International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 06 | June 2022 www.irjet.net p-ISSN: 2395-0072

A Review Paper on Elderly Fall Detection

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Abstract - *According to World Health Organization (WHO), falls are the second driving cause of accidental deaths around the world after road accidents. For elderly adults, fall could be highly risky and might cause life threatening health issues. It can be critical if the injured person does not get quick assistance. Due to the ever growing population of elderly people, there is a dramatic increase in fall detection. Therefore a fall detection system is used to detect a fall and to provide fast assistance for the person who is prone to fall. Currently multiple ideas exist to prevent the elderly from falling by means of technology. The main purpose of this review is to highlight some of the previous studies used for elderly fall detection.*

***Key Words*: Fall detection, Elderly care, Elderly Population, Injury.**

1. INTRODUCTION

Fall is an unplanned descent to the ground with or without injury. Fall accidents form one of the most important health problems in the ageing population. Lack of balance and fall might be symptoms of serious health issues. In this paper Elderly people are mainly focused because they are groups of people who are prone to illness and are not capable of protecting themselves and are most probably left unaccompanied at homes. Falls can cause physical injury and mental trauma which can even lead to anxiety and depression in elderly people. Nevertheless of the cause for a fall, it can be critical if the injured person does not get quick assistance. In recent years, the declining birth rate and aging population have gradually brought countries into an ageing society. Especially in India elderly population will increase to 12% of the national population by 2025 with 8%-10% requiring utmost care. Hence a fall detection system is an important component for elderly care. Fall detection system is needed to detect a fall and to provide fast assistance to the elderly person.

2. FALL DETECTION METHODS

Thavavel Vaiyapuri *et al.* proposed An Internet of Things (IoT) enabled elderly fall detection model using optimal deep convolutional neural network [1]. Firstly, an IoT device captures the input video. The input video is then pre-processed in three levels like resizing, augmentation, and min-max based normalization. Then for feature extraction Squeeze Net model is employed to extract useful feature vectors for fall detection. Finally, a Sparrow search optimization algorithm (SSOA) with variational autoencoder (VAE) based classifier is used for the classification of fall and non-fall events. In case of a fall event, an alert is given to the caretakers via smartphone. The experiment highlighted performance with the maximum accuracy of 99.57%.

Deok-Won Lee *et al.* proposed the double check method using the Inertial Measurement Unit (IMU) sensor and mobile robot [2]. A subject wearing the IMU sensor randomly repeats several actions like falling, standing, sitting and walking. The collected data sets are then input to the trained Recurrent Neural Network (RNN) based fall detection model and results are monitored. The IMU sensor is used to continuously track the user's movement in real time. If a fall is detected, the robot moves to the corresponding area using the location information provided by the IMU sensor. The robot then acquires images using RGB sensors mounted on it. These RGB images are the input to the CNN algorithm and thus it double checks whether a fall truly occurred. This method gives 100% accuracy. The proposed method increases the cost and time of falls but could minimize the occurrence of false alarms and maximize the fall detection precision.

X.Cai *ei al.* proposed a multichannel convolutional fusion dense block strategy for fall detection [3]. The dense block strategy is used to obtain rich information with its densely connected layers and can compress network with less computation and fewer parameters, which will be beneficial for the fall detection. The process of this method is divided into testing and training phase. Ten consecutive frames are input into both phases to make use of spatio-temporal information. The feature map contains both spatial and temporal information obtained from input frames. To train the model supervised learning is applied. During testing phase classification result can be obtained. The proposed method gives 96.6% accuracy.

Yen-Hung Liu *ei al.* proposed a pose estimation based fall detection algorithm using RGB camera [4]. The data set used is highly imbalanced, which meets real-world situation. OpenPose is used to extract the skeleton information from the images. Then feature extraction and feature scaling is done to help the model learn more effectively. For classification, machine learning approach is used. An alarm will sound when the classification model detects a fall event. This method gives 94.2% accuracy.

Chalavadi Vishnu *ei al.* proposed a fall motion mixture model (FMMM) approach for human fall detection representing fall

and non-fall events [5]. Factor analysis is employed on fall motion mixture model to retain relevant attributes of a particular fall or non-fall videos. The efficacy of the proposed method is demonstrated on varieties of surveillance video datasets consisting of narrow angle camera, wide angle camera, and multiple camera views. This method gives 96.6% accuracy.

Hamidreza Sadreazami *ei al.* proposed a radar based fall detection method based on time frequency analysis and deep learning [6]. The data is collected in room environment and is then pre-processed to determine the target range bin. To each return radar signal a short time fourier transform is applied to obtain the spectrogram for different fall and non-fall activities. The spectrograms are processed to obtain binary images and then using morphological operators it is enhanced. Using class-preserving transformations the binary images are augmented and fed into the proposed convolutional neural network for feature extraction. This method distinguishes falls from non-falls with accuracy 98.37%.

