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Personalized Unusual Event Detection Algorithm at Smart Home via Daily Activity and Vision Pattern

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Abstract

There currently are used smartphone applications and video camera systems for emergency detections in home environments. The mobile applications can identify the user behaviors to classify accident situations in indoor areas while carrying the phones on the body or the vision systems detect the video-based accident motions in a limited range of a camera installed at home. To compensate for these limitations, we propose a fusion algorithm to detect personalized unusual events like serious injuries and even near death at home via daily activity and vision pattern. We designed and implemented the fusion classification algorithm based on user activity detection with the smartphone accelerometer, and the behavior identification with a video camera installed at home. We evaluated both the activity and vision pattern algorithm, and simulated the fusion algorithm with high-accuracy performance in scenarios.

Key words: Unusual Event, Activity, Vision, Behavior, Emergency, Fusion, Home

1. Introduction

According to the 2012 report from Euromonitor International [1], the growth in the number of people living alone is rising. The proportions of single-person households by North American, Western Europe, Eastern Europe, and Asia are 27.6 percentage, 31.0 percentage, 27.4 percentage, and 8.8 percentage respectively in 2011. If some emergency situations like serious injuries or near death happen with them and nobody can come to their rescue or call 911 for them, they may be seriously wounded or continuously endangered and never receive help.

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There already exist some types of smartphone applications [2,3,4] and vision systems [5,6,7,8] to detect emergency situations. However, the applications require the users carrying the smartphone at all time to identify the users' behavior in indoor areas on the body. The video camera systems can detect the accident situations in a limited range of a camera installed at home, but the camera cannot cover the whole home areas. We define "unusual events" to be infrequently-generated behaviors of smartphone users, such as no physical activity or an extremely long stayed location.

We propose an efficient fusion algorithm to detect unusual events based on user activity pattern with the smartphone accelerometer, and the behavior identification with a video camera installed at home. The proposed activity classifier detects users' movement behavior(walking, small movement, no movement) to identify if they are in unusual situations. The vision algorithm with a video camera at home classifies human and objects identifies unusual events, but each detection accuracy was insufficient. We designed an extended vision algorithm to combine all of these vision detections for improving the accuracy performance. Finally, we developed a fusion algorithm for boosting the performance by combining all classification results.

In the Section 2, we begin by describing related works in this field. Section 3 describes the algorithms of individual and fusion classifiers, and then in Section 4 we provide evaluation and simulation results. The final Section 5 is the conclusion.

2. Related works

There are human activity detection researches [2,3,4] with an accelerometer to identify unusual events. These researches focused on detecting users' falling situations as unusual events with an accelerometer. The one research [3] describes 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.

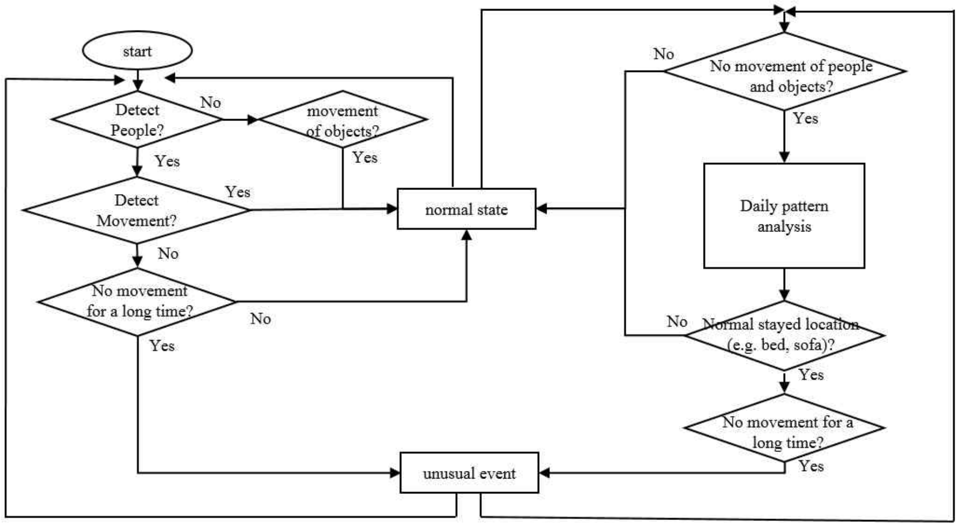
Some vision detection algorithms [5,6,7,8] have been used to identify unusual events with video cameras. These researches identify users' vision-based behaviors and extracted meaningful features to classify abnormal events. In particular, a vision detection research [5] classified human postures using silhouettes and CNN. A research [6] investigated a person's angle, velocity, and rate with the KNN algorithms to identify unusual situations. Additionally, there is a normal behavior identification research to detect pedestrian and non-pedestrian [9].

