Journal of Theoretical and Applied Information Technology
15th December 2011. Vol. 34 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

IMPLEMENTATION OF AN INTELLIGENT SURVEILLANCE SYSTEM FOR ELDERLY

[1]S. KHAWANDI, [2]B. DAYA, [3]P. CHAUVET

[1] Phd student, University of Angers, Angers 49000-France

[2] Prof., Lebanese University, 813-Lebanon

[3] Prof., University of Angers, Angers 49000-France

E-mail: chadi.khawandi@etud.univ-angers.fr

ABSTRACT

One of three adults 65 or older falls every year. Injuries sustained among the elderly because of falls are a major problem worldwide. Demographic predictions of population aged 65 and over suggest the need for telemedicine applications in the eldercare domain. In this paper, we propose an intelligent surveillance system that monitors human activities with a particular interest of the problem of fall detection. To make the motion detection and object tracking fully automatic and robust under different illumination conditions, combination of best-fit approximated ellipse around the face and temporal changes of head position, would provide a useful cue for detection of different behaviors. The system identifies the face, collects data such as speed of movement, and triggers an alarm on the determination of fall event. Reliable recognition rate of experimental results underlines satisfactory performance of our system.

Keywords: *Intelligent System, Elderly Surveillance, Fall Detection, Face Detection, Webcam*

1. INTRODUCTION

Human society is experiencing tremendous demographic changes in aging since the turn of the 20th century. Thus with the population growing older and increasing number of people living alone, supportive home environments able to automatically monitor human activities are likely to widespread due to their promising ability of helping elderly people. Due to aging population, chronic diseases and their management costs are also on the rise. Another important issue is that elderly people are becoming more independent. As medical science advances, people can live with better health and alone up to a very advanced age. Therefore, to let elderly people live in their own homes leading their normal life, while, at the same time taking care of them requires new kinds of systems.

Intelligent vision-based surveillance systems are receiving a great deal of interest especially in the fields of personal security and assistance. These systems are built in order to accomplish several tasks from detection of human presence to recognition of their activities. In the past few decades, vision-based surveillance has been extensively applied on industrial inspection, traffic control, security systems, and medical and scientific research.

Many devices have been developed in the last few years for the falls detection [1][2][3][4], such as a social alarm, which is a wrist watch with a button that is activated by the person in case he/she suffers a fall, and wearable fall detectors, which are based on combinations of accelerometers and tilt sensors. However, these devices may present serious problems. The main problem with social alarms is that the button is often unreachable after a fall, especially when the person is panicked, confused, or unconscious. For the wearable sensors, these autonomous sensors are usually attached under the armpit, around the wrist, behind the ear's lobe or at the waist. However the problem of such detectors is that older people often forget to wear them [5][6][7], indeed their efficiency relies on the person's ability and willingness to wear them. To overcome these problems, we present a vision-based analysis approach for monitoring human activities with a particular interest to the problem of fall detection. The proposed system is based on image processing in real time; this system detects the face of a person in a given area, collects data such as the speed of movement of the person, and determines whether the person has suffered a fall;

Journal of Theoretical and Applied Information Technology
15th December 2011. Vol. 34 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

an alarm is triggered immediately upon the detection of a fall.

In this paper, we review some existing vision-based fall detection systems (section II), then we introduce our proposed system (section III) with additional technical details. The experimental results are presented in section IV and finally the conclusion in section V.

2. RELATED APPROACHES

Information Technology combined with recent advances in networking, mobile communications, and wireless medical sensor technologies offers great potential to support healthcare professionals and to deliver remote healthcare services, hence providing the opportunities to improve efficiency and quality and better access to care at the point of need. However, Computer vision systems try to extract some considerable features from video sequences of movement patterns to detect falls. The data provided by cameras are semantically richer and more accurate than standard sensors.

