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REVIEW ARTICLE

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Review on Fall Detection Techniques based on Elder People

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Abstract: Fall detection is a leading challenge in public health problemsespecially among elder people. To migrate the effects of falls, constant inspection is essential. The various techniques and products associated with fall detection currently been a major area of research for security purpose and health care industries. Taking care of the elders aggregates a major issue in the western societies. Smart homes come out as socially and economically feasible solution. This explores the various fall detection and prevention problems that leads to propose various fall detection systems to solve them. In this, classification associated with falls and various approaches towards fall detection are surveyed. In this paper present a literature review within those categories and identify the approach of treating a fall as an abnormal activity to be a credible research direction.

Keywords: Fall Detection, Smart Phones, Wearable Devices, Vision based approach.

I. INTRODUCTION

Currently, lifestyle of elder people is regularly monitored in order to establish guidelines for rehabilitation processes or ensure the welfare of this segment of the population. In this sense, activity recognition is essential to detect an objectiveset of behaviors throughout the day [1]. A five-year likely research associated with an active ambulatory institutionalized population associated with older people more than65 years uncovered a yearly fall rate of 668 occurrences per 1000, and also increase in frequency for consecutive age ranges over the age of 75 years. Forty-five per cent of most subjects experienced at least one fall throughout the study period [2]. Various studies have shown that fall can depend upon the difference in the response and rescue time. Most of these facts can stress upon the importance of automatic fall detectors, to set up in living area of independent older adults.

Smartphones in the today's environment not only provide a channel for communication but it consists of group of embedded sensors for example digital compass, accelerometer, GPS, microphone and camera that are used to detect the daily routine activities. The modernresearch in activity recognition and fall detection has mostly focus elder people or sportsmen and patients with critical conditions. The ratio of elder people in today's civilization keeps on increasing, that led to force the people to live in medical care institute rather than living independently in their homes. Smart environments have come out as an alternative to support elder people who would like to continue residing individually within their homes. Gerontechnology [1]is used to enhance the period during which older people may reside on their ownwithin their protected environment together with the assistance of information as well as communication technologies, thus maximizing their vital and productive years and reducing the cost of care in later life. Although activities of daily living are useful to analyze user behavior, falls are the most important event that need to be detected. Although there are many mobile activity recognition systems, most of them lack battery draining, and in the last few years, developers have focused their efforts to tackle this problem.In a smart environment, the house should be able to inspect the daily routine activities of subject. It should also able to detect likely happened emergency situations such as any type of falls.

Various studies have been made that proposed various fall detection techniques based on various features provide for fall detection and on the accuracy provided. Various algorithms have already been offered for fall detection systems, therefore higher the complexity of choosing the most appropriate for adoption. Various algorithms tend to be offeredin order to primarily improved the performance based on various parameters such as sensitivity, specificity, accuracy, precision and recall.

The remainder of the paper is arranged as follows. In section 2-3consists of classification of falls followed by various fall detection techniques.Section 4 presents the various existing computational methods for fall detection, while in Section 5defining the related work on fall detection andcompares various existing fall detection techniques. Section 6-7defines the various gaps in study and hence concludes the paper.

II.UNDERSTANDING ELDERLY FALLS

Understanding different fall occurrences, its associated causes as well as their subsequent effects would directthe researchers, engineers as well as health care professionals to build up those methods in order to detect and prevent these uncertain circumstances.

A. Background on elderly falls

In accordance with the WHO, the effects associated with falls is growing worldwide. Actually around 28-35% of individuals aged of 65 and also over fall every year growing to 32-42% for the people more than 70 years of age [3].The fall rate is usually impacted by growing number of elderly. Approximately through the year of 2050 more than one in each group of five individuals will likely be aged 65 years or above [4].This kind of deviationwill probably stimulate an increased rate associated with fall related injuries. Thus, appropriate measures should be taken to endure the effect of its associated fallouts [5].

