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Smart Disaster Notification System

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***Abstract*—The devastations of natural disasters are the lashes of mother nature that hit us every year with a whip. These are inevitable. There are no alternative ways to prevent this incident, but we can take proper steps to reduce its damage. Nowadays a great deal of attention has been given to the potential applications of mobile communication technology. Short Message System (SMS) has a huge impact on the communication system. This paper proposes an android application which can alert people before a natural disaster such as cyclone and flood strike, and tell them the optimal route to the nearest shelter via SMS or voice call. In evacuation process, we have used partition based shortest technique to find nearest shelter place.**

***Index Terms*—Natural Disaster, Notification System, Android, Location Based, Nearest Shelter**

I. Introduction

Natural disasters are the consequences of natural hazards. It does occur a serious breakdown in the sustainability of human beings, animals, and the property. It also occurs economic losses and disruption of economic and social progress. The overwhelming number of dead or seriously injured and homeless people are affected by the occurrence of a natural disaster. A massive amount of money needs to be spent for reconstruction and rehabilitation after the natural disaster. These are nothing but extreme environmental events that impact human activities. Hurricane, earthquakes, tsunamis and volcanic eruptions, as well as floods, are the most frequent threats[1]. Tornadoes and droughts which are also prevalent.

According to the Annual Disaster Statistical Review 2010 [2], 330 natural disasters were registered worldwide in 2003. It was reported that there was a total of 21,610 people died. And among them, 9,871 people died in flood, and 8583 people died due to the storm. The estimated damage was 118.6 billion dollar. It feels bad to know these statistics. But the worst part of the reality is that there is no way of preventing these natural disasters. The only way to our survival against it is to prepare ourselves for what can happen.

Numerous researchers had tried to develop an early disaster warning system for minimizing the potential loss. They came up with some brilliant ways to do it [3], [4], [5]. In this modern time, the mobile phone has really changed the way of communications [6], [7]. It is now the most used communication tools. Some of the researchers tried to use Short Message System (SMS)[8] as an alerting system for the disaster. SMS is used in modern handsets originated from radio telegraphy [9] in radio memos pagers using standardized phone protocols. These are defined as the part of the Global System for Mobile Communications (GSM) series [10] of standards as a means of sending messages up to 160 characters to and from GSM supported devices. But by this method, there is no way of evaluating the level of the disaster because no databases are used. This method only sends messages to the subscribers. But some subscribers may be blind, so this method would not be helpful for those disabled people. Again, researchers used the android technology [4] to ease the system. They used an algorithm to calculate optimal routes to the shelter for evacuation at the time of disaster and showed the data into google map.

Our proposed technique is an android based application that takes the weather updates from websites and calculates the disaster level. Subscribers data can be stored in this applications database. It calculates the optimal route to the shelter from the subscriber's current position and sends voice call/SMS with the warning and the shelter-locations to them. It is able to send the voice call or voice alarm so that the blind subscribers can also get the alert. This is GSM type alerting system, so the subscribers do not need to have an android device in order to receive the service. It also stores previous weather statistics data in the database. Using these data and real-time data, it can predict the upcoming weather by using machine learning techniques. Here it uses the naive Bayes algorithm [11] to predict the weather by analyzing the previous and real-time data.

II. Related Work

Early disaster warning and evacuation approach are very general disaster management system in disaster-prone areas. Nowadays mobile phones play an essential role in disaster

