

Elderly Care-Taking and Fall Detection System

Ankita Sawant¹, Samrat Thorat²

¹Student, Dept. of Electronics Engineering, GCOEA, Maharashtra, India

²Professor, Dept. of Electronics Engineering, GCOEA, Maharashtra, India

Abstract - Rapid aging of global population is the topic of concern, which makes the issue of elderly care increasingly important. Falls of old people is the biggest reason for deaths among elderly together with forgetting intake of prescribed medication. Detection of fall is a leading challenge in public health problems particularly among elder people. These kinds of falls may become fatal if remain overlooked in time. Thus to avoid such accidents and provide medical help in case of such emergency, fall detection system is built. To minimize the fall and its related injuries continuous examination of patients and those who are prone to fall is needed. The given thesis presents Elderly care taking system which detects falls using wearable accelerometer sensors ADXL345 embedded in Raspberry pi with the help of ANN-based algorithm. Also medication system which sets a reminder for proper intake of medicines and a system for keeping check on physiological functionalities.

Key Words: Fall detection system, Wearable Devices, Artificial Intelligence, Accelerometer

1. INTRODUCTION

Elderly are unable to manage their daily actions as they grow older which results in one of the threats in public health issue. According to report from World Health Organization (WHO) adults, with age greater than 65 years, experience the utmost total of fatal falls, also the deaths caused by falls are maximum among elderly specially over the 60 years of age[1]. Females have been found at greater risk in this issue[2]. Following figure is more concerning since falls happen frequently indoors and are associated to daily activities. Not only physical, but these fall could also result in severe psychological effects in elderly. This could cause increase in dependence from elderly. Unnoticed falls occurs more often when patient goes to the toilet. Unassisted fall can negatively impact their health. The time required to provide patient proper treatment after the fall determines the severity of a fall. Also, as the age of elderly increases, they are likely to overlook things which results in safety issues for them. In that context, health troubles of the elderly have become increasingly vital and falls are the most frequent accidents which may often require medical consideration. So, elderly caretaking, recording their medication and fall detection is noteworthy research direction.

To distinguish a fall from other actions based on this definition requires lots of efforts, since there are many similar actions. For example, falling has the most resemblance to lying [3]. Furthermore it is quite difficult to

obtain the real statistics in the daily life, since it is a kind of random and accidental. Therefore this is an intimidating task to build datasets with real fall data for study and analysis. Researchers have gone through lots of work in this field till 2019. The rapid advancement in the area of smart sensors and the Internet of Things has brought various opportunities in fall detection research and created series of research results.

The main objective is to design a system for elderly care-taking by keeping track of intake of their medication, daily activities and emergency situation like falls with the help accelerometer, pulse rate sensor with the help of Raspberry Pi and IoT. The detection of falls by classifying these from other daily activities is focused. For this ANN based model of ML is used.

The remaining paper has been organized as given further: Section II consists of literature Review of fall detection system. Section methodology of given system. Performance analysis with results is given in section IV. Finally, section V summarized the paper and discusses the foremost challenges in research and development in the field of elderly caretaking.

2. LITERATURE REVIEW

For elderly fall detection, several solutions have been suggested since last decades. Based on the used sensor-technology, these solutions are classified into three core categories: Wearable Systems (WS), Non-Wearable Systems (NWS), and hybrid based Systems (FS). In NWS systems vision based devices is used which is robust and powerful for detecting falls. In [16] a real-time human fall detection system using static digital camera which is fixed in the indoor of respective elderly is proposed. The proposed work is based on two techniques, an Ellipse approximation (EA) and Motion History Image (MHI). Nevertheless, the foremost drawback of these kinds of vision systems is their high cost and lacks of privacy for patient since these systems require the sensors that need to be located in the indoor surroundings where the elderly lives.