Khadija Hanifi *ei al.* proposed a Doppler radar signals are divided into windows and each window is first preprocessed to filter [7]. When a window is classified as a fall, following windows are further processed to extract and monitor the person's vital signs using the developed algorithm. During vital signs monitoring, if a major movement is detected, the system assumes that a fall is detected and sends alarm to the caretaker via emergency contact. The proposed model gives 95.3% accuracy.

Diana Yacchirema *ei al.* proposed IOT and ensemble machine learning algorithm based fall detection system for indoor environment [8]. The wearable device is embedded with a 3D axis accelerometer for capturing the movements of elderly people in real time. The acceleration readings are then processed and analyzed using an ensemble random forest (RF) model. This model also alerts emergency services in case a fall is detected. The accuracy of this model is above 94%.

Oussema Keskes *ei al.* proposed a fall detection system based on skeletal data provided by a Kinect v2 camera. The skeletal data are in the form of graphs [9]. The skeleton data are in the form of graphs. Therefore, in order to use it to maximum advantage Spatial Temporal Graph Convolutional Network (ST-GCN) algorithm is required to handle such data in its native form. The spatial convolutional output is then fed into a temporal convolutional layer (TCN), which is used to extract the temporal features throughout successive frames. Finally, the resulting feature vector is fed to a Softmax classifier. This method achieved 97.33% accuracy.

Young-Hoon Nho *ei al.* proposed an automatic fall detector in a wearable device that can reduce risks by detecting falls and alerting caregivers [10]. The wearable device consists of a tri axial accelerometer and a heart sensor. A cluster analysis based user adaptive fall detection using a fusion of heart rate sensor and accelerometer was proposed in which the clusters are generated by normal instances, and any anomaly is considered as a fall. The best feature combination of heart rate and acceleration signals are selected through a two-step feature selection. This method achieved 92.22% accuracy.

Asier Brull Mesanza *ei al.* proposed a Support Vector Machine (SVM) based fall detection system which uses the data provided by a Sensorized Tip which can be attached to different Assistive Devices for Walking (ADW) [11]. The model uses two modules connected in series. The first one detects all falls, while the second differentiates between user and ADW falls. This latter module is designed to avoid false positives due to ADW accidental falls. Feature evaluation of training data set is implemented to detect the most relevant features to design each Machine Learning-based module. Once the training dataset is processed by the Random Forest Algorithm, a set of Support Vector Machines (SVMs) will be trained to implement algorithm of each module. The proposed approach provides high Fall Detection Ratios over 90%.

Xiangbo Kong *ei al.* proposed a skeleton based fall detection method to classify between sleeping on the floor and a fall accident [12]. The skeletal based method is used for simplicity purpose as it is easier to work on skeleton pose compared to a 3D shape. The images taken by the Time of Flight (ToF) camera is send to the edge node to detect the fall. The advantage of edge node is that it reduces computational cost. When a person falls the head joint speed is calculated to differentiate between a fall and a sleep. During a fall accident, the head hits the floor within 50 frames whereas when a person goes to sleep on the floor it takes more than 200 frames. When the head joint of the person is below the threshold it is detected as a fall.

Jixin Liu *ei al.* proposed a multilayer compressed sensing for visual shield sensing coding (MCS-VSSC) which is used to achieve visually shielded video frames [13]. The object features are extracted by an algorithm called block-weighted LBP-TOP (BWLBP-TOP). The MCS VSSC video frame results in blurring of the image which leads to lose of some information. Therefore, inspired by the structure of the GAN, a video classification model suitable for MCS VSSC data, called the private information-embedded classifier was proposed. In this way the problem of cloudy images is tackled. This method gives an accuracy of 97.61%.

3. CONCLUSIONS

Risk of fall is dangerous to all individuals, especially among elder population. Falls can result in complications ranging from fractures to death. If an elderly person lives alone and suffers a fall accident and is not saved in time, they may be in danger or even leads to death Fear of fall limits patient's social and physical activities and decrease patient confidence, which finally leads to depression. Therefore a fall

detection system is necessary which could detect a fall and provide fast assistance by sending alert to the caretaker or hospital. A fall detection system can be applied for elderly care, such as nursing hospitals, health centers and at homes. Different detection strategies are reviewed for fall detection.

ACKNOWLEDGEMENT

We would like to thank the Director of LBSITW and the Principal of the institution for providing the facilities and support for our work.

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