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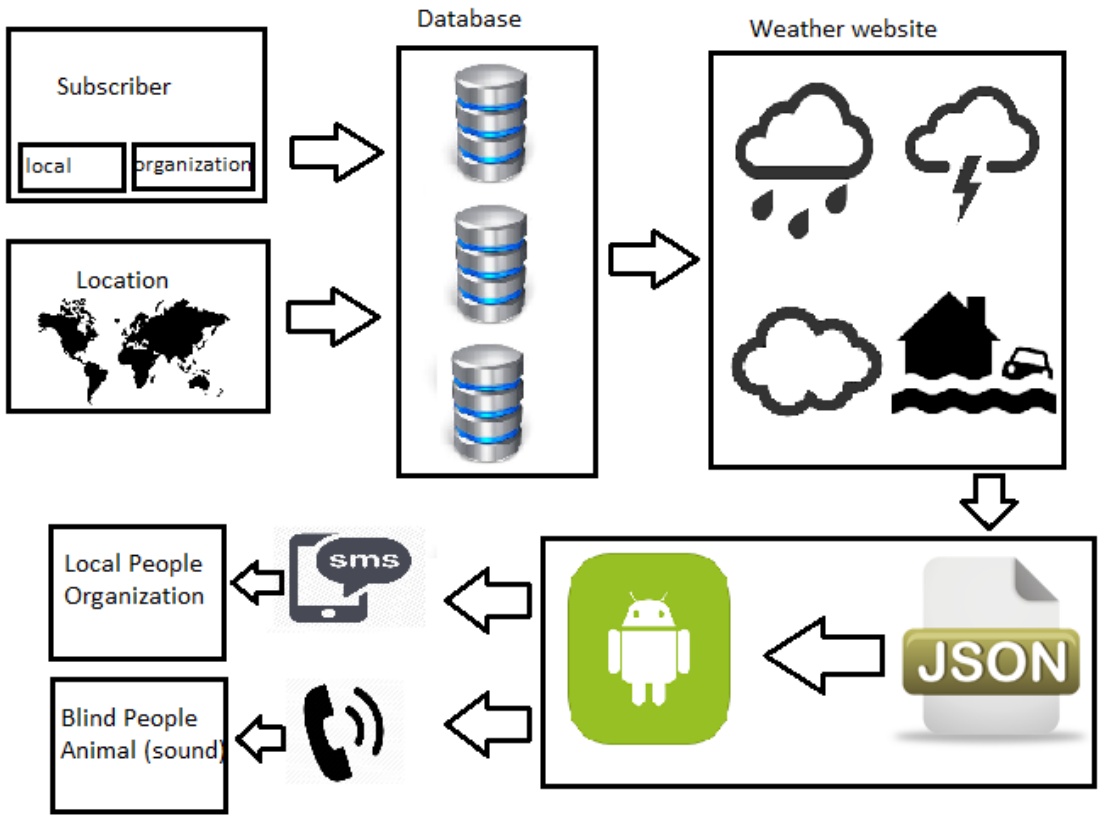

Fig. 1. System Overview

management system in several ways: monitoring, communicate, warning dissemination, evacuation and rescue and relief aid. A number of notification system has been proposed in our real world. In research paper [12], [13], Short Message Service (SMS) is sent to all citizens from the server about the awareness of upcoming flood warning. A huge number of SMS transfer from the server cause network congestion and can break the voice communication system in the same network. To avoid this kind of congestion cell broadcasting service is used to directly send messages to the subscribers in a specific area [14]. But this process fails to help in evacuation process which provides information about the safe region. GSM alarm device is used for evacuation process in which three kinds of warning are sent to the police station or fire brigade station [15]. Although it can avoid network congestion, the GSM alarm is not a faster way for evacuation process.

Satellite communication systems will be very fast, reliable and robust. As a result, well-developed countries like Australia and South Korea are planning to use satellite communication for disaster management [16], [17], [13]. This satellite service maintenance is expensive and developing countries cannot afford this. Very few researchers propose location based services for disaster management on mobile phones. Previous works on location based services for disaster management did not distinguish normal people and blind people. Considering this, Amit Gosavi et. al. [18] presented a location based early warning and evacuation system by visual and audio warnings useful to both normal and blind people.

Natural Disasters such as cyclone, storm, earthquake, Tsunami, and flood have shown the harmful, damaging mode of nature which has taken millions of lives including people and animals. Above all techniques are concern about people warning. Most of them did not discuss evacuation processes by which people get shelter place. Dijkstra's algorithm based shortest path calculation is used to find the nearest shelter place[18]. This process is time-consuming because it searches all paths from the source to destination. For this, we propose a location based smart disaster management system that can warn all subscribers (people, blind people). In the evacuation process, we used partition based trajectory to find nearest shelter place. It is very faster than the previously proposed methods.

