



## CAMERA AND SMARTPHONE BASED AUTOMATIC UNUSUAL EVENT DETECTION SYSTEM IN INDOOR ENVIRONMENT

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### ABSTRACT

*Unusual events which happen at home like fainting have been a serious soundness exposure that decrease the enjoyment of life among society. It leads to implement a home based automated monitoring system like unusual or fall event detectors. A camera integrating a special algorithm was used to classify user's behavior and smartphone's accelerometer sensor was used to gather acceleration samples. After completing implementation of the project we did an experiment on our project. From experimental results we can see that the accuracy of the given algorithm was 91.4%, the precision was 91.6%, and the recall was 98%, demonstrating desired achievement of our approach in finding unusual situations.*

### Introduction

Unusual situations have become a most common reason of physical injury among people. As reported by the World Health Organization(WHO) more than five million individuals die every year as a outcome of injuries[1]. In these injuries, the main reason for death due to unusual event is the delay in calling or mailing necessary information about the unusual situation to caregivers. Unusual event may render a person paralyzed, that is to say, in these situations people need for an automated event detection system.

During the last years, so many researches have been made in detection of accident situations. There are three most common and useful types of unusual event detection systems. First of them is wearable sensor based event recognition system, in which the situation is analyzed by the sensor machines wore by an individual. Second of them is audio based unusual event recognition, in which Frequency elements of the fluctuation produced due to unusual event impact is used for recognizing the event. Last one is camera based accident recognition, in which the surrounding is regularly controlled by a video camcorder and an accident is recognized by analyzing the video.

In this research, we introduce a trustworthy approach using camcorder and tri-axial sensor based motion data from smartphone to recognize unusual situations with high accuracy and a little fake detections. Different motion data-giver technologies give information in a different views. An Unusual event like a fall is a move process of human body immediately. In this



process, human motion information build a particular acceleration signal. The acceleration data at a single time point is not enough to explain human acceleration procedure, but the acceleration signal of a period of time can bring to completion the acceleration information fullness. Therefore, we deal with an unusual event as a motion process and evaluate human body states by acceleration signals to recognize unusual situations which are happened at home. We chose camcorders as a main detector in our research. Because, with cameras we can record and analyze a human's movements easily. In our research, using cameras we detect human body condition change and inactivity position. If the user bring his or her smartphone in a pocket, it is good and in such kind of moment smartphone and camera based algorithms will work together. But sometimes people when they are at home, they may not carry their smartphones in pocket. Like this situations cameras take control of the situation.

This paper is organized as follows. In the section which is named "Related works", we have explained about related works in this research area. The next section which is named "Algorithm" explains the proposed automatic unusual event detection method. In the next section, the experimental results of this proposed method are presented. In the next section we gave our conclusions about this research and in the next last section we have listed a researches which we learnt and analyzed.

## **Related works**

Over recent years, several approaches have been addressed in detection of unusual or accident situations. We learnt and analyzed some of them. Especially, a fall detection research[2] proposed a new algorithm using data from accelerometer and hidden Markov model to recognize falls. A wearable gadget combining with a tri-axial sensor which gives an acceleration data was used to gather motion data from human body. Attribute succession were extracted from the motion information and used as a sequence of observations to train a hidden Markov model of fall recognition. Additionally, there are some video camcorder based researches of unusual event recognition sphere. These researches focused on detecting unusual events with cameras. In particular, a vision detection research[3] classified the stationary factors of aspect ratio and inclination angle to catch accident situations. A research[4] classified human postures using silhouettes and CNN and a research [5] investigated a person's angle, velocity, and rate with the KNN algorithms to identify unusual situations. Additionally, there is a normal activity identification algorithms to recognize pedestrian and non-pedestrian [6].

In addition, there are some activity detection researches with an accelerometer to investigate unusual events. The one of them[7] characterizes an efficient way of automatic fall detection. They aim at constructing an algorithm that automatically recognizes the fall of an elderly person and immediately informs about situation in charge of his/her well-being. Another smartphone accelerometer based research[8] investigated a method using an accelerometer sensor integrated in an android operating system based mobile phone, and evaluated some threshold based methods and sensor data to detect an accident situation. The advantage of using smartphone's acceleration sensors to recognize accident situations are portability and adaptability.



