Elderly Healthcare Data Protection Application for Ambient Assisted Living

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Abstract. The increasing aging of the population requires new kinds of social and medical intervention and the availability of different supportive services for elderly people. Falling is one of the events that usually occur to elderly persons with resultant morbidity ranging from soft injury through to fractures and possibly death. Due the fragility of the elderly persons, falls should be avoided at all costs. New applications and services have been developed allowing the elderly people to be continuously monitored, however an adequate response to the needs of the users will imply a high percentage of use for personal data and information. This article introduces the data protection rules that have to be considered in elderly healthcare facilities for protecting residents' privacy and sensible data that is being shared between persons and applications. Also, this article proposes an automatic video surveillance system for elderly protection via falls detection and prevention. The proposed system utilized the integration of motion detection sensors embedded in network cameras with smart mobile phones in order to develop a platform for pervasive fall detection and prevention. Moreover, the proposed system highlights the consideration of balance between the rights and legitimate concerns of elderly residents and the requirements of an efficient functioning in the healthcare facility.

Keywords: fall prevention, healthcare data protection, elderly monitoring, motion sensing, mobile technology.

1 Introduction

In around 35 years and by 2050, it's estimated that more than one in each group of five people will be aged 65 or over. In this age group, falling is one of the most serious life-threatening events that can occur, as approximately one-third to one-half of the population aged 65 and over (mostly aging care centers residents) experience falls on a yearly basis and half of these elderly do fall repeatedly [1]. That is, the increasing aging of the population requires new kinds of social and medical intervention and the availability of different supportive services for elderly people.

Nowadays, medical science is developed in collaboration between human and technology. Medical professionals and caregivers have to follow strict rules for the protection and safeguard of human life. However, this might be subject to secrecy and respect

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for privacy, nevertheless sensible data is being shared between persons and applications. So, there must be a balance between the rights and legitimate concerns of users and the requirements of an efficient functioning of healthcare facilities [2].

A fall can be defined as unintentionally coming to rest on the ground or other lower level with or without loss of consciousness [3]. Unintentional falls is an ever-increasing problem among the elderly population that presents a common cause of severe injury. However, due to the advances in modern monitoring and detection technologies for old people that report fall events in real time, the average age of global aging population increases continuously in recent years. Aging people are frailer, more unsteady, and have slower reactions, thus are more likely to fall and be injured than younger individuals. Typically, many falls are simply managed using different types of alarm devices to notify others when a falls event occurs. However, it's also essential to offer various practical solutions for improving the quality of life for elderly people along with assisting them and their caregivers against falls. So, falls detection and prevention technologies shall extend beyond simple notification as currently it can be used to screen for falls risk and accordingly to prevent a fall from occurring.

Falling among the elderly happens due to different causes as well as it leads to different consequences. Being aware of those reasons and consequences serves researchers, designers, and developers of fall detection and prevention systems to develop various creative solutions for the problem of elderly falls. Technical staff or caregivers may need to process data and information concerning the users/patients on a daily basis. Due to that fact, they may sacrifice privacy to maintain a flow of data that is quite important for the availability of efficient and trustable healthcare services.

This article brings the concept of elderly healthcare data protection to the light in addition to proposing an automatic video surveillance system for elderly protection via falls detection and prevention. The proposed approach clarifies the utilization of applying the elderly healthcare data protection concept along with the integration of motion detection sensors embedded in network cameras with smart mobile phones in order to develop a platform for pervasive fall detection and prevention. Moreover, the proposed system highlights the consideration of balance between the rights and legitimate concerns of elderly residents and the requirements of an efficient functioning in the healthcare facility. The rest of this article is organized as follows. Section 2 introduces the fundamental guidance rules for healthcare data protection. Section 3 presents the phases of the proposed *FallPrevent* system as well as highlighting system architecture and functionality for elderly fall detection and prevention. Finally, section 4 concludes the article and discusses future challenges.

2 Healthcare Data Protection

Although it is allowable that elderly monitoring and protection systems may respect legal requirements concerning the rights and warranties of the data holder, it must nevertheless be recognized that there are permanent risks of Dataveillance [4]. The dataveillance is the concept of systematic usage of personal data systems in the investigation or monitoring of the actions or communications of one or more persons. On the other side, one must distinguish between requirements concerning privacy and requirements concerning data protection, between warranties of opacity and warranties of transparency [5].

