ELDER CARE SYSTEM USING IOT AND MACHINE LEARNING

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ABSTRACT

Falls among elderly can pose serious consequences such as injury or even fatal ones. Therefore, it is essential that fall are detected early and a way to that is by using IoT platform. The authors have been developing a wearable device for elderly monitoring system utilizing accelerometer. The data from accelerometer is connected to an Internet-of-Things (IoT) platform called ThingSpeakTM. Based on IoT platform, elderly patients can be remotely monitored as long as the care providers have good internet access. The paper presents the experimental results of determining the sensitivity and specificity of the accelerometer used in the proposed system. This is the first step for developing an accurate data acquisition for monitoring purposes. Based on the experimental results, the average percentage for sensitivity obtained for this device is 73.3%, while the average for specificity obtained is 89.3%. Both sensitivity and specificity tests shows promising results which indicates that the device only has a fail rate of 26.7% and error rate of 10.7%.

INTRODUCTION

It may seem that for elders to stay at home is the safest possible place for them to avoid health hazards. But one of the few problems faced by elderly people is the tendency for them to trip or fall down even when they are at home. Falls are a serious problem faced by the elderly; it contributes to disability for elderly people. A fall is an event which results in a person coming to rest inadvertently on the ground or other lower level, not as a consequence of the following: sustaining a violent blow, loss of consciousness, sudden onset of paralysis, or an epileptic seizureAs we age, it brings about a number of physiological changes, not only does it affects our physical appearance but it also causes some health deterioration. The older we are the more frail our body becomes. This causes the body to experience health disorders such as eye sight problems, hearing problems, body joint problems, memory losses and so on . There is no avoiding the grace of aging. We

can only help those affected by relieving their symptoms and prevent further deterioration of the present conditions. Perhaps the best step is to constantly monitor their health status and take immediate action if a serious condition catches our attention. This is the key idea of this project which is to monitor the health condition of the elderly through the advancement of Internet-of-Things (IoT) application. Therefore, with the advancement of technology, a fall detection system can promote home-based rehabilitation, reduce costs for traveling to healthcare providers and definitely can provide early interventions and treatments that can save lives. In general, development of elderly monitoring systems related to fall detection can be divided into two automated surveillance system and wearable devices. In an automated surveillance system, the monitoring of elderly involves the implementation of various sensors within the environment where the subject is located. These sensors provide information such as audio, video and even pressure that can be transmitted wirelessly to a healthcare provider located in a remote location . On the other hand, wearable devices provide a cost effective solutions. Wearables technology consists of many nodes all equipped with sensors, networks and power supplies, where nodes within the same area can communicate with each other . They can be effectively used to monitor and track the conditions of patients in both developed cities and inaccessible rural areas using an intranet network or internet and thereby greatly reducing the workload of healthcare providers, minimize medical errors, and increase the efficiency of working hospital staff, and in the long run reduce the healthcare cost and also improve patient comfort. The authors have been developing a wearable device for elderly monitoring system utilizing accelerometer. The data from accelerometer is connected to an Internet-ofThings (IoT) platform called ThingSpeakTM , where users can collect and store data from various sensors in the cloud for developing IoT application. This paper presents the hardware design of the proposed device. Furthermore, preliminary results of determining the sensitivity and specificity of the accelerometer used in the proposed system are described. This is the first step for developing an accurate data acquisition for monitoring purposes. Sensitivity and specificity tests are done to determine the sensitivity of the accelerometer for various types of falls, to verify overall specificity of the sensor in

which it is able to differentiate a fall and a daily life activity (ADL).

