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A Novel Framework for Fall Detection by Using Ambient Sensors and Voice Recording.

P Megana Santhoshi[1]*, and Mythili Thirugnanam[2].

[1]PhD scholar, School of Computer Science and Engineering (SCOPE), VIT University, Tamil Nadu, India
[2]School of Computer Science and Engineering (SCOPE), VIT University, Vellore-632014, Tamil Nadu, India.

ABSTRACT

Now a day's falls are the second ruling cause to unintentional injury death of elderly person. Fall detection methods are introduced to assist the elderly person. For any type of patient irrespective of age, first one to two hours treatment is crucial at the time of emergency. Before starting the treatment, it would be very helpful if caregivers know exact injury type. This paper aims to propose a framework on IoT and cloud computing based fall detection scheme using ambient sensors along with voice recording. With the help of voice clip and fall alarm, patient had a feasibility to inform exact injury to hospital. Hospital people will facilitate relevant department services to start quick treatment.

Keywords: Ambience based fall detection; voice recorder based health system; wireless sensor networks (WSN's); IoT (Internet of Things); Cloud computing; smart health care system.

Corresponding author

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INTRODUCTION

The number of persons above the age of 60 years is huge growing, especially in India. As per Indian government ministry of statistics, India is the second population country in the world having 1.21 Billion people. In that 35.5% of people are at or over the age of 60. Major problem faced by elderly people is unexpected fall. According to the World Health Organisation nearly 424000 deadly falls per year are occurring. By that reason, falls are the second ruling cause to unintentional injury death after road accidents. Falls are happens due to age, health problems, unbalanced walking, fear of fall again and home hazards.

By using sensor technology, presently there are three types of methods to detect the fall. First method is wearable sensor method, second method is computer vision based sensor method and third method is ambient or environment sensor method. In all these three methods different types of sensors are used like smart accelerometer, gyroscope, pulse oximeter, RBG cameras, kinect camera, micro phones, PIR, RFID and smart tiles.etc; In the proposed system these sensors are integrated with IoT technology. IoT is the Internet of Things, first stated by Kevin Ashton in 1999 to interconnect the things or objects to internet. By using IoT we can gather different formats of data analyze the information and share that information to different devices. Additionally we include the cloud concept to store and manage the data. Based on wireless networks data reaches to cloud, cloud sends the fall detection alarm to caregivers who will provide the immediate assistance to person after a fall.

The paper is encapsulated as follows: Section 2 details the survey on the related work; Section 3 proposes the framework of fall detection technology; and Section 4 concludes with future work.

Related works

Some of the noteworthy research on the fall detection method is tabulated in Table 1.Based on the literature survey, most of the work carried out on fall detection system by using three types of fall detection methods. The first method identifies the fall with the help of wearable sensors which are used to wear on wrist or waist. The second method detects the fall with the help of ambient sensors which are placed at room environment and third method uses computer vision based sensors. The first method having some drawbacks like people need to wear sensor devices always and sometimes there is a chance of forget to wear and also quick battery drain issues will be encountered. In third method, high cost equipments are needed and also people felt inconvenient to be under camera surveillance. In second method ambient sensors like Pyroelectric infrared(PIR), microphone, smart tiles, camera and RFID were detect the falls and sent fall alarms as well as pre-defined keywords to caregivers.

Most of the researchers work achieved by considering body postures, image data and pre-defined voice recognition only. Due to that caregivers will understand only their help is needed but they are not aware identification of exact injury and which department immediate assistance is required to start quick treatment for the patient. For any type of patient irrespective of age, first one to two hours treatment is crucial at the time of emergency. Before starting the treatment it would be very helpful if caregivers know exact injury part. With this motivation, a generic framework for an IoT and cloud computing based fall detection scheme using ambient sensors along with voice recording is proposed to enhance the fall detection methods and to improve the accuracy in fall detection. The detailed description of the proposed framework is discussed in Section 3.

Table 1 Existing survey on fall detection

S.No	*Author(s)*	*Types of fall detection*	*Technique used*	*Observation*
1	Miao Yu,et.al (2012)	Computer vision based	codebook Background subtraction algorithm, directed acyclic graph support vector machine (DAGSVM) system integration, single camera connected to system for posture recognition.	97.08% high fall detection rate and 0.8% a very low false detection rate. Need to solve two problems of multiple moving person silhouette and occlusions.