B.Causes of falls

The causes of falls are due to relation among many factors. Consequently, determining thevarious aspects may reduce the possibility of falling. Risk factors tend to be categorized in three dimensions, classified as factors related to the behavior, factors related to person, factors related to environment [5].

C.Identifying the possibility of falling

Using sufficient evaluation tools as well as methods, computable testing of numerous risk factors needs to be accomplished that reduces the possibility of falling [5].

D.Classification of falls

For all the previously mentioned factors, the need for assist arises. Defining various kind of falls, falls from walking or standing, falls due to coming from ladders etc.

III.CLASSIFICATION OF FALLS AND FALL DETECTION TECHNIQUES

Various types of falls are first analyzed that needs to understand the existing approaches towards fall detection. Various techniques might be of interest when examining several types of falls possibly from walking, standing or even due to coming from ladders etc. Various methods are introduced for fall detection based on the deployment of sensors as: wearable device based, ambience sensor based and camera (vision) based.

A. WEARABLE DEVICE BASED APPROACHES

Wearable devices based approaches is that in which sensors are connected to body of subject to find the motion and location of subject [6].

- Accelerometry-sense acceleration on one, two, or even three axes, provide analog or digital outputs.Development in the technology have brought in those devices that can determine activity making use of accelerometers.
- Fusion of accelerometry and posture sensors-Physiological reactions occurred due to changing pulse rate or even blood pressure may possibly depend on physical activity, which makes the estimation of motion and posture needed in supervising environment.

B. AMBIENT DEVICE BASED APPROACHES

Ambience based devices make an effort to combine audio as well as visual data and event detecting through vibrational data [6].

- Audio and video- Ambient based techniques tend to be traditionally established for the combined evaluation associated with audiovisual signals along with some other particular information including floor vibrational data or even microphone signals taken through environmental sensors.
- Event sensing using vibrational data-The detection associated with activities as well as changes using vibrational data are needed often such as monitoring, tracking and localization etc.

C. CAMERA (VISION) DEVICE BASED APPROACHES

Vision dependent recognition systems take advantage of cameras, positioned on overhead positions, to monitor as well as characterize a person's movement and test the incidence associated with falls. Because of this, various approaches with regard to image examining have been proposed including spatiotemporal features,3D head position analysis [6].

- Spatiotemporal- Shape modelling making use of spatiotemporal features offers essential information associated with human activities that is utilized in order to identify different events.

- 3D head position analysis-Head position evaluation is dependent on head monitoring that determines the occurrence of large movement inside the video sequence. Various state models are utilized to monitor the head based on the magnitude of the movement information.

IV.COMPUTATIONAL METHODS BASED ON DATA PROCESSING

Fall data processing techniques are dependent on the parameters derive from the deployed sensors.Analytical Methods or Machine Learning Methods can implement either onWearable, non-wearable or fusion systems for both fall detection and fall prevention.

A. Analytical methods

Analytical methods are conventional approach design to use mathematical models for attaining interpretation about data with regard to conjecture for example linear regression, time series, transformations. These techniques are generally thresholding methods assuming a fall usually noted wheneverpeaks, valleys or any other form functions inside data signals tend to be detected. These kinds of techniquesare generally utilized in wearable fall detectorsalong with inertial sensors to separate position (inactivity) as well as fundamental movement patterns (activity) [5].

Ambient based techniquesutilize event sensing methods by means of vibrational data which is helpful for supervising, monitoring as well as localization. Camera dependent systems utilize image processing techniques in which acquiring the spatiotemporal features to recognize lying as well as standing posture in the scene.

B. Machine learning methods

Machine studying techniques depend on complicated algorithm to obtain close up understandingupon data to calculate result choices [5]. Beginning with observations after which classification, wearable, ambient as well as camera dependent fall detectors can usually benefit from methods for example Support Vector Machine, Regrouping Particle Swarm Optimization, Gaussian Distribution of

Clustered Knowledge, Multilayer Perceptron, Naive Bayes, Decision Trees to detect and even predict future falls.