Recently some research has been done to detect falls based on using image processing approach. Some methods [10], [11] are based on analyzing aspect ratio of the moving object's bounding box; this method could be inaccurate, depending on the relative position of the person, camera, and perhaps occluding objects. Other methods [8], [12] used the normalized vertical and horizontal projection of segmented object as feature vectors. Some other approaches [9] detects falls using motion history image and human shape variation captured by though wall-mounted cameras to cover large areas. Other systems used the audio information or using 3D trajectory and speed of head to infer events [15]. These mechanisms tend to be more complex and need more additional cost. Despite the achievements that has accomplished in the recent years, there are still a main clear challenge to overcome:

With Visual fall detection; *what appears to be a fall might not be a fall*. Most of existing systems [11], [12], [13], [14] are unable to distinguish between real fall incident and an event when the person is lying or sitting down abruptly.

3. PROPOSED APPROACH

This paper proposes a monitoring system in a home environment with focus on fall detecting.

Firstly, the system starts by removing the background. After the silhouette is acquired, the next step is the skin color detection which is an effective way often used to define a set of areas likely to contain a face or hands; then the system detects the face; for this, the shape of the detected object is compared with an ellipse; then features extraction is involved (speed of person's movement, distance between face and webcam, percentage of face present) to be able to determines whether a fall has occurred, and triggers an alarm upon fall detection.

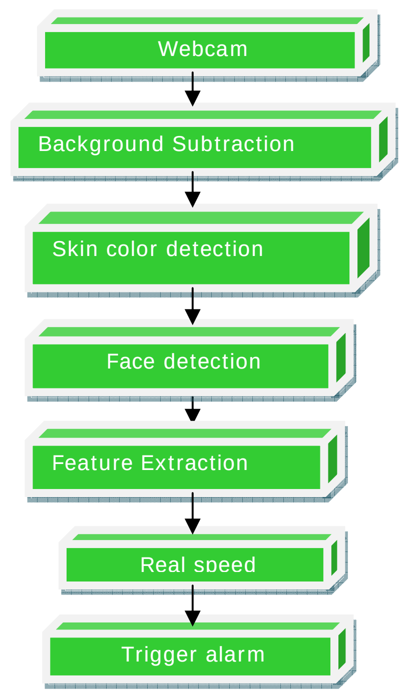

Fig. 1. Flow Diagram of Surveillance System

A. Background Subtraction

Background subtraction is a particularly popular method to detect moving regions in an image by differencing between current image and a reference background image in a pixel-by pixel way.

Fig. 2. a) Captured image; b) Image after background subtraction

Journal of Theoretical and Applied Information Technology
15th December 2011. Vol. 34 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

B. Skin color and HSV detection

The images captured by the webcams are then processed by the system to detect skin color. This is an effective technique for determining whether an image contains a face or hands. In this technique, the appropriate threshold values are defined for all the pixels in a color space. Different color spaces are used to represent skin color pixels: RGB, RGB standard, HSV (or HSI), YCrCb, and HSV. After the detection of skin color pixels, image filtering (erosion and dilation) is carried out.

Fig. 3. Image after skin color detection

C. Face Detection- Approximated Ellipse

After identifying the skin areas, it is necessary to distinguish the face. For this, the shape of the detected object is compared with an ellipse. This correlation technique is very effective and efficient. Based on the comparison with an ellipse, we may have more than one image; such as the hand. In order to solve this issue, each image will be converted into binary image (black and white) then the white contour will be replaced by black. In this state, the object representing the hand goes black but the object representing the face becomes black except the eyes and mouth. After this transformation, we compute the white surface in each picture and the object having the greater white surface is the one of the face and in this case it is detected.

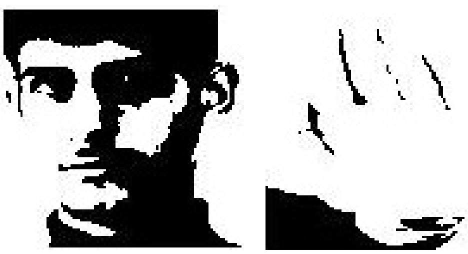

Fig. 4. Face and hand images in binary

Fig. 5. Inversed images for face and hand (white replaced by black)

Fig. 6. Images of face and hand without white contour

After calculating the white surface in each image, we found that the white surface in the face is greater than that in hand, that's why this intelligent system detects the face.