EXISTING SYSTEM

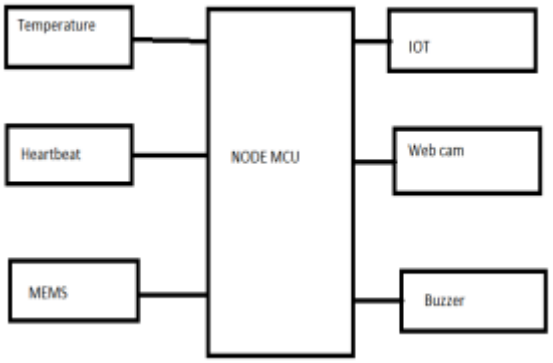
These devices can include smartwatches or health monitoring wearables that track vital signs such as heart rate, blood pressure, and sleep patterns. IoT sensors placed in the living space can detect falls and send alerts in case of emergencies. Placed in different areas of the home, these sensors can monitor the movement of the elderly person and identify any unusual patterns. IoT-enabled medication dispensers can provide reminders and dispense medications at scheduled times. These include sensors on doors, windows, and appliances to monitor daily activities. A robust and secure internet connection is essential for real-time data transmission between IoT devices and the central monitoring system. Data generated by IoT devices can be stored and processed in the cloud, allowing for easy access, analysis, and sharing of information. Utilize a platform for processing the vast amounts of data generated by the IoT devices. Analytics Toolsuch as identifying health trends or anomalies in daily routines. A user-friendly mobile application for caregivers and family members to monitor the elderly person's health and activities remotely. A web-based dashboard for healthcare professionals to analyze historical data and make informed decisions.Instant notifications sent to caregivers or emergency services in case of falls, abnormal health readings, or other emergencies. Allow users to customize the types of alerts they receive based on individual preferences and health conditions. Electronic Health Records (EHR) Integration: Connect the system with existing healthcare databases to provide a comprehensive view of the elderly person's health history. Integrate with healthcare systems through APIs for seamless information exchange. Implement robust encryption protocols to secure the transmission and storage of sensitive health data. Define access levels and permissions to ensure that only authorized individuals can access the monitoring system. Design the system architecture to easily accommodate the addition of new devices or sensors as needed. Ensure that the system can receive updates to fix bugs, improve security, and add new features. Provide training for caregivers and family members on how to use the monitoring system effectively. Establish a support system to address user queries and technical issues promptly. Ensure that the system adheres to

relevant data protection and privacy regulations, such as GDPR or HIPAA.

PROPOSED SYSTEM

Smartwatches or health bands equipped with sensors for monitoring vital signs such as heart rate, blood pressure, and activity levels. Fall detection sensors to identify sudden falls or accidents. Motion sensors to detect movement within the house. Door/window sensors to monitor access and exits. Temperature and humidity sensors for environmental monitoring. Acts as a central hub to collect data from various sensors. Ensures secure communication between devices and the central monitoring system. Storage and processing of collected data. Analytics for trend analysis and anomaly detection. Provides real-time updates and alerts to caregivers. Allows remote monitoring of elderly individuals' health and activities. Sends notifications to caregivers in case of emergencies or irregularities. Integrates with emergency services for quick response. Continuous tracking of vital signs to detect any abnormalities. Medication reminders and adherence tracking.Immediate notification to caregivers and emergency services in the event of a fall. Tracking daily activities to ensure routine and identify any deviations. Detection of extreme temperatures, ensuring a comfortable living environment. Monitoring air quality to detect potential health hazards. Geo-fencing to alert caregivers if the elderly person leaves a predefined area. Integration with emergency services for quick response in critical situations. Panic buttons for immediate assistance. Video calling and messaging features for direct communication with caregivers. Social integration to combat isolation and lone Trend analysis for long-term health assessment Generate reports for healthcare professionals. Timely detection of health issues and emergencies. Rapid response to falls or accidents. Personalized care plans based on real-time health data. Reduced caregiver stress with remote monitoring capabilities. Allows elderly individuals to maintain a level of independence while ensuring their safety. Caregivers have real-time insights into the well-being of their loved ones. Early detection of health issues for proactive intervention.

BLOCK DIAGRAM



LITERATURE SURVEY

Dionyssiotis, Y.: Analyzing the problem of falls among older people. Int. J. Gen. Med. 5, 805–813 (2012)

Falls and fall-related injuries of elderly individuals are an important health problem that threatens their lives. Particularly, regressions related to aging in postural control and challenging dual tasks cause falls. It has been reported that physical training and exercises related to balance are effective in reducing falls in elderly individuals. However, there are inherent difficulties for the elderly in making these exercises effective. Especially as the number of chronic diseases increases, this difficulty increases even more. For this reason, it is important to create alternative methods for performing exercises that increase balance in a more effective and safe environment. As one of these alternatives, hydrotherapy can play a fallpreventing role for elderly individuals with the properties of water that support the balance. With the reduction of the fear of falling in water, the motivation of elderly individuals to exercise may increase. They may also feel more confident when performing balance, motor, and cognitive tasks. With hydrotherapy; It is also possible to provide biomechanical and psychological well-being by making use of the buoyancy, resistance and temperature properties of water. Hydrotherapy and balance training protocols tailored to the individual needs of the elderly population are seen as an effective approach in preventing falls.The rapid increase in the elderly population all over the world and in our country has made it important to plan and implement health measures related to the elderly population . It is expected that the world's elderly population will cover approximately 17% of the total population by 2050 . In our country, according to the data of TUIK for 2021, the elderly population exceeded 8 million and reached 9.7% of the total population. It is estimated that this increase will increase to 11.0% in 2025 and to 16.3% in 2040, increasing in our country as well as in the rest of the world . Aging; it is a period in which changes that continue from birth to death are experienced . It refers to a physical, psychological and social

