'MobAware'-Harnessing Context Awareness, Sensors and Cloud for Spontaneous Personal Safety Emergency Help Requests

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Abstract. Significant increase of crimes against women in recent years and the advent of smart phone and wearable technologies have accelerated the need for personal safety devices and applications. These systems can be used to summon for help during the emergency situations. While several mobile applications that sends emergency help requests are available they need to be manually activated by the victim. In most of the personal emergency situations the victim might not be in a position to reach out for the Smart phone for summoning help. In this research we address this issue by implementing a system that automatically senses certain personal emergency situations, that summons for help with minimal or no user intervention. Summoning of help gets triggered when the smartphone sensors senses an abnormal events such as unusual movement and voice. This system also profiles the spatial information using the crawled web data and provides the contextual information about the risks score of the location. By using sensors and context awareness our system summons for emergency help with minimal/no intervention by the user.

Keywords: Context aware system · Smartphone · Cloud service · Personal safety Emergency help · Decision tree

1 Introduction

Hundreds of physical harassment incidents are reported throughout the world every year. The increased number of violence against the women and children significantly contributes to these incidences [1]. It is not feasible to employ police force and security personnel to prevent these crimes, as covering all the locations is difficult. The 'Nirbhaya' attack in Delhi [1] in which a 23-year-old Indian citizen was brutally harassed in a bus has generated a widespread of fear among women all over the country. This has ushered the era of personal safety systems that can send emergency help requests to police and the caretakers in the event of any dangerous personal safety situation. Several personal safety applications are available for the

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smartphones that can send emergency information to the predefined list of contacts whenever in danger. The situation of the crime scene might not allow the victim to reach out to the smart phone and unlock them to be able to reach out to help. This could be due to the time and physical limitations. This might also due to the fact that the victim might not be in a situation to respond properly when encountered with a surprise attack. These triggering of the alert procedures can be automated and simplified. This might help the victim to reach out and summon the help fast. These can be achieved by harnessing the sensors and actuators in the smartphones and by providing context aware response to the victim in real time. Context aware systems are computing systems that provide relevant services and information to users based on their situational conditions [2]. A context can be best explained with the help of these three features: (1) Location- Where you are; (2) Neighborhood- Who are you with and (3) Environment- What resources are you around [3].

Using Context Aware Systems, this paper proposes a novel application - 'MobAware' in A system that runs on a smartphone that is capable of sensing danger for the user from its environment and automatically sends emergency requests to nearby social network friends, relatives, police stations and Non-Governmental Organizations who specialize in these emergency response procedures. The system avoids the need to make the user manually trigger the application for summoning the help. The proposed system also notifies the user on the risk level of the present location. This context is calculated based on the history of attacks occurred in that area. The application runs as an Android Service [4] in the background, which makes using the Smartphone with the Personal safety application and unobtrusive one. This also helps the user switch to any other applications without having the need to interrupt it. The system also provides a web based interface that can provide real time information such as real-time user tracking and monitoring.

The next section discusses the literature survey followed by our proposed system. In the fourth section the system architecture and implementation details are discussed. In the last section Conclusion and Future Work are discussed.

2 Literature Survey

Context-aware computing has been an interesting research area for more than a decade. It was first mentioned and discussed [5]. The work in [5] describes about an active map service, with the help of context-aware computing, the system was able to provide the context aware information to their clients, about their located-objects and how those objects location changed over time. A detailed survey of the existing context-aware systems and services are discussed [6]. An automated context-aware application using decision trees has been created [7]. The system was used to learn user's preferences to provide personalized services based on the user's context history. A context aware service platform called 'Synapse' [8] has been created to predict the most relevant services a user will use in a particular situation, based on the users habits. The system uses Hidden Markov Model to provide this personalized service [8]. Inferring the user's activity by analyzing the data obtained from a single x-y accelerometer using clustering algorithm and neural networks has been performed [9]. Pre-processing techniques, which can be implemented in mobile devices for extracting user activity from accelerometer data has been proposed [10]. Employing the social networks for sending emergency requests and responses has been implemented [11]. Obtaining of users activities from various mobile and external sensors were used to publicize the users activity in Social Networking sites like Twitter and Hi5 has been proposed [12]. A next generation public safety system designed to be fully context aware to initiate an emergency call to summon response has been developed and deployed at the university campus [13]. There are several mobile applications with the focus on addressing violent crimes like sexual assault, rape, robbery and domestic violence. Some of the popular ones are Circle of 6 [14], Sentinel [15], bSafe [16], Fightback [17] etc. However these applications requires the user to manually trigger by the touch of a button. Dialling of voice calls to the list of contacts by vigorously shaking the mobile 3 times in 5 s [18].

