Predicting Vulnerable Threats Location in Real Time

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Abstract - *In the context of wide usage of smart phone real-time location sharing service can play a vital role in emergency services like e-commerce, courier service, police department and education system. Crowdsourcing is a reliable means by which we can obtain data related to unsafe locations directly from the service users. This information can be used to extract useful insights regarding different kinds of threats like accident, assault, sexual offense and theft that are occurring in a particular region and the frequency of the occurrence of such threats. Information obtained from different sources and users are curated in the database. This stored information is used to analyze data and the necessary information is extracted to declare whether a particular location is potentially unsafe or not.*

In order to facilitate the users with reliable and fastest way of threat notifications, a suitable hardware which is designed especially for location tracking and sharing system. It includes a reliable and secure server-client system for exchanging location data with threat reporting and notification system. This device interacts with the client application installed on a user's mobile via Bluetooth and synchronizes in timely fashion. Using this information, a warning/notification is sent to the users in proximity of unsafe locations. As our further work, we use our model as a process model to develop an appropriate system for any other organization, if formed useful can adapt this model, will be reaching a safer living society.

Keywords: Location sharing, Bluetooth, and mobile application

1 Introduction

With the advancement of wireless technology, mobile positioning technology has emere as an important area of research, and many services like transportation, location-based services, network management and security applications. With the evolution of location-dependent services and growth in wireless systems applications, it continues to demand of accurate and reliable mobile positioning technologies. In the context of wide usage of smart phone among the users' real-time location sharing service can be employed in the education system to track the location of user, especially to ensure the safety of girls. Such a service can enable user to share the location in real-time and also to broadcast the location as well as emergency message. In addition, the threat notification system can help in avoiding the places involving high amount of risk. In this contemporary world women face many threats. This service can play a major role in preventing such threats. It can also provide necessary insights and patterns for establishing necessary security measures. Many existing systems are based on check-in systems which provide location data confining to a single instance or single location. But this system is dynamic and reliable. It provides location data for a period of time. A highly accurate and precise location can be shared in real-time. Especially it provides an easy and flexible means to ensure the safety of women. In e-commerce and courier service, real-time location sharing system can enable us to track the location of package in real-time. This system can also be helpful to share an address or location with friends, contacts or delivery crew to reach us without a hassle. Also, it can be help to take necessary security measures to prevent the crime from happening before in hand.

Crime maps have emerged to the crime investigators and criminal justice agencies as important tool. Earlier days very few criminal justice agencies had used crime maps and few investigators used the resources to inspect the spatial distribution of crime. Advancement of geo based technologies such as crime mapping has experienced explosion of interest among many practitioners and scholars. Crime opportunities are neither uniformly nor randomly organized in space and time. Therefore, crime mappers can reveal these patterns and attempt for a better understanding of role of geo based technology and help the investigators to discovers the solutions to the specific locations [1]. Role of geography in investigation of crime have explored many spatial relationships. Both Quetelet and Guerry examined nationwide statistics for France, identifying that higher property crime rates were reported in more prosperous locations, and also seasonality had a role to play in crime occurrence [1][2]. Shaw and McKay resolved this issue by mapping juvenile delinquents by hand for Philadelphia, Chicago and other cities. It is hard to imagine the effort that went into both data collection and address verification for their map showing individual dots for the distribution of 5,859 lawbreakers in Philadelphia. McKay, Shaw and their graduate students were able to confirm output/pattern, they observed in Chicago, as part of their painstaking work. These patterns suggested delinquency rates varied by zones of community characteristics that, they hypothesized, were the result of city expansion and migration patterns within cities and they found that these patterns to be "regular and consistent" and that "in the absence of significant disturbing influences the

configuration of delinquency in a city changes very slowly"[3][4].

However, in recent years, technological advancements have mostly solved the organizational hurdles, such that crime mapping has seen a wave in adoption of mobile position system, especially among larger US police agencies[5]. Taking advantage of Tobler's first rule of geography that says, "Everything is related to everything else, but near things are more related than distant things", professionals have understood the importance of discovering pattern to effective crime prevention and identify patterns and hotspots. To better understanding of causes of crime, investigators or justice crime agencies can use GIS tool, which can find the information such as census demographics, locations, etc. from the spatial database and help the law enforcement administrators, especially police to solve the problem. Geographic Information Systems is also useful for law enforcement operations, for example allocating police officers and dispatching to exigencies. Technology based crime map reporting started in 1986, when the National Institute of Justice (NIJ) funded a research project to help Chicago Police department (CPD) for neighborhood safety. North-western University and The University of Illinois at Chicago, reported on crime mapping in the book titled "Mapping Crime in Its Community Setting: Event Geography Analysis"[6]. The Spatial and Temporal Analysis of Crime (STAC) program is one of the earliest and widely used hotspot mapping applications. It uses "standard discrepancy ellipses" to display crime hotspots on a map and does not pre-define spatial boundaries. However, some studies shows that STAC may be misleading because hotspots do not naturally follow the shape of ellipses. Thematic mapping is another popular hotspot representation method. Boundary areas are used as the basic mapping elements in thematic mapping. Compared to point mapping, spatial details, and aggregate data is used by thematic mapping. Kernel density estimation (KDE) aggregates point data inside a user-specified search radius and generates a continuous surface representing the density of points. This overcomes the limitation of geometric shapes but still lacks statistical robustness that can be validated in the produced map[7]. Esri ArcGIS is the most widely used Geographic Information Systems (GIS) and its newest component called ArcMap 10.1 includes a Hot Spot Analysis toolbox, which provides users the ability to analyses the hotspot existed in the input spatial dataset[8]. The Abeline Police Department uses a computer-based crime mapping program called RAIDS (Regional Analysis and Information Data Sharing) Online to display crime data to the public using Google Maps[9]. The user is able to search a city or address and then select what crimes they would like to see and the date range of these crimes and a map will come up that shows pin points of these crimes on the map and the user can click on the Analytic tab and this will pull up several charts and these charts show the selected crime in different possible ways. The user can see the crime by day of the week and even by the hour of the day[9].