Therefore, it becomes important to understand that it is not enough to have a legal affirmation of rights. It is also quite important to ensure the effectiveness of these rights. Thus, it is quite important to indicate that technology brings along multiple and quite serious threats to the human rights to privacy and data protection as well as playing an essential role for finding the solution for these problems, while enhancing technological uses in compliance with the legal requirements of privacy and data protection [6].

The Data Protection Acts [7], [8] 1988 and 2003, which were defined to guideline the processing of data on identifiable living people, governed the protection of personal data in order to provide data controllers a legal responsibility to:

- obtain and process personal data fairly;
- keep it only for one or more specified and explicit lawful purposes;
- process it only in ways compatible with the purposes for which it was given initially;
- keep personal data safe and secure;
- keep data accurate, complete and up-to-date;
- ensure that it is adequate, relevant and not excessive;
- retain it no longer than is necessary for the specified purpose or purposes; and,
- provide a copy of his/her personal data to any individual, on request.

The purpose of these guidelines is to assist ensuring, as much as possible, that personal data in their possession is kept safe and secure and to help meeting legal responsibilities as set out previously. For information to be processed fairly, the data subject should know who the data controller is, why the information is being processed and any other necessary information, such as the likely consequences of the processing. The purpose for which personal data is collected and processed should be made clear to the data subject. Data subjects should not be deceived or misled as to the purpose for which their information is held or used. Information should only be obtained from a person who is legally authorized to supply it.

For data to be processed legally, it must not lead to any kind of discrimination and should not go against any other laws such as the Human Rights Act 1998. Data controllers and users must not collect and use personal information unless there is a specific and valid reason for doing so. The data subject must be told what the information will be used for. Finally, personal information collected for one reason must not be used for any other unrelated purpose. That is, only information needed for the specific purpose should be asked for or recorded. Information that is not relevant for the purpose must not be collected simply because it might be useful in the future.

3 The Proposed Elderly Protection Approach

3.1 Architecture and Functionality

The proposed automatic video surveillance system for elderly protection via falls detection and prevention; namely*FallPrevent*, employs typical off-the-shelf IP network cameras and *Android OS* smart phones. We developed an *Android OS* application, namely

CameraWatcher that is installed on the smart phones held by the caregivers for providing true around the clock surveillance so experimented residents can be checked on in their rooms at anytime with the Android smart phone mobile device. A WiFi LAN wirelessly connects the wireless cameras and caregivers smart mobile phones to a server sits in the IT support room. Connectivity via WiFi LAN enables obtaining the best visual profile the network camera can give, which is (30 fps) and a camera response time of a few hundred milliseconds [9]. Figure 1 depicts the architecture components of the proposed *FallPrevent* system showing interconnectivity among different system components.

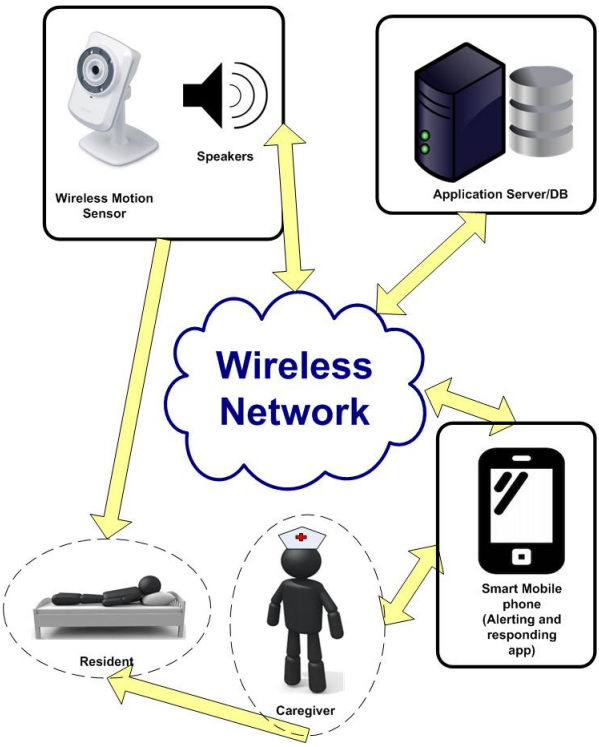

Fig. 1. FallPrevent: System Architecture

The proposed elderly falls prevention system is composed of three phases, as shown in Figure 2. The phases are *Monitoring*, *Movement Detection and Alarming*, *Alarm Confirmation and Fall Prevention*.