V.RELATED WORK

In the last decade, several review papers on fall detection are published that discuss different aspects of the fall detection problem involving various classification techniques, types of sensors and specific feature engineering methods.

Miguel Angelet al. [1] purpose the mobile activity recognition and fall detection system for elderly people using ameva algorithm.This approach uses data retrieved from accelerometer sensors to generate discrete variables. In order to achieve the goal, the core of the algorithm Ameva is used to develop an innovative selection, discretization and classification technique for activity recognition.

KabalanChaccour, et al. [5] presented an overall classification. They willhave dividedup fall detection methods into wearable dependent system, non-wearable dependent system and hybrid or fusion based system. They proposed the classification scheme based on the deployment of sensors to either detect or prevent falls.

Mubashir 120 et al. [6] existing study on fall detection methods using their fundamental algorithms. They will identify fall detection methods into three primary classes: wearable device based, ambience device based and vision based. Within each category, they review literature on approaches using accelerometer data, posture analysis, au-125 dio and video analysis, vibrational data, spatio-temporal analysis, change of shape or posture. They conclude that wearable and ambient devices are cheap and easy to install however, vision based devices are more robust for detecting falls.

Noury et al. [7] report a short review on fall detection with an emphasis on the physics behind a fall, methods used to detect a fall and evaluation criteria 90 based on statistical analysis. They discuss several analytical methods to detect 4 types of falls by incorporating thresholds on the velocity of sensor readings, detecting no-movements, acute conversion of the polarity of the acceleration vector resulting from impact shock and suggest that such methods will result in high false positive rates.

X.Yu et al. [8]provides a survey upon methods as well as and concept associated with fall detection with regard to elderly 100 patients. Yu first evaluate the different falls possibly from walking, sitting, standing, sleeping and then categorize various fall detection techniques as wearable and context-aware system. These techniques have been additionally, categorizing according to activity examination, posture analysis, proximity analysis, inactivity detection, and 3D head motion analysis. Yu further state the need for various algorithms need to combine with various sensors either wearable and vision sensors for providing improved fall detection solutions

Perry et al. [9] present a survey on real-time fall detection methods according to techniques which usually determine only 110 the acceleration, methods which combine acceleration along with other methods.

Hijaz et al. present [10] present a survey on fall detection and monitoring ADL and categorize them into ambient-sensor based, vision based and kinematic-sensor based approaches

Delahoz and Labrador [11] present a review of the fall detection and fall prevention systems along with qualitative comparisons 130 among various studies. They categorize fall detection systems based on external sensors and wearable devices that includes ambient sensors and vision based.They also discuss general aspects of machine learning based fall detection systems such as feature extraction, feature construction and feature selection.

Schwickert et al. [12] present a review of fall detection techniques using wearable sensors. One of the major focus of their survey is 145 to determine if the prior studies on fall detection use artificially recorded falls in a laboratory environment or natural falls in real-world circumstances. They observe that around 94% studies use simulated falls. They also discuss that accelerometers along with other sensors such as 150 gyroscopes, photo-diodes or barometric pressure sensors can help obtain better accuracy, and the placement of sensors on the body can be of importance in detecting falls.

Zhang et al. [13] present a survey of research papers that exclusively use vision sensors, where they introduce several public datasets on fall detection and 155 categorize vision based techniques that uses single or multiple RGB cameras and 3D depth cameras.

COMPARISON TABLE

Here, comparing the various existing techniques for fall detection based on various parameters as techniques used for fall detection, prevention from various types of falls.

Table 1:

Article	Year	Title of the paper	Technique Used	Fall types	Type of sensors	Benefits
Lee et al. [14]	2005	Intelligent emergency response system to detect falls in the home	Represents state the geometric orientation of the portrait, spatial orientation.	Detect fall lying down in 'tucked' position and in 'stretched' position.	Camera	fall-detection system could identifyfall positions while keeping a minimal occurrence regarding false security alarms.

