Detecting Physical Shock by a Mobile Phone and its Applications in Security and Emergency

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ABSTRACT
In this paper, we propose a method for detecting physical shock by a mobile phone and its applications in security and emergency scenarios. We use acceleration signal provided by accelerometers integrated in a mobile phone to detect shocks. The shock is identified by analysis of acceleration pattern using statistical signal processing methods. We propose to use such a shock detection application for increasing security of data access in a mobile phone, as well as identifying scenarios which user of mobile phone experiences risky emergency events.

Categories and Subject Descriptors
I.5.4 [**Computing Methodologies**]: Pattern Recognition – *Applications*

General Terms
Algorithms

Keywords
Physical Shock, Acceleration Signal, Mobile Phone, Security, Emergency

1. INTRODUCTION
Unexpected events such as physical shocks can be signs of critical security or emergency scenarios. In this paper, we propose to use accelerometer sensors integrated in mobile phones for detecting physical shock, and associated security and emergency risks. The event can be for instance having the phone under the risk of being lost or stolen, or having the user of phone experiencing an accident, sudden fall, etc.

Accelerometer sensors have been successfully used in several applications, especially for sensing device orientation or user movements. Rekimoto [1,2] discussed the potential of this technique for tasks such as navigating menus and scrolling. Hinckley et al. [3] demonstrate how accelerometers could be useful for an automatic screen orientation device and scrolling application. Oakley and O'Modhrain [4] describe a tilt based system with tactile augmentation for menu navigation.

Today, as the mobile phones are improved in terms of user interface, access and storage capacity, there are more and more private or company confidential data which are stored or accessed through them. If such a mobile phone is lost or stolen, there is a high risk that this private or confidential data can be exposed. In many scenarios, a user may lose a mobile phone, when the phone drops accidentally out of his pocket/bag and left unattended for a while. When the phone drops on a surface, it experiences a serious shock, and may be left unattended for a while. Such a shock followed by no activity (corresponding to the phone being unattended) changes the acceleration pattern (sensed by accelerometers of mobile phone) accordingly. Applying a proper signal processing and machine learning algorithm (as described in later this paper), such a scenario can be detected. Detecting the possibility that the mobile phone is unattended or lost can enable the phone to be locked and/or restrict access to certain data and functionalities unless an unlocking code is entered. In this way, if the mobile phone is lost or stolen, the risk of access to private and confidential data reduces. In addition, when such a scenario is detected, the mobile phone can issue an alarm or automatically report its location and situation to a designated centre. This can facilitate finding the phone.

Detecting a physical shock can be also useful in emergency scenarios such as an accident involving user of mobile phone. Many accidents such as car accidents or a person falling can be identified by a sudden shock, and subsequently sudden change in pattern of acceleration sensed by the mobile phone. The mobile phone can then automatically inform a designated emergency institution for help. The location of the accident can be also reported.

In the following, we describe our method for detecting physical shock using acceleration data, and present some initial experiments and results.

2. SHOCK DETECTION
A physical shock can be seen as a rapid and huge change in the pattern of acceleration captured by accelerometers integrated in mobile phone. The change in acceleration can be caused due to different sources of movement. In order to detect shock, acceleration signal (along three different axis) is first preprocessed by a high pass filter. This removes low frequency components which can be caused for instance by movements of a vehicle (when user is in a car or public transport), and preserves higher frequency components associated with a physical shock.

Next step is extracting some features form the acceleration signal. We have used absolute magnitude of acceleration, as well as the rate of change in absolute magnitude acceleration as features.

The extracted features are used for training reference statistical models for two classes: normal situation, and physical shock. We have used Gaussian Mixture Models (GMMs) [5] as statistical

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classifiers. Having the reference models, the system can match new samples of acceleration data against reference models and classify the ongoing scenario as shock or normal condition.

In a situation which can be critical concerning security or emergency, the shock is usually followed by a period of *'low activity'*. This means that the mobile phone or its user is left unattended or unobserved. When a shock is detected, our algorithm also checks if it is followed by a period of low activity or low rate of change in acceleration. This allows avoiding false alarms, for instance when a mobile phone accidently falls out of the user hands, but picked up immediately.

3. EXPERIMENTS AND RESULTS

We set up initial experiments for detecting physical shock by a mobile phone. We have used iPhone 3G [6] as the mobile phone. Acceleration signal is provided along x, y, and z axis by accelerometers integrated in iPhone. The acceleration signal is processed as explained in the previous section.

For the experiments, we have collected a database of normal and shock situations. In this database, there are 65 samples of normal situations, and 24 samples of physical shock. In order to obtain physical shock, we let the iPhone to fall on a carpet or wooden floor form a distance of approximately 35 cm. In order to obtain normal condition samples, we let 5 users to carry the iPhone normally in their pocket, hand or bag for a period of 10 seconds. These users do different normal activities such as walking, judging, taking stairs, and taking elevator. We tried to have different variety of scenarios, especially those which can have similarity to a shock (due to high physical activity) such as taking stairs or elevator. In this way, we can make sure that our algorithm is able to distinguish between such cases and a real shock.

The obtained data was used to train reference statistical models for the two cases of normal and shock situations. As statistical model, we have used GMMs with three Gaussians for each situation (class).

During the test of the system, the acceleration data is matched against the reference models for shock and normal situations. If the shock model gives a better match (higher likelihood score) compared to the normal situation model, the case is classified as a shock and a warning is issued. Table 1. summarizes the initial results on detection of shock. True alarm is when a shock is correctly detected. False alarm is when a shock is detected but it is normal situation.

Table 1. Initial results on detection of shock

Accuracy	True alarm	False alarm
91.1%	21	5

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5. REFERENCES

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