multidimensional process that includes changes in physical shape and physiological function of tissues and organs, changes in perception, learning, problem solving, personality traits, as well as changes in function and behavior in social life . Biological changes seen with aging increase the susceptibility to fall directly or with different factors . The inclusion of changes in cognitive and sensory areas that cause balance disorders in the natural aging process causes relapses (7). In addition, the probability of recurrent falls doubles after the first fall, which would qualify such an elderly individual as a high-risk patient (8). It is known that falls occur due to many factors. Impairment of postural control is an important factor that can lead to falls and fall-related injuries. Postural control is the ability to maintain balance and spatial orientation in standing upright with the inhibition of gravitational forces. Postural control is necessary to maintain daily activities such as walking and balance (9). Finding effective ways to prevent falls in the elderly population can reduce disability from falls and fall-related injuries. It can also increase the life expectancy of these individuals.

Balamurugan, J., Ramathirtham, G.: Health problems of aged people. Int. J. Multidiscip. Res. Acad. 2(3), 1–12 (2012)

to increase with advancing age and very often the problems aggravatedue to neglect, poor economic status, social deprivation and inappropriate dietary intake. A high proportion of the total respondents stated that they were suffering from illness seriously. Lack ofmedical facilities in the village and poor economic conditions might be responsible for the lowhealth status of the villagers (Rao et al.,2003). This is corroborate by the finding of Singh (2005)in his study in rural Haryana. Hence, majority of landless rural aged were suffering from one orthe other health problems and physical disabilities.KetshukietuoDzuvichu (2005), in the paper “Health problems of aged among theAngaminagas” mentioned that health is not only a biological or medical concern but also a significant personal and social concern. In general with declining health, individuals can lose theirindependence, lose social roles, become isolated, experience economic hardship, be labeled orstigmatized, change their self perception and some of them may even be institutionalized. Achir(1998), in the paper “Strategies to formulate Family Support System and Community based services for

the care of the old" showed although, changes are good indicators of development, dilemma for support capacity of the family towards the elderly is inevitable. With many womenentering the work force, available support for the elderly has significantly reduced. As aconsequence, the International Year of the Family has appealed to the world to maintain,strengthen and protect the family to ensure continuity of its vital role in preserving dignity, statusand security of its ageing members. Pappathi et al. (2005) In the Paper "Psycho-socialcharacteristics and problems of Rural Aged" showed that the psycho-social perspectives and problems and strategies to welfare of the rural female aged found that a majority suffer from joint pain, blood pressure and chest pain. A few complaint of asthma, piles, lose of weight, diabetesand skin diseases. Only 30 per cent among the rural aged where in good health.Vasantha(1998), In the Paper "Nutrition and Health Problems" found that the rural agedsuffered from nutritional, psychological and other problems, when compare to urban aged. Theaged employed privately and those self employed had more of health problems then not gainfullyemployed person. In general, the male members were found to be literate, economicallyindependent and had less physiological and nutritional problem when compare to the female parts, when literacy level, income level and employment status improve, they seem tohave better health. Nair (1989), a study on"The Aged in Rural India: A study of the Socio-Economic and Health Profile", revealed that the incident and prevalence of chronic as well asnon-chronic disease are more in rural elderly that is 1) respiratory diseases, 2) loco-motorillnesses and 3) blood pressure. The majority of the aged comparatively longer among males

Katz, P., Aron, M., Alfalou, A.: A face-tracking system to detect falls in the elderly. SPIE Newsroom (2013)

Over the past few decades, interest in theories and algorithms for face recognition has been growing rapidly. Video surveillance, criminal identification, building access control, and unmanned and autonomous vehicles are just a few examples of concrete applications that are gaining attraction among industries. Various techniques are being developed including local, holistic, and hybrid approaches, which provide a face image description using only a few face image features or the whole facial features. The main contribution of this survey is to review some well-known

techniques for each approach and to give the taxonomy of their categories. In the paper, a detailed comparison between these techniques is exposed by listing the advantages and the disadvantages of their schemes in terms of robustness, accuracy, complexity, and discrimination. One interesting feature mentioned in the paper is about the database used for face recognition. An overview of the most commonly used databases, including those of supervised and unsupervised learning, is given. Numerical results of the most interesting techniques are given along with the context of experiments and challenges handled by these techniques. Finally, a solid discussion is given in the paper about future directions in terms of techniques to be used for face recognition.The objective of developing biometric applications, such as facial recognition, has recently become important in smart cities. In addition, many scientists and engineers around the world have focused on establishing increasingly robust and accurate algorithms and methods for these types of systems and their application in everyday life. All types of security systems must protect all personal data. The most commonly used type for recognition is the password. However, through the development of information technologies and security algorithms, many systems are beginning to use many biometric factors for recognition task [1,2,3,4]. These biometric factors make it possible to identify people's identity by their physiological or behavioral characteristics. They also provide several advantages, for example, the presence of a person in front of the sensor is sufficient, and there is no more need to remember several passwords or confidential codes anymore. In this context, many recognition systems based on different biometric factors such as iris, fingerprints [5], voice [6], and face have been deployed in recent years.

