Integrated Smart Home Services and Smart Wearable Technology for the Disabled and Elderly

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Abstract: Smart Home is indeed a broad concept which includes the techniques and systems applied to living spaces. While its main goal is to reduce the consumption of energy, it provides many benefits including living in comfort, security and increasing flexibility. Smart homes are achieved through networking, control and automation technologies. Since smart homes offer more comfort and security and provide novel innovative services, people with disabilities or the elderly can take the advantages and improve their life quality. However, for such novel services, an analytical infrastructure which can manage overall data flow provided by various sensors, understand anomalous behaviour, and make necessary decisions. In this study, for efficient data handling and visualisation, an integrated smart service approach based on the use of a smart vest is proposed. The smart vest plays a key role in the proposed system since it provides the main health parameters of the monitored person to the smart home service and enables tracking of the monitored person's location. The proposed system offers many benefits to both people with disabilities and the elderly and their families in terms of increased efficiency of health care service and comfort for the monitored person. It can also reduce the cost of health care services by reducing the number of periodical visits.

1 INTRODUCTION

Smart homes are the houses of the future which includes services connecting the physical world with the digital world. In smart homes, digital devices are connected to each other and the features which provide a base facilitating communication, feedback, and alerting are found. In smart homes, software services and new generation technologies are coupled together with existing devices supported by sensors and actuators. It is a big mistake to think that smart homes only provide remote management advantages and the houses that generate their own energy. Smart homes where we will spend a significant part of our life will be able to provide solutions improving the quality of our life through correct and critical information gained from the novel services of them. For novel services provided by smart home applications, an analytical infrastructure which can manage data flow provided by sensors, understanding anomalous behaviour, and making appropriate decisions must be set up. In addition, the obtained data must be handled, processed and visualized efficiently.

With the increase in the population of the elderly, the importance of home services has started to become more important (Istepanian et al, 2004). Support services are very important especially in diseases that lead to loss of cognitive functions, such as Alzheimer. Here, fulfilling the daily activities is the highest priority for the patients. In this regard, gathering data from various sensors and applying data mining techniques on it enables the detection of the events at home (Moutacalli et al, 2013; Jovanov et al, 2003). A similar study on this topic is presented in (Son et al, 2013). The use of aiding technologies for the care of diabetic patients can prevent existing symptoms from getting aggravated and help in improving them.

However, almost all smart home services rely on localization information (Manley et al, 2007). Wireless sensor networks, one of the most commonly used network technologies for indoor localization, are used for the fall detection and prevention for the elderly and old patients (Wang et al, 2014). Although it is difficult to implement, emerging innovative smart home services are based on image/video based activity recognition systems (Jalal et al, 2012; Jalal et al, 2014).

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It is obvious that there is an integration need for smart home services. Because services provided by different technologies and tools alone are not sufficient enough to improve human life. At the same time, in both the existing and designed systems, there is a need to carry out comprehensive performance analysis and determine acceptable service quality details.

Although there are many studies in the literature such as smart home technologies (Son et al, 2011; Han and Lim, 2010; Jiang et al, 2004), smart clothes (Mitilineos et al, 2013; Vassiliadis et al, 2004; Vassiliadis et al, 2011), data collection and control using wireless sensor networks (Hulsmann and Windt, 2007; Zhu et al, 2012; Francesco et al, 2011; Incel et al, 2012), localization in wireless sensor networks (Tuna et al, 2014; Buratti and Verdone, 2009; Mao et al, 2007; Han et al 2013) and log management system (Daş et al, 2008; Daş and Türkoğlu, 2009; Goel and Jha, 2013; Taghavi et al, 2012), the application and implementation of smart home services for a common purpose is a relatively new topic. Therefore, the services which include and present novel approaches to address the existing problems of the elderly and disabled are needed.

In this study, the use of a smart vest for monitoring the main health parameters of the elderly and disabled people and tracking their locations is proposed. In this way, physical condition related to main parameters will be collected and stored in the management system, and the person's location will be simultaneously tracked using the proposed localization system. To the best of our knowledge, in the literature there are no prior studies proposing an integrated smart home service for the elderly and people with disabilities. Therefore, in this paper, we focus on the integration of innovative smart home services for this goal. The rest of the paper is organized as follows. The description of the proposed approach is given in Section 2. Section 3 presents the data management system of the proposed approach. Finally, Section 4 concludes the paper.

2 INTEGRATED SMART HOME SERVICE APPROACH

In this study, an integrated smart home service which aims monitoring personal activities at home is proposed. In this regard, a smart vest which enables monitoring the main health parameters is realized along with a wireless sensor network-based data collection and localization system and a smart log management and alert system. The integrated service improves the quality of the lives of the elderly and disabled and is not only important for the elderly and disabled but also for their relatives. As shown in Figure 1, different from the existing works in the literature, the integrated service approach proposed in this study combines the techniques which are generally handled separately.

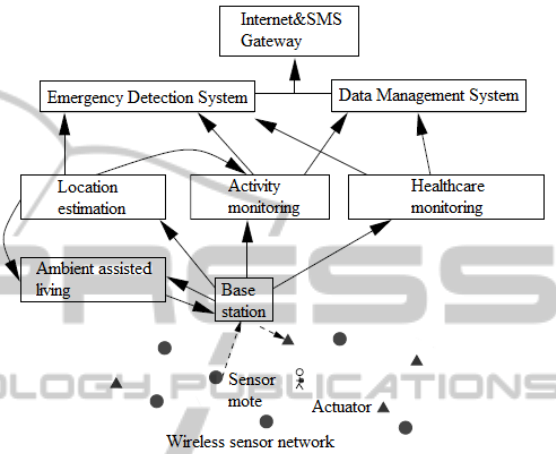

Figure 1: Proposed approach.

