International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Detection and Retrieval of Human Falls on Furniture using Hybrid Method

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Abstract*: *Automatic detection of human falls is very important to detect accidental falls at Medical places , and at places where elderly and vulnerable people living alone at home. Many methods have been proposed to detect human falls using various approaches, but cannot give accurate results in complex environments. This paper proposes a new hybrid method which detects falls and then retrieve relevant images. The proposed algorithm first calculates the features of hybrid methods and retrieve the similar images from the database using various methods. the proposed method achieves up to 97.5% precision and recall of 73%.

***Keywords:** Scene Analysis, GLCM, Wavelet Transform, Histogram, Human fall detection.*

I. INTRODUCTION

The American population aged over 65 is anticipated to grow from 12.4% in 2000 to 19.6% in 2030. Statistically, about one third of those aged 65 and above are likely to suffer falls which may lead to injuries such as fractures and illness [1] and [2]. If they don't get timely treatment sometimes these may get worse, and even lead to death. when people gets aged over certain age , muscles of these elderly people becomes feeble as they get older which worsens there balance. When these persons rise from sitting or relaxing on bed, there blood pressure may go down too much, which leads to chances of falls. These falls may occur not only while walking but also while sleeping on the bed, sitting on a chair. Attending these people manually 24/7 is impossible. Hence we require an automatic fall detection system which can detect falls immediately they occur.

Many Fall detecting systems were proposed in past in order to minimize consequences of these falls. A fall detection system is a platform which is capable of automatically detect falls of subject. The accessible systems are not successful detecting falls on complex background, particularly falls occurring on furniture having diverse features when compared to falls on floor.

Revised Manuscript Received on October 30, 2019.

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To regularly detect falls and simultaneously offer appropriate medicinal salvage, it is exceptionally essential to get a extremely precise fall detecting mechanism to be used in the above mentioned situations which is a big challenge to the already available methods. In order to detect falls researchers are interested in detecting falls and classification of actions and have done many of such works by including above explained concerns and many additional requirements. These techniques are sectioned to 3classes: based on wearable-sensor, method based on ambient-sensor, and method based on computer-vision.

A. Methods Based on Wearable - Sensors:

This method depends upon accelerometer and position and a combination of both where sensors are attached to the body of subject which automatically detect and generate alarms[3].the disadvantage of this method is that they might be heavy some times and may make the subject uncomfortable.

B. Methods Based on Ambient - Sensors:

These methods typically organize external sensors around persons' surroundings. The general features used to detect a person are audio, pressure and infrared array, vibration, etc. [4]. Some of them are provided in [5] by Rimminen et al and [6].

C. Methods Based on Computer-vision:

In Comparison with the other two methods, these methods are have higher accuracy ,less invasive, and robust. It widely uses Depth images that are collected by the Kinect, which are effected by the conditional changes of light and is able to detect the activity characteristics .these are based on a single camera. In [8], it obtains a human profile by using segmentation module for the video captured by the camera at the first step. To alleviate the drawbacks of the available methods described above, a new video based detection algorithm is introduced in this paper to detect human falls on furniture which hybrid method is hybrid method of wavelet and GLCM methods. The given algorithm achieve scene analysis using Wavelet based method , GLCM , and histogram methods and calculate their respective features and retrieves the similar images to reference image from dataset, by analyzing their difference in features the falls on the furniture are detected. one of the problem with other methods is that they detect falls only after they occur, but this proposed method retrieves even image having the person with similarities of fall by detecting falls even more earlier of their occurence .

II. RETRIEVAL AND DETECTION OF FALLS USING HYBRID METHOD:

A. Wavelet Transform:

Wavelets can be explained by presenting how they are different from Fourier transform. The time domain function f(t) describes a signal. Fourier transform F(ω)of a signal, where it takes frequency as input , and gives a complex number as output where real part gives the strength of the cosine of that frequency, and the imaginary part gives the strength of the sine.

Wavelets are defined as the signals which are confined to both scale and time ,and generally don't have a even outline. a wave with limited length and have zero as average value. they exhibits orthogonality which is best for representing compact signals ensuring that the information is not represented in excess. Original mother wavelet is decomposed to numerous scaled and shifted illustration of the original image/signal . the signal is decomposed into component wavelets using wavelet transform. The advantage of Wavelets is that it is capable to divide the very minute details in a signal/image. To differentiate extremely fine information in a image/signal, small wavelets are used, and large wavelets used to classify coarse information. several wavelets are available to be choosen from .the different kinds of wavelets are: Morlett and Daubechiees, etc [9], [10]. A specific wavelet can be chosen from the available wavelets.