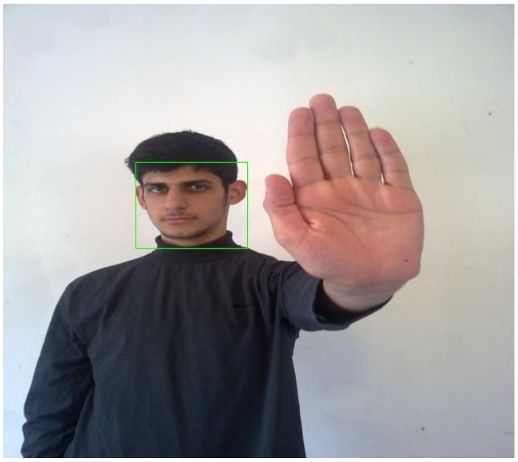

Fig. 7. Face detected

D. Feature Extraction

One major point in recognition system is the feature extraction, i.e., the transition from the initial data space to a feature space that will make the recognition problem more tractable. So we analyze the shape changes of the detected face in the video sequence. To this aim, three main features that retain the motion information will be determined:

Journal of Theoretical and Applied Information Technology
15th December 2011. Vol. 34 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

1) Distance between face and webcam

The distance (in percentage) between the face and the webcam is estimated by calculating the area of the detected face. (width * length) .
Depending on the surface of the object detected (detected face) we distinguish four cases:

TABLE I AREA AND DISTANCE

Surface	Distance
➢ 20000	So close
10000 - 20000	Close
7000 - 10000	Medium
4000 - 7000	Far

If the surface is less than the 4000 pixel, the face is very far from the webcam or it is not in the control area (in this case the surface is almost zero)

Fig. 8. Distance: so close, close, medium and far

2) Face presence

For the effective surveillance of an elderly person and detection of fall, a large field of view is necessary to track the person's movements in an area.
To satisfy this requirement, more than one webcam is used in the proposed system. The percentage of face in the images captured by a webcam is calculated. Thus, if the person moves away from the field of view of a webcam and the percentage of face present in each image captured by that webcam reduces, the control system automatically switches to another webcam. This percentage is obtained by using the following expression:

$$Z = X/Y = (width/width0) \times (length0/length)$$

TABLE II FACE PRESENCE

Z	Face Presence
$Z >= 0.95$	Good
$0.76 < Z < 0.95$	Acceptable
$Z < 0.76$	Weak

Fig. 9. Face presence: good, acceptable and weak

3) Planar speed and actual speed

The planar speed of movement is calculated using the following formula:

Planar speed = distance/time (pixel/s)
Distance: distance between two faces in consecutive frames (pixel)
Time: processing time between two consecutive images

The accuracy of fall detection depends on both the speed and the distance between the face and the webcam. The actual speed is defined as

Actual speed = planar speed × (1/Z)

TABLE III SPEED

Distance	Speed
0-20	Null
20-163	Normal
163-321	Medium
321-642	High

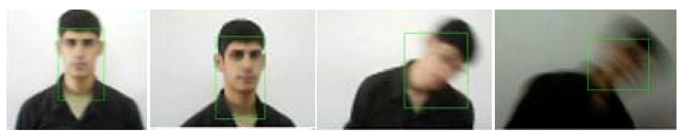

Fig. 10. Speed: null, normal, medium and high

4. EXPERIMENTAL RESULTS AND DISCUSSION

In our study, the video is considered as several captured images displayed successively. In order to evaluate the overall system performance, we apply the proposed approach to the captured images with single fixed camera monitoring static scene. In this section, we present the results obtained using the proposed surveillance system.

Journal of Theoretical and Applied Information Technology
15th December 2011. Vol. 34 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Fig. 11. Face detected/followed in different positions

The actual speed can be classified into the following categories:

- Low speed: 0–200
- Normal speed: 200–400
- Medium speed: 400–600
- High speed: 600 and above

Below, we present the results obtained for several frames captured using the proposed monitoring system

TABLE IV FALL DETECTION

Frame	Width	Length	Zoom (zoom %)	Actual speed	Remarks
1	84	85	15.32%	-	
2	98	93	15.19%	531.10	Medium speed
3	83	90	15.12%	421.72	Medium speed
4	81	92	15.28%	263.89	Normal speed
5	80	76	13.60%	217.43	Normal speed
6	84	82	15.32%	613.73	High speed →Alarm