In the proposed approach, for monitoring the main health parameters of the elderly and disabled people and tracking their locations, a smart vest is used. The smart vest collects various 3 parameters related to the physical condition of the monitored person and sends them to data management system over a wireless sensor network (WSN), a kind of wireless network consisting of hundreds to thousands of low-power multi-functional sensor nodes with sensing, computation and communication capabilities (Akyildiz et al, 2002; Alemdar and Ersoy, 2010; Kiokes et al, 2014). It also enables the monitored person's location to be tracked simultaneously.

The smart vest to be used in the scope of the experimental studies will be developed by off-the-shelf circuit components, sensors and flexible printed circuit boards. The antenna will be embedded in the smart vest and it will not restrict the person's freedom of action. In the smart home, the approach which determines the smart vest's location on a relative basis is going to be followed to determine the localization of the person (who is wearing the smart vest.) Based on the signals received from the smart vest which also acts as an antenna, the smart vest's location will be solved using the approach of classifying the fixed nodes with known locations with similar attenuation

factors to itself. In this method which is based on the determination of suitable geometric points, both attenuation factors and the smart vest's location will be estimated. The proposed localization method is suitable for simple sensor nodes with limited processing power and memory resources.

At the heart of the offered smart home services, a smart home management system lies. The most important component of the smart home management system which will connect external world by the use of web-based services is a novel data management system. The novel data management system will be able to provide the monitoring of all events and visualize the events in order to extract the patterns which will be used to estimate possible problems in the future. For instance, by monitoring an old person during 10 days, it will be able to extract activity patterns, record all events occurred and trigger the alerts when deviations from normal activities happen. Thus, it will be possible to inform the person's relatives or institutions which provide health services. The proposed data management system will be able to trigger an alarm if a record is not generated within a determined period and it will deliver the real-time tags and alarms to specified users by SMS, e-mail and smart phone notification messages. Therefore, it is necessary to store the generated logs by keeping the error risk at minimum and without overlooking security measures.

3 INTELLIGENT DATA MANAGEMENT SYSTEM

In the proposed approach, the data management system shown in Figure 2 is responsible for storing logs collected from sensors after cleaning them, extracting patters and generating behaviour profiles after analysis, understanding anomalous behaviour, and triggering alerts by making appropriate decisions. It can be seen as the core of the proposed approach.

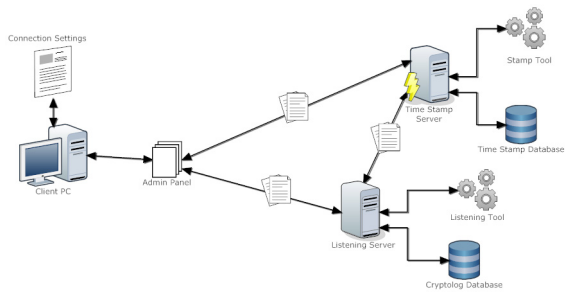

Figure 2: Data management system.

Raw data in logs are not suitable for being processed by the proposed system. Therefore, before being processed, it must be processed to eliminate the records which are not usable or irrelevant to the process. Data pruning process shown in Figure 3 is responsible for this.

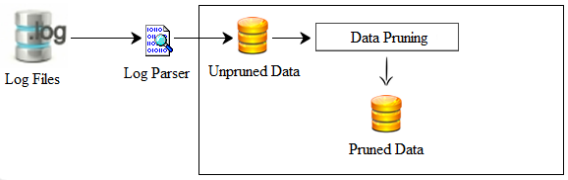

Figure 3: Data pruning process.

Data sent through a set of selected port numbers is captured and logged on along with date information. In the data management system shown in Figure 2, using the services of *Listening Server*, *Listening Tool* is responsible for listening for a set of selected ports. *Cryptolog Database* is responsible for recording and the daily reporting of the logs generated by *Listening Tool*. *Admin Panel* stores login information and log records, and at the end of the day sends the recorded log data after being checked to *Stamp Server* for stamping. In addition, *Stamp Tool* stamps the log data coming from *Listening Server* and stores them on *Time Stamp Database*. *Admin Panel* users are enabled to check whether the log data stored on *Cryptolog Database* have been changed after having been stamped by *Time Stamp Database*.

4 CONCLUSIONS

Currently, there are Smart Home systems which can control precisely the heating, the lighting and the electrical appliances and be remotely controlled. However, they can also perform other specific tasks if innovative services are integrated. If this is done and essential electronic components, products, software systems, services and methods are integrated, the smart home can assist people with disabilities or the elderly in their daily lives, and greatly enhance their life quality since they generally stay in their own home longer and at the same time wish to remain autonomous and independent. In this study, an integrated system involving a smart vest and a set of smart service components is proposed. In the proposed system, the smart vest provides the main health parameters of the monitored person to the integrated system and enables tracking the monitored person's location. Since the data gathered

from different sensors can be correlated to produce an overall picture of the monitored person's health, the proposed system offers several advantages to health care providers.

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