We extended our previous fusion researches [10,11] to detect behavior events for boosting the accuracy performance. These researches combines accelerometer, audio, camera, GPS, WiFi sensors to improve each senser's accuracy. An individual classifier algorithm with only using one sensor provides a limited performance as well as its accuracy is varied in a variety of research domains. We designed the fusion algorithm to boost unusual event detections in home environments with our previous research experience.

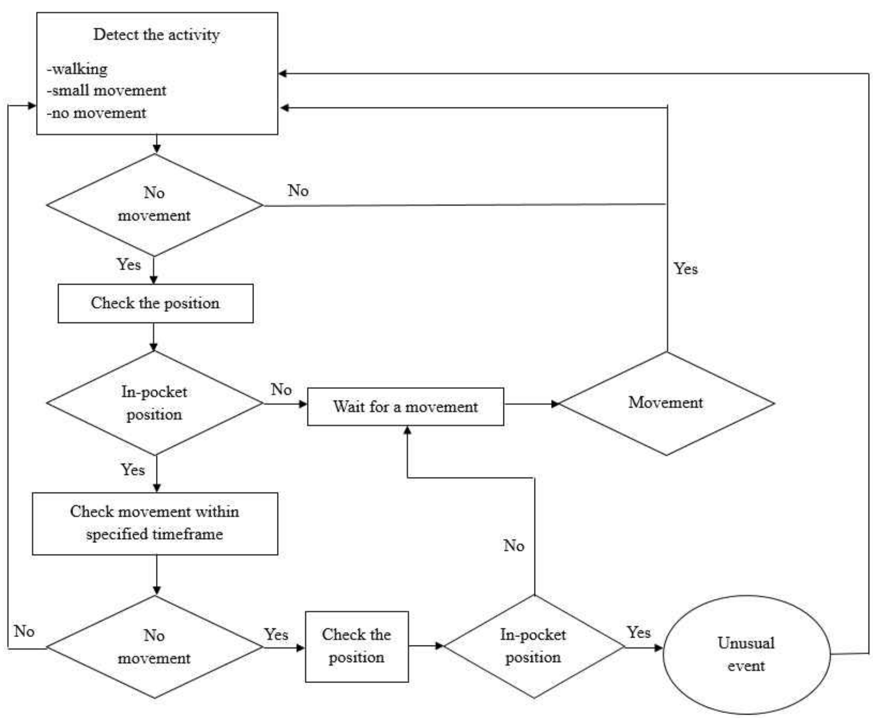
3. Algorithms

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.

First of all, we developed our vision algorithm as shown in Figure 1 with video cameras in two main parts. The first part is to detect people or objects and then second part classify vision-based activity behaviors. Initially video camera checks if it is there people or not in the room. If somebody is detected, then the system analyzes whether the person is moving or not. If the user stops movement, the algorithm measure the stayed time. If there is any movement within a specified timeframe, unusual event is detected. The algorithm returns to the initial stage for continuous identification after completing the classification.



[Fig. 1] Flowchart diagram for the vision classifier



[Fig. 2] Flowchart diagram for the activity classifier

This mobile application is designed for android smartphones and it works as a background task in order to collect all the user’s motion data. By analyzing user’s movements this mobile application tries to detect a long time of no movement. We used several sensors like accelerometer, light sensor and proximity sensor to implement this application. We found the accelerometer sensor gives really informative data for human activity detection in repeated experiments.