To overcome this drawback, WS systems has been proposed, [6], [7], [9], [10], [11], [13] which typically utilize inertial sensors such as gyroscopes and accelerometer, generally mounted on the body of elderly in order to record the fall. Generally, in WS systems accelerometers are used since they recommend advantages such as low cost, low weight, low power consumption, small

size, ease of operation, can be attached on the various body locations and, most importantly, portability. As a result, one of the most frequently used method for fall detection involves the use of a tri-axial accelerometer along with a threshold-based algorithm. These papers used various locations for placement of these sensors like shoes, chest, and stomach on belt or on palm. Given work use the concept of thresholding in order to identify the fall. Less computation cost and complexity are one of the biggest advantages while using the threshold-based methods rather than other methods.

However, thresholding method is not adequate for detecting variety of falls since the system needs to find certain threshold for each kind of fall. Generally the system misinterprets the falls with ADL. Lately, machine learning (ML) techniques have been projected on WS systems to deal with these shortcomings and improve fall detection accuracy. Statistical inference of data models is used in ML for making automated predictions.

Given paper follow the similar approach using a ANN-based model for fall detection, but the construction of system is in different way. First of all, data of actions of elderly is captured by a 3D-axis accelerometer ADXL345. Then, the elderly fall is determined by a ANN-based system, which is built and trained on raspberry pi. Primarily, the system training is done using past information from datasets of falls. Subsequently, system detects the fall events learning by the trained model.

3. METHODOLOGY

The present system consists of two blocks:

1. Intelligent Medibox for recording the regular intake of medication.
2. Fall Detection (FD) system to detect the fall.

The proposed system consists of four major components: accelerometer, a Smart IoT gateway, communication network and Cloud services.

For this purpose, a 3-axis accelerometer, pulse rate and IR proximity sensors are used, which are responsible for assembling data from engagements of elderly person in real-time with the help of Raspberry Pi 3B+. Raspberry Pi 3 Model B+ is a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet. A 3D-axis accelerometer ADXL345 captures the data from activities of elderly. Given accelerometer is a thin, small, low power and has high resolution measurement at up to ± 16 g. formation of digital output data is in 16-bit two complement and is accessed using I2C digital interface. Acceleration is measured in g-force, i.e. acceleration due to weight. Thus on free body it is measured 1G vertically. When the subject lose the balance

and fall, our bodies are easy to dump to a certain direction, which causes our certain part of bodies to touch and hit the ground until our bodies render a quiescent state. There are four falling postures included in this study, i.e. frontal fall, back fall, left fall, right fall.

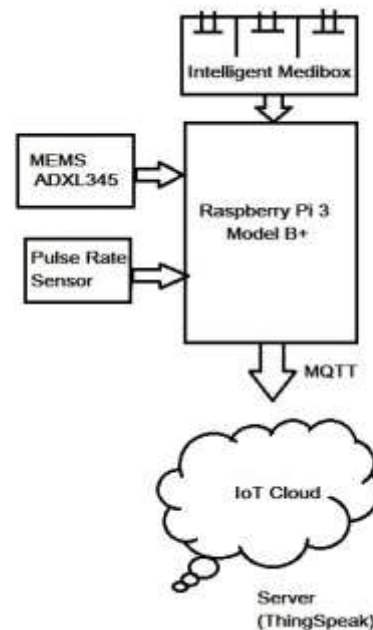


Fig -1: Block Diagram of proposed system

To recognize the four falling postures, a machine learning technique is employed. In given research, the neural network classifier is developed to decide the correct activity. Neuron is the basic element of a neural network. This is a simple mechanism that aggregates many inputs and applies a nonlinear transfer function, and generates the result as a model prediction. Many neurons of this kind are connected in a organized way to form a neural network. The neurons in such networks are arranged in layers. Typically, there is one layer for input neurons, one or more layers of the hidden layers, and one layer for output neurons.

Each layer is fully interconnected to the preceding layer and the following layer. The links between neurons have given specific weight, to determine the strength of influence one neuron has on another. The information flow starts at input layer through the processing layers and ends at output layer to generate predictions. The weights are adjusted during training in order to equal predictions at the target values; the network learns to generate better and better predictions. Back propagation method is used for adjusting the weight and correcting the error.

