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A SURVEY ON FALL DETECTION SYSTEMS

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Abstract

Unobserved human falls can be dangerous and can badly affect health. Falls can cause loss of independence and fear among the older people. Sometimes falls may even lead to death. So, many fall detection systems have been developed in the recent past and still efficient fall detection systems are an area of research. This paper presents a study on many of the currently available systems to detect falls which includes fall detection based on many sensors like accelerometer sensor, camera, contrast vision sensor, etc. Also examined the problems with these solutions and identified their main features.

Keywords – Fall Detection, Ageing, Sensors, Accelerometer.

1. INTRODUCTION

Injuries occured due to falls are a huge problem among older generations and falls represents 40% of all injury deaths [1]. Falls are a great cause of fear and lack of confidence and independence among older people. Every 1 in 3 elderly suffers from falls each year. As the time delay between fall event and rescue time increases, the chance for death also increases. So a rapid response by directly reporting to care givers after the detection of a fall is very much important. Thus an efficient fall detection system with fall alert techniques including location and time in the alerts are very helpful.

In this paper, a survey on different fall detection systems are analysed which are based on different sensors. This include: accelerometer sensor, measuring the tilting motion and orientation of a device; gyroscope, adding an extra dimension to the information provided by the accelerometer by tracking rotation or twist; camera; contrast vision sensor, etc. The important aspect of fall detectors is, it may help to reduce the time delay in which the elderly remain lying on the floor after falling. This time is one of the key factors that determine the severity of a fall.

The fall detectors can be mainly classified into two types: ***context-aware systems*** and ***wearable devices.***

Context-aware systems use sensors placed in the environment to detect falls. In context-aware systems, the mainly used sensors are cameras, floor sensors, pressure sensors and infrared sensors. The main advantage of context-aware systems is that the person need not wear any special device to detect fall. But their operations are limited to the places where the sensors have been already deployed [2].

Wearable devices are small electronic sensor-based devices which are worn by the bearer under, with or on top of the clothes [3]. Most of the wearable fall detectors are in the form of accelerometer devices. Some of them work as a combination of other sensors such as gyroscopes to obtain the information about the patient's position in order to construct a more accurate fall detector. The main advantage of using smartphone as a wearable device is the availability of cheap built-in sensors included in smartphones.

2. LITERATURE SURVEY

2.1. Context-Aware Systems

Lee et al. [4] proposed a vision-based method for monitoring falls at home, in the year 2005. The system uses state and geometrical orientation of the silhouette, spatial orientation as well as speed of the centre of the silhouette. The different fall types considered are: fall lying down in a stretched position and fall lying down in a tucked position. The sensor used in this system is camera. The performance and efficiency of the fall detector is expressed in terms of sensitivity (SE) and specificity (SP). The sensitivity (SE) is the ability of a fall detector to accurately classify a fall event as a fall, while the specificity (SP) is the ability of a detector to accurately classify activities of daily living (ADL) as ADL [5]. The SP obtained was 80.5% and SE was 93.9%. Based on the height of the subjects, personalized thresholds are established.

Miaou et al. [6] have proposed a fall detection system using omni-camera images in the year 2006. The sensor used in this system is camera. The system considers ratio of people's height and weight for detecting falls. The efficiency of the system is found with a specificity (SP) of 86% and a sensitivity (SE) of 90%. In this system, finding a proper threshold statistically for different values of height or weight alone cannot improve the performance of the system.

Vishwakarma et al. [7] proposed an automatic detection of human fall in video in 2007. This system is able to detect sideways, forward and backward falls. The main features considered are aspect ratio, horizontal and vertical gradient distribution of object in XY plane and fall angle. The system uses camera sensor to detect a fall event. The system achieved a specificity (SP) of 100% and sensitivity (SE) of 100%. Both outdoor and indoor video having different types of possible falls are considered in this system.

Fu et al. [8] in 2008, presented a contrast vision system designed to detect accidental falls using a contrast vision sensor. The main feature used in this system for fall detection is change in illumination. The system will detect backward, forward and sideways falls. The performance of the system is declared as: 3 possible scenarios evaluated with positive results. Instantaneous motion vectors are evaluated and fall hazards are instantly reported with low computational efforts.

