipment and electronic whiteboards where the staff of doctors and nurses has relevant information of the patient, reports the presence of nurses or doctors in the room, and continuously monitors the system for fault detection and alarms to alert staff by means of pagers and wireless phones. The operator can make group calls, monitor and setup service requirements, locate staff members, verify service needs and identify sites with staff availability.

The device I'm Home [4] allows taking vital signs of patients at home through sensors, which are sent to the cloud and then it is reviewed by the physician through mobile devices. When a parameter goes outside the normal range, for example, if the pressure rises above 180 or if the temperature rises above 38 degrees, the alarm triggers a call to the call center, which in turn communicates with the patient through a videoconference. I'm home records temperature, heart rate, blood pressure and oxygen levels. The device can be used by patients recovering from the hospital, people with severe lung disease, cancer patients after chemotherapy and elderly people.

E-doctor [5] is a platform for home monitoring in real-time using bluetooth. The application works with physiological sensors and it uses smartphones as gateway. It allows monitor several patients at once. The application presented in [6] uses a WSN (Wireless Sensor Network) tele-monitoring system for health care. It proposes a milti-protocol architecture with physiological sensors and biokinetic sensors. Is uses multiple gateways and it can handle several patients. The application presented in reference [7] is an experimental application that uses a smartphone as Gateway, the bluetooth protocol, physiological sensors, specifically to monitor heart rate, and Internet to transmit data to a remote center. The application presented in [8] is a pilot application that works with Bluetooth and Zigbee (802.15.4) protocol; it offers a redundant system in case of failure of a protocol. It uses sensors and physiological biokinetic sensors.

The e-Health system presented by Cervantes et al. [9] is a research application based on wireless sensor networks that works with physiological sensors, ZigBee (802.15.4) with bridge to WiFi and a personal computer as gateway. The application Cardiosentinal presented by Gao et al. [10] is a sensors application for remote monitoring of cardiac signals with smartphones that is active 24 hours a day. It allows monitoring several persons with cardiac problems and it is run on an infrastructure that allows to act at a given moment in case of a medical emergency. The application presented by Hu et al. [11] is one of the classic applications along with others like "Codeblue" and MEDiSN, which were the precursors of medical treatments and disease control technology, specifically with the use of sensors. This application has evolved to real time streaming using different protocols and different sensors.

A detailed study of sensor networks and applications oriented to collect and analyze biomedical signals is presented by Campaña-Bastidas and Londoño-Peláez [12]. The characteristics of the applications described above (and others in the literature) have a common denominator; the information collected through sensors takes place in real time. However, only a few consider the operation and evolution of the monitored parameters to predict emergencies, or they do not perform data analysis to generate alerts, recommendations or suggest any specific treatment.

From the information included in this section and other works in the literature, we acknowledge that there is a tendency for the use of smartphones to capture and transmit data from sensors. However, the most important limitation of most of the works related to our work is that the use of real-time information analysis is not yet predominant for giving suggestions for health control. In addition, none of the applications consider monitoring the location together with health control approaches, both optimized with the aim at enhancing the quality of like for wandering patients. These basic aspects are of particular relevance to the PAVISALE project.

III. CONCEPTUAL FRAMEWORK

The general objective of our work is the design, development and implementation of a permanent control system for patients that need special care, namely patients that suffer from disorientation disorders or diseases such as senile dementia, schizophrenia or Alzheimer.

The Figure 1 shows a graphical representation of the system platform that we are targeting in our research.

The proposed solution includes the following elements:

• Users' (patient) wearable devices that allow capturing physical activity signals and special biomedical parameters for wandering persons.

• Wireless access technology to support ubiquitous transmission of such information to the cloud.

• Localization infrastructure based on GPS via Wi-Fi or other wireless network.

• Storage and real-time analysis services in the cloud. The cloud will be used to store raw biological and location information of the patients. Data mining and learning algorithms will be executing in the cloud to track, analyze and to determine whether the patient is within appropriate biological levels and also whether the patient is physically located in areas that could fall within his/her location patterns. Algorithms development in this phase are critical because the platform will deal with a large number of patients and also, with specific needs. Scalability passes through efficient and scalable analysis mechanisms that will be addressed in this phase of our developments.

• Real-time self-learning system with manifold objectives: i) to determine patients' behaviour parameters; ii) to monitor for thresholds crossing of biomedical parameters; iii) to give suggestions for healthy life aligned to patients' medical state and evolution.

• Web and mobile applications for users; this is caregivers and/or residence personnel to follow-up, monitor, and react to incidents or events related to the health of the patients.

• A web service interface where administrators can program, and update health control parameters and follow-up guidelines for each patient.

