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ORIGINAL ARTICLE

Intelligent alarm system for people with physical disability: design and a pilot study from Iran

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ABSTRACT

At present, there are examples that the patient's heart rate is measured by placing a finger on a device or it is possible with the help of mobile phones. But all of these tools are effective only when the patient becomes aware of the fluctuations. In this paper, we attempt to design a system to prevent possible dangers faced by patients with various types of disabilities, which, in the event of a place of an attack, reveals the physical condition and vital signs. The system consists of two parts, including software and hardware parts. The hardware part includes sensors and central controllers. While the software part includes an installable application on the user's mobile phone. This app is composed of two parts, including patient-side or transmitter application (Sender), and relatives, hospital, emergency service provider or doctor-side or receiver application (Receiver). We recruited 15 patients with physical disabilities from whom data were acquired. Data of 22 falling events were collected; altogether, 19 falling events were submitted for analysis. The rest of the events were rejected because of age restriction inclusion criteria. Findings have confirmed the helpfulness and usefulness of the method to process the proposed model properly and detect, track, and classify physically disabled people as moving objects. Our findings demonstrated the rational performance of the suggested fall detection system in the tested situations.

Key words: fall detection system, physically disabled people, computer network, information systems, wireless technology

INTRODUCTION

Today, as medical science is developing and progressing, it is essential to use technology in prevention, control, and treatment.[1] Some of the problems that patients with a physical disability and their guidance suffer from are lack of recognition or lack of attention to small fluctuations and disorders, which can exacerbate the risks and injuries to the patient by intensifying it. Suppose a patient with a heart condition is driving or is athletic; whether the patient or his relatives and his doctor can be informed instantaneously of his vital signs such as heart rate and blood pressure can help prevent irreparable harm.[2] Measurement of vital signs such as blood pressure and heart rate or patient falling in a moment and in all states of sleep and awakenings, or rest or physical activity from a patient is hard and even impossible at present.[3] So far, many devices relevant to the field of rehabilitation have been developed to control these problems, each with its own specific problems.[4]

The advance of artificial intelligence has led to the development of intelligent devices that help overcome the physical and cognitive challenges of the people with physical and mental disability.[5] New technologies have led to many hops for people with disabilities. In the past, electric scooters and hearing aids were among the assistive technologies for the people with physical disability; today, artificial intelligence has accelerated this process.[6] A large and growing body of literature has investigated and focuses on designing and developing new and applicable devices for the elderly and subjects with physical disabilities. The different idea exists in the designing intelligent alarm system; some are designed based on the voice.[7] Alternatively, designed to improve people's mobility with physical disabilities, which was successful.[8] Kakria et al. set up a real-time heart monitoring system between the doctor and the patients to follow up cardiac events, which is useful not just in disabled subjects, even in normal subjects, is applicable.[9]

Intelligent Alarm Systems with gathering health information of patients and sending data to a medical server are helpful in monitoring and preventing subsequent events. This system is applicable as an implant or use as an exterior instrument, like smartphone or computer. In this way, the clinical data are collected, interpreted, and any life-threatening detected, inform the medical staff via the alarm system. Despite the one billion people suffering from various types of mobility impairments, there is a need for a large market for assistive technologies.[10] Due to their disabilities, people with disabilities are lagging behind the daily progress of society. But information technology, especially artificial intelligence can fill this gap. [11] Artificial intelligence is like a miracle potion that helps people with disabilities take a big step forward in a proper and accurate way.[12]

In Iran, for many years has been focused on helping the people with disabilities in the main sectors including, health, education, quality of life, and social fields.[13] However, these people are struggling with many problems in Iranian society, the most obvious of which is the lack of proper public transport for them.[14,15] This has caused them to have trouble with their most basic daily tasks and prefer to stay at home instead of going out. According to the results of the latest census, nearly one million and fifty thousand of Iranian people have various degree of disabilities; About 600,000 people with physical and movement disabilities and about 350,000 Iranians with mental disorders.[16-18] On the other hand, some statistical experts believe that the real statistics of disability are higher, because especially in villages and small towns, some households consider disability as a defect for the whole family.

To the best of our knowledge, there is no device that can meet all the conditions mentioned above. At present, there are examples that the patient's heart rate is measured by placing a finger on the device or it is possible with the help of mobile phones. But all of these tools are effective only when the patient becomes aware of the fluctuations.