Anderson et al. [9] in the year 2009, suggested a 3D representation of humans (voxels) with the help of multiple cameras. The two levels of the fuzzy logic first find out a state and then the activities. At low level: silhouettes from each camera, to build a set of voxels and at an intermediate level: height, major orientation of the body, centroid, and similarities in the major orientation formed with the ground plane normal is found. The system is able to detect at least, falls forward, backwards, and to the side (showing recovery, trying to get back up, and stay motionless) using camera. The system got an SE of 100% and SP of 93.75%.

Rimminen et al. [10] presented a Fall-detection method using a floor sensor which is based on near-field imaging in 2010. Features used for detecting falls are related to the near-field imaging floor mainly the number of observations, the sum of magnitudes and dimensional features. The fall types include: backward to sitting, backward to lateral, arm protect, onto knees, rotate right and left, right and left lateral. Both SE and SP obtained was 91%. The fall-detection performance is also valid for multiple people in the same room.

Zhang et al. [11] in 2012, proposed a privacy preserving automatic fall detection system using RGBD cameras. The features used for fall detection are: Deformation and person's height. Fall from chair and fall from standing are the different fall types considered. The system achieved an accuracy of 94%.

2.2. Wearable devices

Lindeman et al. [12] in 2005, have proposed a fall detector placed at head level which is an acceleration based fall detection system using an external accelerometer sensor. The fall detection technique uses a Threshold Based Method (TBM) which is based on the spatial direction of the head, the impact and the velocity right before the initial contact with the ground. The corresponding fall types are: falls to the front, side with a 90° turn, back, back with hip flexion and falls backwards against a wall, while picking up an object and collapse. The system achieved high sensitivity and specificity. Accelerometers for detecting the fall are integrated into a hearing-aid housing, which was fixed behind the ear.

Zhang et al. [13] presented a Fall detector using machine learning strategies in the year 2006. The Machine Learning Method (MLM) includes: separation of magnitude and temporal features from the acceleration signal and one-class Support Vector Machine classifier. The system is wear at the waist. This external accelerometer based fall detector is able to detect soft fall and hard fall in the ground, stairs and slopes. The accuracy was found to 96.7%.

Bourke et al. [14] in 2007, done an investigation into the ability to discriminate between falls and Activities of Daily Living (ADL). The detection technique is TBM using information from the impact. The system designed is able to detect backward falls, forward falls and lateral falls left and right, obtained with legs straight. The fall detection system with accelerometer sensor is placed at trunk or thigh. For trunk SP is 100% and for thigh SP is 83.3%.

Li et al. [15] presented a fall detection system which uses both accelerometers and gyroscopes in the year 2009. It is a TBM analyzing the posture and the intensity of the activity. The system considers, sideways, forward, backward and vertical falls and falling on stairs and fall against walls ending with a sitting position, as a fall event. The device should be worn at chest or thigh. It got an SP of 92% and SE of 91%.

Shan et al. [16] conducted an investigation of a pre-impact fall detector in 2010. The MLM including, a discriminant checking apply to the time based statistical features to select the characteristics, and Support Vector Machine is used for performing fall recognition. The fall types includes: lateral falls left and right, forward falls and backward falls. The fall detector must be placed at the waist. The obtained SP and SE is 100%.

Lee et al. [17] performed a study on the sensitivity and specificity of fall detection system using mobile phone technology in the year 2012. Fall detection is done through TBM considering the impact. Backwards, forwards, lateral right and lateral left fall events are considered for fall detection. The system achieved SP of 81% and SE of 77%. The motion signals received by the phone are compared with the motion signals recorded by an independent accelerometer.

3. CONCLUSION

Fall detectors are important to provide a rapid aid to the fall victim inorder to avoid serious health problems. But fall detection is a complicated process. This review provides an analysis of several existing systems for fall detection as well as their classifications, in a chronological order and identifies the features of each of the systems.

The conclusion obtained is that, at present, there is no standardized solution for fall detection. Since accelerometer provides more accurate results, the best and efficient way to detect falls are by using accelerometer sensors. The latest trend in fall detection is smartphone based fall detectors. In future, for fall detection using smartphones, the efficiency of using other sensors like gyroscope and barometer in smartphones can be studied.

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