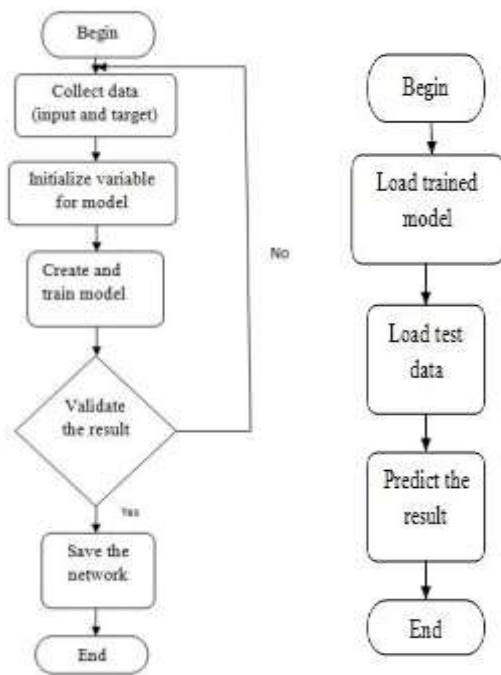


Fig -2: Training Algorithm Fig -3: Testing Algorithm

The activation values from receptor neuron is passed further, which are then weighted and summed up to the output neuron,

$$O_k = \sum W_{jk} a_j$$

The output weights W_{jk} are trained in a manner similar to the training of a two-layer back-propagation network. First of all some random value is initialized to the weights in range $(-0.001 < w_{ij} < 0.001)$, and then they are updated at each cycle by the formula,

$$w_{jk}(t) = w_{jk}(t-1) + \Delta W_{jk}(t)$$

The change value is calculated as

$$\Delta W_{jk}(t) = l1(r_k - O_k)a_j + a\Delta W_{jk}(t-1)$$

which is analogous to the formula used in the back-propagation method.

Additionally, the system has reminder system for elderly which is made by IR proximity sensor. The Intelligent Medibox setup has a box separated into several compartments, with attached IR. The box is connected to a real time clock, a Raspberry Pi B3+ which processes the activities and accordingly displays the pill details and time of intake to caregivers In case the person fails in intake of medication IR receiver will sense it and send the signal to system.

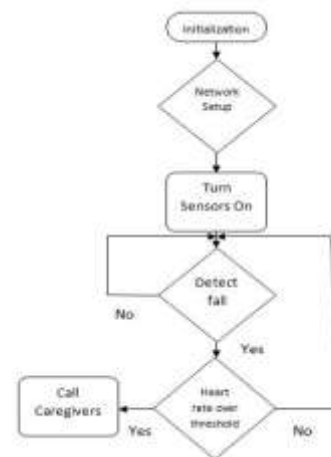


Fig -4: Process flow schematic of fall detection system

If a fall is determined, the system checks heart rate of the patient to make sure of the fall. If the result is positive or there is inconsistency in consumption of medicines an alert is set off and the system automatically reacts by sending notifications to the care takers of elderly people. Finally, the system built on cloud provides services. Additionally a new model is built using the data of fall detected.

4. PERFORMANCE ANALYSIS

10 healthy volunteers contributed in the study of age 20 to 25 years old, weight 50 to 70 kg and height 161 to 181 cm. Each participant wore the system on the belt of his jeans and repeated 5 times a sequence of tasks (moving upstairs, moving downstairs, walking, running, standing, fall forward, fall backward, fall right, fall left, lying, sitting). The number of hidden layers is 5. The Data acquitted from accelerometer and pulse rate sensor is given to the raspberry pi where it is analyzed to detect the fall. ANN model is formed using Sci Kit tool.