Here we attempt to design a system to prevent possible dangers for patients with various types of disabilities, which, in the event of a place of attack, reveals the physical condition and vital signs. In this research, we have tried to solve all the problems that other equipment on the market has with the minimum volume and weight and the minimum invasive method so that the patient does not suffer from constant contact with it, as well as in comparison with the sample. External products are both in terms of quality and in terms of price in better conditions, produced and provided to the cardiovascular patients of this land. Our concept was based on the basis of that vital signs such as heart rate or patient falling can be measured using sensor technology, Bluetooth technology can be used to transmit vital signs such as heart rate or patient falling, smartphones and GPS technology can be used to communicate with companions as well as to locate the patient at the moment of the crisis.

METHODS

Study population and ethical consideration: In a pilot study, fifteen consecutive patients from Golestan and Imam Khomeini Hospitals who underwent long-term monitoring as part of the evaluation were enrolled during 2016–2017.

Patents, inclusion and exclusion criteria: Fifteen consecutive patients with disabilities from three different units who underwent long-term monitoring as part of the routine evaluation were recruited during 2016–2017. Inclusion criteria included patients greater than 18 years old, and those with mobility impairment, able to push a manual wheelchair. Individuals without a disability, vision loss that prevents them from seeing video elements on the screen, unstable cardiovascular conditions, unable to push a manual wheelchair, unable to understand study directions, were excluded.

Ethical consideration: The study was approved by the Research Ethics Committee at Ahvaz Jundishapur University of Medical Sciences and all participants provided informed written consent.

Design: The system consists of two parts, including software and hardware parts (Figure 1).

1. **Hardware part** includes sensors and central controllers.
    - **Sensors:** Includes heart rate transducer sensor to voltage (mounted on the left chest), pulse rate transducer sensor to voltage (mounted on the lower part of the left elbow joint), vibration sensors (two) for installation on the left and right-hand

muscles, and a remote sensing sensor module that is located on the central machine and measures the distance from the ground.

- **Central controller:** This part is mounted on the individual belt and connected to all sensors and receives and processes sensor data. After the processing stage, the encoded data is encrypted and sent to the user by the Bluetooth module.

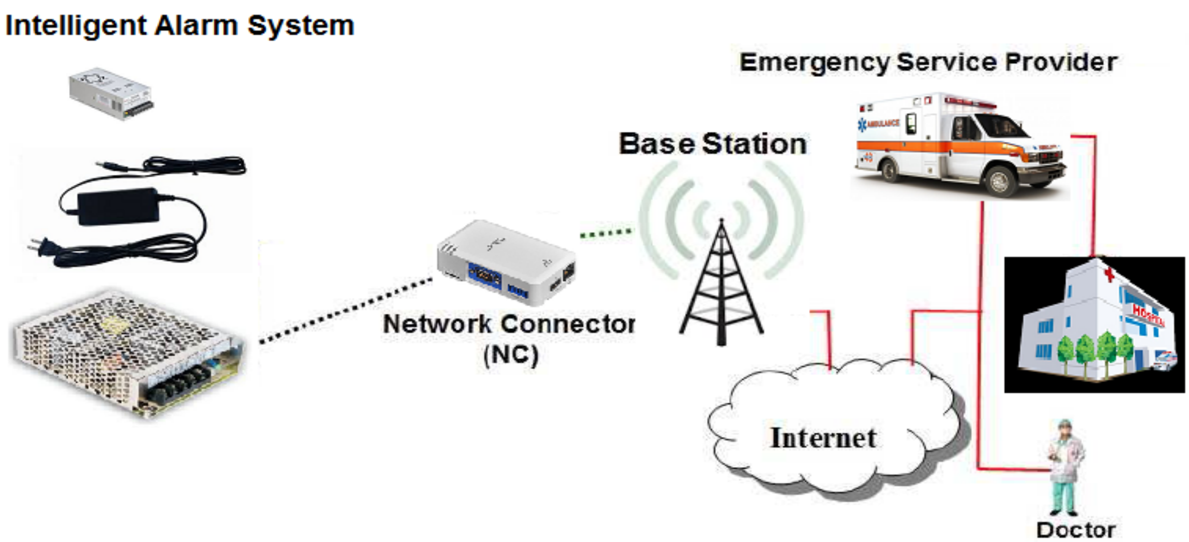

Figure 1 Communication architecture of the Body Sensor Networks for intelligent Alarm System for physically disabled people.

