Vision based approach to human fall detection

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Abstract— Day by the count of elderly people living alone at home increases. Fall is one of the major risks for elderly people. Sometimes older people may get serious injury to their backbone (spinal cord) and that may lead to death. Sometimes fallen injured elderly may be lying on the ground for several hours after a fall incident has occurred. This makes it important to have a fall detection system. There is different approach to human fall detection such as sensor based, accelerometer, another possibility is camera based system. In this paper, we propose a novel and robust fall detection system. Our approach is based on motion history. Our algorithm provides promising results on video sequences of daily activities and simulated falls.

Keywords— Activity analysis, chute dataset, fall detection, openCV, Silhouette, motion history image, background subtraction

INTRODUCTION

The contents of each section may be provided to understand easily about the paper. Falls are one of the major risk for seniors living alone at home, sometimes causing injuries. Nowadays, the usual solution to detect falls is to use some wearable sensors like accelerometers or help buttons. However, the problem of such detectors is that older people often forget to wear them. Moreover, in the case of a help button, it can be useless if the person is unconscious or immobilized. To overcome these limitations, we use a computer vision system which doesn't require that the person wears anything. Another advantage of such a system is that a camera gives more information on the motion of a person and his/her actions than an accelerometer.

In this paper, we propose novel computer vision based fall detection system for monitoring an elderly person in a home care, assistive living application. In this work, two robust methods are presented based on two features: human centroid height relative to the ground and MHI based fall detection. Indeed, the first feature is an efficient solution to detect falls as the vast majority of falls ends on the ground or near the ground. However, this method can fail if the end of the fall is completely occluded behind furniture. Fortunately, these cases can be managed by using second MHI based human fall detection where we calculate angle of falling and if the falling object found below threshold angle then declared as a fall.

The paper is organize is as follow. In Section I we explain a literature survey regarding fall detection system, Section II will discuss silhouette based human fall detection system, Section III will handle algorithm of a system and in section IV we will see the results regarding the human fall detection system with quantitative and qualitative analysis. Finally we conclude the paper in section V.

I. LITERATURE SURVEY

Miao Yu et.al [1] author propose a more robust fall detection system based on estimating the density of a fall with respect to corresponding video feature, and falls are then detected according to the obtained density information. In this paper, a new fall detection system based on head tracking and human shape analysis. This system is composed of two calibrated cameras, and 2-D head tracking and human shape analysis are applied to both video recordings recorded by the two cameras both covering the area where a person performs activities are used. A more robust fall detection system can potentially be achieved by the combination of audio and video information, which is well known as multimodal processing, and another subset of one class classification technique, boundary method, will be used in future work for fall detection to cope with the high-dimensional feature situation.

Homa Foroughi et.al [2] Proposed Human fall detection based on combination of integrated time motion images and eigenspace technique. Applying eigenspace technique to ITMIs leads in extracting eigen motion and finally multi-class Support Vector Machine is used for precise classification of motions and determination of a fall event. We have considered wide range of motions, consisting normal daily life movements, some abnormal behaviors and also unusual events. While existent systems deal with limited movement patterns, we tried to simulate real life situations by Multi-class SVM classification system reduced the false detection considering wide variety of different postures.

Caroline Rougier et.al [3] Proposed method is based on the fact that the motion is large when a fall occurs. So, the first step of our system is to detect large motion of the person on the video sequence using the Motion History Image. When a motion is detected, we analyze the shape of the person in the video sequence. During a fall, the human shape changes and, at the end of the fall, the person is generally on the Ground with few and small body movements. A change in the human shape can discriminate if the large motion detected is normal (e.g.: the person walks or sits) or abnormal (e.g.: the person falls)

Ugur Toreyin1 et.al [4] proposed system Three state HMMs are used to classify events. Feature parameters of HMM are extracted from temporal wavelet signals describing the bounding box of moving objects. Since wavelet signals are zero mean signal it is easier to define states in HMMs and this leads to a robust method against variations in object sizes. In addition, the audio track of the video is also used to distinguish a person simply sitting on a floor from a person stumbling and falling. Wavelet signals can easily reveal the periodic characteristic which is intrinsic in the falling case. After the fall, the aspect ratio does not change or changes slowly. Since, wavelet signals are high-pass filtered signals, slow variations in the original signal lead to zero mean wavelet signals. This method could be inaccurate, depending on the relative position of the person, camera, and perhaps occluding objects. Similar HMM structures can be also used for automatic detection of accidents and stopped vehicles in highways which are all examples of instantaneous events occurring in video.