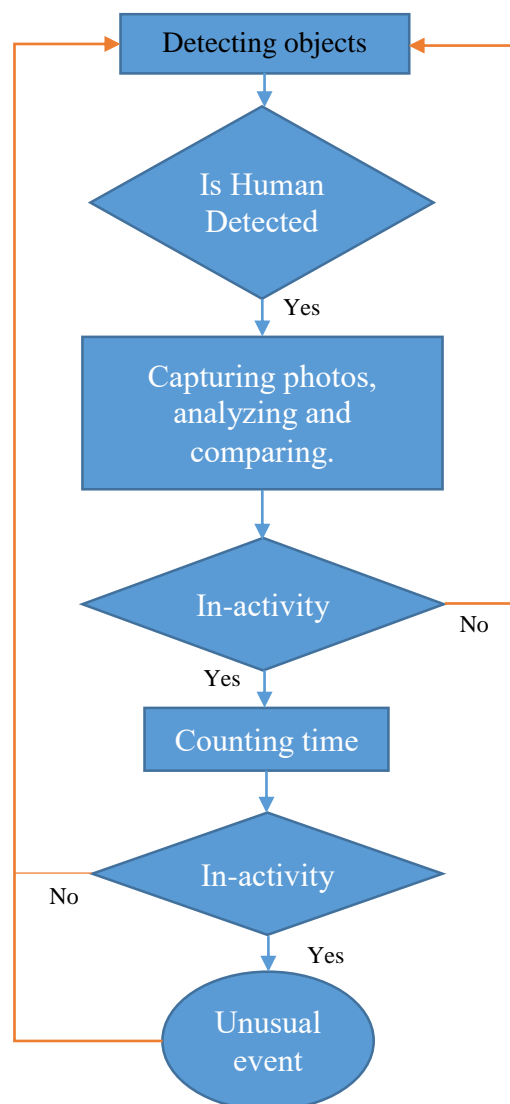
We extended our previous fusion researches [10, 11] to detect behavior events for boosting the accuracy performance. These researches combines accelerometer, audio, camera, GPS, Wi-Fi sensors to increase accuracy of every sensor.

## Algorithm

### *Vision classifier*

Before development of our algorithm, we collected and investigated more than 100 videos, which included people's daily activities who are at home. Based on what we have learned we created the algorithm for video cameras and smartphones, which can detect unusual event detection automatically.

Our algorithm of vision classifier is described in this section (shown in Figure 1). Initially, the system stays in the “Detecting objects” state. The system stays in this state until a human is detected. After that, the system moves to one of the most important part of the system which captures two photos every second. After capturing a photo this method analyzes human’s position, human’s activity and compares current photo with the next captured photo. This process lasts until detecting in-activity position or no human situation.



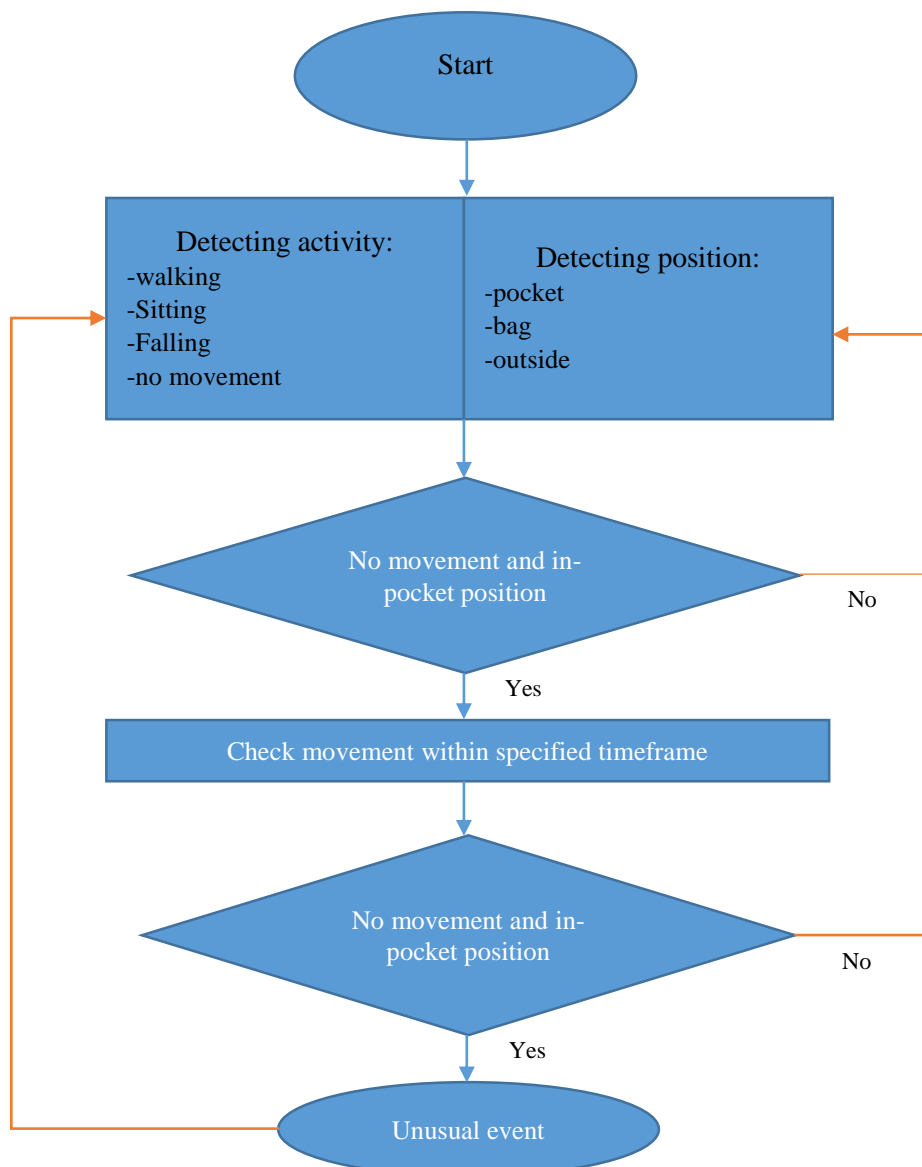
**Figure 1** Flowchart diagram for the vision classifier



