Poster Abstract: Accurate, Fast Fall Detection Using Posture and Context Information

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ABSTRACT

Traditional fall detection is only based on acceleration analysis. In this work we present a novel fall detection method that also utilizes posture and context information. This information can help reduce both false positives and negatives. Our solution also strives for low computational cost and fast response.

Categories and Subject Descriptors

J.3 [**Computer Applications**]: Life and Medical Sciences—*health*; D.4.7 [**Operating Systems**]: Organization and Design—*distributed systems, real-time systems and embedded systems*

General Terms

Design, Algorithms

Keywords

Body Sensor Networks, Personal Monitoring

1. INTRODUCTION

Falls are crucial adverse events for elderly people and patients. According to [4], more than 33% of the elderly aged more than 65 have one fall a year. Falls are also dangerous for people from special career fields such as firemen. Hence, reliable fall detection is of great importance.

Since falls are dangerous, *detection accuracy* and *fast response* are necessary for fall detection. Existing solutions mainly use accelerometers to monitor vertical acceleration and body orientation to detect falls [2]. However, from the acceleration perspective there are many fall-like activities such as sitting or lying down quickly and jumping. All of these activities have large vertical acceleration and thus may result in false positives. Body orientation is useful for simple falls where people just fall down horizontally on the ground, but it cannot determine whether a fall happens when people jump into bed or onto a couch.

To improve activity recognition accuracy, a large body of work uses complex inference techniques like hidden Markov models to analyze acceleration data [3], but this kind of method costs excessive amounts of computational resources and does not respond fast enough. In addition, this kind of method is not often suitable for fall detections because it needs activity patterns, which are particularly difficult to obtain for falls.

Our work investigates a novel fall detection method that utilizes acceleration, posture and context information. Posture information can be used to distinguish many fall-like activities such as sitting down quickly and jumping from falls. Context including environmental information (e.g. room location and furniture positions) and personal profiles (e.g. health status and age) will also be exploited. Using such environmental information can significantly reduce false positives. False negatives can be reduced by adapting detection thresholds according to personal profiles. Moreover, our solution strives for low computational cost and fast response.

2. PROPOSED SOLUTION

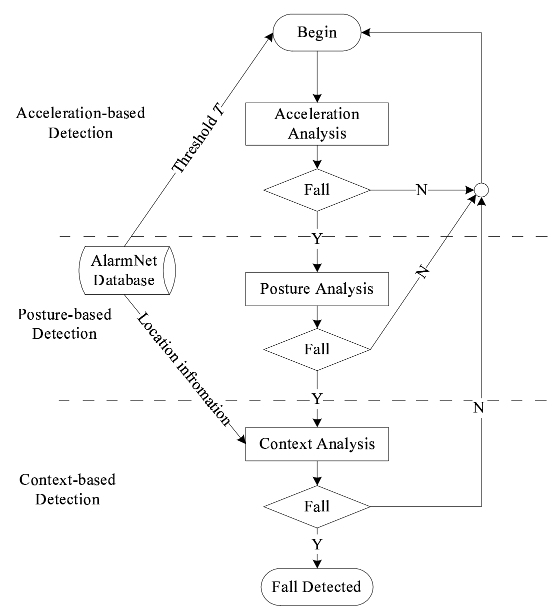

Figure 1: Fall detection using acceleration, posture and context information.

As shown in Fig. 1 our fall detection algorithm can be divided into three phases: acceleration-based detection, posture-based detection and context-based detection.

Acceleration-based detection: A three-dimensional accelerometer is attached to the chest to monitor vertical acceleration. Usually there is a nonperiodic large vertical ac-

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celeration in a fall, so if the acceleration becomes larger than a threshold T between time t_1 and t_2, smaller than T between time t_2 and t_2+c (c is a constant) as shown in pattern P_1 of Fig. 2(a), a fall might have happened. The threshold T can be adjusted according to a person's specific profile, e.g. if a person has a leg fracture or history of frequent falls we can lower T to reduce false negatives. Personal profiles are stored in a back-end database. In our solution we will obtain personal profiles from an assisted-living system called AlarmNet [5]. The database within AlarmNet contains both environmental information and personal profiles.

Acceleration analysis can be used to distinguish fall-like activities with periodic large accelerations (e.g. rope skipping) from falls. However, acceleration analysis alone is not able to eliminate activities like quickly sitting down or jumping that also demonstrate a nonperiodic large vertical acceleration.