Systems that identify people based on their biological characteristics are very attractive because they are easy to use. The human face is composed of different structures and characteristics. For this reason, in recent years, it has become one of the most widely used biometric authentication systems, given its potential in many applications and fields (surveillance, home security, border control, and so on) [7,8,9]. Facial recognition system as an ID (identity) is already being offered to consumers outside of phones, including at airport check-ins, sports stadiums, and concerts. In addition, this system does not require the intervention of people to operate, which makes it possible to identify people

only from images obtained from the camera. In addition, many biometric systems that are developed using different types of search provide good identification accuracy. However, it would be interesting to develop new biometric systems for face recognition in order to reach real-time constraints.

Owing to the huge volume of data generated and rapid advancement in artificial intelligence techniques, traditional computing models have become inadequate to process data, especially for complex applications like those related to feature extraction. Graphics processing units (GPUs) [4], central processing unit (CPU) [3], and programmable gate arrays (FPGAs) [10] are required to efficiently perform complex computing tasks. GPUs have computing cores that are several orders of magnitude larger than traditional CPU and allow greater capacity to perform parallel computing. Unlike GPUs, the FPGAs have a flexible hardware configuration and offer better performance than GPUs in terms of energy efficiency. However, FPGAs present a major drawback related to the programming time, which is higher than that of CPU and GPU.

There are many computer vision approaches proposed to address face detection or recognition tasks with high robustness and discrimination, such as local, subspace, and hybrid approaches However, several issues still need to be addressed owing to various challenges, such as head orientation, lighting conditions, and facial expression. The most interesting techniques are developed to face all these challenges, and thus develop reliable face recognition systems. Nevertheless, they require high processing time, high memory consumption, and are relatively complex.

Rapid advances in technologies such as digital cameras, portable devices, and increased demand for security make the face recognition system one of the primary biometric technologies.

Jokanovic, B., Amin, M. G., Ahmad, F., Boashash, B.: Radar fall detection using principal component analysis. In: Proceedings of the SPIE Radar Sensor Technology XX, vol. 9829, p. 982919 (2016)

Falls are a major cause of fatal and nonfatal injuries in people aged 65 years and older. Radar has the potential to become one of the leading technologies for fall detection, thereby enabling the elderly to live independently .Existing techniques for fall detection using radar are based on manual feature extraction and require significant parameter tuning in order to provide

successful detections. In this paper, we employ principal component analysis for fall detection, wherein eigen images of observed motions are employed for classification. Using real data, we demonstrate that the PCA based technique provides performance improvement over the conventional feature extraction methodsn many countries, a rapid growth of the elderly population, aged 65 and over, is expected over the next 40years.1-3 This will lead to a greater burden not only on those of working age, but the overall economy as well,in supporting the aging population. As such, there is a increasing interest in assisted living technologies thatenable self-dependent living within homes for the elderly. Approximately 30% of people over the age of 65 falleach year, and for those over 75, the rates are even higher. Most seniors are unable to get up by themselves after a fall, and it was reported that, even without direct injures, half of those who experienced an extended period oflying on the floor (>1 hour) passed away within six months after the incident. Thus, prompt fall detection cansave lives, lead to timely interventions and most effective treatments, and reduce incurred medical expenses.Unlike camera based systems which have garnered considerable research interest in recent years, radar technology offers non-invasive monitoring capability regardless of lighting conditions and its use does not raise anyprivacy concerns.4A radar transmits an electromagnetic signals and records the backscatter from targets. Itestimates the velocity of a moving target by measuring the frequency shift of the wave scattered by the objectrelative to the transmitted signal which is known as the Doppler effect. Doppler measurements play a fundamental role for target detection, tracking, and classification in radar systems and find broad applications, rangingfrom defense and security to weather forecasting.5-7Radar can detect both biomechanical and biometric human signatures.8-11 The former correspond to thegross-motor motions of different body components, such as torso, arms and legs. The latter monitor heartbeat and respiration, which provide information about the health condition and enable detection of persons instationary activity modes, including standing, sitting, sleeping and laying down. As such, radar technology hasbeen successfully used for human motion classification in defense and security applications.8Recently, radar hasfound applications in health care industry.12 - 14For assisted living applications, most of

the proposed radar fall detectors are based on manual feature extraction which can be a tedious task involving tuning of parameters and thresholds. In this paper, we propose anapproach based on principal component analysis (PCA) which alleviates the burden on the human operator. Theproposed approach is similar to the one used for face recognition. We process spectrograms of human motionsas images and use them to perform eigen decomposition. The eigen images can be considered as features of human motions and employed in the classification process. The use of principal components for extracting featuresfrom micro-Doppler signatures has been successful in the radar community for defense related applications.