When human's in-activity is detected, the system moves to the "Counting time" state. While counting time state, the system waits for a human's movement within specified timeframe. If there is still no movement at the specified time, an unusual event will be detected and the system comes back to the first part of the system.

### **Activity classifier**

In this section the algorithm of smartphone based activity classifier (Figure 2) is described.



**Figure 2. Flow chart diagram for activity classifier**

After starting process, the system comes to "detecting" method. This method has two parts. First of them detects user's activity like walking, sitting, falling, no movement and at the same time second part of the method detects position of the smartphone. For example in-pocket,



bag or outside positions are detected by second part of the method. This method works until no movement and in-pocket position are detected at the same time. Then the system moves to the next state which is called "Check movement within specified timeframe". In this state the smartphone based algorithm checks movement within specified time and if there is no movement within given time and the device still in-pocket position unusual event will be detected. After detecting unusual situation the system gives an alert and comes back to the initial part of the system.

### Experimental Results

To gather data samples of human motion we did an experiment to store acceleration frequencies and video records of every unusual events and activities of regularly life. 5 volunteers stimulated unusual events in 7 scenarios which are listed in Table 1. For example they performed common activities of regularly life comprising no-movement, sitting and falling. Every motion was repeated one by one 30 times. The total number of stimulations was 210 including unusual events and normal daily activities.

| Motion Process                    | Description  |
|-----------------------------------|--|
| No movement                       | Simulate doing no movement within long time  |
| Sitting on a sofa                 | Simulating no movement or small movement on a sofa   |
| Lying out of camera sight         | Sometimes cameras which are installed at home do not see objects. Such kind of moments our smartphone based algorithm will detect the situation. |
| Bathroom                          | Usually in bathroom there is no cameras and smartphones are also not brought to bathroom.  |
| Lying on a bed for a long time    | A human who lies on a bed does small movements and it can be cause for false unusual event detection.  |
| Doll in room                      | Testing camera based algorithm if it does not recognize a doll as a human.   |
| Falling down and no user movement | Stimulating a fall and no movement within specified time.  |

Table 1. Scenarios for experimenting

After gathering enough data, in order to test the recognition performance of proposed work, we calculated accuracy, precision and recall.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$



Where TP(true positive) meant that an unusual event existed and the system algorithm recognized it. FN (false negative) meant that an unusual event occurred but the system failed to detect it, FP(false positive) meant that the algorithm recognized an unusual event but there was no accident situation, TN(true negative) meant that the method did not recognize an unusual situation and the unusual situation did not exist.