The end-users (patients) will be provided with a wearable device that will implement diverse sensors for vital signal measurement. The capabilities of the wearable device will be aligned to the needs of the patients. The information from the devices will be transmitted to a cloud storage service through a wireless access point. The system will be designed to be aware of the capabilities and nature of the wearable devices and it will

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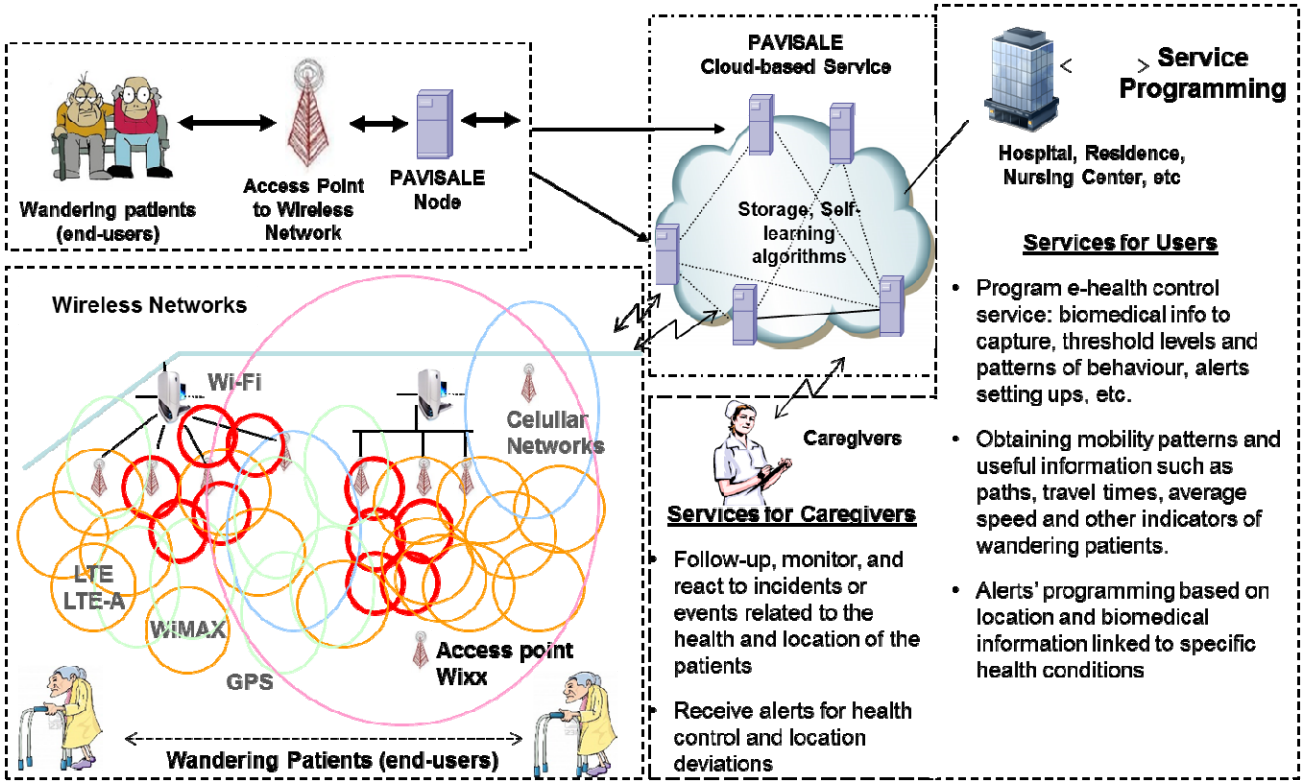

Figure 1. Services supported by the location-based service platform

implement appropriate gateway transmission devices coupled with the sensors.

The users of the platform (caregivers, residence/hospital staff) will have at hand a localization infrastructure that will follow-up, monitor, and react to incidents or events related to the location of the patients.

The cloud service will gather and store the patients' information making use of appropriate anonymization techniques or encryption security protocols to ensure confidentiality.

The self-learning component will analyse the biomedical information in order to detect anomalies as well as to suggest new activities and reinforce those that have produced good results in the patients. The self-learning component will provide services for analysis, recommendation and alert generation. Alerts will be sent to the specialized staff of the residence (end user) through a web application that could run in tablets, PCs, smartphones, etc. Also, the patient could receive the alert if he/she is capable of reacting to such alert accordingly.