Haifeng Zhang [9] suggests that the spatial patterns of four types of crime (assault, auto theft, robbery and burglary) and their relationship with neighborhood characteristics in the City of Nebraska, Omaha by using GIS procedures and ordinary least square regression methods. As two alternative measures of crime rates, location quotients of crime and crime density were employed. This paper has three important findings. The first finding is, the rationale of the employment of official crime rates for neighborhood crime study is questionable; Second finding is, even though the location quotients can be used to highlight the prevalent types of crime across urban neighborhoods, they possess very limited use for the statistical analysis; and the third finding is, crime density focuses on the spatial intensity of crime and is more appropriate as the indicator of neighborhood level crime than population-standardized crime rates and location quotients. Gupta. R suggests that the need of effective utilization of Information Technology in public safety management is increasing in the present Indian scenario of crime[10]. This paper applies the utilities of GIS to identify the hotspots of crime as well as to facilitate the development of investigation preference strategy for policing. K. Jaishankar suggests that in India, though the Police agencies of Hyderabad, Bangalore, Mumbai, Goa, Delhi, Kolkata, Trivandrum and Chennai use custom-made GIS and its application is still in an elementary stage. There is a felt need for the fullest application of this potent technology in Indian police department. Arthur Getis[11] and Richard Wright suggests that his paper reviews modern crime analysis with regard to the research and educational challenges outlined by the University Consortium for Geographic Information Science. Author had reviewed Internet based GIS tool and application of web-based public participation. The spray-can tool allows users to spray areas of interest on map, with the ability to weigh areas using the intensity of the spray and users can attach comments to their inputs. The rest of the paper is organized as follows. Section two discusses the related work of the proposed work. Section three formulates the proposed systems. Sections four explains the testing and experimental results and presents simulations that demonstrate the tracking of users and give some intuition about the observed results. We conclude in section five with mention of the future likely enhancements of the system.

2 Proposed Approach

The notification hardware is connected to the client application via Bluetooth and syncs for new information. Whenever there is an incident in the neighborhood, the user can use the client application or web page to report the incident by filling the form fields. This information is sent to the server which is stored in the database. The server runs data mining algorithms periodically and identifies potential crime hotspots. Whenever a user is in proximity to these crime hotspots a notification is sent to the client application which is then delegated to the hardware to display on the screen so that the user can know the notification at a glance.

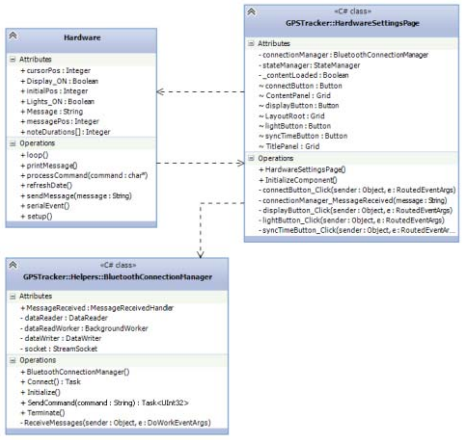

Figure 1: Class diagram of notification hardware

The Figure 1 shows the class diagram where Hardware, HardwareSettingsPage are the classes. The Hardware class has Display_ON, Lights_ON, and Message as main attributes and setup(), loop(), refreshDate(), printMessage(), sendMessage() and serialEvent() as main operations. The HardwareSettingsPage class has SyncTime(), Display() and Light() events as main operations. This class helps in configuring the notification hardware from the client application. The BluetoothConnectionManager class has Connect(), SendCommand() and ReceiveMessage() as main operations. This class opens the socket connection through which both client application and notification hardware reads and write commands using serial reader and writer streams. The positions are normally scattered over an area due to measurement errors. This happened when GPS positions are logged over time. This scattering point is known as scatter plot and area within estimated parameters is called the confidence region. GPS industrialists use this point to illustrate their equipment accuracy, they analysed the confidence region with a radius that describes the probability within the specified accuracy.

