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A solution to detect and prevent the falls of geriatric patients

Abstract. *Advanced technologies are effectively used in healthcare applications. One of areas is support of taking care of older adults, which is a growing problem in contemporary societies. The research results in designing new systems and solutions, dedicated to solve particular problems or to cover the caretaking problem in general. Among such systems and solutions, the special ones are systems designed to help to solve the fall detection problem. In this paper, the review of such solutions is presented, advantages and disadvantages are discussed. The novel conception of such system is presented and discussed and conclusion is drawn.*

Streszczenie. *Ochrona zdrowia coraz efektywniej wykorzystuje rozwiązania, oparte na nowoczesnych technologiach. Jednym z obszarów ich stosowania są systemy wspierania opieki nad osobami starszymi, które to zagadnienie stanowi narastający problem współczesnych społeczeństw. Wyniki badań pozwalają na projektowanie różnorodnych systemów i urządzeń, zarówno przeznaczonych do rozwiązywania określonego problemu opieki, jak też wspierających cały proces. Pośród nich szczególną klasę stanowią rozwiązania przeznaczone do wspomagania nadzorowania możliwości wystąpienia upadku. W niniejszym artykule zaprezentowano przegląd istniejących rozwiązań w tej klasie i omówiono ich charakterystykę. Przedstawiono także nowatorską koncepcję systemu tej klasy. (**System wspomagania detekcji i zapobiegania upadków dla pacjentów geriatrycznych**).*

Keywords: fall detection, fall prevention, geriatric problems, technology support in healthcare.
Słowa kluczowe: detekcja upadków, prewencja upadków, problemy geriatryczne, rozwiązania technologiczne w ochronie zdrowia.

Introduction

As the societies are aging worldwide, the need of care increase rapidly. According to European Commission Statistics [6], over two past decades the share of citizens over 65 increased by 3.6 percent. By 2060 the European population of older adults over 65 is evaluated to be halved in 65-79 age group and to increase by two and a half times for over 80 age group. Therefore the number of people exposed to fall problems is expected to significantly increase.

Along with development of awareness of the problem, there are proposed means to reduce the fall risks and consequences. Exposure to risk of a fall is itself a significant factor of decreasing the living quality. This is an important issue, especially in group of older adults, for whose the fall consequences can be far more serious when compared to young ones [1, 3, 4].

Advancement in development of microelectronics and microinformatics affects many aspects of life. One of more important areas of implementing microdevices and systems are healthcare applications. Such systems are applied in various measurement devices, diagnostic support, control and monitoring etc.

As the contemporary technology offers efficient, powerful and energy-saving devices, the areas of applying and capabilities offered still grow. In the group of people that require more than regular care, the significant class are people under exposure to the fall situation. Those can be ones suffering from certain diseases in various ages and older adults naturally exposed to risk of fall due to reduced physical capabilities.

The IT technology can be used to construct devices and systems designed to support life activities of people exposed to the risk of fall. It is known that individuals living with the fear of falling suffers from degradation of life quality and physical discomfort. Use of some system or device that can alarm or warn third party (family, caretakers, etc.) of the fall incident can increase the comfort of living for those people. In addition, such a solution helps to reduce the fall consequences, by helping to get the help early.

Detection of falls – a review of solutions

There are used many technology solutions to support fall detection [5]. Wearable alarms typically consist of a wireless transmitter and alarm button. Faller (older adult) can manually use such a device and call help after a fall incident, if necessary. The example is Philips Lifeline Medical Alert System. It can help older people to call proper help in a fall situation at the push of a button [7]. There are also automatic fall detectors that do not require human intervention, such as Tunstall Fall Detector [8].

Another solution to detect the fall incident is a video monitoring system. These systems use some image-processing algorithms and are capable to detect a fall event (SIMBAD [9]).

Finally, there exist passive alarms that use floor vibration detectors [10, 11]. Fall detectors do not prevent a fall but send some information (alert) to other person (caregiver).

Although these solutions does not prevent fall events, they are very important in helping to overcome a fear of falling, which significantly improves quality of life.

Falls prevention – a review of solutions

Researchers from UK [12] presented usability of website that provides older adults with advice to help motivate them to under-take physical activities that prevent falls. The aim was to investigate opinion of older people and caregivers in the field of usability and acceptability of website for preventing falls (balance training). Usability was investigated, because website must be easy to use and friendly for older adults. Authors summarized that most of participants believe that websites "was generally well received among older people" suggesting that online tailored advice could be a promising new avenue in motivating older people to undertake strength and balance training.