Abdullah, A., Ismael, A., Rashid, A., ElNour, A.A., Tarique, M.: Real time wireless health monitoring application using mobile devices. Int. J. Comput. Netw. Commun. (IJCNC) 7(3), 13–30 (2015)

In the last decade the healthcare monitoring systems have drawn considerable attentions of the researchers. The prime goal was to develop a reliable patient monitoring system so that the healthcare professionals can monitor their patients, who are either hospitalized or executing their normal daily life activities. In this work we present a mobile device based wireless healthcare monitoring system that can provide real time online information about physiological conditions of a patient. Our proposed system is designed to measure and monitor important physiological data of a patient in order to accurately describe the status of her/his health and fitness. In addition the proposed system is able to send alarming message about the patient's critical health data by text messages or by email reports. By using the information contained in the text or e-mail message the healthcare professional can provide necessary medical advising. The system mainly consists of sensors, the data acquisition unit, microcontroller (i.e., Arduino), and software (i.e., LabVIEW). The patient's temperature, heart beat rate, muscles, blood pressure, blood glucose level, and ECG data are monitored, displayed, and stored by our system. To ensure reliability and accuracy the proposed system has been field tested. The test results show that our system is able to measure the patient's physiological data with a very high accuracy.Health is one of the global challenges for humanity [1]. According to the constitutions of World Health Organization (WHO) the highest attainable standard of health is a

fundamental right for an individual [2]. Healthy individuals lead to secure their lifetime income and hence to increase in gross domestic product and in tax revenues. Healthy individuals also reduce pressure on the already overwhelmed hospitals, clinics, and medical professionals and reduce workload on the public safety networks, charities, and governmental (or non-governmental) organizations. To keep individuals healthy an effective and readily accessible modern healthcare system is a prerequisite. A modernized healthcare system should provide better healthcare services to people at any time and from anywhere in an economic and patient friendly manner. Currently, the healthcare system is undergoing a cultural shift from a traditional approach to a modernized patient centered approach. In the traditional approach the healthcare professionals play the major role. They need to visit the patients for necessary diagnosis and advising. There are two basic problems associated with this approach. Firstly, the healthcare professionals must be on site of the patient all the timeand secondly, the patient remains admitted in a hospital, wired to bedside biomedical instruments, for a period of time. In order to solve these two problems the patient oriented approach has been conceived. In this approach the patients are equipped with knowledge and information to play a more active role in disease diagnosis, and prevention. The key element of this second approach is a reliable and readily available patient monitoring system (PMS). The need for a real time recording and notification of vital signs of a patient is of prime importance for an effective PMS. By encapsulating the advantages of modern bioinstrumentation, computers, and telecommunication technologies a modern PMS should acquire, record, display, and transmit the physiological data from the patient body to a remote location at any time. For more efficient, timely, and emergency medical care the PMS must also be incorporated with an alarm system. In order to alert the patient as well as the health care service providers the PMS should not only monitor and analyze the critical patient's data but it should also send alarming messages in case the monitored data go outside their normal ranges. Hence, an active database system must be associated with the PMS. Most of the proposed PMSs are centralized in a sense that all patients' data are stored in a single server. By using necessary firmware and software the server can be connected to an open communication network via TCP/IP