During *Monitoring* phase, after installing the network wireless motion sensing units (cameras), above the beds in residents' rooms, vision sensors within those cameras started obtaining motion detection information about the person on the bed. A visual sensor (camera) installed above the bed monitors any movements by the person on the bed in a non-restrictive manner.

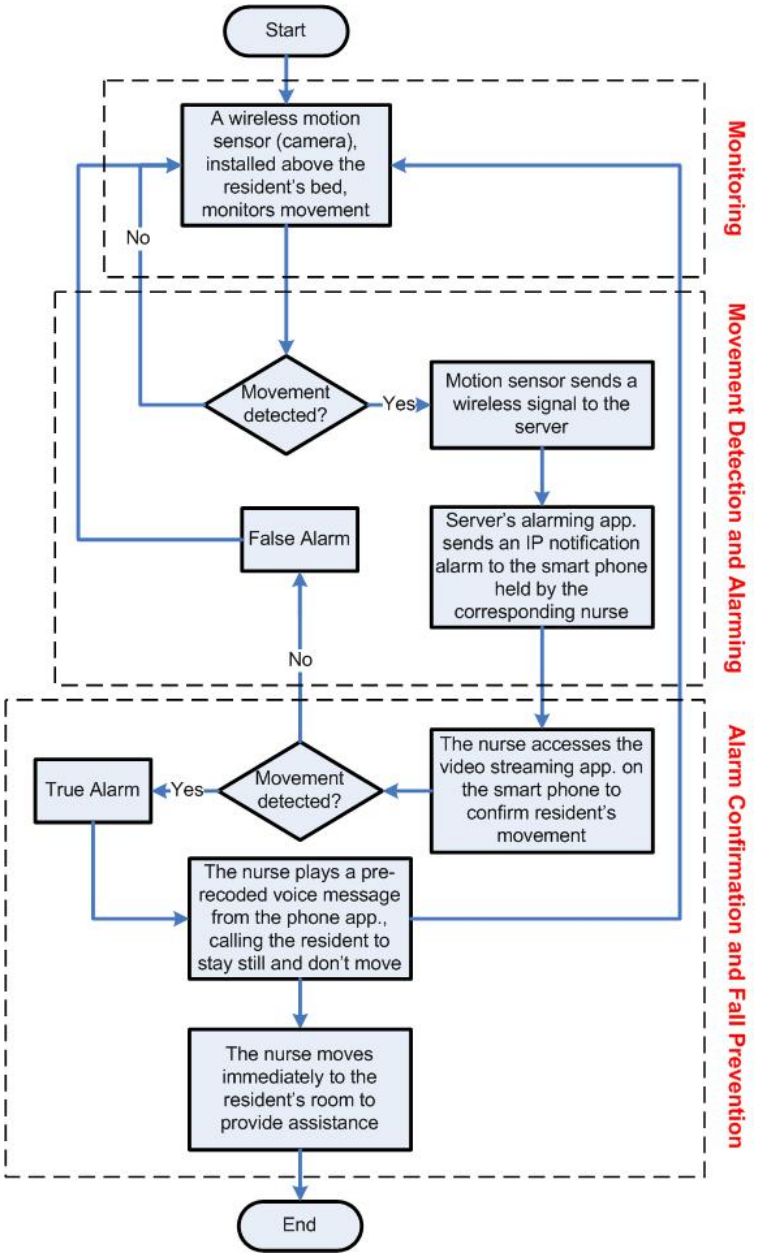

Fig. 2. FallPrevent: System Phases

For *Movement Detection and Alarming phase*, if a fall was suspected (a movement was detected), an automatic IP notification alarm would be sent to the mobile phone of the corresponding caregiver for that room with information including the date, time, Room number, and patient ID or name.