3 Proposed System

The proposed 'MobAware', system (Fig. 1.) senses the environment of the user and automatically sends emergency requests based on the level of dangerous circumstance or scenario. The architecture of the application is given below. The system has three major subsystems. They are described in the following sections.

1. **Cloud Service:** The cloud service consists of crawlers for information acquisition from various news feeds and social networks. A crawler is a program that visits

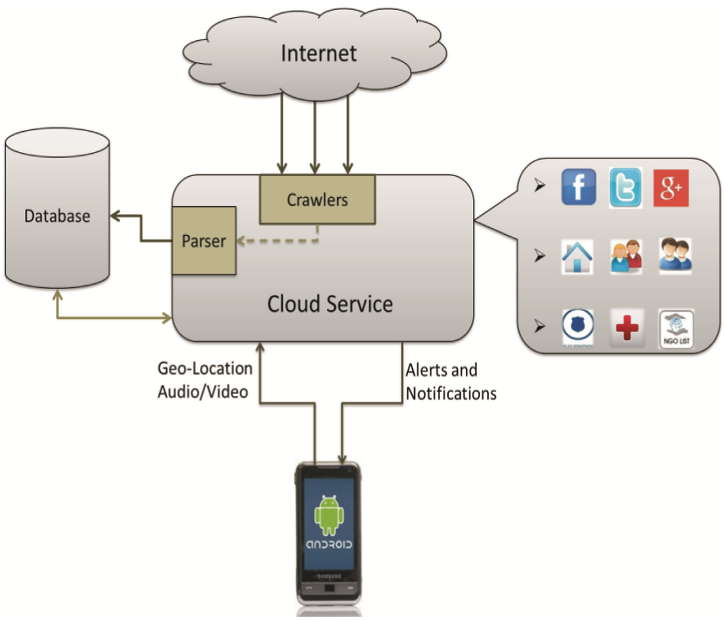

Fig. 1. Overall architecture diagram

several news media web portals and information database systems, acquires information from those sources. This data is then parsed and further processing is done on this data to extract the physical security incidences like, theft, accidents, robbery, assaults, specific attacks against women, children and other vulnerable citizens etc. The data crawled is categorized based on the location, based on the available GIS data and stored in a database which contains all the previous histories. Based on the number of incidents and severity of the incidence which occurred a score is provided. The higher the score for a location the risky the location is categorised as. This cloud service also has interface to the social networking systems including Facebook, Twitter and Google+. Based on the configuration of the individual settings the system sends emergency help requests to the friends list in the social network platforms. The system also interfaces with a short messaging service (SMS) to inform the users, systems and organizations which uses voice/SMS services for the incident response. The system also contains the information on nearby police stations, Non-governmental organizations specializing in first aid and responses, based on the user's current location. This ensures the quick response times to respond to incidents. The system can also be queried by the user for the risk levels of the location before visiting the location. This feature helps the user to take necessary precaution/avoid the visit including the avoiding the visits in the night time which is deemed unsafe etc. This information is available in the web portal that is dedicated for the personal safety.

2. **Smartphone Application:** A smartphone application has been designed and developed for the Android operating system. The mobile application consists of four sensors illustrated in Fig. 2. With the help of these four sensors the mobile application gathers data about the user's location and the users surrounding environment. The data obtained by the sensors is sent to a Decision tree where, based on the input given it determines whether the user is in unsafe condition or not. The application also has a SOS feature in which the user can manually trigger the alert service by pressing a button in the event of need for the manual intervention.