2. **The software part** includes an installable application on the user's mobile. This app composes two-part, including patient-side or transmitter application (Sender), and relatives, hospital, emergency service provider or doctor-side or receiver application (Receiver).

- **Patient-side application (sender):** This application receives data from the central hardware system by smartphone Bluetooth and compares them to their pre-determined standard charts. Then, the result is recorded in its database and in case of any abnormal event, the user sends the accident report and user's location (using Mobile GPS) to SMS messages to the user in advance. This application has the USER ADAPTIVE feature, which stores the heart rate and other symptoms in the normal state of the person in the first place and compares this information. The software consists of two parts, one part being installed as the sender or on the patient's phone, and the other part of the receiver on the phone of the person responsible for the patient, such as the parent or children, the doctor or anyone else who is somehow associated with the patient, which can help the patient when the problem arises. Initially, the signals are sent from the sensors mounted on the patient's body to the central processor. The processor receives pulses from each sensor into 32-bit intelligible data, and then through the

Bluetooth module in the hardware component embedded in the mobile device of the patient. This operation takes place once every five seconds. At this point, the software analyzes the received 32-bit data and extracts the data for each part for subsequent processing (Figure 2). Besides, for software there are three modes, including off, Sport, and normal, of which the critical condition is different in normal mode.

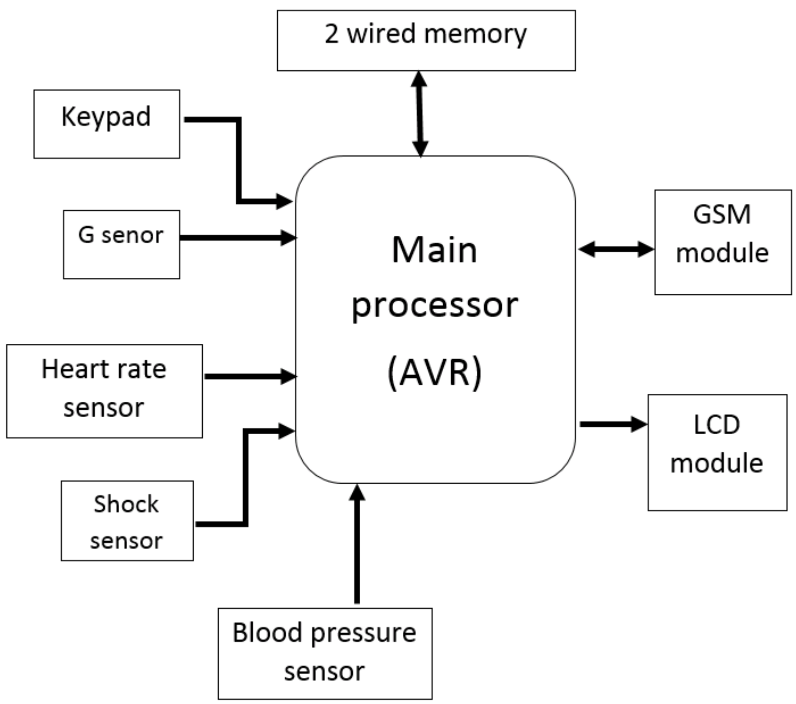

Figure 2 The received data is stored in the software database every five seconds once and temporarily and after one hour the data are collected and their average are registered permanently in the databank, and the operation continues the same way. Of course, during this whole period, each five-second packet is generalized to one minute, and in the absence of normal data, and after assurance, the vital signs, along with the exact location of the incident as SMS All numbers that are already defined for the software are sent.

Relatives, hospital, emergency service provider or doctor-side or receiver application: It receives the message is sent from the patient's application, and a page appears first to indicate which message is sent from the patient's side. This is useful for doctors or families when having more than one patient. Then the vital signs of the patient, who is now in a low-risk, moderate-risk or high-risk situation, and finally, the exact geographic location of the patient is displayed on a map. Also, the recipient of the message can immediately contact a patient by tapping a button. If the patient is not able to respond, the patient side application will be in the Auto Answer mode.

Main model of falling and measurement

The main and the most important steps of the model, include set initial parameters and threshold values, open input file, build a background model, retrieve current frame, localize foreground areas in each processed frame, perform classification for each detected object, if the classification step gives a positive result, go to next step, otherwise perform Mean-Shift tracking for the recently detected object, then check predefined thresholds for each scenario: check object's position—if the object's position does not change for more than *K* frames and its proportions do not change to exceed *P*, start the alarm, and finally if the end of the sequence is not reached, go to 4th step, otherwise terminate the processing (Table 1).

