An Approach for Improving the Older People's Perception of Video-Based Applications in AAL Systems – Initial Study

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Abstract. It is an indisputable fact that the inclusion of video surveillance tools in the Active and Assistive Living (AAL) system contributes to a significant increase in reliability, especially in the detection of critical life-threatening conditions. Therefore, the efforts of researchers are focused on the development and implementation of innovative technological solutions and algorithms for image processing, which allow to overcome a number of privacy issues. Despite these efforts, the widespread use of video-based applications in AAL systems is still limited due to the older people's fears of being watched.

This study presents a new approach, consisting in the change of the synergy between the two main elements of AAL systems - the person in need of care and the video-based technological solution that detects/confirms the need for help. The essence of this approach is to provide a choice to the assisted person to activate/deactivate the video surveillance system depending on the personal assessment of his/her condition. This does not exclude the possibility that in the absence of a deactivation command, in a certain period after the announcement of the forthcoming activation, video monitoring to be turned on autonomously.

Initial studies were conducted with five people (75-84 years old) residents of an elderly hostel. When only accelerometer sensors were used to detect falls, the number of false alarms was quite high. After installing video cameras in the rooms of three of the participants, the number of confirmed alarms based on video analysis decreased to almost zero. For one of these three people, who had several incidents of falling out of bed in the previous period, 3 falls were registered with a camera in 24 days and were alerted on time.

Keywords: AAL, assistance of elderly, fall detection, perception of video monitoring.

1 Introduction

Over the last two decades, the interest of researchers and businesses has focused on the development of a variety of assistive devices and systems, and technologies for smart homes that will allow people to live independently until old age. The three generations of technology designed for supporting the independent living of adults are described in [1]. Specific features of the first generation include wearable devices for responding to an emergency situation that requires the user to initiate an alarm. Typically, the adult presses the button or pendant to raise the alarm in the event of an emergency, such as fall. The obvious benefits relate to the security and safety of the older people which reduce the stress levels for them and their relatives and caregivers. However, a specific weakness of this technology is demonstrated when the user has not capacity either physically or mentally to trigger the alarm or not wearing the device. A typical scenario is night going to the bathroom/toilet where the risk of falling is significant and in this high-risk situation the alarm will not be activated because the older person is not wearing the device. The second generation of AAL technologies overcomes some of the limitations of the first generation, by means of utilization of different sensors in order to detect potential emergency situations and call for assistance without relying to the older adult to trigger the alarm. Despite the obvious potential benefits, some users find these technologies intrusive and annoying, especially in the case of false alarms. The third generation of AAL technologies includes the integration of wearable devices and environmental sensors in the everyday environment not only for monitoring and assistance, but also for prevention. These systems integrate intelligent computer systems and assistive devices into everyday context, trying to be unobtrusive and easier to accept for older people.

A systematic literature review on AAL technologies, products and services regarding the interaction with users and involvement of end-users in the processes of development and evaluation of AAL is presented in [2]. The presented results show the need to improve the integration and interoperability of existing technologies and to promote user-oriented (user-centric) developments with a strong involvement of end-users in terms of usability and accessibility.

A systematic analysis of end-users' expectations from the services in an AAL system for older people monitoring and preventing dangerous situations, thus helping their independent living, is described in [3]. The study examines the usefulness and accessibility of specific services provided that could support independent living and improve the quality of life of older people in four identified categories, which include monitoring of physiological data, daily activities, environmental data and social interaction, in order to indicate a clear level of priority in each category of services from the point of view of end-users. Among the examined 45 parameters, events and situations considered as important to be detected and/or monitored, the highest priority levels were given to detection of fall and fear of falling in person activities monitoring, and monitoring of physiological parameters as heart rate, body temperature, blood glucose levels, blood oxygen levels and vital signs at night. Fear of falling is a major health problem among the elderly, present in older people who have fallen, but also in older people who have never had a fall [4].

Despite the high appreciation of the usefulness of these technologies and services, the older people have some concerns [3]. On the one hand, there are the concerns about privacy and intrusion into their personal space, especially with continuous video surveillance. On the other hand, the use of many different devices and technologies creates a feeling of insecurity in the end-users that they are unfamiliar and not be able to manage with them, and in the same time a fear of not being controlled by these devices. The older people have a feeling of losing control on these situations. In addition, they have concerns about possible additional costs they had to pay. In fact, keeping the costs of the devices and services low is a key requirement for older adults. The only way to make the monitoring devices and systems acceptable for the older people is to maintain reasonable compromise between usefulness and privacy and security issues, thus improving their perception.

In an extensive literature study on fall detection systems in old age [5], it is generally agreed that the use of different sensors that complement each other in different situations provides a more robust approach to falling detection. Thus high accuracy will be achieved while minimizing false alarms. For detection of falls as wearable devices the most popular and used are accelerometers, while for visual detection the Kinect (RGB-D depth cameras) and web cameras are most popular. The low-resolution IR thermal array sensors are a good choice to be used in the areas like dressing rooms, bathrooms and toilets.