protocol. Thus a patient can be monitored from a remote location. Existing and widespread mobile phone networks can assist in this regard. Recently, mobile networks are considered critical for solving future global health challenges [3]. With the global market penetration of the mobile phones the mobile healthcare system (i.e., mHealth) is a matured idea now. By using the mobile phone healthcare system can be made available for people, who are living in remote areas without much access to other types of communications. Even a simple mobile phone can become a powerful healthcare tool now. Text messages and phone calls can quickly deliver real-time and critical information of a patient to a remote location. Thus the patients, living in remote areas, can reduce unnecessary back-and-forth travel to the far located healthcare centers. However, mobile devices have become "smart" now to do more rather than simply transmit medical information and advice. Smartphone, supported with high speed data services, has revolutionized healthcare by playing the role of a powerful medical device for monitoring the patients' health. Heart disease and diabetics monitoring and controlling systems are very much common now. An estimated 95,000 healthcare applications are available today and over 200 million people have downloaded these applications to their smartphones [4]. It is estimated that 500 million people will be using healthcare applications by the year of 2015 [5]. It is also estimated that smartphones and tablets will be the most popular technological developments for doctors since the invention of the stethoscope. In the United States smartphones are being used by the physicians not only to access medical reference material, training contents, and professional journals but also to use them for patient monitoring, imaging, and bedside care. Smartphones enable patients to take a more active role for the betterment of their own health such as managing appointments, updating prescriptions, and accessing their medical records. Thus smartphones have maximized healthcare professionals' time and enhanced the efficiency of the existing healthcare systems. In this paper we present a smartphone based wireless healthcare monitoring system (WHMS), which can provide real time online information about medical status of a patient. In addition alarming and reminding messages about the patient health status can also be sent to patient mentors for necessary medical diagnosis and advising. The proposed system consists of sensors, a data acquisition

unit, smartphone, and the LabVIEW program. The system is able to display, record, and send patient's physiological data. Moreover, the proposed WHMS also supportsInternet connectivity so that the healthcare professionals can monitor and access patients' data from anywhere of the world at any time. The patient is equipped with biomedical sensors, which transform the changes in the monitored physiological quantities into electronic data that are measured and recorded. The LabVIEW program assists monitoring and displaying the data. The patient's temperature, heart beat rate, muscles, blood pressure, blood glucose level, and ECG data can be monitored by our present system. Our careful design of the hardware and software components of the system is able to fulfil any further requirement of the users.

Luštrek, M., Gjoreski, H., Kozina, S., Cvetkovi, B., Mirchevska, V., Gams, M.: Detecting falls with location sensors and accelerometers. In: Innovative Applications of Artificial Intelligence Conference, pp 1663–1667 (2011)

Due to the rapid aging of the population, many technical solutions for the care of the elderly are being developed, often involving fall detection with accelerometers. We present a novel approach to fall detection with location sensors. In our application, a user wears up to four tags on the body whose locations are detected with radio sensors. This makes it possible to recognize the user's activity, including falling any lying afterwards, and the context in terms of the location in the apartment. We compared fall detection using location sensors, accelerometers and accelerometers combined with the context. A scenario consisting of events difficult to recognize as falls or nonfalls was used for the comparison. The accuracy of the methods that utilized the context was almost 40 percentage points higher compared to the methods without the context. The accuracy of pure location-based methods was around 10 percentage points higher than the accuracy of accelerometers combined with the context.The world population is aging rapidly, threatening to overwhelm the society's capacity for taking care of its elderly members. The percentage of persons aged 65+ in the developed countries is projected to rise from 7.5 % in 2009 to 16 % in 2050 (United Nations 2009). Even more alarmingly, the ratio of the working-age population (15– 64) to those aged 65+ is projected to decline from 4.3 to 2.3. This urgently drives the development of technical solutions to help the elderly live longer

independently with minimal support of the working-age population. There are at least two reasons why fall detection is one of the most active topics in elderly care. First, falls and the fear of falling are important causes for nursing home admission (Tinetti and Williams 1997). And second, fall detection can be tackled fairly effectively with the currently available technology. The usual approach is with accelerometers, which detect the high acceleration upon the impact with the ground. Accelerometers are accurate,lightweight and inexpensive. Their limitations are that some safe activities result in high acceleration, and more importantly, not all falls result in high acceleration. We developed an alternative approach to fall detection in the European Union project Confidence (2011). A Confidence user wears up to four tags on the body. The locations of these tags are detected with radio sensors, and from the tag locations the user's activity and location in the apartment are inferred. Such rich information enables reliable detection even of atypical falls. However, the equipment is expensive and somewhat cumbersome, so it probably needs a few years to mature. In this paper we compare fall detection with location sensors and with several accelerometer-based methods. We show that a typical fall and the lying after a fall can indeed be reliably detected with accelerometers. However, to recognize atypical falls, some contextual information is needed. In our case it consists of the location in the apartment, which is provided by location sensors.