Table 1 Initial system parameters with built-in sensors and their uses.

Built-in Sensors of SP	Usual Use in SP
Accelerometer	Senses the changes in orientation of SP and adjusts the viewing angle accordingly.
Gyroscope	Detects angular momentum (roll, pitch and yaw); facilitates game.
Magnetometer	Senses the Earth's magnetic field; works as a digital compass.
Barometer	Measures atmospheric pressure; facilitates weather widgets.
Image Sensor	Provides still picture and video capturing facilities.
Microphone	Sound capture.
Wi-Fi sensor	Facilitates wireless communication through Wi-Fi.
Bluetooth Sensor	Facilitates wireless communication through Bluetooth.
Location sensors (GPS)	Targets or navigates by map or picture with the help of GPS satellites.
Temperature Sensor	Measures temperature; facilitates weather widgets.
Humidity Sensor	Measures humidity; facilitates weather widgets.
Ambient Light Sensor	Adjusts the display brightness.
Proximity Sensor	Detects how close our SP's screen is to our body.
Touch Sensor	Helps to operate the SP through touching.
NFC Sensor	Establishes communication between similar device by touching or bringing them into proximity.
Infrared Sensor	Can sense temperature.
Back-Illuminated sensor	Adjust the light captured while capturing a photograph.

RESULTS

We recruited 15 patients with physical disabilities of which data were acquired. Data of 22 events; altogether, 19 events were submitted for analysis (Table 2). The rest 3 events were rejected because of the age restriction inclusion criteria. The architecture of the detection system, was based on software which runs on the Android smart-phone consists of numerous modules, which judges whether a fall has occurred or not. Before, during and after the main events, the software will connect to a service that has a protocol for sending SMS messages or calls to a caregiver that could be family members or healthcare providers.

Table 2 List of Falling Events in the Study Group

Patient code	Gender	Age (years)	Detected event	Reported event	Duration (Seconds)
CA1	M	29	2	2	25
CA2	F	54	2	2	35
CA3	M	38	1	1	20
CA4	M	41	1	1	45
CA5	M	21	0	1	25
CA6	M	39	2	2	60
CA7	F	25	1	1	30
CA8	F	48	1	1	40
CA9	M	51	1	1	55
CA10	M	37	2	2	50
CA11	M	23	0	1	25
CA12	F	31	1	1	20
CA13	M	51	1	1	45
CA14	M	53	1	1	25
CA15	M	43	1	1	60
Overall	**15**	**38.9 ± 11.19***	**17**	**19**	**37.3 ± 14.3***

***** ***Mean** ± **Standard deviation (SD)***

A person was properly tracked on the subsequent frames, of which a person enters the scene in frame No. 495-500, the modeling module detects a moving object and classifies the event correctly despite the incompleteness of an object's shape (Figure 3A). In the next event, a person lying on the ground with a red rectangle in frame No. 571, which the system triggers the alarm, because the threshold value is exceeded (Figure 3B). In case a person remains lying on the ground the system constantly informs about the detected event (Figure 3C).