A Ψ(t) is a mother wavelet which is limited in time domain that has two important properties,

$$\int_{-\infty}^{\infty} /\Psi(t)/^2 dt = 1 \qquad (1)$$

$$\| \Psi(t) \|^2 = \int_{-\infty}^{\infty} \Psi(t)\ \Psi(t)^* dt = 1 \qquad (2)$$

Wavelet transform is given as

$$wf(s,u) = f(t)\ \frac{1}{\sqrt{s}} \varphi^*(\frac{t-u}{s}) dt \qquad (3)$$

Inverse wavelet transform is given as

$$f(t) = \frac{1}{c_\Psi} \int_0^{\infty} \int_{-\infty}^{\infty} W\ f(s,u) \frac{1}{\sqrt{s}} \Psi(\frac{t-u}{s})\ du \frac{ds}{s^2} \qquad (4)$$

$$c_\Psi = \int_0^{\omega} \frac{/\Psi(\omega)/}{\omega} d\omega < \infty \qquad (5)$$

The wavelet transform is a method of selecting a basic wavelet function with zero integral in time-domain.

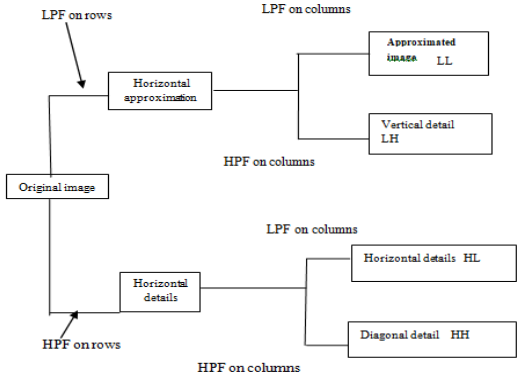

Fig1. Wavelet feature extraction

B. GLCM Feature Extraction:

GLCM stands for Gray-level Co-occurrence matrix. The GLCM collects information regards to pixel pairs of as it contains 2nd order statistics .It shows the way pixel brightness occurs in a image.

GLCM matrix is formed at different angles(in degrees of 0,45,90,135)and at a distance d=1. Harlick offers various measures i.e. energy ,entropy , contraast, correlation etc. The dimensions are calculated at various angles. A texture mentions - to touch smooth, silky and rough etc.

A GLCM texture calculates the relation between two pixels. The GLCM matrix is created by calculation of how often specific pixel intensity value take place in an image.

The GLCM properties can be given as :

A GLCM is square shaped and is symmetrical about the diagonal. Most of the neighboring cells are identical with less contrast. one level gray difference exits when the difference is 1 cell away from the diagonal.[11],[12]..the gray level difference increases As the distance from the diagonal increase. The texture is which are grouped in accordance with the degree. The features extracted are:

Contrast: it is a measure of difference in intensity values between neighbouring pixels . contrast is of 0 value for a constant image .

Range=[0,size(GLCM,1)-1)^2

$$\sum_{i,j=0}^{N-1} P_{i,j(i-j)^2} \qquad (6)$$

Correlation: It is a measure of correlation of each pixel value to its neighbour over the entire image which gives the linear dependency of neighboring pixel . For a perfectly positively/negatively correlated image,the correlation value is 1 and –1 and it is NaN to a constant image and correlation value Ranges [-1,1] and the formula is

$$\sum_{i,j=0}^{N-1} P_{i,j}(\frac{(i-\mu_i)(j(-\mu_j))}{\sqrt{(\sigma_i)^2(\sigma_j)^2}}) \qquad (7)$$

Energy: It uses texture which calculates orders in an image. Energy provides the sum of square elements present in a matrix. Its range is [0 1]. Its value is 1 for a constant image,.

$$\sum_{i,j=0}^{N-1} P_{(i-j)^2} \qquad (8)$$

Homogeneity: It is measure of the closeness between distribution of elements in the GLCM and its diagonal. The Homogeneity value of diagonal GLCM is 1 and its range is [0,1].Opposite of homogeneity values is contrast, which decreases exponentially from the diagonal. The weight used in contrast is given as (i-j)^2 and 1/1+(i-j)^2 in homogeneity ,it is.The equation is[11]

$$\sum_{i,j=0}^{N-1} P_{(i-j)}/R \qquad (9)$$

C. Using Histogram Values:

In image processing histogram is related to intensity values of pixel in an image.