One of such accuracy measuring technique is Distance Root Mean Squared (DRMS). DRMS is a single number that expresses 2D accuracy[12]. In order to calculate the Distance Root Mean Squared horizontal position errors, we need standard errors (σ) from the known position in the directions of the coordinate axis. DRMS is the square root of the average of the square errors as shown in Equation (1) below.

$$\text{DRMS} = \sqrt{\sigma_x^2 + \sigma_y^2} \qquad \text{---------- (1)}$$

Standard errors (σ) of estimated coordinates (x, y) of each point being positioned can be predicted from the corresponding variances on the diagonal of the covariance matrix. Table 1 describes the most commonly used position accuracy measures and their probability.

Table 1: Position Accuracy Measures

Accuracy Measures	Formula	Probability	Definition
DRMS	$\sqrt{\sigma_x^2 + \sigma_y^2}$	65%	The square root of the average of the squared horizontal position errors.
2DRMS	$2\sqrt{\sigma_x^2 + \sigma_y^2}$	95%	Twice the DRMS of the horizontal position errors.
CEP	$0.62\sigma_y + 0.56\sigma_x$ (Accurate when $\sigma_y/\sigma_x > 0.3$)	50%	The radius of circle centered at the true position, containing the position estimate with probability of 50%.
R95	$R(0.62\sigma_y + 0.56\sigma_x)$ (R=2.08, when $\sigma_y/\sigma_x = 1$)	95%	The radius of circle centered at the true position, containing the position estimate with probability of 95%.

3 Experimental Results

The Figure 2 compares the signal strengths based on location accuracy. The signal strength is classified as Good, Average and Poor. The location accuracy refers to the the radius of 68% confidence. In other words, if we draw a circle centered at this location's latitude and longitude, and with a radius equal to the accuracy, then there is a 68% probability that the true location is inside the circle. This accuracy estimation is only concerned with horizontal accuracy, and does not indicate the accuracy of bearing, velocity or altitude if those are included in this Location.

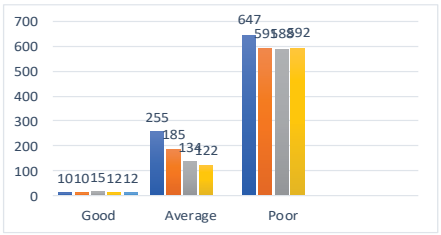

Figure 2: Location Accuracy vs. Signal Strength

The lower the distance measure value is, the higher the probability that the accurate location is determined. Hence it can be observed from the Figure 2 that the most accurate location information is obtained when there is a good signal strength and similarly the obtained location data is less accurate when there is a poor signal strength. The Figure 3 compares the signal strengths based on threat notification latency. The signal strength is classified as Good, Average and Poor. The threat notification latency refers to the time taken in seconds for the client application to receive the threat notification after the server sent the notification. It can be

observed from the Figure 3 that the latency is less where there is good signal strength and the latency is more when there is poor signal strength. This factor is crucial since the service is time-sensitive and needs to transfer data in real-time.

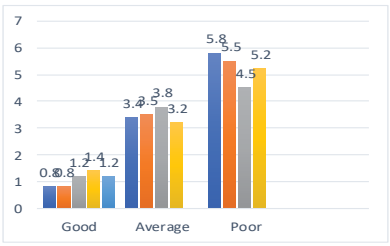

Figure 3: Threat Notification Latency vs. Signal Strength

The Figure 4 shows the probability of occurrence of different threats in the area. The threats are classified into Accident, Assault, Sexual Offense, Theft and Others. Based on the crowdsourcing data, the probability of occurrence of each kind of threat in a location is measured which helps in narrowing down the types of threats to be sent in threat notifications to the users. Also, it further narrows down the search for types of threat in a location.

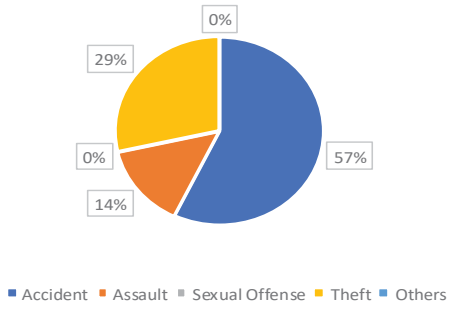

Figure 4: Probability of threats

4 Conclusions and Future Scope

This paper has been an effort in sharing the location of a user and get threat notifications in real-time. It can also be helpful to share an address or location with friends, contacts or delivery crew to reach us without a hassle. The client application is installed on the users' mobile and set to track the location and is seamlessly uploaded to the server using advanced real-time communication techniques. This data can be used by the college management as well as the head of the department to enforce necessary measures. A user can also share location confining to certain constraints like a period of time and with a certain group of users. An emergency message can be triggered by the user along with the location information to broadcast to the college management, parents and to the nearby police station. The information gather from the crowdsourcing can be used to identify potential crime hotspots to warn the service users who are in proximity to those hotspots thereby decreasing the probability of those users from being effected.

Many directions for future enhancements are open. Among them, we can mention:

- the use of other technique like artificial intelligence.

- the use of the cloud-computing paradigm to solve even more challenging data mining problems.

5 References

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