Miaou et al. [15]	2006	Customized fall detection system using omnicamera images	Works on MapCam in order to record graphics as well as works image processing over pictures, by using height, weight and detection history adjust detection sensitivity.	Not specified	Camera	Along with the change associated with number of individual's height as well as width, obtain the associated thresholds
Vishwakarma et al. [16]	2007	Automatic detection of human fall in video	Apply two-state finite in order to constantly keep track of individuals and their activities.	Forward, sideways, backward falls	Camera	Using inside, outside as well as omni-video accurately identify individual falling person.
Cucchiara et al.[17]	2007	A multi-camera vision system for fall detection and alarm generation	Multi-camera vision method for finding as well as monitoring people	Not specified	Camera	A multi-client and multi-threaded transcoding server provides live video streaming to remote users in order to ensure effectiveness regarding received alarm.
Fu et al. [18]	2008	An Address-Event Fall Detector for Assisted Living Applications.	Contrast vision system intended to identify detect unintentional falls	Backward, forward and sideways falls	Camera	fall hazards tend to be instantly detected along with reduced computational effort
Lie et al. [19]	2010	A fall detection system using k-nearest neighbor classifier	Making use of kNN classifier as well as critical time difference, a fall detection technique is created.	Not specified	Camera	Activities are categorizing as: standing position, temporary position as well as lying down position.
Diraco et al. [20]	2010	An Active Vision System for Fall Detection and Posture Recognition in Elderly Healthcare	For automatic detection of falls, active vision system is developed.	Backward falls, forward falls, lateral falls	Camera	Data about 3D region of the centroid of individualsis combined with detection of activity.
Rougier et al. [21]	2011	Robust Video Surveillance for Fall Detection Based on Human Shape Deformation	During a video sequence considered the human shape deformation.	Forward falls, backward falls,	Camera	Fall is a vital element in order to identify, on the other hand the lack of movement soon after the fall is required for endurance. This system provides better performance.
Mastorakis et al. [22]	2012	Fall detection system using Kinect's infrared sensor	Velocity and inactivity calculations are performed, to detect whether fall has occurred.	Backward, forward and sideways falls	sensors	Able to discovering walking falls correctly without considering any kind of false positive activities.

F. De Backereet al. [23]	2014	Towards a social and context-aware multi-sensor fall detection and risk assessment platform	Both fall detection and fall prevention are identified.	lateral falls, Backward falls, forward falls	Camera	Improve flexibility, consistency and sensitivity
Miguelet al. [1]	2016	Activity recognition and fall detection using ameva	Monitors the daily life activities done by user	Sit, stand, walk, bend, any type of fall detected	Camera vision sensor	Increase the user acceptance and reduce the risk of forgetting.

VI. GAPS IN LITERATURE

There are several waysfor fall detection as mentioned before however there are several concerns that should be resolved. Most of the existing techniques are limited to some significant features of elder people.Some critical issues as low complexity and low runtime energy consumption are addressed.

Fall can depend upon the difference in the response and rescue time. To detect and even predict the fall, before it happens is a big challenging issue, thus system able to detect likely happened emergency situations such as any type of falls. When it comes to providing, high accuracy and better performance, sensor based systems lack consistency. Further research should in made in order to make system more automatic and without much intervention. The most of the existing techniques has certain shortcomings, because it has neglected many things some of them are:

- The use of efficient feature selection techniques can be done to improve the accuracy rate further for fall detection of elder people.
- Most of the existing techniques are limited to some significant features of elder people.
- The integration of feature selection technique and generalized simulated annealing have been ignored to improve the accuracy rate further for fall detection of elder people.

VII. CONCLUSION

In conclusion, the most important concepts of fall detection are studied. Understanding elderly falls and the cause behind falls are addressed. After introducing types of falls, various fall detection techniques are also addressed. Then the important existing fall detection methods based on data processing are defined. This review provides the various fall detection with older adults and hence compare the performance of varioustechniques based on parameters such as accuracy, features usedfor fall detection and prevention from various types of falls.

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