A Histogram is a graph which Shows the number of pixels in a image at every different intensity values of a given image which means it gives frequency of pixel intensity values . There are 256 different possible intensities for a grey scale image. The Histogram values are even calculated of color images. For a color images individual histograms values are calculated of red , green and blue channels are used, or a 3-D histogram is formed ,with 3axes representing red, blue and green channels and the brightness of every point which represents the count of pixel. It is basically taken as picture of essential histogram in the required image format, or it can be data file containing he histogram statistics.[15]

The histogram can be used and changed using lots of image enhanceement operators. The Two operators closely related to histograms are histogram equalization and contrast stretching .They depends on the assumption of a image to utilize complete intensity range in order to display the maximum contrast. The Contrast stretching uses a image having the intensity values that can't span over full range of intensity and stretched linearly.

Histogram is used in image processing for image analysis and image equalization and also in image thresholding in computer vision.

III. PROPOSED HYBRID METHOD

A . Activity-Characteristics Of Human Fall:

The falling activities occurs due to numerous reasons most of them occur while walking, and most frequent when people lie or sit down on the like sofa or a chair. As most of these characteristiics are unique falls like falling on sofa and some of the human daily activity are alike whereas, the falling activities occurs due to numerous reasons most of them occur while walking, and most frequent when people lie or sit down on the like sofa or a chair. As most of these characteristiics are unique falls like falling on sofa and some of the human daily activity are alike whereas, traditional methods can't differentiate them from ADLs. Therefore, detecting the fall on furniture is a difficult issue. This algorithm first calculates the activity characteristics by calculating the features of each method like wavelet features, GLCM features or hybrid method and the last one using histogram. Then retrieves the frames with similar features from the hybrid method database.

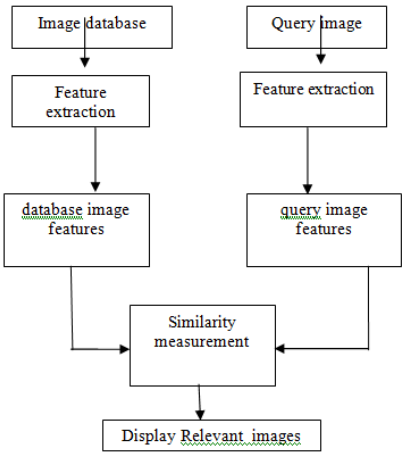

Fig.2. Block diagram of proposed method

B. Algorithm of fall and ADL recognition :

This paper proposes an algorithm to differentiate falls from ADLs activities based on extracted features from activity characteristics. given that there are n frames in the database. We define sample collection p ={p1,p2,p3,...,pn}, and each of these sample has m characteristics pi={pi1,pi2,pi3,...,pim}.calculate the distance between P_{ij} and μ_{ij} Y = $\mu_{ij} - P_{ij}$ (10)

Algorithm 1: Automatic Decision Engine

Input: sample collection p={p1,p2,p3,...,pn}.

k is the total number of class.

