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ECE 1778 – Creative Applications for Mobile Devices

Final Report – Mayday: A Distress Detection Application

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1. Introduction

In situations where potential theft, kidnapping, rape or other life threatening circumstances become an issue, the need for a distress-reporting method becomes apparent. It can be said that receiving an earlier distress report could prevent or despise such perilous situations. A distress-reporting method, implemented within a system, should provide a means to contact authorities, family or friends, in the case of an anomaly. As a consequence, it can be argued that deploying such system would decrease the severity of threatening circumstances, such as robbery. In addition, in situations where elderly persons are in need of careful attention, authorities can be notified in cases of unexpected falls or abnormal conditions.

One can say that in such situations, emergency phone calls can be made; however, it is apparent that this may not be possible in all cases. In many dangerous situations the attacker would have the victim under direct surveillance, hence disabling the victim from performing any kind of distress reporting. Therefore, an intelligent distress detection and report system is within preference. Such an intelligent system can be implemented on smart mobile devices as a safety-report application to reduce or induce the threats of hazardous cases and to increase the user safety assurance.

2. Overall Design

Mayday application consists of four main modules or subsystem each of which provides a specific anomaly detection mechanism. These subsystems include “Sudden Movement Detection”, “Loud Noise Detection”, “Voice Pattern Recognition”, and “Brain Wave Stress Detection”.

Employing the accelerometer, the system is able to detect sudden movements, such as being pushed to the ground, or a state of unexpected scape and running. This module can also be used by shaking the handbag containing the mobile phone, in order for the victim to activate the alarm.

The device microphone is used for both the loud noise detection and voice pattern recognition subsystems. In cases where the attacker asks the victim to follow their specific orders, the system detects loud noise and triggers the alarm. In addition, the user may also use this module as a tool to activate the alarm system by screaming or making loud noise.

The system samples the noise received by the phone (with the maximum value of 32760). The sampling rate is 100/sec. Afterwards, these samples are normalized between 1 and 100. The system would detect an abnormal situation when receiving five consecutive values larger than a predefined threshold.

The sudden movement detection subsystem adds up the squared values received from the sensor readings along x, y, z axes. The earth gravity is then subtracted from the sum and compared to the threshold.

Additionally, defining a number of keywords, the user can send a distress signal. These keywords include: “Mayday”, “Help”, and “911”. However, in order for this module to perform properly, the device needs to be connected to the Internet to interact with one of the Google libraries.