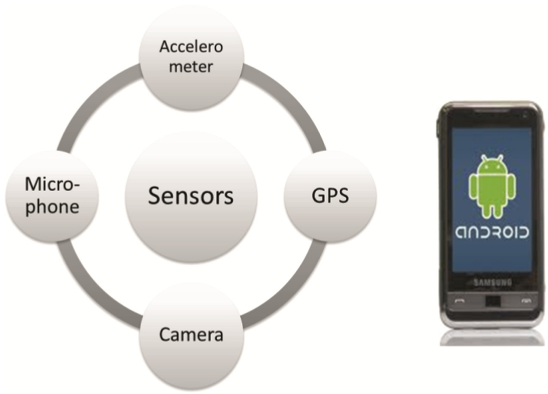

Fig. 2. Different sensors used by the system

3. **Web Portal:** When the "Mobaware" application is installed in the user's mobile for the first time, the system provides a facility to register user information etc. Once the account is created, the user is provided with the credentials to log in and use the web portal [21], which is created for managing the personal safety of the individual. The web portal can be used for monitoring and tracking the user. The web portal contains the real-time location of the user marked in a map. The map also shows the availability of nearby friends, police stations, NGOs and hospitals and their respective distance from the user. This web portal can also be used to monitor the places where any alert request is made in real time. The map also shows the number of attacks and physical violence, which occurred in the past. This information updated on a daily basis. Figure 3 shows city-wise distribution of registered rape cases, which was collected using the systems crawlers and Analytics subsystems in the month of April, 2015.

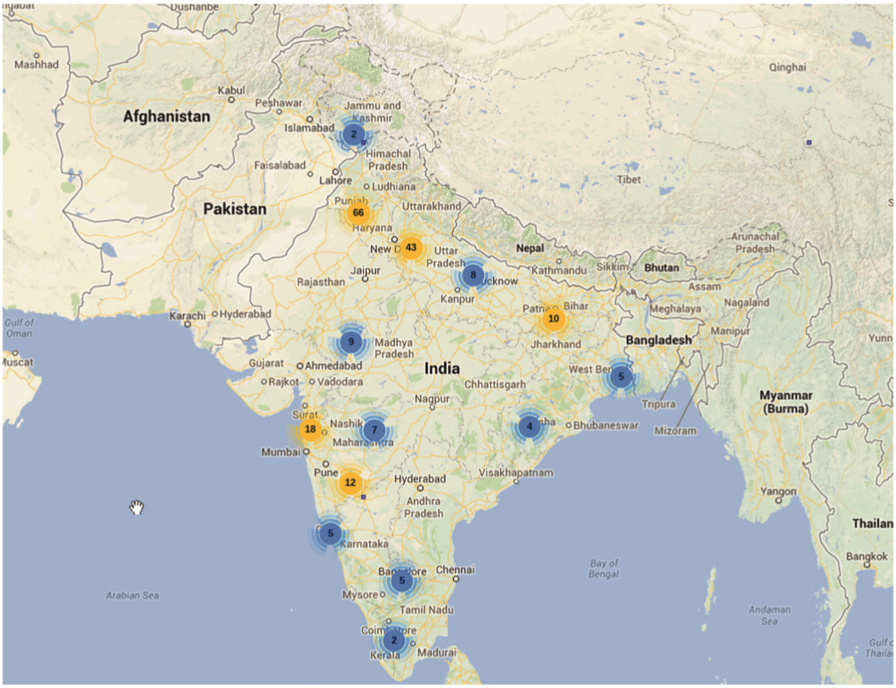

Fig. 3. Places with registered rape cases across India in month of April 2015

4 Implementation Details

The three main system functionalities of this system are listed below:

1. **Context Finding and Auto-Alerting:** Several smartphone applications [14–17] are available at the application market store. Most of these applications have a software

based SOS button that requires the user to manually trigger the alert button for sending emergency requests while in danger. However in an adverse situation of physical assaults, the time and freedom to take the smartphone application and unlocking it to perform the trigger is limited. Hence, we proposed a cloud based system that is aware of the context of the environment and surroundings and initiates the help requests automatically in adversarial circumstances. The sensors present in the smartphone helps to achieve this by acquiring the context aware data. This data is pre-processed and fed in to the analysis engine which follows the algorithm described below. Figure 4 is the pictorial representation of the algorithm.