Extensive literature studies have recently been published in the framework of COST Action CA19121 on audio and video-based solutions in AAL [6] and related ethical, social and privacy issues [7]. Despite the different application scenarios and diverse goals, the general requirements in the design of AAL solutions are to provide support in everyday life in an unobtrusive, convenient and user-acceptable way.

Trying to propose a solution for real life situations overcoming the above mention concerns of older people we employ a user-centered approach where the assisted person is a final element in the decision-making system for control and activating video surveillance.

In Section 2 the devices used and the algorithm for processing the data from the accelerometer to detect a fall are described. The proposed approach to improving the perception of the elderly by changing the role of the assisted person from a passive object of observation to an active subject controlling the video surveillance process and the initial results of our study are presented in Section 3. Section 4 continues with a discussion of how this approach can be further developed in specific scenarios. Finally, conclusions are drawn and future work is outlined.

2 Method and Devices for Falls Detection

To test the reliability and assess the personal perception of video-based fall detection solutions, two test systems were developed. In the first one, the detection is performed by analyzing the signals from a 3D accelerometer. In the second, images from a video camera are captured and processed. According to the plan of experimental studies, the results of two scenarios for tracking and detecting falls were considered.

Scenario 1: The assisted person wears the accelerometer sensor continuously and upon detection of a potential fall, the camera is activated, confirming or rejecting the occurrence of such an event.

Scenario 2: The video camera is permanently active (or turns on at regular intervals) and the obtained frames are analyzed to detect potential falls.

A system configuration based on a 3D accelerometer built into a wristwatch was used. The smartwatch EZ *eZ430-Chronos* (Texas Instruments) was chosen because of the built-in accelerometer, the availability of a wireless interface for data transmission and especially because of the inclusion an USB emulator that connects the watch to a PC for real-time in-system programming and debugging (fig. 1).

Fig. 1. Smartwatch EZ *eZ430-Chronos* with accessories for programming and debugging.

The data from the three axes of the accelerometer transmitted via the wireless interface to a laptop were processed in MATLAB with a fall detection algorithm including the following consecutive steps (fig. 2):

- Summing of the discretes on the three axes;
- Calculation of the first derivative of the summed signals to express rapid changes in acceleration;
- Raising to second power of the first derivative to express high-amplitude components;
- Application of threshold criteria to identify a sharp changes in the acceleration corresponding to potential fall.

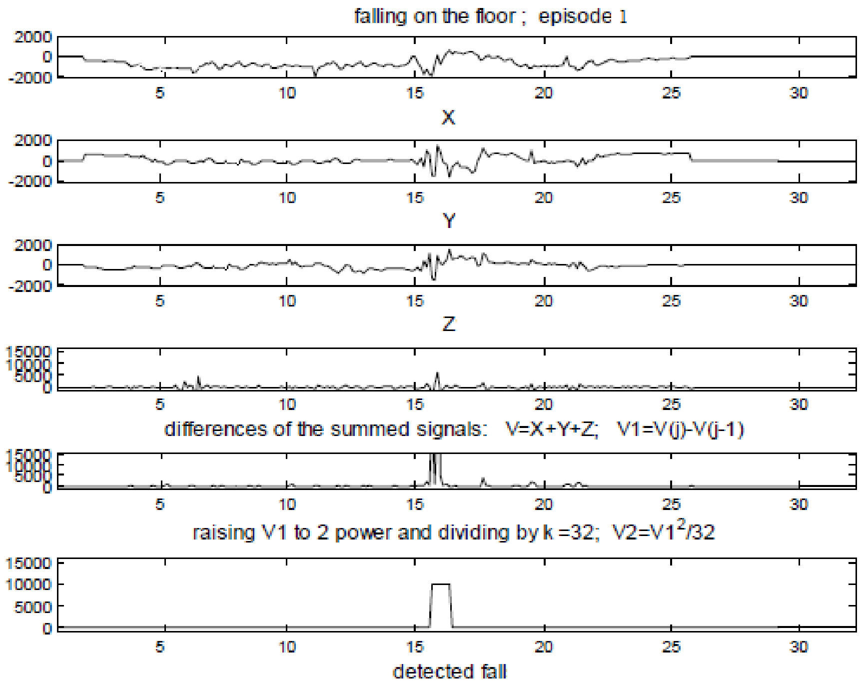

Fig. 2. Visualization of consecutive steps in the fall detection algorithm with an example of correct detection of a fall on the floor.

With the developed system we had conducted preliminary laboratory tests with volunteers [8], both to assess the reliability of detecting falls and the ability to distinguish falls from daily/night activities such as: free movement indoors; movements during sleep, reading, watching TV, cooking. The obtained results had demonstrated a high degree of reliability and specificity.