Output: C={c1,c2,c3,...,ck}

Steps

1. Calculate the wavelet coefficients and their standard and mean coefficient of an reference image , which are taken as wavelet features{p1,p2} and store them as a vector .
2. Extract the videos frames from the dataset and repeat the same process mentioned in step 1 for every frame (sample) in the dataset .These are taken as {m1,m2}for each frame.
3. $\mu_{ij}$is used to represent wavelet features of all the frame in the dataset. μ_{ij} ={mi1,mi2}.
   P_{ij} Represents wavelet features of reference image . P_{ij} ={p1,p2}.
   i represents number of frame
   j represents number of feature
4. calculate the distance between $\mu_{ij}$and P_{ij} i.e., Y= $\mu_{ij} - P_{ij}$
5. If Y=0 human fall detected .
6. Else no fall is detected.
7. Extract most similar image to the reference image.
8. When using GLCM method construct a GLCM matrix and GLCM coefficients like energy ,homogeneity etc. These values are taken as P_{ij} ={$\{P_{i1},P_{i2},P_{i3},P_{i4},P_{i5},P_{i6}\}$}
9. Then calculate the same for each frame in the dataset which are taken as $\mu_{ij} = \{\mu_{i1},\mu_{i2},\mu_{i3},\mu_{i4}\}$
10. Same process is repeated from step 4 to 6.
11. For the combination of wavelet and GLCM features repeat the process from 1to3 and 7to8. Then combine these features a P_{ij} ={ $P_{i1},P_{i2},P_{i3},P_{i4},P_{i5},P_{i6}\}$ and μ_{ij}={$\mu_{i1},\mu_{i2},\mu_{i3},\mu_{i4},\mu_{i5},\mu_{i6}\}$
12. Same process is repeated from step 4 to step 6
13. when using histogram calculate the histogram values of both reference image and frames from dataset.
14. same process is repeated from 4 to 6.

The features of every image is taken as input, and the distance between P_{ij} and $\mu_{ij}$to get the difference values.

Next, the decision factor is calculated by the differences between reference image and image database. It chooses the decision factor with minimum value to inorder to detect falls. Here, we extract three kinds of features (for three types of behaviours (walk, sit and fall). [14].

Wavelet Features: initially a reference image with a fall person is taken and wavelet transform is performed on it where it undergoes different levels of filtration process and gives wavelet coefficients. The mean deviation and standard deviation coefficients were computed and are stored ,in the sameway it is calculated for all the frames taken from the dataset. These features are then compared. The frames with high similarities with the reference image were retrieved. The retrieved images are those which have either the person is fallen or person having maximum similarities which may contain images of person of about to fall or falling. Through this we can detect a fall person and also when a person is falling.

GLCM method: initially an image with a fall person is taken and Gray level concurrence matrix is calculated. Using the GLCM matrix , required features like energy, contrast, correlation and homogeneity can be calculated and stored. Extracted video frames were taken and each frame is given to the algorithm, it calculates the GLCM features as given above. Later the features of image are compared with the features extracted from dataset. Then the frames with high similarities with the reference image were retrieved. These retrieved images are those which have either the person is fallen or person having similarities of about to fall or falling. Through this we can detect a fallen person and also when a person is falling.

Histogram method: histogram method also calculates the histogram values for both query image frames from dataset.

Hybrid method:The same process is done as mentioned in wavelet and GLCM method where similar images are retrieved . The paper proposes another method which combines the features of both GLCM and wavelet transform(hybrid method). In this method the GLCM features then wavelet coefficients are calculated as usual for the reference image ,then these are combined together .This process is repeated for the video taken frames from the dataset .these features are compared and the images similar to the reference image are retrieved from dataset. From the results it is observed that the results are more accurate when both the methods are used combinely than when used separately. Thi paper presents results of various activities for some ADLs(walk, sit on a chair ,lie on a sofa ,sit on a sofa) and two falls which are sit to fall and walk to fall using all three methods . When using wavelet transform on an ADL activities.

IV. RESULTS & ANALYSIS

The algorithm is tested using 'UR - fall detection dataset' [13] . This dataset contains 70 videos which are categorized into 40 ADLS and fall videos of 30. Initially frames were extracted from dataset videos by splitting the videos. This paper presents results of various activities for some ADLs(walk, sit on a chair ,lie on a sofa ,sit on a sofa) and two falls which are sit to fall and walk to fall using all four methods.

Precision :precision is explained as the capability of system in retrieving the similar images to the given query(reference) image.

Recall rate: It is measure of sensitivity. It measures the capability of given system as the ratio of number of similar image retrieved with their similar images in the database. In detail the results, presented are precision and recall which were calculated based on number of similar images retrieved for a given query image.

$$\text{recall} \frac{\text{number of similar image retrieved}}{\text{total number of similar images in the database}} \quad (7)$$

$$\text{precision} = \frac{\text{number of similar image retrieved}}{\text{total number of images in the database}} \quad (8)$$

Equations . (7) and (8) calculates the recall and precision for the given query image. The recall-precision value were presented in table 2 which was computed for the given query image. The paper presets results for various methods and are compared. Every activity have 20 similar images in the dataset but for observation only 15 images where retrieved in the output. When wavelet transform is used to detect fall behavior it can detect 53 out of 60 fall videos and 56 out of 60 fall videos when GLCM is used, 56 when histogram method is used and 59out of 60 when both wavelet and GLCM is used. From the results it is observed that the combination of both wavelet and GLCM is used.