S.No	Author(s)	Types of fall detection	Technique used	Observation
2	Yi He,et.al (2012)	Wearable device based(smart phone)	Multimedia Messaging Service (MMS); Tri-Accelerometer; Fall incident detection algorithm.	The system would be working only when the smart phone is mounted on the waist. There is a problem of adaptation. And phone battery also consider.
3	Xiaomu Luo et.al (2012)	Ambience device based	Pyroelectric infrared sensors, Zig-bee protocol, two-layered hidden Markov model.(pattern recognition algorithm)	This system had so many advantages than camera based fall detection. But it considers very few human activities only.
4	Charalampos Doukaset.al(2012)	Wearable device based	Cloud computing, Internet of things, textile sensors,	There is a need to integrate wireless technologies like 6LoWPAN and DASH7 for assessing power consumption and communication improvement. People sometimes forget to wear the wearable devices.
5	Koshmak, G. et.al (2013)	Wearable device based(Android based smart mobile)	3-axis acceleration sensor, multifunctional application based on Android operating system.(Carry out both activity and Physiological data monitoring), fall detection algorithm.	This system acquired 94% accuracy in finding falls and calculation of pulse rate and oxygenation. For improving performance of system needs to integrates with smart home system and also consider velocity parameter with impact and posture.
6	Ahmet Yazaret.al (2013)	Ambient device based	Vibration and passive infrared sensors(to detect moving person in a region of interest) and single-tree CWT	Single-tree CWT feature extraction method is 100% accurate when compared to discrete Fourier transform and mel-cepstrum methods. Due to vibration and PIR sensors system is robust.
7	Quan Zhanget.al (2013)	Wearable device, speech recognition and video clips.	Accelerometer sensor, microphone, cloudPIS.	This system acquires 94%. Need to integrate microphone into fall sensor. In speech recognition only 5 pre-defined keywords are used.
8	Zhenhe Yeet.al (2014)	Wearable device based	3-axis acceleration sensor, Zigbee, 3Gnetwork, 1-class SVM (support vector machine) classification algorithm.	This system acquired high accuracy in all falling actions expect where quick recovery is happening at the time of slipping actions.
9	Koshmak,G.et .al (2014)	Wearable device and ambience based.	Wearable sensors and context data, Dynamic Bayesian network, fall detection algorithm.	Author combines the wearable device sensors data and context data from external sensors to get reliable fall detection. The system is costly due to multi sensor fusion process.

S.No	Author(s)	Types of fall detection	Technique used	Observation
10	Hristijan Gjoreskiet.al (2014)	Both wearable and ambient device based	Inertial sensors, location sensors, context-based fall detection algorithm.	Context-based method considers body accelerations, location and elementary activities to detect a fall. COFDILS system achieved 96.6% accuracy in fall detection and 93.3% in activity recognition when placing the single sensor including one inertial and one location sensor at chest.
11	Javier Cuboet.al (2014)	Ambient device based	Service based cloud computing, IoT, gateways.	Heterogeneous devices are connected to cloud of things to remotely access and monitor the data at run-time and react to emergency situations.
12	Ahmet Yazaret.al (2014)	Ambient device based	vibration and two Pyroelectric infrared (PIR) sensors, sensor fusion algorithm, winner-takes-all decision algorithm.	Multi-sensors are used to falling Person detection, human footstep detection, human motion detection, and unusual inactivity detection.
13	Samuele Gasparriniet.al (2014)	Computer vision based(on-ceiling configuration)	Microsoft Kinect® depth sensor, Ad-Hoc segmentation algorithm, Inter-frame processing algorithm	This system solves the privacy issue. There is a need to transmit data through wireless networks.
14	Hristijan Gjoreski,et.al(2014)	Wearable device based (elastic sports-wear)	Two wearable accelerometers, Machine learning algorithms.	The performance of activity recognition was 99% and fall detection was 78%.Tailoring the sensors into dress needs user approvals.
15	Ahmet Turan Özdemiret.al(2014)	Wearable device based(motion sensor units at six different positions)	Each sensor unit contains three tri-axial devices (accelerometer, gyroscope, and magnetometer / compass.) six machine learning techniques (k-NN classifier, LSM, SVM, BDM, DTW, and ANNs).	As per k-NN and LSM system achieve Sensitivity, specificity, and accuracy all above 99%. As per performance and computational requirements of Machine learning techniques accuracy is above 95%.
16	Eduardo Casilariet.al (2015)	Wearable device based.(smart phone and smart watch)	Accelerometer and a gyroscope, Bluetooth, 3g/4g network, Diverse fall detection algorithms.	The experimental result shows that the performance of system is increased with dual devices than single device. But the system had the limitation as limited battery of android device.
17	Lei Yanget.al (2015)	Computer vision based.	Kinect sensor, single-Gauss model, spatio-temporal context tracking algorithm.	In this system author considers the distances from head and centroid to the floor plane are used as judgment. To enhance robustness another parameter judgement also required. There is a need to improve the resolution and scope of the depth image.
18	J. Sree Madhubalaet. al (2015)	Computer Vision based	Microsoft Kinect sensor with Raspberry pi, SIM800 GSM modem, Canny Algorithm, Contour Approximation Method, Depth Image.	In this system only three posture are consider. There is a need to improve the smaller movement tracking of elderly people.