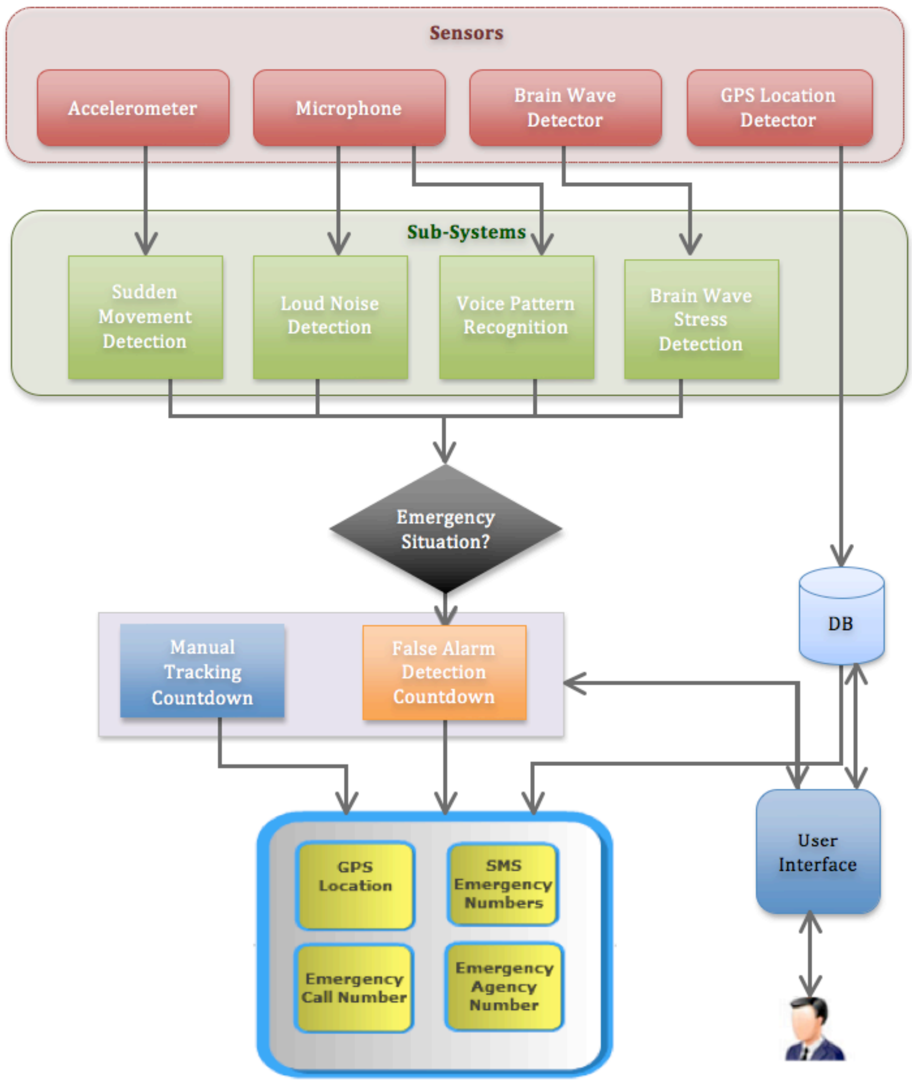

Figure 1 - System Architecture

The fourth subsystem is a brain wave stress detection mechanism that collects raw data from the NeuroSky Mindset, which is connected via Bluetooth. This module then processes the raw data and extracts two main characteristics of the brain, *meditation* and *attention*. Based on the meditation level of the brain, the system sets a threshold that indicates the stress level of the user. The meditation meter indicates the level of the user's mental calmness or relaxation. If the value of the user's brain meditation falls below this threshold, the stress detection subsystem detects an abnormal situation.

As illustrated in figure 1, the user interacts with the system through the Graphical User Interface (GUI) in order to change any available settings and/or data stored on the main database.

When the system detects an abnormal behaviour by means of its various detection components, a false alarm prevention mechanism is activated accompanying a siren that alerts the victim of the detection of an abnormal situation. Using a countdown counter (adjustable through the settings), the application waits for the user to deactivate the alarm, however, refusing to do so, the system sends the distress signals to predefined authorities.

This mechanism has two main advantages. It is designed to prevent as many false alarms as possible. Additionally, this feature acts as a safety mechanism by playing a loud siren, which may frighten the attacker. After being unable to cancel the false alarm (after the counter is exhausted), a distress signal is sent to the authorities and a phone call is made to the designated phone number. The text message contains the last known GPS location of the user.

3. Statement of Functionality & Screen Shots from App

Since this application is aiming to be used in hazardous situations, the main page needs to be wisely designed. Considering the fact that the user is stressed and under pressure at the time, the main page is designed as plane and user-friendly as possible. For the situations where the system fails to detect a threat, due to the low-security settings of the user's "Customized" mode or other reasons, a large button is designed.

As shown in figure 2, this button is placed in the middle of the page and is used to make a phone call to the emergency response agency (e.g. 911). Three smaller buttons are also placed on the main page. By pressing the left button, a phone call will be made to an authority. The emergency phone number can be earlier defined. The middle button will send text messages to a list of predefined contacts in order to notify them of the hazardous situation in addition to the GPS location of the victim. The right button is used to send the user's GPS location to the predefined SMS (Short Message Service) contact list. The difference between this button and the previous one is that the Distress Text Messages button will send a distress text message, while the GPS Address would only send the GPS location of the user as a safety option.

Figure 2 – Application's main page

Figure 3 - Mode selection menu

Additionally, the main page has a menu item that pops up when the setting button on the phone is pressed. This menu contains three options: (1) Settings, (2) Mode selection, and (3) Exit.

Mode selection option enables the user to select the different modes of this application. Figure 3 demonstrates a schematic view of this page. These modes include:

(1) Default mode: which employs two subsystems (loud noise detection and sudden movement).