Fig. 2 shows the graph of precision-recall for four methods. The given graph illustrate that the hybrid method is very effective and also robust for image retrieval. As mentioned in [16] and [17] Experimentally, when the number of similar images retrieved increases, the recall and precision improves. The most useful part of these methods is that they can retrieve not only fallen image but also those with person while falling when fallen person is given as query image. In comaprison to other three methods histograms retrives less number of similar images. Next stands the wavelet methods and then GLCM, but when both are used combinely yeilds greater resultswhich is hybrid method. Fig 3 shows the output of wavelet transform when a query image containing the image of a fallen person is given and contains the retrieved similar images. In the same way fig 4, 5,6 contains outputs of GLCM histogram and combination of Wavelet and GLCM methods, these outputs indicate that hybrid method gives more accurate outputs when compared to the other three methods.

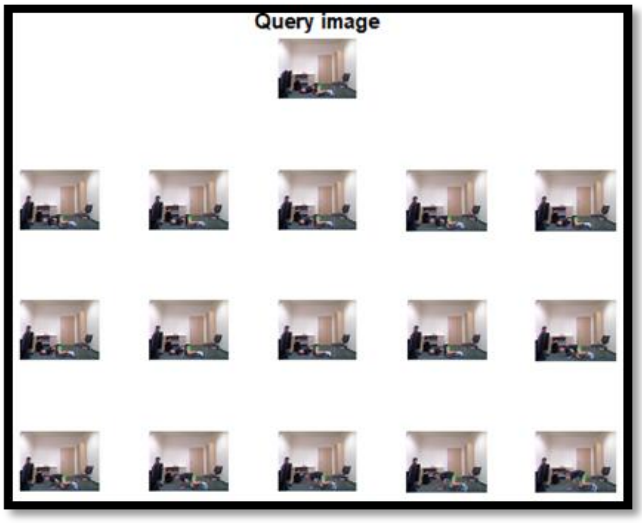

Fig3 : output of wavelet transform

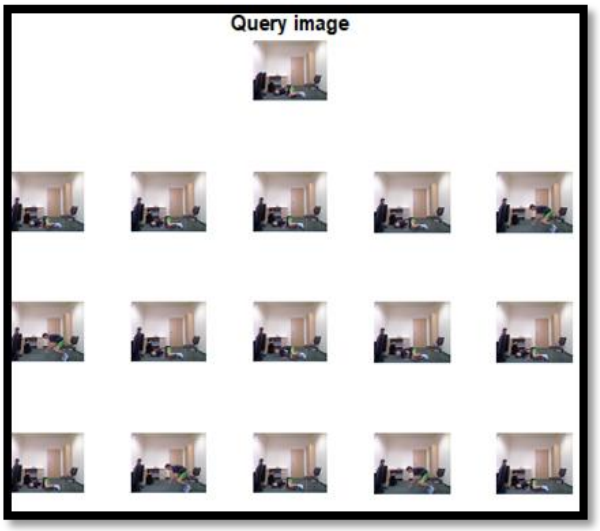

Fig5 : output of Histogram method

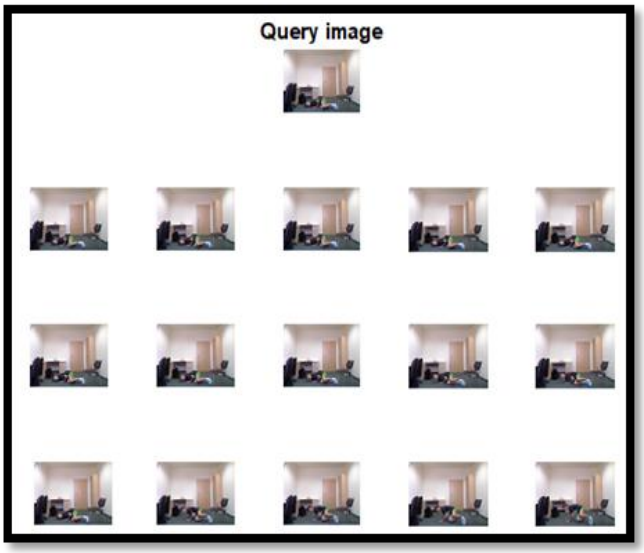

Fig4 : output of GLCM method

Table1.Experimental results of proposed algorithm

Total number of videos	No. of videos detected as falls			
	wavelet feature	GLMC features	hybrid method	histogram
30	27	29	30	29
30	26	26	30	25
30	27	28	29	28
30	25	27	30	27