III. Proposed Solution

The main purpose of Smart Disaster Notification System is to alert people before the time of disaster and tell them the optimal route to the nearest shelter. In our system, we divide the whole application in some module. First one is database building that consists of subscriber information and locations whose probability of disaster is measured. The second one is based on locations in which our proposed methods take information from the weather website. After that these information will be converted to JSON (JavaScript Object Notation) [19]

format. Then, according to JSON information, the system will be able to understand the probability of disaster and then the system will send nearest shelter information to the subscribers. The architecture of our proposed technique depicts in figure 1. Each part of our system will be explained details in the next few sections.

A. Preliminaries

The consequence of natural hazards is called the natural disaster. There are different kinds of a natural disaster such as cyclone, storm, earthquake, Tsunami, flood etc. Different kinds of natural disaster occur at the different time in the different geographical area. Some recent examples of violent natural disasters are the 2011 Japan earthquake and Tsunami, the 2010 Haiti earthquake, the 2007 cyclone SIDR, the 2004 Indian Ocean Tsunami, the 1991 Bangladesh cyclone. Geographically few South Asian countries are situated in between the Himalayas and the ocean, on the delta of wide rivers, means that the countries are very exposed to flooding [20]. The people live in coastal areas have to face several storms each year and cultivable lands disappear in the river due to river erosion. Such countries are most affected by the planets climate changes and the number of cyclones. Hence, there is also the risk of Tsunami in these countries. Our disaster preparedness system protects the people from upcoming disaster. For this, it uses SMS, voice call or voice alert. Our proposed work can be implemented on Android mobile phones. Android [21] is an operating system for mobile devices such as smart phones and tablet computers developed by Open Handset Alliance led by Google. As android is more open and comprehensive than other mobile operating systems, this is the best selling product worldwide. It also allows the building of new applications at lower cost. Consequently, this is more interactive for users. Hence, an android mobile platform has been used in our proposed disaster awareness system.

B. Input into database

We will keep the record of subscribers in the database. In there we will store the subscriber name, location, mobile number. Based on the subscriber locations we can give them the proper warning about the disaster. Smart disaster notification system will fetch the information from it and sends a notification to the subscribers. Sending notification will depend on the update from the websites.

C. Update from website

This application will take the update from the website and evaluate the level of disaster. Then it will convert the data into JSON format. The following figure 2 shows the update process.

D. Minimum distance calculation

We determine the optimal route to the nearest shelter and show it to the application and in case of the non-android user we just give them the placement of the nearest shelter. If figure 3 subscriber gets a disaster awareness message from the

Fig. 2. update from website

system. The system will send nearest shelter information. Here if we calculate Euclidean Distance [22] we find nearest shelter point is B. But that existing path is so far than path A. For that reason we use trajectory partitioning method[23] to calculate the distance between two places. Trajectory partitioning means path partitioning, which is very important because proposed algorithm has used sub-trajectories.

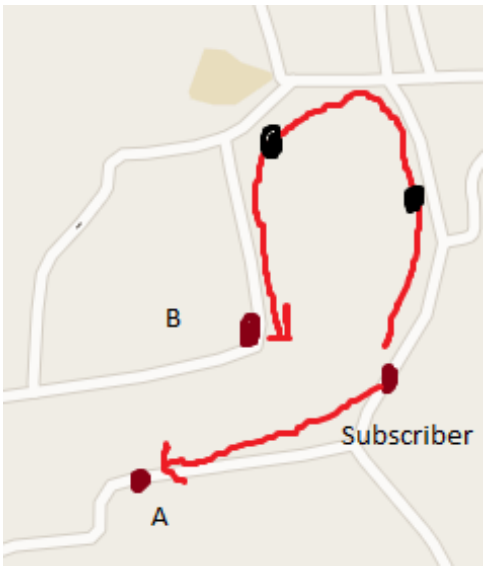

Fig. 3. Calculation of nearest shelter place.