Concerning *Alarm Confirmation and Fall Prevention phase*, on receiving a notification alarm, for avoiding false alarms, the corresponding caregiver accesses the live video streaming option in the smart phone application to confirm resident's movement. For each resident, a voice message has been previously recorded by one of his/her family members in order to be triggered remotely by the caregiver, calling the resident to stay still and don't move, till having assistance.

So, on confirming resident movement (true alarm), the caregiver selects an option in the smart phone application remotely triggering the recoded voice message till reaching the resident's room and providing immediate assistance. Otherwise, the caregiver just cancels the alarm (false alarm) and considers that the resident was not intending to move away from the bed as he/she went back to the still status.

3.2 Experimental Population and Data Protection Application

The targeted population is the elderly residents of the Edmonton ChinaTown Care Center [10] during the first six months of the year 2013 (January to June 2013). A *benchmark dataset* was constructed by focusing on a specific sample of the whole population represented by the elderly residents of 8 rooms existed in the second and third floors (4 rooms at each floor). To protect the privacy of individuals, we excluded and removed all personally identifying information, including the person's name, Social Security Number (SSN), medicare number, and birth date. Data records about monitored residents in the *benchmark dataset* are consisted of [Room_No., Resident_ID, Age, Gender, Medical history, Falls history]. Medical history field contains health-related data about the resident such as being with diabetes, hypertension, heart disease, asthma, cancers, arthritis, visual impairment, mobility disorders, etc. Also, data about medications for each resident is saved in his/her record. Falls history field contains recordings about (number of falls/day, cause, injury type [arm/leg/back], etc.).

Additionally, for protecting residents' privacy, an approval has been obtained, from each one of the elderly residents in the 8 tested rooms. That approval notifies the resident (or his/her family) that a network camera will be deployed in his/her room just above the resident's bed (for experimental reasons) to monitor and detect any movement by the elderly resident at that room and send notification alarm for the corresponding caregiver's mobile phone if any movement detected. The movement sensor embedded into the cameras installed at each one of the tested 8 rooms is pre-programmed to automatically turn on and operate daily (from 7:00PM till 8:00AM) the next day, the case that satisfies privacy protection rule of "only information needed for the specific purpose(s) should be recorded". According to the CEO of the care facility, during the duration (from 7:00PM till 8:00AM), caregivers experience the highest ratio of elderly residents movement tendency and falling accordingly.

Moreover, the *benchmark dataset* contains detailed data records about the history of falling within 6 months officially retrieved from the care center documented records. The *FallPrevent dataset* will be constructed by saving details about alarm events

triggered due to resident's movement on a daily basis. Residents' movement and falls behavior records in the *FallPrevent dataset* will be used for comprehensive assessment for the proposed *FallPrevent* system after operating for 6 months or more.

Hence, it can be concluded that the design of the proposed elderly falls prevention system takes into consideration the healthcare data protection guidelines previously stated in section 2. That is, the participating residents know who the data controller is, why the information is being processed, what the information will be used for, manual records have been legally obtained from the care center employees legally authorized to supply it, the collected data has been processed legally and free of discrimination, no personal data has been collected, collected data will not be used for any other unrelated purpose, and finally only the data needed and previously stated has been recorded and no irrelevant data has been collected as it might be useful in the future.

4 Conclusion and Future Work

Elderly people in long-term care facilities or generally aging persons with cognitive impairment are at high risk of falling and more specialized technology solutions must be developed specifically for these populations. Gathering and sharing data and information between hospitals, healthcare facilities, physicians, caregivers, and other professionals improves the healthcare services. Nevertheless, it cannot be forgotten that privacy and data protection are fundamental rights of the patients.

A number of future directions are currently considered for developing the elderly protection fall prevention system proposed in this article. The suggested developments have to strongly consider the fundamental rights of the patients for privacy and data protection as well. One main challenge for future developments of the proposed elderly fall prevention system is via enabling RFID based tracking for caregivers with considering their status (busy/idle). That is, to incorporate an additional RFID based localization and tracking module with the proposed system. That approach will enable the system to assign and alarm the idle caregiver whose location is the closest to the room of the resident in risk, without assigning certain caregiver to specific room(s).

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