Table2. Precision and recall values of proposed methods

Activity	Wavelet feature		GLCM feature		hybrid method		Histogram	
	Recall	precision	Recall	precision	Recall	Precision	Recall	Precision
Sit on chair	69	92.3	64	85	75	100	67.6	90
Sit on chair to fall	73.3	97.6	78.3	97.7	70	93.3	70	93.3
Adl walk	68.3	91	71	94.9	72	96.8	67.6	96.7
walk to fall	72	95.8	78	98	75	100	73	97
Average	70.65	94	72	93.9	73	97	69.5	94.3

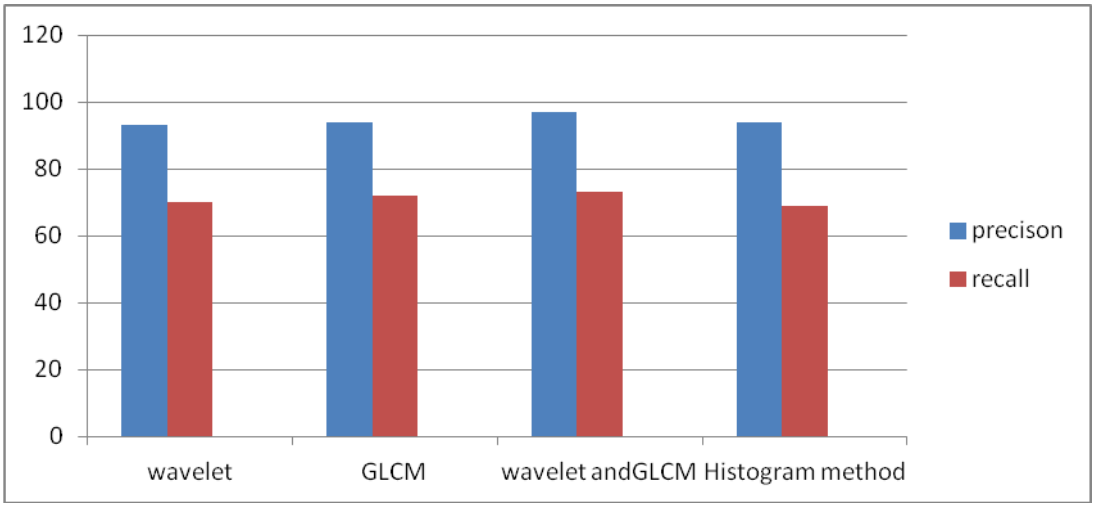

Fig 2 Precision –Recall Graph

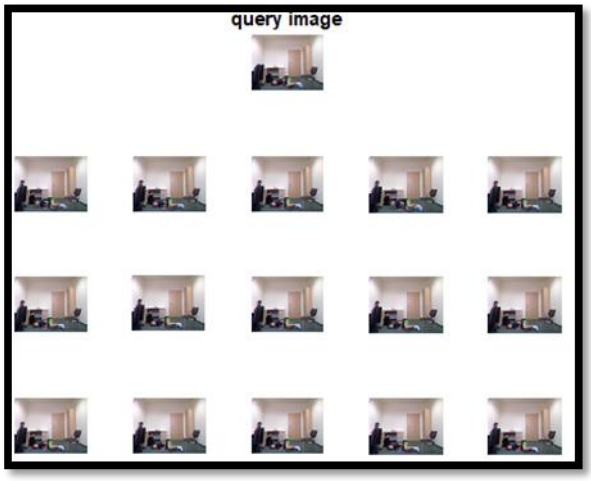

Fig6 : output of hybrid method

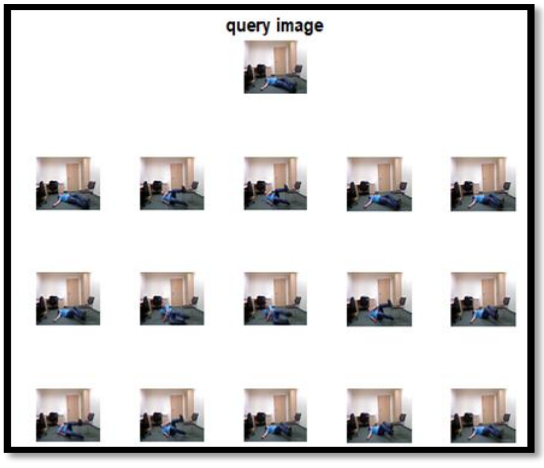

Fig8 : output of GLCM method when person while walking

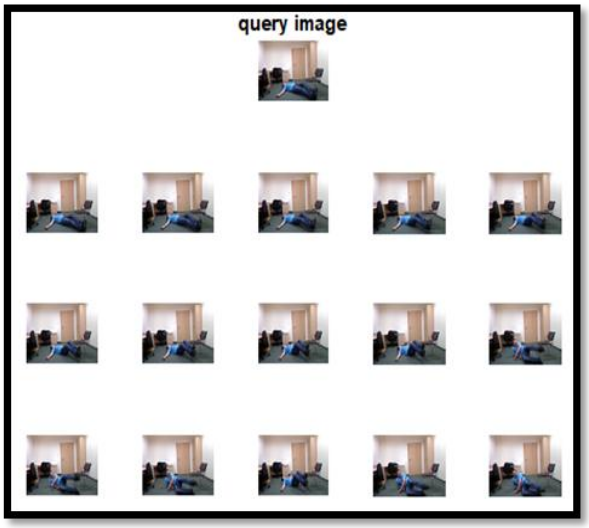

Fig10 : output of hybrid method while while walking

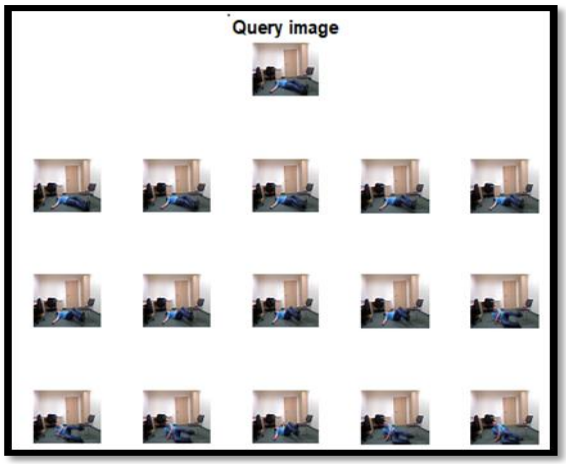

Fig7 : output of wavelet transform when person falls

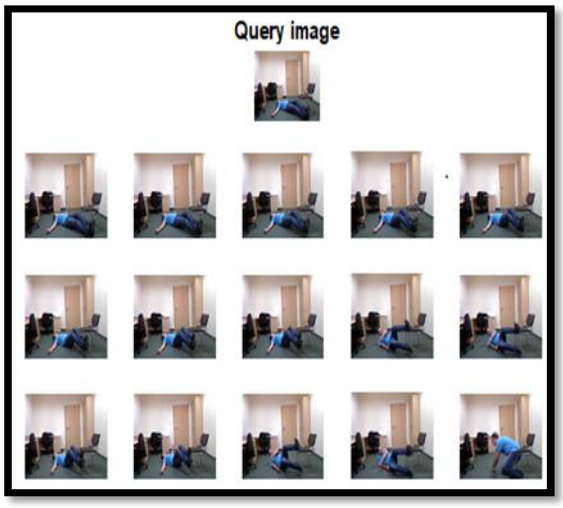

Fig9 : output of Histogram methodwhen person falls

The other noticeable advantage is that this algorithm can even detect falls when the person is in falling stage which is very useful. Every method obtains most similar images to the given (query) reference image.

Fig 7 to 10 are the outputs of all four methods when applied to dataset containing person falling while walking.

IV .CONCLUSION

Fall detection systems which are useful in detecting falls occurring with elderly persons or patients, are becoming increasingly important in surveillance to offer timely support in case of injury. This paper presents an algorithm which detects human falls using a hybrid algorithm .This can be used at home and in even in health care hubs. This algorithm extracts the features using hybrid method and retrieves the similar images from the dataset by comparing with the reference image features .The paper also efficiently compare the results obtained from hybrid method with the other feature extraction method and found to be more precisecompared to other methods . The advantage of this method is it can even retrieves similar images even when a person is about to fall.