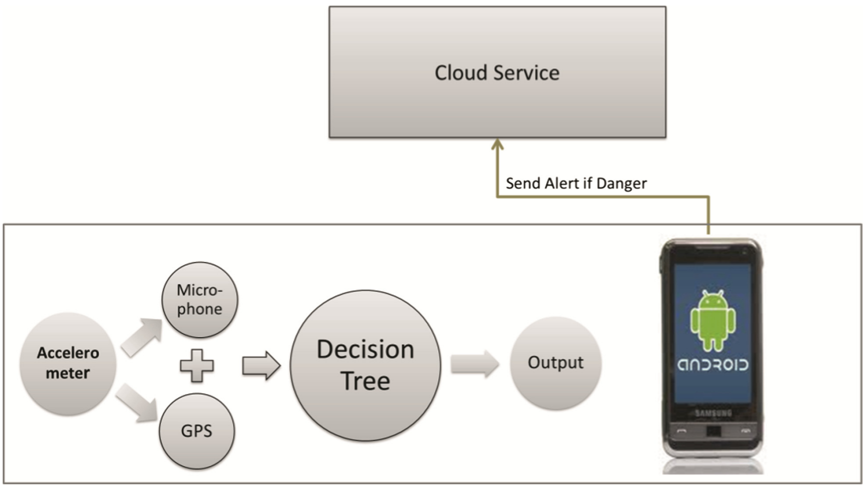

Fig. 4. Context identification and alerting

Algorithm:

- Listen for any unusual shake/motion by using accelerometer.
  - Invoke Microphone and GPS sensors.
- Microphone and GPS Sensors starts working in parallel.
  - Listens for any audio signal with the help of Microphone.
    Find the maximum, minimum and average amplitude of the audio signal.
    Perform offline voice to text conversion of the audio signal.
  - Identify the location of user with the help of GPS Sensor.
    Find out the User Activity.
    Compute the risk factor of travelling in that area.
  - Provide the obtained results to a Decision Tree.
- Identify the situation of the user based on the input of Decision tree and store it.
- Repeat steps 1–3 two more times.
- If the output of the decision tree suggests adversarial situation more than once i.e. minimum of 2 out of the 3 outcomes then send alert message.

The mobile uses three sensors for the working of this feature:

1. *Accelerometer*: An accelerometer is a component device that measures proper acceleration [19]. It is one of the motion sensors used by smartphones and other wearables to detect and monitor motion or vibration. In this system accelerometer is used to observe any shake or vibration. When it observes shake, the system invokes the Microphone and GPS sensors.
2. *Microphone*: Whenever the microphone is invoked it listens for some audio signal. It then finds the maximum, minimum and the average amplitude of the signal. It also performs a voice to text conversion and checks whether words like 'Help', 'Save' are in it or not which results in further action.
3. *GPS*: Using the GPS facility the system identifies the current location of the user. Based on the speed with which the user is travelling it estimates the current activity of the user; i.e. it tries to identify whether the user is walking, exercising, idle or on a vehicle. Once the location data is fed into the system from the GPS sensor signal, the next step is to assess the risk score of travelling in that location. The risk score of a particular location is calculated based on factors like:
   - Number of past occurrences of known assault incidents in that area and its surrounding locations.
   - Proximity to First aid places, Law enforcement offices, Hospitals, NGOs etc.
   - Time of travel.

The values obtained by microphone and GPS is given as input to decision tree. The decision tree based on its input decides whether the user is in adversarial circumstance.