The activity algorithm as shown in Figure 2 firstly check whether the user is moving or not. In this state, the application can detect user’s various activities like walking, running, small movement and no movement. Whenever the user stops moving or the smartphone detects no movement, the application checks the position of the mobile phone to check if the smartphone located in-pocket position or outside position. If the application identify if the device is locating in an in-pocket position of the body after detecting no movement. The application then classify if the user stopped moving and checks movement within a specified timeframe. If there is a no movement in a long time and the smartphone is still in an in-pocket position, it identified as unusual events. The algorithm returns to the initial stage for continuous identification after completing the classification.

Our fusion algorithm combines user activity pattern with the smartphone accelerometer and the vision behavior identification with a video camera installed at home. We evaluated both the individual activity and individual vision pattern algorithm in the next section, and simulated the fusion algorithm with high-accuracy performance in scenarios.

4. Evaluation Results

Our vision classifier is extended by the existing SSD mobilenet algorithm [12] to detect objects. We analyzed identification performances of the existing vision algorithms(Haar cascade [8], Hog cascade [8], SSD mobilenet [12]) to detect objects in a variety of home environments. We collected 100 or more CCTV video data and measured each algorithm’s accuracy, recall, and precision performance as shown in Figure 3. Overall, we found the SSD mobilenet to be better than other existing algorithms. We extended the SSD mobilenet algorithm to our vision classifier algorithm combing all of the detected objects for identifying unusual situations.

Recognition person	Algorithm		
	Haar cascade	Hog cascade	Object Detetion - ssd_mobilenet
Accuracy	0.09	0.34	0.68
Precision	0.096	0.36	0.68
recall	0.48	0.52	0.92

[Fig. 3] Performance results of the vision classifier

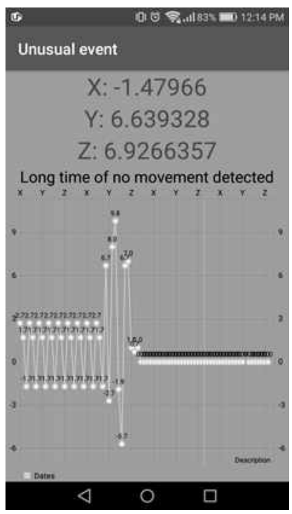
We simulated to measure the performance of the fusion algorithm with five volunteers. We have designed five scenarios: falling down and no user movement, Lying out of camera sight and no user movement, object movement and no user movement, charging or no carry on pocket, and lying on a bed for a long time. The results of our experiment are reported in Figure 4 for each situations.

	Falling down and no user movement	Lying out of camera sight and no user movement	Object movement and no user movement	Charging or no carry on pocket	Lying on a bed or chair for a long time
Only activity classifier	○	○	○	x	○
Only vision classifier	○	x	○	○	○
Fusion algorithm	○	○	○	○	○

[Fig. 4] Fusion simulation results

The volunteers performed unusual situation in four ways which are shown in Figure 4. First situation was stimulation of falling and do no movement. In this step, both of our systems detected an unusual situation perfectly. The volunteer as shown in Figures 5 first walked around the room and stopped movement after falling down. The vision algorithm detected this unusual event 100 percent. Additionally the mobile application as shown in Figure 6 drew the graph of the user's movement and detected that the user stopped moving.

[Fig. 5] Person detection via the vision classifier



[Fig. 6] Smartphone application for the activity classifier

Despite our smartphone application detected next unusual event stimulation which was sit in a chair and no movement, our system for video cameras could not detect it. In the next situation, the smartphone was on charging position therefore in that situation our mobile phone algorithm could not detect the unusual event but video camera detected that situation one hundred percent. Furthermore, our last stimulated unusual event was measured accurately by smartphone and video camera.

5. Conclusion

We set out to built a system, which could detect long time of no movement of individuals who are at home. We collected related works, analyzed them, developed an algorithm, tested it and in total built a smartphone and camcorder based unusual event detection system. The system achieved reasonable accuracy and accurately measure a long time of no movement. It is true that there are several technologies in the market for unusual events, but our goal was to construct a system that uses the gadgets people use in their daily lives. As smartphones and video cameras are available in almost every house. In addition the use of smartphones and camcorders for detecting accident situations has the advantage of not carrying additional wearables or sensors by the users and minimized cost by not buying extra wearables

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