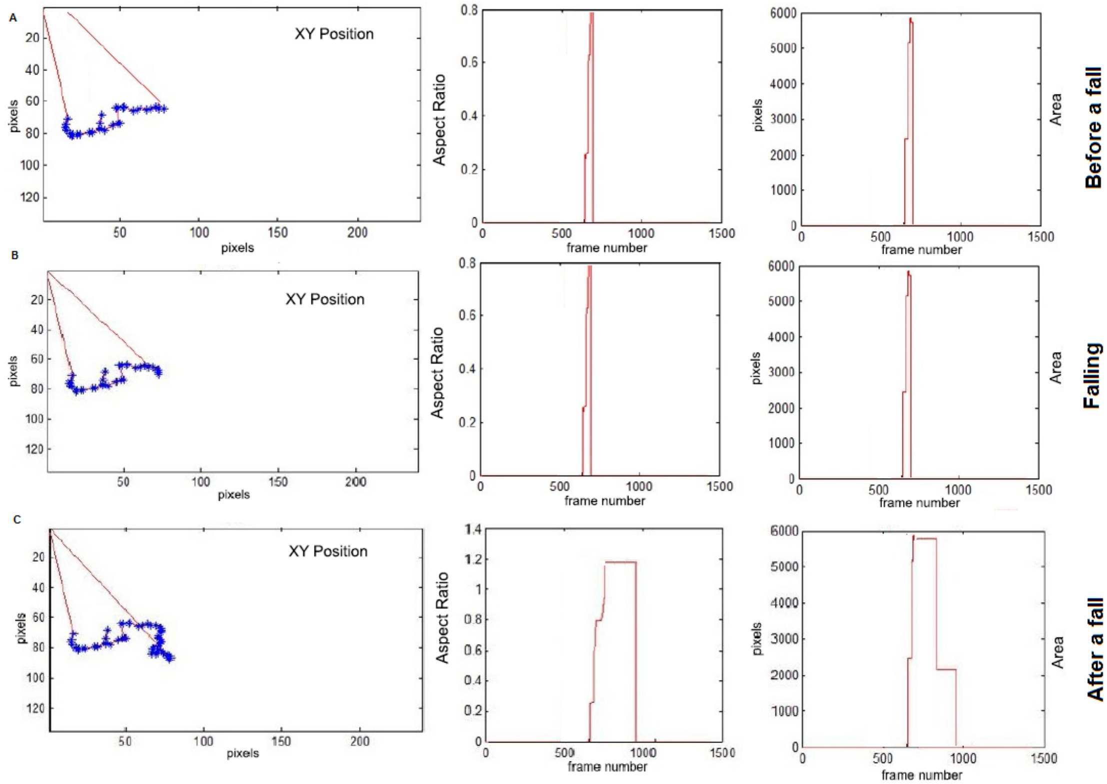

Figure 3 The analysis of an exemplary sequence of events; before a fall of a person (A), a falling person (B), and after a fall of a person (C)

The outcomes of event detection are presented in this section in a form of charts illustrating the predictability of parameters values. Charts A1, B1, and C1, show that the event occurs around frame 550 with constant aspect ratio, while the area is smaller than the original object. Simultaneously the speed of movement is close to zero (Figure 4). Charts A2, B2, and C2, show a situation when a person falls around frame 490 but moves slightly till frame 1300, which leads to triggering the alarm around frame 1300, when the speed of movement drops down (Figure 4). Charts A3, B3, and C3, show a situation that a person enters the field of view around frame 380 and moves around till frame No. 500, when an event is detected. Finally, the alarm is triggered around frame No. 580, when the speed of movement drops down (Figure 4).