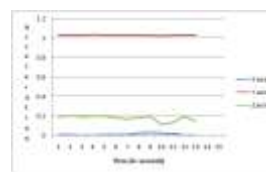


Chart -1: Fault analysis model for sleeping case

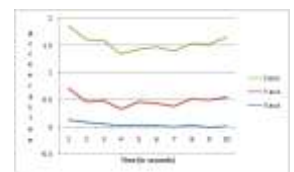


Chart -2: Fault analysis model for walking case

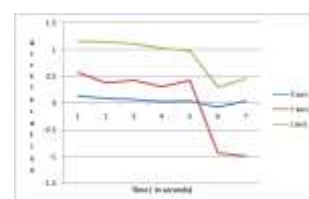


Chart -3: Fault analysis model for falling case

Chart 1 to 3 illustrates the values of acceleration in x, y, z axis with respect to time using accelerometer. Above graph concludes that for sleeping there is less deviation in acceleration, while falling sudden change in acceleration occurs which is helpful in determining fall. The value acquired through accelerometer is analyzed through ANN model which thereby detect the fall. When the fall happens or person forgot to take medicines certain message is posted on the twitter account of patient. Everyone who follows him is able to see that message as given in fig. 7. Thus the patient could get the emergency treatment.



Fig -5: Notification as shown in caregiver's phone While training the model 98% accuracy is obtained.

5. CONCLUSION

Reliable fall prevention or notification after detection is essential in independent living facilities for the elders. The paper proposed a reliable and low-cost human fall prediction and detection with the help of tri-axial accelerometer. To reduce the cost and complexity we utilize accelerometer placed at human upper trunk. In terms of timing performance, this method is able to complete evaluation in short time period and therefore to make the falling prediction priors to the collision of human body with lower objects. This makes it a reliable tool to be applied together with other protection equipments such as air-bags to prevent fall injury of elders.

The thresholds methods with the help of tri-axial acceleration are mostly used to detect falls nowadays, but our method can applied to both fall detection and prediction. This study accomplished fall prediction and detection with the help of tri-axial accelerometer and pulse rate sensor. As far as the authors' knowledge, besides this method, to predict and detect falls accurately, both tri-axial accelerometer and gyroscope are needed until now. Fall detection is the initial step to protect the elderly but not the final one. It can help reduce the interval from falling to

rescuing, but it cannot prevent the human from being injured. We have attempted and achieved good performance of predicting a fall before an elderly person is injured (hitting the door) using one existing health care dataset.

REFERENCES

- [1] Khalil Niazmand, Claudius Jehle, Lorenzo T. D'Angelo and Tim C. Lueth, "A New Washable Low-Cost Garment for Everyday Fall Detection", 32nd Annual International Conference of the IEEE EMBS Buenos Aires, Argentina, August 31 - September 4, 2010.
- [2] Ma, X.; Wang, H.; Xue, B.; Zhou, M.; Ji, B.; Li, Y. Depth-Based Human Fall Detection via Shape Features and Improved Extreme Learning Machine. *IEEE J. Biomed. Health Inform.* 2014, 18, 1915-192
- [3] Raveendra Hegde, Dr. B G Sudarshan, Dr. S C Prasanna Kumarb, Dr. Hariprasad S A, Dr. B S Satyanarayana, "Technical Advances in Fall Detection System - A Review", 2013
- [4] D. A. Skelton and S. M. Dinan, "Exercise for falls management: Rationale for an exercise programme aimed at reducing postural instability,"
- [5] Qiang Li, John A. Stankovic, Mark Hanson, Adam Barth, "Accurate, Fast Fall Detection Using Gyroscopes and Accelerometer-Derived Posture Information" *Wearable and Implantable Body Sensor Networks*, 2009. BSN 2009. Sixth International Workshop Digital Object Identifier: 10.1109/BSN.2009.46
- [6] Khalil Niazmand, Claudius Jehle, Lorenzo T. D'Angelo and Tim C. Lueth, 'A New Washable Low-Cost Garment for Everyday Fall Detection', 32nd Annual International Conference of the IEEE EMBS Buenos Aires, Argentina, August 31 - September 4, 2010.
- [7] Ziyu Lv, Feng Xia, Guowei Wu, Lin Yao, Zhikui Chen. "iCare: A Mobile Health Monitoring System for the Elderly"
- [8] SHOU-HSIUNG CHENG, "An Intelligent Fall Detection System Using Triaxial Accelerometer Integrated By Active Rfid", 2014 International Conference on Machine Learning and Cybernetics, Lanzhou
- [9] S.Y.Sim, H.S.Jeon, G.S.Chung, S.K.Kim, S.J.Kwon, W.K.Lee, K.S.Park, 'Fall detection algorithm for the elderly using acceleration sensors on the shoes'. 33rd Annual International Conference of the IEEE EMBS Boston, Massachusetts USA, August 30 - September 3, 2011.
- [10] Febus Reidj G. Cruz, Marloun P. Sejera, Mark Bryan G. Bunnao, Bradley R. Jovellanos, Prince Lester C. Maaño, Carissa Jane R. Santos, "Fall Detection Wearable Device Interconnected Through ZigBee Network", 2017 IEEE
- [11] Alan K. Bourke, Karol J. O'Donovan, John Nelson and Gearóid M. ÓLaighin, 'Fall-detection through vertical velocity thresholding using a tri-axial accelerometer characterized using an optical motioncapture system'. 30th Annual International IEEE EMBS Conference Vancouver, British Columbia, Canada, August 20-24, 2008.
- [12] Jer-Vui Lee, Yea-Dat Chuah and Kenny T.H. Chieng " Smart Elderly Home Monitoring System with an Android Phone", *International Journal of Smart Home* Vol. 7, No. 3, May, 2013
- [13] Kaban Chaccour y, Graduate member, IEEE, Amir Hajjam El Hassani, Rony Darazi, Senior member, IEEE, and Emmanuel Andresz, "From fall detection to fall prevention: A generic classification of fall-related systems", *IEEE TRANSACTIONS ON SENSORS*, VOL. XX, NO. X, JUNE 2016