S.No	Author(s)	Types of fall detection	Technique used	Observation
19	Muhammad Salman Khan et.al (2015)	Ambient device based(micro phones)	Dual micro phones, Source separation technique, Mel-frequency cepstral coefficient, one class support vector machine (OCSVM) method	This system achieves better performance when compared with single microphone based methods. Computational cost of source separation is high.
20	Erik E. Stone,et.al (2015)	Ambient device based	Microsoft Kinect and a two-stage fall detection System, decision tree, dynamic background subtraction algorithm.	In this system, falls are happened in the view of sensor only consider.
21	Michael Cheffena et.al (2015)	Ambient device based (Smartphone audio)	audio features (such as the spectrogram, Mel frequency cepstral coefficients (MFCCs), linear predictive coding (LPC) and matching pursuit (MP) and Four different machine learning classifiers (K-NN, SVM, LSM, ANN)	This system works well, only when the phone is in distance of 5meters.This system cannot consider the slow falls. The system gives 98.97% sensitivity, 98.49%specificity and 98.72% accuracy.
22	João Santos, et.al (2015)	Wearable device based	Internet of Things; Mobile Gateway; Intelligent Personal Assistant; Body Sensor Network. GPS. Bluetooth, wearable sensor MOTO 360. Accelerometers and gyroscopes.	The system considers effective falls only with accuracy of 93.3%. There is a chance to use Bluetooth Low Energy technology in Body Sensor Network to solve power consumption related issues.
23	Alicia Y.C. Tanget.al (2015)	Wearable device based (waist or wrist)	Wearable sensors and SIMCOM SIM900 Quad-band GSM GPRS Shield hardware.	This system contains some limitations in setting threshold values. And there is no GPS module in the system to track location. It sends only sms to contact person after 15 sec of fall happened.
24	Dragan Perakovićet.al (2015)	Wearable device based	Wearable sensor, cloud computing, IoT.	This service has the ability to work 24/7. There are no experimental results for measuring accuracy.
25	Jian Heet.al (2016)	Wearable device based	3D acceleration and gyroscope, k-NN algorithm and sliding window, Bluetooth.	This system had accuracy of 97.7%, sensitivity of 94% specificity of 99%.

PROPOSED FRAMEWORK

Based on literature survey there is a possibility to enhance the fall detection methods and need to improve the accuracy in fall detection. Efficient fall detection improves the confidence, individuality and life time of elder persons. Hence, this work aims to propose an IoT and cloud computing based fall detection framework using ambient sensors along with voice recording. The proposed framework consists of various phases such as the data acquisition phase, fall detection phase, voice recording phase and the intimation phase. The block diagram shown in below figure 1 describes the proposed ambient sensors and voice recording based fall detection system.

