% http://www.michaelshell.org/tex/testflow/

\documentclass[conference]{IEEEtran}

%\documentclass[journal]{IEEEtran}

%\usepackage{algorithmic}

%\usepackage{graphicx}

\usepackage{epsfig}

\usepackage{color}

\usepackage{array}

\usepackage{amsmath}

\usepackage{fontenc}

\usepackage{textcomp}

\usepackage{amsthm}

%\usepackage{url}

%\usepackage{balance}

\usepackage{algorithm}

\usepackage{algpseudocode}

\usepackage{pifont}

%\usepackage{mathtools}

\newtheorem{mydef}{Definition}

\newtheorem{myex}{Example}

%\usepackage[lined, ruled, linesnumbered]{algorithm2e}

\ifCLASSINFOpdf

\else

% or other class option (dvipsone, dvipdf, if not using dvips). graphicx

% will default to the driver specified in the system graphics.cfg if no

% \DeclareGraphicsExtensions{.eps}

\fi

% correct bad hyphenation here

\hyphenation{op-tical net-works semi-conduc-tor}

\begin{document}

%

% paper title

% can use linebreaks \\ within to get better formatting as desired

\title{Smart Disaster Notification System}

%

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%and~Yong-Koo~Lee,~\IEEEmembership{Member,~IEEE,}% <-this % stops a space

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%}

% make the title area

\maketitle

\begin{abstract}

%\boldmath

The devastations of natural disasters are the lash of Mother Nature that every year hit us with a whip. They are inevitable. There are no ways to this day that can prevent from happening, all we can do is prepare. Now-a-days a great deal of attention is recently being paid to the potential of mobile communication technology. Short Message System (SMS) has huge impact in the communication system. This paper is about an android application which will alert people before natural disaster such as Cyclone, Flood and tell them the optimal route to the nearest shelter via SMS, voice call and voice alert. In evacuation process we used partition based shortest technique to find nearest shelter place. %It is very faster than state of the art methods.

\end{abstract}

\begin{IEEEkeywords}

Natural Disaster, Notification System, Android, Location Based, Nearest Shelter

\end{IEEEkeywords}

\IEEEpeerreviewmaketitle

\section{Introduction}

\label{sec:Intro}

Natural disasters are the consequences of natural hazards. It does occur a serious breakdown in sustainability of human, animals and property. It does also occur economic losses and disruption of economic and social progress. The overwhelming number of dead or seriously injured and homeless people are affected after the occurrence of a natural disaster. The massive amount of money to be spent for reconstruction and rehabilitation equates to a natural disaster. They are nothing else but extreme environmental events that impact human activities. Hurricane, earthquakes, Tsunamis and volcanic eruptions are the most frequent threats as well as flooding \cite{khalid2015flood}, tornadoes and droughts which are also prevalent.

According to the “Annual Disaster Statistical Review 2010” \cite {guha2011annual}, 330 natural disasters were registered worldwide in 2003. Within that, there have been a total of 21,610 people who have been killed where the number of people killed by floods was 9,819 and the number of those killed by storms were 8583. And the estimated damage was 118.6 billion dollar. The statistics only got worse. But the worst part really is that there is no way of preventing natural disaster. The only way we can survive these is through preparing for what may come.

Researchers had tried to give early warning system to minimize the loss. They came up with some brilliant way to do it \cite{zimmers2015alert,fajardo2010implementation,lo2015developing}. In this modern time mobile have really changed the way of communications \cite{laird2007mobile,rahman2012location}. It is the most used communication tool. Some of them tried to use Short Message System (SMS)\cite{mahmud2012sms} as an alerting system for the disaster. SMS is used on modern handsets originated from radio telegraphy \cite{turner2013wireless} in radio memo pagers using standardized phone protocols. These are defined as the part of the Global System for Mobile Communications (GSM) series \cite{waidyanatha2007challenges} 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 send message to the subscriber but subscriber could be blind, so this method would not be helpful for blind people. Again researchers used android technology \cite{fajardo2010implementation} to ease the system. They used algorithm to calculate optimal route to the shelter for evacuation at the time of disaster and showed the data into google map.

Our proposed “Disaster Notification System” is an android based application which takes weather update from website and calculate the disaster level. Subscriber’s data can be stored in this application’s database. It can calculate the optimal route to the shelter from the subscriber’s current position and send voice call/ SMS with warning and shelter location to them. It sends voice call or voice alarm so blind subscriber can also get the alert. This is GSM type alerting system so subscriber don’t need to have an android device in order to receive the service.