Nuttapong Worrakulpanit et.al [5] proposed a method which will compute acceleration value of human's movement for indicating the changing rate of human motions. In our assumption, human fall is high acceleration activity, whereas fast walking and running are considered as low acceleration activities. Thus standard deviation of C-Motion method together with the orientation standard deviation of the ellipse is able to discriminate actual fall from other activities. C-Motion method will return a high value computation result because this method considers velocity of motions.

Homa Foroughi et.al [6] proposed a novel method to detect various posture-based events in a typical elderly monitoring application in a home surveillance scenario. These events include normal daily life activities, abnormal behaviors and unusual events. Combination of best-fit approximated ellipse around the human body, projection histograms of the segmented silhouette and temporal changes of head position, would provide a useful cue for detection of different behaviors. Extracted feature vectors are fed to a MLP Neural Network for precise classification of motions and determination of fall.

Muhammad Jamil Khan et.al [7] proposed approach is based on a combination of motion gradients and human shape features variation.The estimation of the motion of the person allows detecting large motion like falls. But a large motion can also be a characteristic of a walking person, so we need to analyze further to discriminate a fall from a normal movement. To discriminate fall motion from other we use Global Motion Orientation to detect the direction of motion. An analysis on the moving object is performed to detect a change in the human shape, width to height ration α up to a certain threshold considered to distinguish fall from other activities.

Jared Willems et.al [8] proposed to study the existing fall detection algorithms. Not only the fall detection algorithm. On its ownbut the system set-up was presented. In this paper the use of low cost cameras is preferable because of cost-related issues and that it should be possible because most background subtraction algorithms don't need high quality video input. One of the most used and most simple techniques to detect a fall is the aspect ratio of the bounding box. A second method to detect a fall is the use of a fall angle. Some other algorithms make use of the centroid of the falling person. The last simple feature we want to present is the horizontal and vertical gradient [2]. When a person is falling, the vertical gradient will be less than the horizontal gradient. It is clear that all methods mentioned above do work only in specific circumstances. Therefore, it is necessary to combine a number of these techniques to get a reliable system to detect a fall.

II. PROPOSED SYSTEM

The proposed system is consisting of five main modules to detect fall from video.

1. Video acquisition from database or web camera
2. Background subtraction / motion detection
3. Preprocessing
4. Object tracking

5. Activity analysis

1. Video acquisition

The video was taken from real time web camera or from recorded videos. In proposed system we were working on Chute dataset. Dataset consist of fall video sequences which were recorded at different location like “Home”, “coffee room”, “office”, “lecture room” etc.

2. Background subtraction

In indoor environment, cameras were placed at fixed location. So background subtraction is little bit easy for such environment. In this case, background subtraction gives whole silhouette of moving object as well as edges. So task is to build a background which does not contain any foreground object. I proposed system we set first frame as a background image and next frames were subtracted frame background image.

The absolute difference between the background (V(x, y, t)) and current frame V(x, y, t+1) is given by

$$D\ (t+1) = |V(x, y, t+1) - V(x, y, t)| \ \ldots\ldots (1)$$

This difference image show the change in the intensity level for the pixel location which is changed in two frames. Threshold is applied on image to advance the subtraction. The equation for Thresholding is given by

$$\text{Binary} = \begin{cases} 1 & D < th \\ 0 & \text{else} \end{cases} \quad \ldots\ldots\ldots\ldots\ldots..(2)$$

Thresholding operation gives binary image. The output of the background subtraction is silhouette. The subtracted output need some enhancement for better results so we were applied some preprocessing Operations on subtracted image.