For partitioning, we first took the starting and ending point of the route. Then from the starting point, we move towards using the trajectory points. In the first trajectory point, we measured the perpendicular distance with respect to the line which was drawn from the starting and ending point of the route. We used equation 1 to measure the perpendicular distance where (m, n) is the coordinate of the trajectory point, d is the perpendicular distance, and $Ax + By + c = 0$ is the equation of the line. Then we check the perpendicular distance to the given limit to check whether it would need to partition the trajectory. If the distance is greater than the given limit, we would partition the trajectory into two parts. Figure 4(a) shows the approximate solution structure. The other partition will replace the existing line which was used to measure the perpendicular distance. Then from every point, we follow these steps and determine the trajectory path and store them in the array and finally shows the result. In figure 4(b) $P3$ trajectory

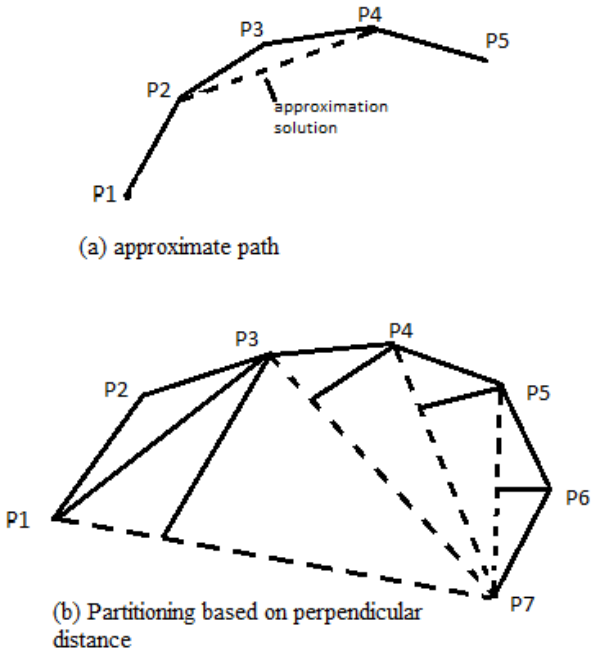

Fig. 4. Calculate Minimum distance function for path shelter

partitioned into two parts. Then we measure the perpendicular distance for the partitions. For left partition the distance is lower than the given limit, so we can take the partition as an approximate solution and store the result in an array.

$$d = \frac{|Am + Bn + c|}{\sqrt{A^2 + B^2}} \tag{1}$$

Algorithm 1 and 2 shows the procedure to determine the distance of the trajectory path from the starting point to ending point. In algorithm 1 for every trajectory tr_i, we found the minimum distance of the subscriber u. Then we select the start point $tr_i[pos]$. And call the $distance$ function explained in the algorithm 2. Then we recommend a shelter point to the subscriber u. In algorithm 2 for each $position$ and for each starting point SP_i we check the perpendicular distance with the given limit. If the distance is greater than the given limit, then we can call the $distance$ function twice for the left and right partition. If the perpendicular distance is lower than the limit we took the approximate solution and store the result. Lastly, it calculates the total distance from the two partition or with the approximate distance for each trajectory and returns the result in the algorithm 2.

E. Predicting weather

Smart disaster notification system stores weather data into the database. Then it applies machine learning techniques to find the pattern from these data. After that, it predicts whether there will be any disaster by using real-time data. It here

TABLE I
ALERT CLASSIFICATION

Disaster	SMS	Voice Alert
Rainfall	Yes	Yes
Heavy Rainfall	Yes	Yes
Cyclone	Yes	Yes
Wildfire	Yes	Yes
Flood	Yes	Yes

predicts rain/ flood possibility by analyzing weather statistics data. It uses Naive Bayes algorithm to find the pattern from the weather statistics data. Equation 2 is for Naive Bayes classifier.

$$P(C_i|X) = \frac{P(X|C_i)P(C_i)}{P(X)} \tag{2}$$

Where X represents a vector and C represents class.