An 1.0 Mega pixel IP camera HS-691B-M186I H.264 was chosen for the video monitoring. The camera is equipped with 9 Φ5 LED lights (IR distance: 10m), for night-vision and a number of wired and wireless interfaces that allow connection to network architectures. In our configuration the images were transmitted wirelessly and processed by the same laptop to which the smartwatch with the accelerometer was also connected.

3 Results

A series of tests were conducted with residents at hostel for adult to assess the reliability and personal perception of the solutions developed to detect falls. The tests complied with all rules for such non-medical study, including: detailed preliminary information and instructions to the participants; written consent for participation; supervision and permanent control by the management and staff of the institution.

Five people (75-84 years old) were involved in the studies. In accordance with Scenario1, they were given smartwatches and after a comprehensive explanation and consent on their part, an initial stage for collecting data from the accelerometer sensors was started. The recapitulation after seven days showed a large number of false detected falls. Some of these false events were due to the removal of the smartwatch, but there were also trivial ones, such as: hands shaking after washing, movements to repel insects, use of saltern, etc. Similar results were expected and they confirmed the difference between controlled laboratory tests and in-situ application. To a large extent, these problems can be overcome by including additional sensors located at different points on the body, but this would cause a significant discomfort and would not be acceptable by the participants. To overcome these problems we intended to implement video cameras and verify the events detected by the accelerometers. Despite all detailed and comprehensive explanations about processes of images capturing, processing and storage, data encryption, authorized access, etc., the installation of cameras in the rooms of the participants was perceived completely negative. These terms and their meanings were completely incomprehensible and unacceptable from the elderly.

The situation took a serious positive turn when the approach for video monitoring was changed. In case when potentially life-threatening condition (fall) is detected by accelerometer, the system announces, by audio or light timer during the night, that the video camera will be activated after 30 seconds (this interval is adjustable). If the assisted person is in good condition, not requiring video monitoring, he/she can cancel the camera activation in the specified period, otherwise the camera turns on. Three of adults agreed to install cameras in their rooms, having opportunity to control them remotely. In this way the highest priority in the decision-making process for activation/deactivation of the camera was given to the assisted people. One of these three people, with limited movement abilities, had several incidents of falling out of bed at night in a previous period. The staff had not helped him until the morning. When the cameras were turned on in half-hour image recording mode (Scenario 2), 3 falls were registered and alarmed within 24 days. One of the falls was detected by the accelerometer and confirmed by a camera. The other two are detected only by camera. This allowed for timely assistance on the 5-th and 17-th minutes after the events. In the other two people, the alarms were reduced to almost zero, due to a personal decision for cameras deactivation on the lack of reasons for video monitoring.

4 Discussion

A core element in the proposed approach is the change in the synergy between the two main elements of AAL systems – the person in need of help and the technological solution detecting and confirming the need of help. This decision was in result of the hypothesis that if the assisted person was given the opportunity to make the final decision on turning the video cameras on or off, this would lead to easier perception of video surveillance. Three of the participants in this initial study agreed to install cameras in their rooms. The results of a one-month follow-up to detect falls and potentially life-threatening conditions confirmed the undeniable advantage of combining a traditionally used method such as accelerometry with video monitoring. The number of falsely detected events was reduced approximately to zero. During the test period there were three incidents (falls), which were correctly detected and alerted, so that timely assistance was provided to the person who fell into a helpless state.

Personally controlled video monitoring can be introduced for frailty people and people with cardiovascular diseases prone to heart attack, stroke, unstable blood pressure and other potentially life-threatening conditions.

The planned future research is aimed at expanding the possibilities for interactive communication between the assistive system and the assisted person. The inclusion of an audio communication system would allow remote control of cameras by voice commands, as well as automatic recognition of characteristic sounds (moaning, groaning, shouting for help) in cases of potentially life-threatening conditions confirmed by video monitoring. Video surveillance can be combined with other existing solutions for fall detection, such as smart floor coverings, audio systems with multiple microphones, infrared motion sensors.

5 Conclusion

The integration of video cameras is undoubtedly a major factor in increasing the reliability, especially in the recognition of life-threatening conditions by AAL systems. A significant part of the efforts of researchers and engineers are aimed at overcoming the main problem of video-based systems - the privacy. Despite the latest technological solutions, protocols and algorithms for transfer, image processing, standards for storage and access to personal data, potential users remain highly suspicious and almost always refuse video monitoring as an opportunity to receive an adequate care on-time. To overcome these obstacles, future technological implementations should provide an opportunity for easy personal control of the video monitoring process by users when they are able to do so. When users are unable to control the process, video-based systems must be automatically activated to explicitly confirm or denied a potential critical situation.

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