3. Preprocessing

Preprocessing is a step where image noise is removed by using Gaussian or median filter. Other way is a morphological operation. Morphological operations are used to selective extraction of image. Applying structuring element B on binary image A is defined by

$$A \ominus B = \{b + z |\ B_z \in E\} \ \ldots\ldots\ldots\ldots\ldots (3)$$

The dilation of A by the structuring element B is defined by:

$$A \oplus B = \bigcup_{b \in B} A_b \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

4. Object tracking

To track the silhouette area we need to calculate the centroid of the object. The centroid of the object is calculated as $xCi = \frac{\sum_i^k xi}{k}$, $yCi = \frac{\sum_i^k yi}{k}$............ (5)

Where, xi is the location of white pixel on x Coordinate, yi, is the location of white pixel on y Coordinate. With the reference of centroid of the silhouette we can track the foreground object.

5. Activity analysis

Fall detection is the complex task to recognize. Within the room there were few places where the person spends most of time in a day. So we need to place camera with a proper angle.

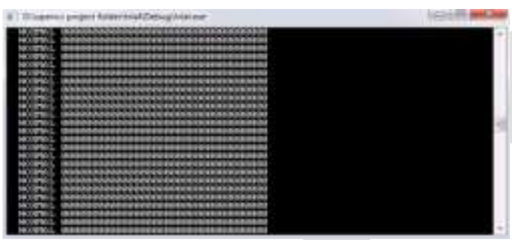
In proposed system, we consider a reference line which is at some height from the ground. If the centroid of the silhouette is found below reference line then consider as a fall else non fall.

III. RESULT

The results of proposed system are taking on the basis of Qualitative and Quantitative analysis.

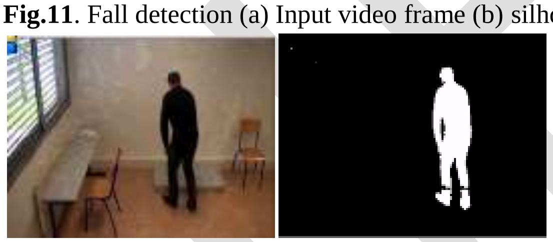
1. Qualitative analysis

(a) (b)



(c)

Fig.11. Fall detection (a) Input video frame (b) silhouette output (c) output shows fall detection



(a) (b)

(c)

Fig.12. Fall detection system (a) Input video frame (b) silhouette output (c) output shows normal activity

2. Quantitative analysis:

Quantitative analysis is done using three metrics viz. Detection rate, false alarm rate and success rate. These metrics are calculated based on following parameters:

1. **True Positive (TP):** Fall present and shown detected.
2. **True Negative (TN):** Fall not present, shown not detected.
3. **False Positive (FP):** Fall not present but shown detected, (also known as false alarms).
4. **False Negative (FN):** Fall present but shown not detected. (Also known as misses).

These scalars are combined to define the following metrics

$$\mathrm{DR} = \mathrm{TP}/(\mathrm{TP}+\mathrm{FN}) \quad \text{(6)}$$

$$\mathrm{FAR} = \mathrm{FP}/(\mathrm{TP}+\mathrm{FP}) \quad \text{(7)}$$

$$\text{Success Rate}(\%) = \mathrm{DR}/(\mathrm{DR}+\mathrm{FAR}) \quad \text{(8)}$$

IV. CONCLUSION

IN THIS WORK, WE IMPLEMENTED THE SYSTEM WHICH AUTOMATICALLY DETECTED FALL. OUR SYSTEM IS DESIGNED FOR ONE PERSON IN THE REAL TIME. THE IMPLEMENTATION OF THIS APPROACH RUNS AT 15-20 FRAMES PER SECOND. THE APPLICATION IS IMPLEMENTED IN C++ USING OPENCV LIBRARY IN WINDOWS ENVIRONMENT WITH A SINGLE CAMERA VIEW.

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