- [14] Yu-Hung Lu, Chung Chih Lin, "The study of smart elderly care system", 8th International Conference on Information Science and Technology, 2018
- [15] Basavaraj G M, Ashok Kusagur, "Vision Based Surveillance System for Detection of Human Fall", 2017 2nd IEEE International Conference On Recent Trends in Electronics Information & Communication Technology (RTEICT), May 19-20, 2017, India
- [16] Ravi Narasimhan, "Skin-Contact Sensor for Automatic Fall Detection", 34th Annual International Conference of the IEEE EMBS San Diego, California USA, 28 August - 1 September, 2012.
- [17] Marie Tolkiehn, Louis Atallah, Benny Lo and Guang-Zhong Yang, 'Direction Sensitive Fall Detection Using a Triaxial Accelerometer and a Barometric Pressure Sensor', 33rd Annual International Conference of the IEEE EMBS Boston, Massachusetts USA, August 30 - September 3, 2011
- [18] Ronald Nocua, Norbert Noury, Claudine Gehin, Andre Dittmar and Eric McAdams, 'Evaluation of the autonomic nervous system for fall detection', 31st Annual International Conference of the IEEE EMBS Minneapolis, Minnesota, USA, September 2-6, 2009.
- [19] Yi He, Ye Li, and Shu-Oi Bao, 'Fall Detection by Built-In Tri-Accelerometer of Smartphone', Proceedings of the IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI 2012) Hong Kong and Shenzhen, China, 2-7 Jan 2012.
- [20] Mezghani N, Ouakrim Y, Islam MR, Yared R, Abdulrazak B., "Context aware adaptable approach for fall detection bases on smart textile.", In: 2017 IEEE EMBS International Conference on Biomedical and Health Informatics (BHI). ; 2017.
- [21] Tong L, Song Q, Ge Y, Liu M. "HMM-Based Human Fall Detection and Prediction Method Using Tri-Axial Acceleromete", IEEE Sens J. 2013;
- [22] Aguiar B, Rocha T, Silva J, Sousa I., "Accelerometer-based fall detection for smartphones" , In: 2014 IEEE International Symposium on Medical Measurements and Applications (MeMeA). ; 2014:1-6. doi:10.1109/MeMeA.2014.6860110.
- [23] S. KHAWANDI, A. BALLIT, B. DAYA, "Applying Machine Learning Algorithm In Fall Detection Monitoring System" , 2013 5th International Conference on Computational Intelligence and Communication Networks 978-0-7695-5069-5/13 \ \$26.00 © 2013 IEEE\
- [24] <http://www.who.int/mediacentre/factsheets/fs344/en/> (accessed on 7 January 2019).