F. Sending notification

After getting updates from websites minimum distance is calculated and then a notification is sent to the subscriber who already registered in the database. This notification is both audio and text message because subscriber can be blind.

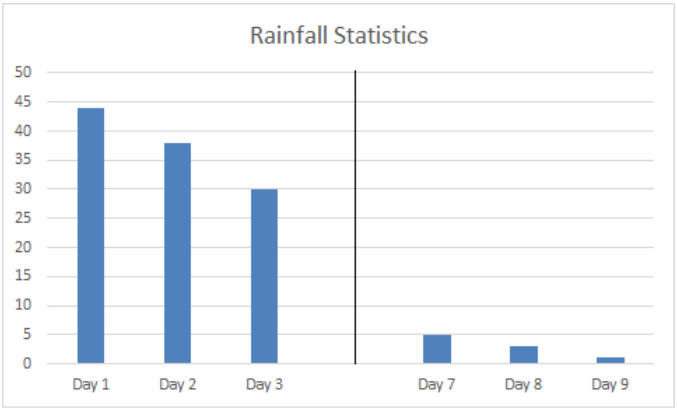

Fig. 5. Weather Update statistics view.

G. Location tracking of victim

At the time of disaster, subscribers are in the middle of it. Then for rescue, this application determines the victims location by using GPS for android or triangulate location using the mobile network for non-android phone and send back the data to the rescue center.

IV. IMPLEMENTATION

In our implementation, we have used Android based smart technology. For alerting people, we first insert their data into the applications database. In the database, subscriber locations are also saved. Then the application communicates with the server. Determining the kind of situation server responses with a JSON file containing the weather information. This application reads the JSON file and converts the data into a

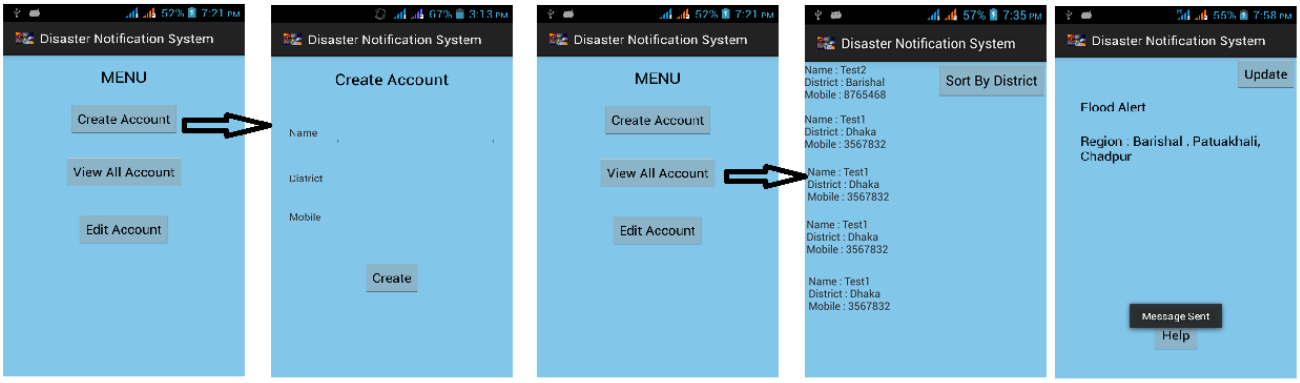

Fig. 6. Application Demonstration.

message which would be sent to the people whose data are in the database. If JSON file gets some disaster like as Cyclone, Flood, Wildfire it sends SMS or voice call to the subscribers.

A. Database Design

This is an Android application so we used SQLite database[24]. This database contains three attributes which are subscriber name, mobile number, region. The attribute mobile number acts as a primary key because the mobile number is unique for subscribers. In the weather server, we create database tables for storing the weather status and to store the position of the shelter.