Jia, N.: Detecting human falls with a 3-axis digital accelerometer. Analog. Dialogue 43, 7 (2009)

Elderly fall detection systems based on wireless body area sensor networks (WBSNs) have increased significantly in medical contexts. The power consumption of such systems is a critical issue influencing the overall practicality of the WBSN. Reducing the power consumption of these networks while maintaining acceptable performance poses a challenge. Several power reduction techniques can be employed to tackle this issue. A human vital signs monitoring system (HVSMS) has been proposed here to measure vital parameters of the elderly, including heart rate and fall detection based on heartbeat and accelerometer sensors, respectively. In addition, the location of elderly people can be determined based on Global Positioning System (GPS) and transmitted with their vital parameters to emergency medical

centers (EMCs) via the Global System for Mobile Communications (GSM) network. In this paper, the power consumption of the proposed HVSMS was minimized by merging a data-event (DE) algorithm and an energy-harvesting-technique-based wireless power transfer (WPT). The DE algorithm improved HVSMS power consumption, utilizing the duty cycle of the sleep/wake mode. The WPT successfully charged the HVSMS battery. The results demonstrated that the proposed DE algorithm reduced the current consumption of the HVSMS to 9.35 mA compared to traditional operation at 85.85 mA. Thus, an 89% power saving was achieved based on the DE algorithm and the battery life was extended to 30 days instead of 3 days (traditional operation). In addition, the WPT was able to charge the HVSMS batteries once every 30 days for 10 h, thus eliminating existing restrictions involving the use of wire charging methods. The results indicate that the HVSMS current consumption outperformed existing solutions from previous studies.Falls of elderly people are common in houses, hospitals, and health care centers, with 30 percent of falls leading to harm or injury. Nineteen percent of falls happen during movement from one location to another, and 84 percent occur in hospital rooms. Furthermore, the areas near beds and chairs are the locations of the majority of falls [**1**]. Most elderly people who fall during daily activities require special care, which limits their movement. The falls generally occur during elderly movement. Monitoring the vital signs of patients or elderly people, such as fall detection during daily activities using wireless body area sensor networks (WBSNs) after they are discharged from hospital, is important for achieving positive patient outcomes. This approach assists doctors in terms of monitoring a patient's health status and providing first aid to them in critical situations [**2**]. Previous works have considered several proposed systems or wearable devices for monitoring patients' vital parameters, such as heart rate [**3**], acceleration [**4**], SpO_2 [**5**], and ECG [**6**]. Some of the related works adopted a GPS module to send the geographical location of the patient or elderly person to a central station monitored by the doctor [**7**]. In addition, these studies used various types of wireless technology such as WiFi [**8**], Bluetooth [**9**], ZigBee [**10**], and GSM [**11**] for transmitting patient parameters to the doctor for monitoring purposes and alerting them when critical situations occur.

One of the most significant challenges associated with designing wearable health

monitoring devices is the power consumed by the components of these devices. When these components consume high amounts of power, battery lifetime decreases and the system becomes inefficient. Some past studies did not consider approaches for solving this power consumption problem when designing patient monitoring systems or devices. In addition, these devices exhausted a considerable amount of current (~100–500 mA) because they continually monitored patients' vital signs during daily activities. However, other research works have adopted power reduction techniques such as sleep/wake methods data-driven algorithms [**10**], transmission power control (TPC) algorithms [**22**], modification of transmitted data [**23**], sampling and transmission rates [**24**], low-power idle mode [**25**], adaptive TPC , data rate control , routing protocol , and duty cycle to reduce the power consumption of WBSNs for different applications such as fall detection, human activity monitoring, motion detection, vital signs monitoring, and localization.

In WBSNs, most of the power consumption has been found to be dissipated during the transmission and reception process specifically GSM. In recent works, radio components [**35**] such as GSM and GPS modules and microcontrollers have been considered power-hungry modules relative to the heart rate and accelerometer sensors, which consume a small amount of power. Reducing the power consumption of these components while collecting accurate measurements, obtaining geolocation information, and transmitting data to a remote location poses challenges. In this work, a human vital sign monitoring system (HVSMS) was proposed and prototyped for measuring vital parameters of the elderly, such as heart rate and acceleration, using two bio-sensors: an accelerometer and a heartbeat monitor. In addition, the upper arm was used as the location for attaching the HVSMS because the outer skin of the body in this location is very smooth and has high conductivity for the green LED of the photoplethysmography (PPG) sensor. The proposed system consisted of an accelerometer and a heartbeat sensor, a microcontroller based on the ATmega328p, a GPS module, a GSM module, and a 3.7 V/8400 mAh Li-ion rechargeable battery. Moreover, wireless power transfer (WPT) based on magnetic resonator coupling (MRC) was adopted for recharging the batteries of the proposed system to dispense with the need for charging by an electrical connection. In addition, a power reduction

algorithm (i.e., data-event algorithm) was proposed to significantly limit the power consumed and increase the battery life of the HVSMS. The main operation of the proposed power reduction algorithm mainly depends on the active and sleep modes of the main components of the HVSMS (i.e., GSM and GPS).