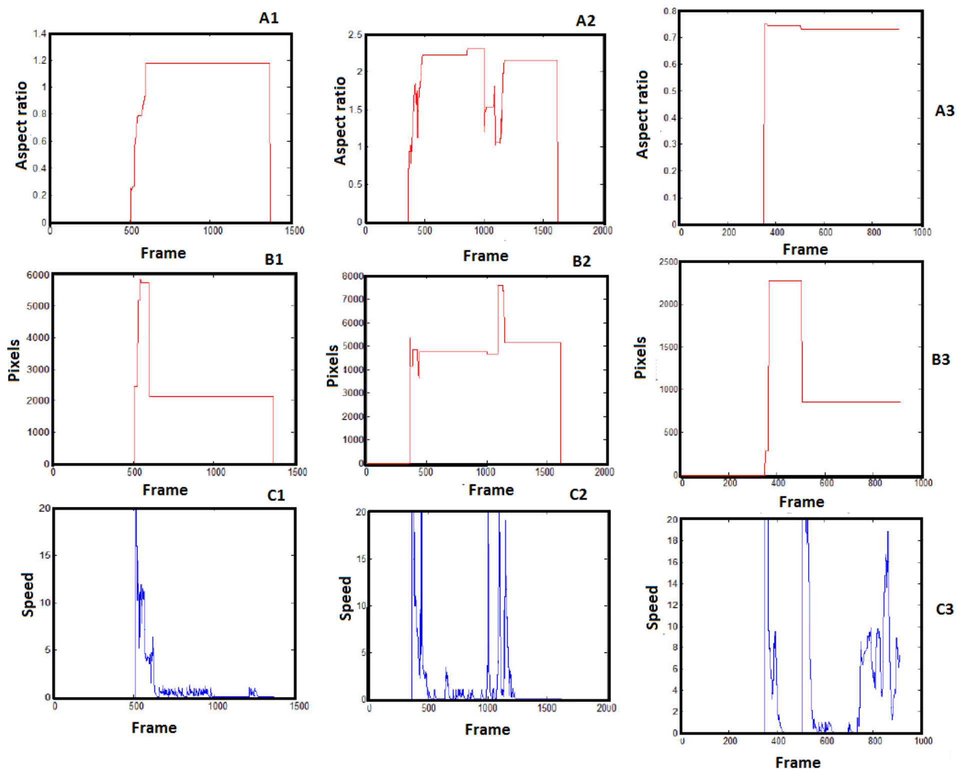

Figure 4 Parameters of moving object evaluated at the action classification stage; a sample frame after the alarm activation and plots representing object trajectory as XY position of an object's centroid, aspect ratio (A), area of an object's bounding box in pixels (B), and a relative speed in the image plane (C).

DISCUSSION

The purpose of this study was to introduce a new low-cost fall detection system with a highly portable sensor for physically disabled people. Intelligent alarm system for physically disabled people is a solution that takes advantage of monitoring and alarm automation systems, and aims to solve all the problems that other equipment on the market has with the minimum volume and weight and the minimum invasive method so that the patient does not suffer from constant contact with it, as well as in comparison with the sample.

In the field of diagnosis and prediction of adverse events in physically disabled people using brain signals, several reports have been presented and the results obtained in each of the reports indicate the extraction of appropriate features of the brain signal to distinguish and predict these groups of people.

In the present study, an overview of the intelligent alarm system was presented, to give attention to how the system works in controlling physically disabled people and in the situation of an event such as a fall. Findings have confirmed the helpfulness and usefulness of the method to process the proposed model properly and detect, track and classify physically disabled people as moving objects. To solve the fall detection problem, many devices using the inertial sensors have been introduced so far, which differ in the placement, sensors, and approach.

Moreover, those devices compose various limitations and accuracy (Table 3).

Table 3 Latest introduced fall detection systems that compose various limitations and accuracy

Study ID	Country	System	Limitations	Target people	Outcome
de Miguel et al., 2017[27]	Spain	Camera-Based Fall Detection System	The camera may suffer from the drawback of its low dynamic range. Besides the height of detectable	Elderly	Tests conducted on over 50 different fall videos have shown a detection ratio of greater than 96%.
Ejupi et al., 2017[28]	Canada	wavelet-based approach	---------	Healthy subject	Device potentially achieves a high sensitivity of fall-related actions recognition.
Mao et al., 2017[29]	China	optical sensor-based fall monitoring systems	re-identify the threshold of acceleration for accurate fall detection and verify the best body location to place the sensors	Healthy subject	Better fall detection accuracy and portability can be achieved
Lin et al., 2017[30]	Taiwan	Camera-Based Line-Laser Obstacle Detection System	The camera may suffer from the drawback of its low dynamic range. Besides the height of detectable, the obstacles must be larger than the plane level of the line-laser.	Elderly	It is suitable to be installed on customer wearable devices, and the overall costs of the products are acceptable compared to shoes.
Tran et al., 2017[31]	Vietnam	Multimodal features from Kinect sensors in scalable environment	It concludes a fall or non-fall based on skeleton if this one is available. However, it did not verify the reliability of skeletons during fall, this leads to some mis-detections.	Any of living space	Has a lower false alarm rate while keeping the highest accuracy.
Ahmed et al., 2017 [32]	Pakistan	A classification-based fall detection system	---------	Elderly	demonstrate the reasonable performance
Aziz et al., 2017 [33]	USA	SVM-based detection system	young adults falling in a laboratory setting may not accurately simulate the movement patterns that are typical of falls in older adults	Both Young and Elder people	system showed higher fall detection and substantially lower false positive rate than the existing fall detection systems
He et al., 2017 [29]	China	An Unobtrusive Detection System Based on Kalman Filter and Bayes Network Classifier	There was not any available data for real-world falls in China	Elderly	The smart phone can issue an alarm to caregivers so as to provide timely and accurate help for the elderly, as soon as the system detects a fall.