Another issue is education in the matter of safe dealing with the fall incident. Medical professionals and therapists can teach older adults how to safely get up from a fall. Elderly patients' caregivers can get information from special Web sites (e.g. LearnNOTtofall [13], Falls Prevention Network [16], Fall Prevention Center of Excellence [17], British Columbia University [18] or form online community of healthcare professionals dedicated to falls prevention (e.g. Prevention of Falls Network Earth [14], IStop-Falls [15] There are many projects on fall prevention (other that those listed in [14, 15] using ICT technology – for example: Fall Detector for the Elder (FATE); A wearable miniaturized fall detection system for the elderly (FallWatch) or Automatic monitoring of Activities of Daily Living using Contactless Sensors (AMACS).

System conception

The idea of the system structure is presented in fig. 1. There are three elements: personal sensor device, PC station and guard station.

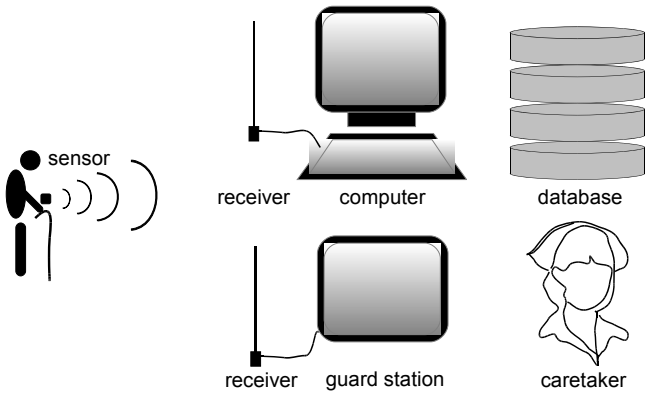

Fig.1. Conception of Fall Detection System

Logic structure of proposed system and data interchange scheme are presented in fig. 2.

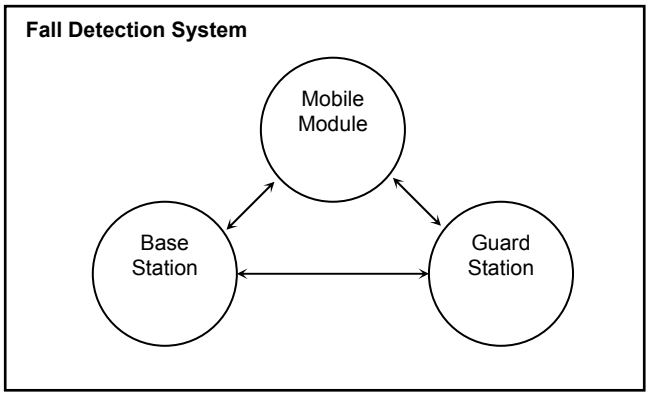

Fig.2. Structure of Fall Detection System

System comprises three elements: (1) Mobile Module, with microcontroller, appropriate sensors, real-time clock as a time reference, warning/signalling module and radio-communication module; (2) Base Station as the main processing unit, which controls the system and performs data processing; (3) Guard Station for signalisation (for a care-taking person).

The system is designed to interchange necessary information between all elements.

Detailed structure of system elements is presented in fig. 3.

The personal detector comprises three accelerometric sensors (for X, Y and Z axes), a low-power high-performance microcontroller and radio link.

Detector operates in two modes: learning mode and regular operation. In the learning mode the device performs measurements and transmits the data continuously to the PC station. The PC system acquires information concerning typical dynamics of body movements of the person in concern and creates a map of non-alarming movement vectors values.

The learning process can be performed again when needed, e.g. when physical characteristic of body movement will change for any reason.

Once the data are stored, the movement vectors data are programmed into the personal detector, which switches to regular operation mode.

In this mode the device is analyzing in real-time the accelerometric data in three axes and calculates the patient's body movement vectors. To minimize the energy consumption, the device is equipped with energy-saving sleep functionality, activated when there is no acceleration observed for the predetermined time. When the measurements indicate that a potentially hazardous situation occurred, e.g. a possible fall incident took place, the device is signalling the situation to the guard station, where the further action is taken. The actions can be: sounding the alarm, sending notification via GSM etc.