Posture-based detection: Using posture information can make fall detection more accurate. Posture can be calculated from positions of different parts of the body. For example, we can attach six Cricket [1] listeners to the chest, waist, knees, and elbow joints to get their positions. According to these positions we can calculate the angles between the trunk and upper arms, the angles between the trunk and upper legs, and the angle between the upper legs. Based on these five angles we can determine posture. If a person is sitting or jumping, there is no fall. Otherwise, we continue to do context-based detection.

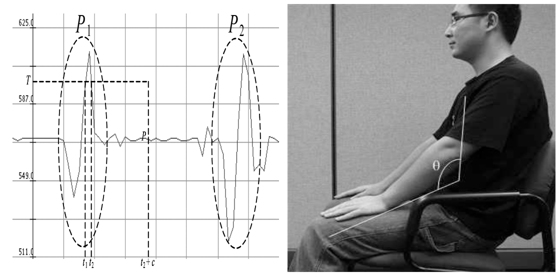
Context-based detection: Context information includes environmental information like room location, furniture positions, and physiological information like blood pressure. With this information we can correctly detect fall-like activities that are hard to distinguish in previous steps. For example, lying down on a bed can be detected as a fall. However, in context analysis, if we find a person is in the bedroom and near to a bed, and has normal physiological information, we know he is lying down rather than falling.

Speed analysis: Our solution does not need complex computation, so the detection process can be implemented in an aggregator like a PDA or cellphone. Moreover, no continuous data readings are needed in any of the three steps, which makes our solution fast.

3. PERFORMANCE EVALUATION

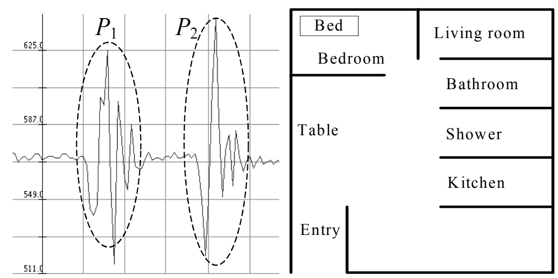
Fig. 2(a) shows the vertical acceleration patterns for sitting down and falling. Pattern P_1 is for sitting down, and P_2 is for falling. The two patterns are very similar and thus hard to distinguish using accelerometers only. However, the sitting posture will be easy to recognize with the help of θ, the angle between the trunk and upper legs as shown in Fig. 2(b).

Fig. 3(a) illustrates acceleration patterns for lying down (P_1) and falling (P_2). The patterns are also hard to distinguish. Moreover, posture analysis is not as useful as in the last example because postures of lying down and falling are similar. We will refer to context information to solve this problem. Fig. 3(b) shows the AlarmNet experimental space at University of Virginia. AlarmNet can collect information including which room a person is in and the distance between the person and bed. Considering both this and physiological information we can distinguish the two patterns: if a person is near to a bed and has regular physiological readings like blood pressure, he should not have fallen, but be lying down.



(a) (b)

Figure 2: (a) Acceleration patterns for sitting down and fall; (b) Angle between the trunk and upper legs when sitting.



(a) (b)

Figure 3: (a) Acceleration patterns for lying down and fall; (b) AlarmNet experimental space at UVa.

4. CONCLUSION

In this work we present a fall detection algorithm that can reduce false positives by using posture and context information. The method can also reduce false negatives by adapting the acceleration threshold to a personal profile. It also features low computational cost and fast response.

5. REFERENCES

[1] http://cricket.csail.mit.edu/.

[2] J. Chen, K. Kwong, D. Chang, J. Luk, and R. Bajcsy. Wearable sensors for reliable fall detection. In *Proceedings of the 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference*, pages 3551–3554, Shanghai, China, Sept 2005. IEEE.

[3] R. K. Ganti, P. Jayachandran, T. F. Abdelzaher, and J. A. Stankovic. SATIRE: A software architecture for smart attire. In *Proceedings of MobiSys'06*, Uppsala, Sweden, June 2006. ACM Press.

[4] N. Noury. A smart sensor for the remote follow up of activity and falldetection of the elderly. In *Proceedings of 2nd Annual International IEEE-EMB Special Topic Conference on Microtechnologies in Medicine and Biology*, pages 314–317, 2002.

[5] A. Wood, G. Virone, T. Doan, Q. Cao, L. Selavo, Y. Wu, L. Fang, Z. He, S. Lin, and J. Stankovic. ALARM-NET: Wireless sensor networks for assisted-living and residential monitoring. Technical report, Department of Computer Science, University of Virginia, 2007.