Study ID	Country	System	Limitations	Target people	Outcome
Hsieh et al., 2017 [34]	Taiwan	Hierarchical Fall Detection system Using a Multiphase Fall Model	____________	Both Young and Elder people	Proper fall detection system with respect to the individual differences
Tsinganos and Skodras, 2018 [35]	Greece	Wearable Sensor Data Fusion to a Single Sensor Machine Learning Technique in Fall Detection	____________	Elderly	The methods presented and the comparison of their performance provide useful insights into the problem of fall detection.
Mostafa et al, 2018 [36]	Malaysia	A fuzzy-logic-based adjustable autonomy (FLAA) model	Does not investigate the behavior of multi-agent systems in the long term. Moreover, the test data do not reflect the patterns of some real-world movement activities or fall situations.	Elderly	The FLAA model improves the accuracy and performance of these agents in detecting and preventing falls.
Santoyo-Ramón et al, 2018 [37]	Spain	A wearable Fall Detection System (FDS) based on a body-area network	In terms of the area where the user can be monitored or their high probability of spurious interference caused by external factors such as changes in the light, noises, presence of another individual, displacement of furniture, domestic pets or other falling objects, etc	Experimental normal people	The contribution of the different factors involved in the detection of a fall and discerning if they lead to significant changes in the final performance of the system.
Cates et al, 2018 [38]	Korea	A machine learning-based fall detectors, an insole system and novel fall classification model	The insole did not fit everyone's foot perfectly, which affected the orientation of the FSR sensors with respect to the foot, in turn affecting the measured force of each FSR.	Experimental normal people	Reducing the burden that is associated with wearable sensors and increasing user comfort by inserting the insole system into the shoe
Khojasteh et al, 2018 [39]	Multi-central	A fall detection using an on-wrist wearable accelerometer	____________	Experimental normal people	The rule-based systems represent a promising research line as they perform similarly to neural networks, but with a reduced computational cost.
Coahran et al, 2018 [40]	Multi-central	The HELPER system is a ceiling-mounted fall detection system that sends an alert to a smartphone	____________	Elderly	The sensitivity of the system was high, but numerous false alarms brought down positive predictive value.
Mauldin et al, 2018 [41]	USA	Smart-Fall, an Android app that uses accelerometer data	The models cannot discern between certain directional	Elderly	A Deep Learning model for fall detection generally

Study ID	Country	System	Limitations	Target people	Outcome
		collected from a commodity-based smart-watch Internet of Things (IoT) device	characteristics of ADLs and falls that may only be accessible through raw accelerometer data		outperforms more traditional models.
Lukas et al, 2019 [42]	USA	A wireless sensing heterogeneous system-in-package (SiP) containing an ultra-low power (ULP) SoC, a non-volatile boot memory (NVM), and a 2.4 GHz frequency shift key (FSK) radio	The system lifetime by increasing the system power consumption.	Experimental normal people	Reduces the system's power consumption by reducing the code size and number of memory accesses required
Santos et al, 2019 [43]	Brazil	Accelerometer-based human fall detection using convolutional neural networks	____________	Elderly	Presents better results for fall detection
Saadeh et al, 2019 [44]	Pakistan	A patient-specific (PS) fall prediction and detection prototype system that utilizes a single tri-axial accelerometer attached to the patient's thigh	____________	Elderly	The model achieves high sensitivity and specificity
Miao et al, 2019 [45]	China	Neuromorphic Vision Datasets	____________	Experimental normal people	The neuromorphic vision sensor is a perfect sensor to solve the privacy problems which always occurs for traditional frame-based cameras
Kong et al, 2019 [46]	Japan	Robust Self-Adaptation Fall-Detection System Based on Camera Height	camera-based methods are limited to a very restricted area	Elderly	Fall-detection accuracy is affected by camera height, against which ETDA-Net is robust, outperforming traditional deep learning based fall-detection methods
Kamel Gharghan et al, 2019 [47]	Iraq	Energy-Efficient Elderly Fall Detection System Based on Power Reduction and Wireless Power Transfer	power consumption	Elderly	HVSMS current consumption outperformed existing solutions
Khan et al, 2019 [48]	UAE	Internet of things based multi-sensor patient fall detection system	Thing-Speak limits the update rate of data to one reading/second, whereas the motion sensing chip collects and transmits data at a rate of ten readings/second	Experimental normal people	The accuracy of the device in classifying fall versus non-fall activity is high
Tahir et al, 2020 [49]	UK	Hardware/Software Co-design of Fractal	The cost of higher power consumption	Elderly	A very high fall detection accuracy

Study ID	Country	System	Limitations	Target people	Outcome
		Features based Fall Detection System			
Chander et al, 2020 [50]	USA	Wearable Stretch Sensors for Human Movement Monitoring and Fall Detection in Ergonomics	Obstruction of capture volume, privacy, false alarms, and battery life	Experimental normal people	A promising technology to detect falls by assessing ankle joint kinematics
Cai et al, 2020	China	A Gradient Boosting Decision Tree (GBDT) -Based Fall Detection	____________	Experimental normal people	The good performance of the proposed GBDT-FD algorithm

In the beginning, the system installs on the patient's body, and it is straightened in a safe and normal state with the patient's body and stored in the base of the databank; so that the software can gauge the symptoms received with the normal status data. The software takes into account the critical state of the person in terms of the received data, and this critical state can be classified into three categories: low risk, moderate risk and high risk, for example, in low-risk situations, only one person is informed, in the moderate risk up to three people, and in high-risk situations up to five various people will inform.