|                                   | Overall | True positive | True Negative | False Positive | False Negative |
|-----------------------------------|---------|---------------|---------------|----------------|----------------|
| No movement                       | 30      | 29            | 1             | 0              | 0              |
| Sitting on a sofa                 | 30      | 29            | 0             | 1              | 0              |
| Lying out of camera sight         | 30      | 29            | 1             | 0              | 0              |
| Bathroom                          | 30      | 0             | 14            | 0              | 16             |
| Lying on a bed for a long time    | 30      | 29            | 1             | 0              | 0              |
| Falling down and no user movement | 30      | 30            | 0             | 0              | 0              |
| Doll in room                      | 30      | 29            | 0             | 1              | 0              |
|                                   | 210     | 175           | 17            | 2              | 16             |

Table 2. Experimental results of unusual event detection algorithm

Table 2. summarizes the experimental results of the unusual event recognition method. As we can see from the table the volunteers performed stimulation of unusual situation in seven ways. First stimulation is named “no movement”. In this situation(Figure 1) the volunteer stimulated normal movement and longtime no movements like unusual event 30 times and our system detected 29 of them clearly but one normal situation was detected as an accident situation. In the second case, volunteers stimulated just sitting on a sofa for a long time. In this situation we got excellent result. That is to say, there was 29 accident situations and just 1 normal situation and our system fully detected these situations.



Figure 1. Person detection via vision classifier

Next scenario is named “Lying out of camera sight”. We stimulated that situation, because camera which is installed at home can not see all sides of home. For example in some situation camera may not see user. In such a situations, if some unusual event happens with user, despite camera does not work, our smartphone application will detect that situation. Therefore we decided to stimulate this situation and our system detected all positions correctly. However if some unusual event occurs when user is in bathroom, our system can



not recognize it. Because, usually in bathroom there is no camera and user does not bring his smartphone to bathroom.

Our next stimulation is named “lying on a bed for a long time”. We decided to stimulate this scenario because when a human is sleeping, he/she does a little movements. Therefore some unusual event detectors may detect this situation as an accident situation. When we stimulated this situation we got excellent result. Our system detected all 29 true positive and 1 true negative stimulations perfectly.

Next unusual event stimulation is one of the most common situation around elderly people. It is named “Falling down and no user movement”(Figure 2). Our volunteers performed to stimulate this scenario 30 times and our system detected all of them perfectly.

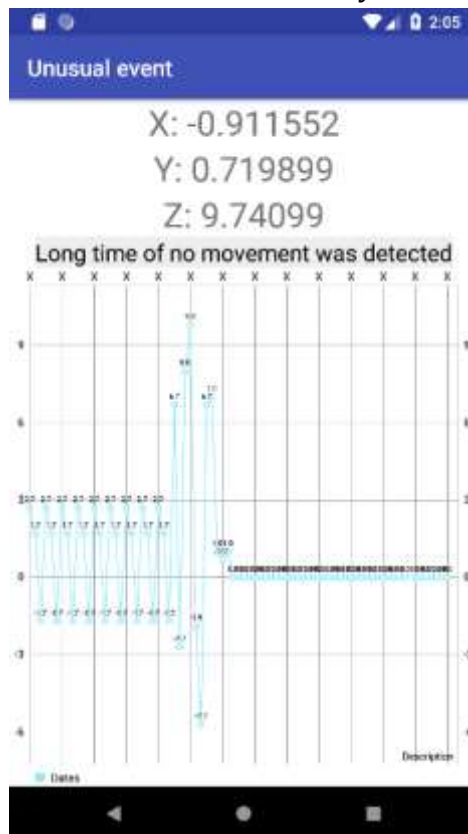


Figure 2. Smartphone application for the activity classifier

Our next stimulation is called “Doll in room”. In this situation we putted a doll like a human to room. And our system detected 29 true positives and just 1 false positive result.

| Accuracy | Precision | Recall |
|----------|-----------|--------|
| 91.4%    | 91.6%     | 98%    |

Table 3 Results of proposed work

Table 3 shows experimental results of the proposed work. From the results we can say that the accuracy of described algorithm was 91.4%, the precision was 91.6% and the recall was 98%. That is to say, the introduced work can recognize unusual situations efficiently.

### Conclusion

In this paper we have described a fusion algorithm of detecting unusual events using camera installed at home and accelerometer data retrieved from smartphone which is placed in human’s pocket. First of all, we gathered related works, analyzed them and made our own



algorithm. After completing the implementation, we tested our system and got excellent result. That is to say, the system achieved reasonable accuracy. In addition, the use of mobile phone and camera for detecting unusual event have the advantage of not carrying additional wearable technologies by the user and minimized cost by not buying extra technologies or gadgets. In our next researches, we are planning to make unusual event detector application for smartwatches.

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