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Original Research Article

MOTION HISTORY IMAGE BASED 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. In this paper, we propose a MHI based fall detection system. Our approach is based on angle of falling. Our algorithm provides promising results on video sequences of daily activities and simulated falls.

***Keywords*-**Activity Analysis, Chute dataset, fall detection, Open CV, silhouette.

Introduction: 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

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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.

Proposed System:

MHI based human fall detection system

Overview:

Firstly, the detection system will analyze the movement of human. Therefore, the foreground segmentation method is employed for indicating human's location on the image. After that Motion History Image method is applied. This method provides information of movement. Next, the C-Motion method is calculated from Motion History Image. The calculated C-Motion value will describe the speed of movement. Later, the standard deviation of C-Motion value is calculated. This method provides the information about the changing rate of human motion. If this standard deviation value has high changing rate, it indicates that there is unusual activity. If this value has high changing rate, it shows that fall may arise, which verify after the fall arise by our defined conditions. If the calculated standard deviation value is high, then it indicates that fall may arise.

Motion History Image

Motion gives crucial information about fall, because no serious fall occurs without a large movement. Based on this observation, we decided to extract some motion information from the video sequence. Optical flow is commonly used to detect motion in a video sequence. But, optical flow is not well-suited for real-time application, and can generate errors in case of large movement as it happens during a fall. Another attempt to extract motion is the "Motion History Image" (MHI), first introduced by Bobick and Davis. The MHI is an image where the pixel intensity represents the regency of motion in an image sequence, and therefore gives the most recent movement of a person during an action. The MHI is commonly used for activity recognition.

To define a MHI, we first extract a binary sequence of motion regions (x, y, t) from the original image sequence I(x, y, t) using an image-differencing method. Then, each pixel of the Motion History Image $H\tau$ is a function of the temporal history of motion at that point, occurring during a fixed duration τ (with $1 \leq \tau \leq N$ for a sequence of length N frames) [34].

$$H\tau(x,y,t) = \begin{cases} \tau & \text{if } D(x,y,t) = 1 \\ \max(0, H\tau(x,y,t-1) - 1) & \text{otherwise} \end{cases}$$

The result is a scalar-valued image where more recently moving pixels are brighter. MHI is useful in our case, because it is not necessary for us to detect the direction of the movement, we want above all to quantify the motion of the blob of a person. The motion will be high in the case of a fall.

Foreground Segmentation: First, we need to extract the moving person in the image. For this purpose, we use a background subtraction method described in the article which gives good results on image sequences with shadows, highlights and high image compression.

Motion Gradient Estimation: 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.

Motion Gradient Image: Motion gives crucial information about fall, because no serious fall occurs without a large movement. Based on this observation, we decided to extract some motion information from the video sequence. Capturing a foreground understandable silhouette of the moving object or person is obtained through application of background subtraction technique. As the person moves, copying the most recent extracted silhouette as the highest values in the motion history image creates a layered history of the resulting movement; in general this highest value is just a floating point timestamp of time elapsing since the application was launched in milliseconds.

a. ***Timed* Motion History Image**

In this paper, proposed method use a floating point Motion History Image, where new silhouette values are copied in with a floating point timestamp. This MHI representation is updated as follows:

If current silhouette is at (x, y)

$$H\tau(x,y,t) = \begin{cases} \tau & \text{if } D(x,y,t) = 1 \\ \max(0, H\tau(x,y,t-1) - 1) & \text{otherwise} \end{cases} \quad \text{---------- (13)}$$

Where, τ is the current time-stamp, and is the maximum time duration constant associated with the template. This method makes our representation independent of system speed. We title this demonstration the *timed* Motion History Image (*t*MHI).

Fig.1 Time Motion History Image

b. Making Motion Gradients Image

Observe the right image in Fig.1 (tMHI) that if we took the gradient of the 0MHI, we would get direction vectors pointing in the direction of the movement of the body. Note that these gradient vectors will point orthogonal to the moving object boundaries at each “step” in the tMHI giving us a normal optical flow representation. Gradients of the tMHI can be calculated efficiently by convolution with separable Sobel filters in the X and Y directions yielding the spatial derivatives: S (x, y) x and S (x, y) y. Gradient orientation at each pixel is then:

$$\emptyset(x,y) = \arctan \frac{Sy(x,y)}{Sx(x,y)} \quad \text{------------ (1)}$$

We must be careful, though, when calculating the gradient information because it is only suitable at positions within the tMHI. The surrounding boundary of the tMHI should not be used because inclusion of non-silhouette pixels would be took part in corrupting the result of gradient calculation. Only tMHI inside pixels of silhouette pixels should be examined. Additionally, we must not use gradients of MHI pixels that have a contrast which is too low or too high in their local neighborhood. Applying the above criteria to the raw gradients yields a masked region of valid gradients. Next work is needed to estimate the magnitude of motion that as follow

$$M(x,y) = \sqrt{S_x^2(x,y) + S_y^2(x,y)} \quad \text{------------------ (2)}$$

After calculating the motion gradients, we can then extract motion features to varying scales.

c. Global Motion Orientation

Calculation of the global orientation should be weighted by normalized tMHI values to give more influence to the most current motion within the template. A simple calculation for the global weighted orientation is as follows:

$$\alpha = \frac{\sum_{(x,y)} angDiff\,(\phi(x,y), \phi_{mf}) * norm(\tau, \delta, tMHI_{\delta}(x,y))}{\sum_{(x,y)} norm\,(\tau, \delta, tMHI_{\delta}(x,y))} \quad \text{------ (3)}$$

Where,

α, is the global motion orientation,

Φ, is the base reference angle,

Φ **(***x*, *y***)** is the motion orientation map found from gradient convolutions,

norm (τ, **δ**, $tMHI_{\delta}$ (x, y)) is a normalized *t*MHI

angDiff (Φ(*x, y), Φ_{ref}*) is the minimum, signed angular difference of an orientation from the reference angle.

From above equation we can calculate angle of orientation (α) then set a threshold angle for fall. If the angle of orientation is found in some apart of lower side of circle then the activity is treated as a fall otherwise normal as shown in below fig.

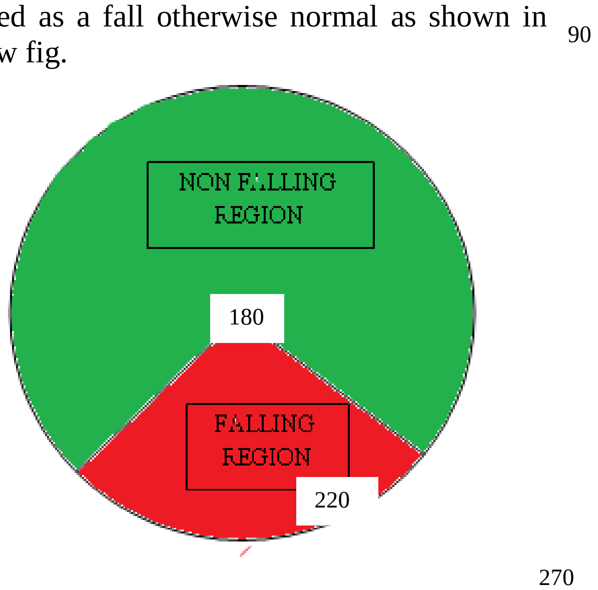

Fig.2. Concept of fall detection and angle of orientation using MHI

Above fig shows that angle of orientation. If the falling angle is found between 220^0 - 310^0 then we can classify as a fall otherwise not.

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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