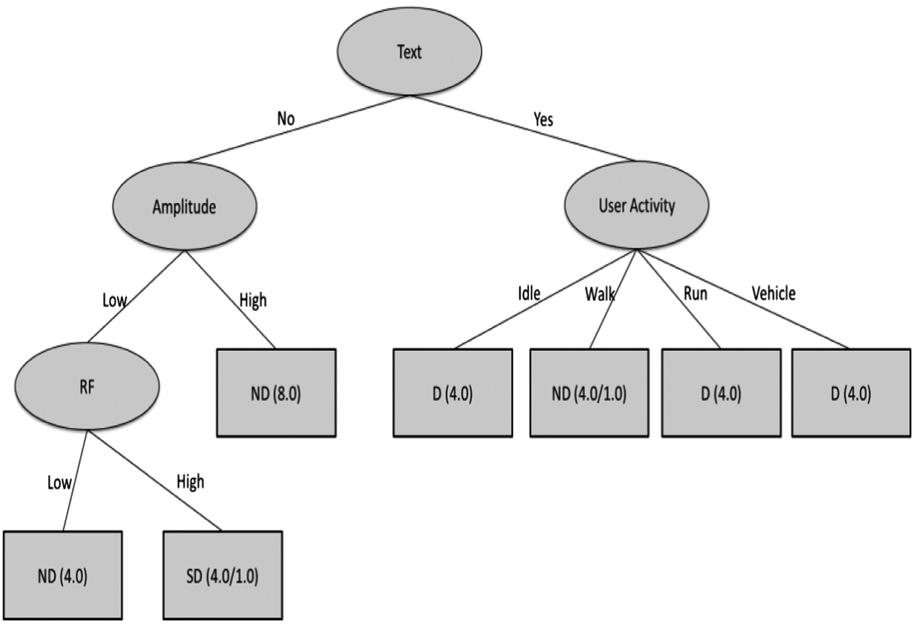

Fig. 5. Pruned decision tree

The entire process is repeated three times. If the output of the decision tree suggests adversarial circumstance for the user at least for 2 times out of the three instances or semi dangerous for all three cases, the mobile sends a signal to the cloud service a request to ask for help immediately. The pruned decision tree and the training data are shown in Figs. 5 and 6 respectively. One of the biggest concerns for the first responder system is the number of false positive calls or the emergency requests. These have detrimental effect in the first responder systems. Firstly false positive calls/emergency requests take away the precious times of the first responders who otherwise could be helping the actual needy people. Secondly, it can overwhelm the entire first responder system, in such a way that they might even start ignoring the true emergency calls. Thirdly the end user

Amplitude	User Activity	Text	RF	Verdict
Low	Idle	No	Low	ND
Low	Walk	No	Low	ND
Low	Run	No	Low	ND
Low	Vehicle	No	Low	ND
Low	Idle	No	High	SD
Low	Walk	No	High	ND
Low	Run	No	High	SD
Low	Vehicle	No	High	SD
Low	Idle	Yes	Low	D
Low	Walk	Yes	Low	ND
Low	Run	Yes	Low	D
Low	Vehicle	Yes	Low	D
Low	Idle	Yes	High	D
Low	Walk	Yes	High	ND
Low	Run	Yes	High	D
Low	Vehicle	Yes	High	D
High	Idle	No	Low	ND
High	Walk	No	Low	ND
High	Run	No	Low	ND
High	Vehicle	No	Low	ND
High	Idle	No	High	ND
High	Walk	No	High	ND
High	Run	No	High	ND
High	Vehicle	No	High	ND
High	Idle	Yes	Low	D
High	Walk	Yes	Low	ND
High	Run	Yes	Low	D
High	Vehicle	Yes	Low	D
High	Idle	Yes	High	D
High	Walk	Yes	High	SD
High	Run	Yes	High	D
High	Vehicle	Yes	High	D

Fig. 6. Training data for decision tree

of the emergency application him/herself might be annoyed and might lose the faith in the system. This is the reason for repeating the process three times is to increase the efficiency of the system by removing the false positives due to user negligence and unrelated triggers.