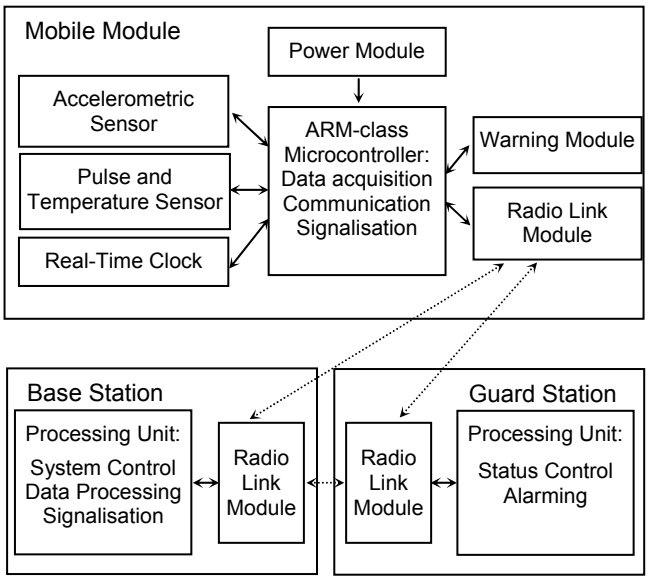

Fig.3. Structure of Fall Detection System Modules

System operation

The personal detector comprises a number of elements: intelligent power control module, 3D accelerometric sensor, real-time clock, main processing unit, radio link module and optional pulse sensor and signalling module. The power control module is responsible for minimizing the energy consumption, as the device is battery-operated. When the microcontroller indicates the need of switching to the sleep mode, the module reduces the power and when the watchdog circuit detects that there is a need of waking up the system, the full power is restored.

Accelerometers provide information about body movements, measured in three dimensions. Optionally, the system can be equipped with pulse sensor. Real-time clock provides precise time reference, a warning/signalling module can produce alarming sounds in particular situations, and radio-link module is responsible for bi-directional, safe and reliable data transmission.

Data analysis

Use of the system will allow to collect the body movement dynamics data, and to monitor the movement trajectory in different situations, in particular in those related to unintended body position changes and falls. Data analysis and comparison with predefined patterns will allow to detect the fall incident and inform caretakers. In addition, it will allow to deduce the possible fall cause and presumed consequences.

To process the data efficiently, the system operation is divided in two phases. In the learning phase the personal

unit only transmits information measured by accelerometers, and the data processing is performed by PC software. The learning phase should take at least few days, to measure individual movement parameters of a patient, and it should not cover the fall situation.

Collecting the data allows to create a movement vectors map, that defines the limits of particular movement parameters. Such a map after completing the learning stage must be transmitted to the personal unit and the unit will switch to regular operation phase. In that mode the device is analyzing the measured movement parameters and performs control of the calculated values with those defined in the map. Exceeding the values is interpreted as detection of fall situation.

Conclusion

Advanced technology is widely used in healthcare applications. The area of research on older people falls detection and prevention is subject to numerous projects. Proposed solutions vary from simple information systems (supplying specific information in tailored way), professionals-based information centres and web-sites, dedicated personal devices and various surveillance systems to integrated care solutions. Systems discussed in this paper are designed to cover certain class of problems. In this paper there is proposed a system for early detection of a fall events, with capability of analysis of body movement vectors and patterns, which can be used to determine a map of safe ranges of parameters and to detect potentially dangerous situations. As the system is designed to monitor an individual, the data analysed in long term can provide information on the physical condition changes, which can be useful in diagnostics.

Among other features, the system presented has advantage of mobility (both personal unit and guard station) and therefore it can be used in far more situations than those using dedicated building installations, video surveillance or floor vibration detectors.

The mobility of the system is very important feature. It is observed that people exposed to risk of fall tend to reduce their physical activities because of increased fear of falling. This leads to degradation of physical efficiency, which again increases both risk of fall and the fall consequences. To cut this vicious circle it is very important to encourage such people to be physically active.

As the system presented significantly helps to improve safety regardless of location, it can improve considerably the quality of life for this group, especially in case of older adults.

Further research will be aimed to define the signal parameters that can be used to detect pre-fall situations and to allow to issue a fall warning.

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