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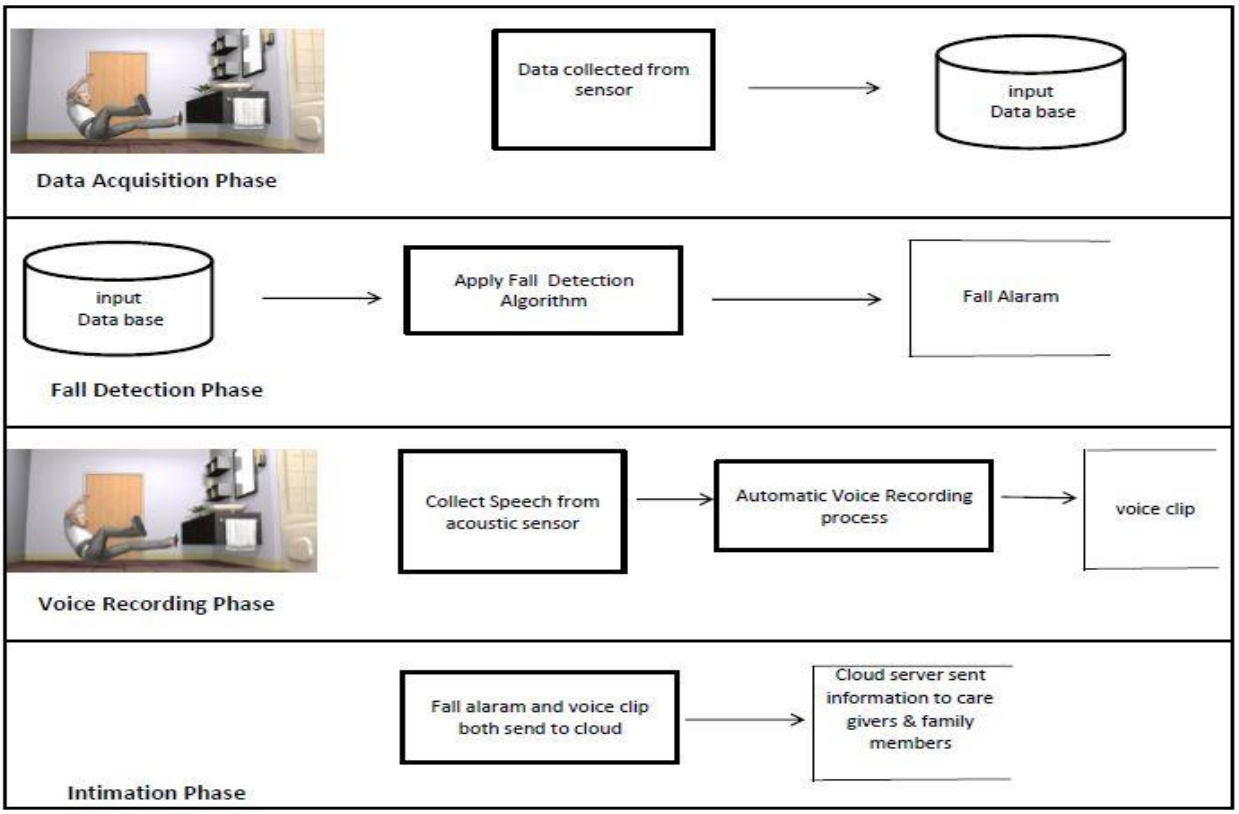
Figure 1: Framework for ambient sensors and voice recording based fall detection



Initially ambient sensors and acoustic sensors are placed in room environment to capture the elderly person fall inputs. Sensors are integrating with IoT (Internet of Things).

Data acquisition phase

Whenever an event of fall happens, data acquisition phase sensors i.e ambient sensors and acoustic sensors immediately gather the data and send to the system data base. System database stores the data for further processing.

Fall detection phase

In fall detection phase, modern fall detection algorithm is applied to that data which is stored in database to detect the real fall by analysing real fall situations of a human. By using this modern fall detection algorithm we can differentiate normal activities of a human from human fall and it creates fall alarm.

Voice recording phase

After generating fall alarm voice recording phase starts working by taking the human voice response from micro phones which are integrated with acoustic sensors. In this phase micro phones are placed at room environment and a fallen person had a possibility to tell the situation what happened to him. That voice is automatically recorded and generates voice clip.

Intimation phase

In the intimation phase both fall alarm and voice clip send to cloud through wireless networks. Finally fall detection information is sent to hospital people and family members. Due to that voice clip, patient had a

feasibility to inform exact injury to hospital so that hospital people will facilitate relevant department services to start quick treatment.

In the proposed framework, we are recommending ambient sensors to avoid the drawbacks of wearable sensor method and vision based sensor method. In ambient sensors, we select the Passive infrared sensors (PIR sensors) to capture the human motion. The PIR is one of the technologies in thermal imaging. It recognises the human motion based on temperature change. Low-dimensional temporal data stream is the output of PIR sensor. By using this temporal data, we are proposing a modern fall detection algorithm which is a combination of 'hidden markov model classification' and 'horizontal motion energy' would classify the human activities (such as sitting, standing, walking, jogging and fall) to differentiate the fall from non-fall and it will generate the fall alarm. Once fall alarm originated, automatic voice recording starts working to record the human voice response by using microphones. Both fall alarm and voice clip send to cloud through wireless networks. Finally fall detection information is sent to hospital people and family members by cloud system.

CONCLUSION AND FUTURE WORK

For any type of patient irrespective of age, first one to two hours treatment is crucial at the time of fall. Before starting the treatment it would be very helpful if caregivers know exact injury type. In this paper we propose an automated framework for an IoT and cloud computing based fall detection scheme using ambient sensors along with voice recording to enhance the fall detection methods and to improve the accuracy in fall detection. The proposed framework will tryout that efficiency with the help of voice clip, patient had a feasibility to inform exact injury to hospital so that hospital people will facilitate relevant department services to start quick treatment.

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