Here the value in text is yes if any keywords like 'Help', 'Save' etc. are present and vice versa. Also RF is the risk factor calculated. The output of the decision tree can be any of: dangerous (D), semi-dangerous (SD) and non-dangerous (ND).

2. **Real-Time User Tracking:** As mentioned in the previous sections, MobAware system has a dedicated web portal that can be used for tracking and monitoring the user in real time. For tracking a particular user, the user has to go thru a registration process, which is a mandatory. The user also needs to provide an explicit consent for the permission to tract the user. The web portal currently leverages Google maps GIS system [20] for displaying the current location of the user. By default the map is shown as zoomed in to make it easy and visually convenient for the people to track and monitor a user. While privacy could be thought of it as a concern, but due to the fact that the application helps to protect a user from the adversarial circumstances outweighs the privacy concern. The map is updated every 5 s and current information is provided for the accurate tracking purposes. The map also indicates several landmarks that includes nearest police stations, hospitals and a list of friends whose current geo-location is available along with the distance and direction from them.

Fig. 7. Tracking Bob in real-time in Google maps

Figure 7 gives an example in which a friend of Bob is tracking him. The person, tracking Bob gets to see the exact location of Bob, his current activity and the speed with which he is moving. In the map one can also see nearby police stations, hospitals, and online friends and the distance from them.

3. **SOS Report Abuse:** SOS or Report abuse is another important feature provided by MobAware system as shown in Fig. 8. This is used when there is a need to manually trigger the process of summoning help or to send emergency help requests. This facility could be used in two scenarios:
   (i) User is in adversarial circumstance, but is able to manually trigger the SOS button. For example, suppose Alice is walking alone in an area, which is not densely populated. She observes some anti-social elements have been following her for some time. In this case, she could press the SOS or Report Abuse button in the mobile application to call for help.
   (ii) A user is summoning for the help on the behalf of others who was assaulted or is in adversarial circumstances. In this scenario suppose Bob just went through a nearby lane. He notices Alice (stranger to Bob) is being assaulted by a group of anti-social element. Now when Bob wants to help Alice he could use the mobile application and trigger the SOS or Report Abuse button calling for help.

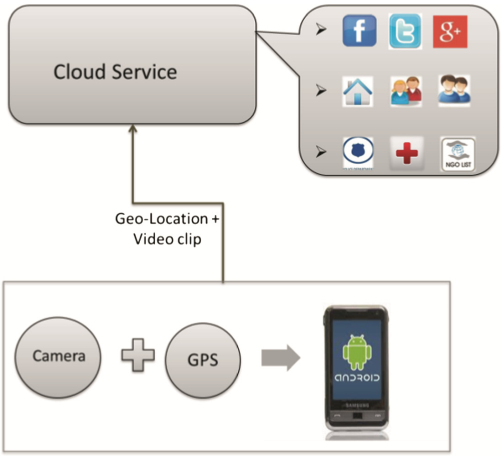

Fig. 8. Report abuse flow diagram

The advantage of the SOS Report Abuse button is that it uses video and GPS features of the mobile. Whenever a SOS or report Abuse button is pressed, the camera of the mobile automatically starts to record a video. In this way the user could convey the exact situation of that area very easily. The video along with GPS location is sent to the cloud for sending alert messages.

5 Conclusion

The ability to gather user's context and determining whether he is in an adversarial situation in real-time could be very useful for many people in combatting physical violence. This is especially useful for the people who travel frequently. In this paper, the authors have proposed an automated context aware application, which could be used for women, children and other vulnerable people to ensure the safety and security. A prototype and a product has been built and being used as a limited pilot testing. With the integration of context aware systems, mobile technology and social networks and by automating the emergency request sending procedure, significantly reduces the time taken by the responders which is crucial to helping the victim. Currently pilot testing is being conducted, the results of which will be published in the future work in addition to extending the features in dedicated wearable systems with a focus on personal safety.

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