REFERENCES:

1. C. Wang, S. J. Redmond, W. Lu, M. C. Stevens, S. R. Lord, and N. H. Lovell, ‘‘Selecting power-efficient signal features for a low-power fall detector,’’ IEEE Trans. Biomed. Eng., vol. 64, no. 11, pp. 2729–2736, Nov. 2017.
2. Cdc.gov, “Public Health and Aging: Trends in Aging — United States and Worldwide.” W. Min, H. Cui, H. Rao, Z. Li and L. Yao, "Detection of Human Falls on Furniture Using Scene Analysis Based on Deep Learning and Activity Characteristics," in *IEEE Access*, vol. 6, pp. 9324-9335, 2018.
3. P. Pierleoni, A. Belli, L. Palma, M. Pellegrini, L. Pernini, and S. Valenti, ‘‘A high reliability wearable device for elderly fall detection,’’ IEEE Sensors J., vol. 15, no. 8, pp. 4544–4553, Aug. 2015
4. ubashir M., Shao L Seed L. A Principles and approaches. Neurocomputing. 2013;100:144–152. doi: 10.1016/j.neucom.2011.09.037.
5. Rimminen H, Lindström J, Linnavuo M, Sepponen R‘’ Detection of falls among the elderly field.’’IEEE Trans Inf Technol Biomed. 2010 Nov; 14(6):1475-6.
6. Zigel Y, Litvak D, Gannot I“A method for automatic fall detection of elderly people using floor vibrations and sound--proof of concept on human mimicking doll falls” IEEE Trans Biomed Eng. 2009 Dec; 56(12):2858-67.
7. Yu M., Yu Y., Rhuma A., Naqvi S.M., Wang L., Chambers J.A. An online one class support vector machine- based person-specific fall detection system for monitoring an elderly individual in a room environment. IEEE J. Biomed. Health Inf. 2013;17:1002–1014.
8. Anderson D., Keller J.M., Skubic M., Chen X., He Z. Recognizing falls from silhouettes; Proceedings of the 28th Annual International Conference of the IEEE Engineering in Medicine and Biology Society; New York City, USA. 30 August–3 September 2006; pp. 6388–6391.
9. Othman Khalifa, “Wavelet Coding Design for Image Data Compression”, The International Arab Journal of Information Technology, Vol. 6, No. 2, pp. 118-127, April 2009.
10. A. Alice Blessie1, J. Nalini and S.C.Ramesh, “Image Compression Using Wavelet Transform Based on the Lifting Scheme and its Implementation”, IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 3, No. 1, May 2011.
11. P.Mohanaiah ,P.Sathyanarayana, L. GuruKumar “Image Texture Feature Extraction Using GLCM Approach” International Journal of Scientific and Research Publications, Volume 3, Issue 5, May 2013.
12. http://matlab.izmiran.ru/help/toolbox/images/enhanc15.html
13. Kwolek and M. Kepski, ‘‘Human fall detection on embedded platform using depth maps and wireless accelerometer,’’ Comput. Methods Programs Biomed., vol. 117, no. 3, pp. 489–501, Dec. 2014.

14. Rao, Z. Li and L. Yao, "Detection of Human Falls on Furniture Using Scene Analysis Based on Deep Learning and Activity Characteristics," in *IEEE Access*, vol. 6, pp. 9324-9335, 2018.
15. Abed, Mohammed & Salman, Dawood." Content based Image Retrieval based on Histogram. International Journal of Computer Applications." International Journal of Computer Applications 110(3):975-8887 · January 2015.
16. M. Narayana, Sandeep V.M, and Subhash Kulkarni, "Skeletal Distance Mapped Functional Features for Improved CBIR", International Congress for Global Science and Technology (ICGST)-GVIP Journal, Vol.11, Issue 3, pp.47-56, June 2011.
17. M. Narayana, Subhash Kulkarni, "Performance Evaluation of Distance Metrics: an Application to CBIR", International Journal of Advances in Science and Technology (IJAST), Vol. 4, No.3, pp-98-112, March 2012.

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