(2) Tracking Countdown mode: when selected, the system expects safety confirmations from the user every ‘t’ seconds. This time can be set through the setting page. Figure 4 illustrates this feature. Refusing to press the “OK Button” before the exhaustion of the countdown results in sending the GPS location of the user via text messages to the designated authorities and calling the emergency number immediately.

Figure 4 - Manual safety countdown

(3) Voice Recognition mode: in this mode, the application keeps listening until the voice recognition module extracts and detects keywords such as “Mayday”, “Help” and “911”.

(4) Customized mode: the settings of this mode can be modified through the “Customized mode settings”.

(5) Brain Wave Sensor mode: this mode interacts with the NeuroSky Mindset in order to detect stress level of the user.

Settings menu item redirects the user to the settings page. Figure 5 demonstrates this page. This page contains six main choices. These options are:

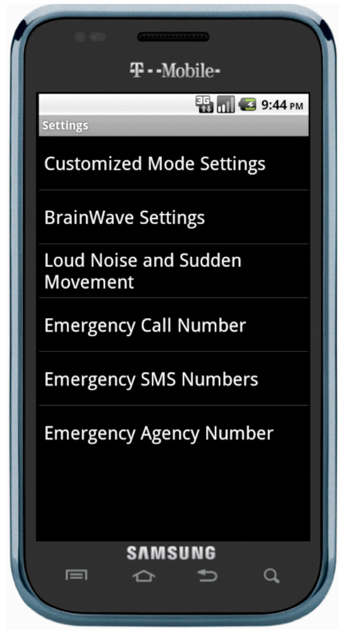

Figure 5 - Settings page

- ***Customized Mode Settings*****:** This option provides a means to set and define the "Customized" mode. This item redirects the user to another page that contains the "Auto Detection" and "Manual Detection" setting sections. Figure 6 demonstrates the customized mode setting page.

- ***BrainWave Settings*****:** This option enables the user to set the MAC address of the NeuroSky Mindset. In addition, in order to further customize the compatibility of the application, the user is able to set the stress level of the Brain Wave sensor. As indicated on the manual documentation of the NeuroSky Mindset, values between 1 and 20 demonstrate strongly stressed, values between 20 – 40 show slightly stressed and any value above 40 indicate normal or meditated state of the mind.

- ***Loud Noise and Sudden Movement*****:** The loud noise and sudden movement thresholds can be adjusted through this option. Since the level of the sensitivity to noise and device movements depend on the device hardware and the environment in which the application is used, the sensitivity of the phone to the noise and movements is variant. Therefore, by these options, the user is able to define both loud noise and movement thresholds.

- ***Emergency Call Number*****:** The user can set one emergency phone number by using this option.

- ***Emergency SMS Numbers*****:** This option enables the user to set as many contact numbers as they prefer.

- ***Emergency Response Agency Number*****:** The emergency phone number is not the same in all countries (e.g. 110 and 911). This option enables the user to set and change this number.

Figure 6 - Customized mode settings

As indicated earlier, in cases where the system automatically detects an emergency, the user receives a warning message that asks the user to deactivate the detection system n the cases of false alarms. As shown in figure 7, if the user fails to cancel within a predefined amount of time, the system would then perform the distress reporting procedure.

In order to further incorporate the user behaviours with the application and to provide a wearable distress detection device, we initially proposed the "Abnormal Gait Patter Recognition" subsystem. However, due to high complexity of the human gait patterns, this component requires extensive research on human behaviours. In addition, employing the user brain activities leads to the higher accuracy and user-interactivity of the application. Therefore, we decided to implement the "Brain Wave Stress Detection" component instead. Employing such component combines the mental state of the user with all the other functionalities of this application, enabling the application to be aware of the mental stress level of the user.

In addition, we proposed to include "Finger Gesture Recognition" as an extra option. However, since the user is under pressure in the time of attack, memorizing and recalling the patterns would not be a wise option. Therefore, having the simple yet functional large buttons on the first page, we decided to remove this extra functionality.