Many researchers attempt to use smart alarm systems to foster regular activities of people with multiple disabilities so far. Lancioni *et al*, evaluated a treatment approach based on alarm signals and staff prompts with two treatment phases to foster daytime urinary continence of a person with multiple disabilities, and reported that study person became almost totally free from large accidents and retained his improvement over time.[19] Besides, Arends *et al*, evaluated the performance of a smart detection tool of major seizures in adult patients with intellectual disability with an acoustic monitoring system developed by CLB ('CLB-monitor') and video camera, and claimed that such smart alarm system has high sensitivity and moderate positive predictive value may be used alone or in multimodal systems.[20] Later on, Frontoni *et al,* attempt to introduce an autonomous and automated domestic for people with physical and motor disabilities using different Smart Objects (SOs), which such people able to communicate with each other in a cloud base infrastructure in a device with the effectiveness of alarm systems. They proposed a new technique to improve the accuracy of the smart alarm system with information fusion between different devices, proving robust and reliable results in real environments.[21] Recently, García-Peñalvo *et al,* presented various and recent development on sensor technologies for caring people with disabilities, focusing on the different configurations and novel technologies that can be used in the field, and considered the best placement of the sensor, on the body, to gain the most accurate readings of user levels, under various conditions, as well as determined the placement of the sensor based on wearer convenience.[22]

Physical disability due to health-related disorder and motor and cognitive problems can be permanent or temporary. [23] Designing products with a comprehensive design that is suitable for people with any degree of physical disability is one of the goals of continuous development of new technologies. [24] Creating new tools for people with any degree of physical disability will help such people, who are usually out of the community and miss many social and employment opportunities, return to society. [25] In the past, people with any degree of physical disability were ignored when designing and manufacturing many facilities, but today, efforts are being made to design products that are adapted and accessible to the whole community, including these people. [26] Even many of the new features of products suitable for people with any degree of physical disability.

LIMITATIONS

The present study has limitations, including first the artifact removal process, of the used algorithm and the types of event detections. Second limitation was single pixels or small groups of several pixels scattered randomly on the foreground image plane.

RECOMMENDATION

In short, artificial intelligence has a lot of potential for improving decision making, but successful implementation of this type of system in the field of rehabilitation, in addition to paying attention to the principles of the case need for any other information system, organizational, behavioral, cultural, economic, educational and technical factors also needs especial attention, thus, expert systems and those related researchers should be performed to provide appropriate solutions and answers related to the use of such systems in the professions about people with different disabilities. Software development based on the methods tested in the present study can be recommended as a network or mobile application. Also, expanding a network to gather information from users interested in using such software and estimating the effects and results of system recommendations can be useful. By using artificial intelligence-based smart systems, self-propelled vehicles also promise more mobility to people with disabilities. When the use of self-propelled vehicles flourishes in society, they can be an effective asset for people with various disabilities, as they will no longer be dependent on the help of other people or public transportation.

CONCLUSION

This system has the ability to provide a weekly and monthly daily report to a doctor. Data stored as a graph on the app itself or on the paper output, or in the case of a physician collaboration, will be displayed online on the doctor's web site. For this study, we successfully developed and evaluated a newly developed a detection system to smartly detect falls in people with physical disability and tested it on a small number of patients at the treatment site. Due to the advantages and disadvantages of different available systems and methods, our smart system could be very practical. This intelligent system will not only help to better understand falls in hospitalized patients, but also highlight the factors influencing falls, thus helping to identify the patients who are most at risk for falls. More facts about this system using a larger data sample can provide more feedback to improve it.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests

Authors declares that they have no conflict of interest.

Ethical Approval

This research was approved by Ethics Committee (EC) of Ahvaz Jundishapur University of Medical Sciences and all patients were signed the informed consent prior to recruitment.

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