B. Application Testing

Figure 5(a) shows that statistics of rain on some days. By running naive Bayes algorithm it predicts that heavy rainfall may cause the flood and it can affect some areas. So the JSON file points to those possible affected areas. If the statistics show no promising situation of disaster system, it points to no warning in figure 5(b). The system searches if there is anyone exist in affected regions, it sends them the alert. By this, only the affected people get alerts, not all the people in the database. Table I shows the overview of the alert classification.

Figure 6 shows inner looking of the application. For inserting data into the database users need to press the create account button and give the information. After completing registration, data of the people are saved in the database. A user also can edit or delete account information by choosing Edit Account Menu. After pressing the Edit Account button there are two options edit account or delete accounts. If the user wants to edit account, then the user has to provide the mobile number which is unique (primary key) and then edit the information. For deleting account user have to again give the mobile number. The system will then search the database corresponding that mobile number and will delete that information. When apps requests for weather updates, website calculates the situation of the disaster and make JSON report according to the condition of the weather.

Algorithm 1 MinDistance (TR, U)

```
for each u ∈ U do
    for each tr(i) ∈ TR do
        Find minDistance u to tr(i)
        Select startPoint = tr(i)[pos]
        minDistance = Distance (tr(i) , SP)
    end for
end for
Recommand minDistance up to u
```

Algorithm 2 Distance ($tr_i[pos]$, SP)

```
for each psoition ∈ tr_i[pos] do
    for each SP_i ∈ SP do
        Check PD with the given limit /* PD = Perpendicular Distance */
        Distance (tr_i[pos], i)
        Distance (i, SP_i)
    end for
    Calculate total distance
end for
```

V. Result

In our system, we have warned people before disaster via SMS also told them the optimum route to the shelter. A lot of works exists with the same types of feature but our contribution is we have used partition based trajectory distance where others system used Dijkstra's algorithm or Euclidean distance to measure the optimum path to the shelter position. A comparison of our works with other works is shown in table II.

Table III shows the comparison between Euclidean distance and trajectory distance. We can see that for every test case the Euclidean distance is smaller than the trajectory distance. Because Euclidean distance only calculates through the direct path using coordinate of two places. But there may not be direct paths from those two places. In this case, trajectory dis-

TABLE II
COMPARISON WITH OTHER WORKS

Research Work	Alert People	Tell user shelter position	Algorithm used for measuring optimal path	Weather Prediction
Our Work	Yes	Yes	Partition based trajectory distance	Yes
Marius et. al[12]	Yes	No	No	No
Jovilyn et. al[4]	Yes	Yes	Euclidean	No
Amit et. al[18]	Yes	Yes	Dijkstra's	No
Gamini et. al[15]	Yes	No	No	No
Rahman et. al[7]	Yes	Yes	Eucledian	No

tance is more accurate than the Euclidean distance. Hence, we can calculate the nearest shelter and recommend the subscriber. The approach which Amit Gosavi [18] took, used Dijkstra's algorithm to find the nearest shelter where as we have used partition based trajectory distance. Also, our application gives weather prediction using real-time and archived weather data.

TABLE III
TRAJECTORY PATH RESULT

Test Case	Euclidean Distance	Calculated Trajectory Distance
1	1.95 Km	5.1 Km
2	0.18 Km	0.19 Km
3	1.07 Km	1.39 Km
4	3.46 Km	3.96 Km

VI. DISCUSSION AND CONCLUSIONS

Disaster does not consider any geographical boundary. To minimize the losses in these natural phenomena we should prepare ourselves. Android technology allows us to get information from the websites easily. And our disaster notification system must be a solution to help and give the necessary instructions to the people that would save many lives. This application gives alert before any potential disaster like heavy rain, flood, wildfire etc. may happen. This also provides the optimal route to the nearest shelter. Also, it predicts flood by analyzing previous weather data.

In future work, we will try to predict cyclone by using the previous cyclonic weather data. We will try to create awareness of other unexpected disasters like tsunami and earthquake that usually happen very quickly.

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