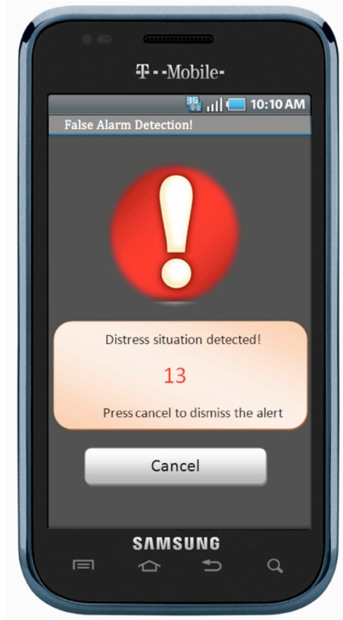

Figure 7 - False alarm preventer

4. What would you do differently – what did you learn?

Since our application employs various hardware sensors, its functionality can vary from device to device. We gained experience working on the issue of device dependencies and provided features to adjust these sensitivities as a solution. The LG Android device encountered problems when getting samples from the microphone. This was due to the use of the core functions that were employed to receive the voice samples. However, these core functions, which are highly dependant on the audio driver of the device, perform well on Samsung Galaxy S Vibrant phone.

On the other hand, since our main test device was running an old version of Android (version 2.1 – API 7), the functionalities of voice pattern recognition were limited. As a consequence, this subsystem can only be invoked as an "Intent", hence could not be incorporated with other concurrently in use intents and activities. This is the main reason we decided to provide only the sudden movement and loud noise detection as the customized mode choices. The same issue happened with the Brain wave subsystem. Since this component runs several threads in the background to maintain the Bluetooth connectivity, incorporating it with other sensors was not feasible.

Having this information, we would write the application for the API 8 and newer. In addition, we would avoid as much hardware dependencies, caused by using the core functions, as possible by employing higher-level functions (APIs) that enable the application to perform on a wider range of devices.

5. Contribution by group members

The initial outline of the application was presented by Helia. The structure of the application was broken down into two major parts. These parts include the implementation of the sensors and the GUI design. Helia implemented the recognition of different voice patterns and also the detection of sudden movements of the device. The Tracking mode, the Brainwave and the loud noise detectors were completed by Siamak.

The GUI for the tracking countdown and the false alarm detection was implemented by Siamak. The main page, menu options, customized mode settings and the mode selection layouts were implemented by Helia. The integration between the individual modules and the activities were done by Siamak.

The Brainwave remote sensor hardware kit was installed by Helia. This required the connectivity of the Bluetooth chipset (BlueSMiRF Silver) to the NeuroSky BrainWave detector, using the Arduino Mega microcontroller board. Furthermore, Helia designed and built the device that harnessed the required sensors to the forehead and ears of a given user. The NeuroSky mindset was later tested and deployed for the demonstration purposes. The Bluetooth receiver in the application and the parser to extract the required data was implemented by Siamak.

Both team members contributed equally in the testing and debugging of the device. Helia's personal phone was used due to the requirement of a device that utilized an Internet connection, SMS capability and the ability to make emergency phone calls. Therefore most of the debugging was done on her phone; hence the application works best on smart phones with API 7.

6. Apper Projects

Both group members of this project are programmers. However, it can be indicated that the use of this application may influence the security and safety level of single individuals, hence result in decrease of assaults and violations.

7. What next?

The brain wave detector can be further explored. Since the NeuroSky Mindset detects Alpha, Beta, Gama, and Theta waves, more features can be extracted from these signals in addition to the meditation state of the brain. An interesting application can graph the returned values from the detector while the user is performing various activities and then give the user a summary of their daily brain states.

An interesting extension would be to sense the heartbeat of the user, and in the case of abnormal heartbeat pattern detection, the alarm system can be activated.

The current GUI is designed for devices with four-inch displays. As a future work, a device-independent GUI can be designed.

Furthermore, in addition to sending distress signals to family and friends, the phone can start recording voice/video of the scene and uploads the captured files to a server.

In order to commercialize this application, free trials with limited access to the settings can be provided to a number of elderly residential houses and/or schools in order to obtain some feedback on the functionality of this application. Then the full version can be offered if the functionality of the application is satisfactory.

Word count: 2475 including the cover page.