5. CONCLUSIONS

Injuries sustained among the elderly because of falls are a major problem worldwide. 28%–35% people in the age group of 65 and over suffer at least one fall in a year. The risk of falling increases with age, and, in two cases out of three, the accident occurs at home. It has been observed that people who suffer a fall at home and are left unattended for an hour or more usually die within six months of the accident. The proposed system allows automatic fall detection by triggering an alarm upon the fall detection. The main limitation in this context is the the brightness and lighting conditions that can affect the face detection. Test results show that the system is reliable and reduce hospitalization costs by improving the living conditions of elderly people; also this work could be the first phase of implementing a network monitoring system for fall detection using more than one webcam.

REFERENCES

[1] N. Noury, T. Hervé, V. Rialle, G. Virone, E. Mercier. "*Monitoring behavior in home using a smart fall sensor and position sensors*". In IEEE-EMBS. Microtechnologies in Medicine & Biology", Lyon-France,Oct 2000; 607-610.

[2] N. Noury, A. Fleury, P. Rumeau, A.K. Bourke, G. O. Laighin, V. Rialle, J.E. Lundy, "*Fall Detection - Principles and Methods,*" 29th Annual Int. Conf. of the IEEE Engineering in Medicine and Biology Society, Lion (France), pp. 1663-1666, August 2007.

[3] N. Noury et al. "*A telematic system tool for home health care* ". Int. Conf. IEEE-EMBS, Paris,1992; part 3/7, pp. 1175-1177.

[4] B.G. Celler et al. " An instrumentation system for the remote monitoring of changes in *functional health status of the elderly* ". In, 2, N. F. Sheppard, et al., eds., Int. Conf.IEEEEMBS, New York, 1994, pp. 908-909.

[5] G. Coyle et al." *Home telecare for the elderly* "Journ. Of telemedicine and telecare 1995, 1,pp. 1183-1184.

[6] G. Williams et al. "A smart fall and activity monitor for telecare application ". *Int. Conf. IEEEEMBS, Hong-Kong*, 1998, pp.1151-1154Conference on, 13(16):493 – 498, 2008.

[7] Yamaguchi. "Monitoring behavior in home using positioning sensors" *Int. Conf. IEEE-EMBS, Hong-Kong*, 1998; 1977-79

[8] Arie Hans Nasution and S. Emmanuel; Intelligent Video Surveillance for Monitoring Elderly in Home Environments, *International Workshop on Multimedia Signal Processing* (MMSP), Greece, October 2007.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[9] Caroline Rougier, Jean Meunier, Alain St-Arnaud, Jacqueline Rousseau, "Fall Detection from Human Shape and Motion History Using Video Surveillance" Advanced Information Networking and Applications Workshops, 2007, *21st International Conference*, Vol. 2 (2007)

[10] B. T¨oreyin, Y. Dedeoglu, and A. C¸ etin. HMM based Falling person detection using both audio and video. In *IEEE International Workshop on Human-Computer Interaction*, Beijing, China, 2005

[11] S.-G.Miaou, P.-H. Sung, and C.-Y. Huang, "A Customized Human Fall Detection System Using Omni-Camera Images and Personal Information" *Proc of Distributed Diagnosis and Home Healthcare*(D2H2) Conference, 2006

[12] R. Cucchiara, A.Pratti, and R.Vezani, "An Intelligent Surveillance System for Dangerous Situation Detection in home Environments" , in *Intelligenza artificable*, vol.1, n.1, pp. 11-15, 2004.

[13] Nait CH, McKenna SJ. "Activity summarisation and fall detection in a supportive home environment", *Int. Conf. on Pattern Recognition* (ICPR), 2004

[14] Tao, J., M.Turjo, M.-F. Wong, M.Wang, "Fall Incidents Detection for Intelligent Video Surveillance" , *ICICS2005*

[15] C.Rougier, J.Meunier, A. St-Arnaud, J.Rousseau, "Monocular 3D Head Tracking to Detect Falls of Elderly People", *International Conference of IEEE Engineering in Medicine and Biology Society*, Sept 2006