To date, there are two types of products related to the solution described earlier: i) systems for locating wandering persons [13] and ii) wrist bands for physical activity registration [14][15]. The proposed solution covers completely the functionality of systems for locating wandering persons, and it greatly enhances the functionality of the wristbands for physical activity registration. Our solution does not only measure the taken steps, but it also offers real-time measurement of sensitive vital signs for wandering persons which comprise temperature, heart rate, skin humidity or breathing. Also, the main innovation that differentiates our approach from other products is that it incorporates a system that analyses the activity and parameters of all users (patients), offering tips to follow a healthy life style, and the auto prediction of possible health problems. In the next section, we elaborate on the technological challenges and contributions to all actors involved in the solution presented in our work.

IV. TECHNOLOGICAL IMPACT

The expected growth on the quantity of wandering patients for the next years demands the deployment of new solutions that help enhance the quality of life of persons with wandering behaviour, and also that can provide support for more efficient attention and follow up for wandering patients in health centres, residences and hospitals.

This is not an easy task because wandering patients can be elderly, and they may present a combination of various health conditions that require personalized care and continuous monitoring. The constant monitoring of diverse biomedical parameters and the periodic tracking of biomedical information of several wandering patients is only possible by means of the use and development of diverse technologies that include: design of electronic devices with restrictions of usage, portability, and energy efficiency, a safe and plug-and-play communication protocol that guarantees the smart gathering of biomedical data, the development of new scalable storage and information analysis services, and finally, smart tools that allow hospital directors/administrators and technical staff of residences to track physical location, as well as monitor the evolution of biomedical parameters of patients. The contributions to the state of the art in all actors involved in the solution proposed in this paper are described hereafter.

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A. Impact on health care operators

The contributions to health care operators are manifold and they are summarized in this section.

The system will extend the health care operators' role to a more active role that is commonly taken by specialized service operators at expensive costs. In this sense, public and private hospitals as well as diverse residencies with wandering patients will be enabled to define and operate autonomously the health care services for their communities according to the parameters, and the desired tracking for each patient.

The system will allow hospitals, residences, etc., acquire and define patterns of e-health services, which could be instantiated in several places for patients with similar needs. This would also have an impact on the reduction of operation and maintenance costs in e-health care services.

Cost reduction has a domino effect on critical aspects of e-health services provision, such as: i) increase the offer of service operators; ii) improve existent services by integrating new devices for the monitoring of biomedical signals with improved capabilities.

The proposed system will be designed to be flexible and scalable allowing for the integration of new specialized or emerging monitoring devices.

The system will be tested in real environments. Moreover, an important effect of its application in real environments is that it will bring new business models for its exploitation in commonly neglected environments such as rural residencies, regional hospitals, and remote homes with patient tracking needs.

B. Impact on device manufacturers

The proposed system will allow manufacturers of electronic/wearable devices to get know-how for developing emerging technologies for monitoring and tracking healthy life of wandering patients. In addition, they will design and develop more and better devices that could be integrated to platforms of monitoring and analysis of large volumes of information. The above will have an impact towards mass production of devices with improved capabilities. Finally, device manufactures will adapt to market evolution to address the requirements of the increasing number of wandering patients in the world.

C. Impact on wandering patients

The proposed system will have a significant impact on wandering patients, since the researched technologies in this work will allow the provision of services for systematic location tracking and biomedical data monitoring in general. Wandering patients could enjoy such advanced services at affordable prices and in consequence an increase in its quality of life due to the assistance and personalized tracking of location and health control.

D. Impact on family members

The family members of wandering patients would benefit from our platform system in several ways. They would be able to monitor and pay special attention about biological information and physical location of their relatives through their smartphones, tables, etc. With this regard, family members could be warned when the patient may experience deviations of biological state or in case the patient gets lost at a given time. With the support of the platform system, family members could call for assistance or they could be able to provide the caregivers access to the patient in cases when the latter ones attend the alerts triggered by the system. Family members could enjoy these services at affordable prices and they would increase their quality of life as they would be supported by an intelligent and reliable system when looking after their wandering relatives.

V. CONCLUDING REMARKS

This paper has presented work in progress towards a platform system aimed at providing support in e-health control and provision of location services for wandering patients through real-time medical and mobility information analysis. The conceptual framework presented in this paper indicates that e-health control and location services for wandering patients can be achieved with appropriate enhancements of wearable devices that can transmit biomedical information towards an analysis system that can monitor, analyse and store medical information in run-time aligned to the needs of wandering patients' health control and mobility targets. This paper has presented the core ideas with which we think that we will contribute to the state of the art in the critical nature of providing support in e-health control and provision of location services for wandering patients. Mainly, we expect to contribute to the state of the art with an implementation of the conceptual design presented in this paper, and the specific algorithms that would analyse and process the large amount of biological information to enhance the quality of life of wandering patients.

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