The DE algorithm was written inside the microcontroller. It leads to the GPS and GSM modules being turned off (i.e., zero power consumption) when the HVSMS in the patient monitoring system indicates that this switch is appropriate. In contrast, the DE algorithm places the GPS and GSM module in active mode and the biosensors in sleep mode when a patient fall occurs and the heart rate is normal or abnormal. Accordingly, in the last case, an alert message is sent from the HVSMS to the doctor in the emergency medical center (EMC) based on the GSM network. The microcontroller also sends three text messages to the EMC via GSM, and includes patient heart rate status and the geographical location of the patient fall (determined by GPS). Falls among elderly persons aged 65 years and older have gradually increased in recent years, according to the American Center for Disease Control and Prevention (CDC). More than 1 million elderly people fall and are treated in emergency departments due to a fall that causes a head injury or hip fracture each year in the USA.

Noury, N., Fleury, A., Rumeau, P., Bourke, A.K., Laighin, G.O., Rialle, V., Lundy, J.E.: Fall detection-principles and methods. In: Proceedings of the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp. 1663–1666 (2007)

Fall detection of the elderly is a major public health problem. Thus it has generated a wide range of applied research and prompted the development of telemonitoring systems to enable the early diagnosis of fall conditions. This article is a survey of systems, algorithms and sensors, for the automatic early detection of the fall of elderly persons. It points out the difficulty to compare the performances of the different systems due to the lack of a common framework. It then proposes a procedure for this evaluation.he fall in the elderly is a major public health problem as it causes many disabling fractures [1] but also has dramatic psychological consequences which reduce the independence of the person . It was established that the earlier the fall is reported, the lower is the rate of morbidity-

mortality The detection of the fall is also an interesting scientific problem as it is a ill-defined process which one can approach using various methods. Although the concept of a fall is in the common sense, it is difficult to describe it precisely, and thus to specify its means of detection. It can be described as the rapid change from the upright/sitting position to the reclining or almost lengthened position, but it is not a controlled movement, like lying down, for example. In 1987 the Kellogg international working group on the prevention of falls in the elderly defined a fall as "unintentionally coming to ground, or some lower level not as a consequence of sustaining a violent blow, loss of consciousness, sudden onset of paralysis as in stroke or an epileptic seizure" [7]. This definition has been used in many research studies, as it is general enough to be extended to include falls resulting of dizziness and syncope, consequences of an epileptic fit or cardiovascular collapses, such as postural hypotension and transient ischaemic attacks. This paper presents a short review of the academic researches on the fall detection, the physics of a fall and the means for its detection are discussed, then the paper ends by presenting a proposal of a common evaluation framework for the fall detection systems.

Kangas, M., Konttila, A., Winblad, I., Jamsa, T.: Determination of simple thresholds for accelerometry-based parameters for fall detection. In: Proceedings of the 29th Annual International Conference of the IEEE EMBS, pp. 1367–1380 (2007)

The increasing population of elderly people is mainly living in a home-dwelling environment and needs applications to support their independency and safety. Falls are one of the major health risks that affect the quality of life among older adults. Body attached accelerometers have been used to detect falls. The placement of the accelerometric sensor as well as the fall detection algorithms are still under investigation. The aim of the present pilot study was to determine acceleration thresholds for fall detection, using triaxialaccelerometric measurements at the waist, wrist, and head. Intentional falls (forward, backward, and lateral) and activities of daily living (ADL) were performed by two voluntary subjects. The results showed that measurements from the waist and head have potential to distinguish between falls and ADL. Especially, when the simple threshold-based detection was combined with posture detection after the

fall, the sensitivity and specificity of fall detection were up to 100 %. On the contrary, the wrist did not appear to be an optimal site for fall detection.HE increasing population of elderly people (aged 65+) is mainly living in a home-dwelling environment and needs applications to support their independency and safety. Falls are one of the major health risks that affect the quality of life among elderly by producing fear and resulting in decrease in mobility and activity . It appears that elderly people are willing to accept new technologies to support their independence and safety . Body attached accelerometers and gyroscopes have been used to detect human movement and especially falls. The placement of an acceleration sensor to optimize the location of a fall detector has been studied in some extent. The placement site at the waist has been suggested to be the most efficient, since at this site the acceleration signal is similar and evenly distributed betweendifferent fall types . Furthermore, waist attached accelerometers are located near to the body center of gravity providing reliable information on subject's movements, with the exception of movements of arms and legs.

CONCLUSION

The placement of the device around the lower abdomen or torso of the patient is found to be the best location since it is the center of gravity for the human body, and it is much more stable and not prone to incorrect prediction along the course of experiments. As a fall occurs, a human center of gravity is destabilized, and this is what causes the human to fall down. The average percentage for sensitivity of the device is 73.3% while the average for specificity is 89.3%. Therefore, both sensitivity and specificity tests show promising results for this device.

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