The remaining sections of the paper are organized as follows. In section \ref{relatedworks} describes related work on disaster notification systems. Section \ref{sec:problem} introduces our proposed disaster notification model. Implementation of our proposed technique has been described in section \ref{implementation}. Result has been shown in section \ref{result}. Application of the systems and discussion as well as the future research are shown in section \ref{conclusion}.

\begin{figure\*}[htp]

\centering

\includegraphics[width=.95\textwidth]{fig/architecture.eps}

\caption{ System Overview }

\label{Figure:overview}

\end{figure\*}

\section {Related Work}

\label {relatedworks}

Early disaster warning and evacuation approach is very general disaster management system in disaster-prone areas. Now-a-days mobile phones play essential role for disaster management in several ways: monitoring, communication, warning dissemination, evacuation and rescue and relief aid. A number of notification system has been proposed in our real world. In research paper \cite{cioca2008sms, jeong2009national}, Short Message Service (SMS) is sent to all citizens from the server about the awareness of upcoming flood warning. Huge number of SMS transfer from the server cause network congestion and can break the voice communication system in same network. To avoid this kind of congestion cell broadcasting service is used to directly send messages to the subscribers in a specific area \cite {scherner2005notifying}. But this process fails to help in evacuation process which provides information about 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 \cite{jayasinghe2006gsm}. 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 \cite{park2006one, aloudat2011toward,jeong2009national}. This satellite service maintenance are 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 \cite{amit2014} presented a location based early warning and evacuation system by visual and audio warnings useful to both normal and blind people.

Natural Disaster such as cyclone, storm, earthquake, Tsunami and flood etc has showed 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 about evacuation process by which people get shelter place. Dijkstra's algorithm based shortest path calculation is used to find the nearest shelter place\cite{amit2014}. This process is time consuming because it search all path from the source to destination. For this, we propose a location based smart disaster management system that can warn all subscribers (people, blind people and animals). In evacuation process we used partition based trajectory to find nearest shelter place. It is very faster than previous proposed methods.

\section {Proposed Solution}

\label{sec:problem}

The main purpose of “Disaster Notification System” is to alert people before the time of disaster and tell them the optimal route to the nearest shelter. For doing these we divided the whole application in some module. First one is database building that consists of subscriber information and locations whose probability of disaster is measured. Second one is based on locations in which our proposed methods take information from weather website. After that these information will be converted to JSON (JavaScript Object Notation) \cite{bray2014javascript} format. Then according to JSON information the system will be able to understand the probability of disaster and then system will send nearest shelter information to the subscribers. The architecture of our proposed technique depicts in figure \ref{Figure:overview}. Each part of our system will be explained details in next few sections.

\subsection{Preliminaries}

\label{preliminaries}

The consequence of natural hazards is called natural disaster. There are different kinds of natural disaster such as cyclone, storm, earthquake, Tsunami and flood etc. Different kinds of natural disaster occurs at different time in 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 \cite{latif2011openstreetmap}. The people lives in coastal areas have to face several storms each year and cultivable lands disappear in river due to river erosion. Such countries are mostly affected by the planet’s climate changes and 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 \cite{developers2011android} 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 system, this is the best selling product worldwide. It also allows building of new applications at lower cost. Consequently this is more interactive for users. So, the android mobile platform has been used in our proposed disaster awareness system.

\subsection{Input into database}

We will keep record of subscribers in the database. In there we will store subscribers name, location and mobile number. Because of the subscribers location we can give them the proper warning about the disaster. Disaster Notification System will fetch the informations from it and send notification to the subscribers. Sending notification will depend on update from website.

\subsection{Update from website}

This application will take update from website and evaluate the level of disaster. Then it will convert the data into JSON format. The following figure \ref{Figure:update} shows the update process.

\begin{figure}[htp]

\centering

\includegraphics[width=.45\textwidth]{fig/updatefrm.eps}

\caption{ update from website }

\label{Figure:update}

\end{figure}

\subsection{Minimum distance calculation}

We will try to determine the optimal route for 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 \ref{Figure:optimal} subscriber get a disaster awareness message form the system. The system will send nearest shelter information. Here if we calculate Euclidean Distance \cite{krislock2012euclidean} 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\cite{lee2007trajectory} to calculate distance between two places. Trajectory partitioning means path partitioning which is very important because proposed algorithm has used sub-trajectories.

\begin{figure}[htp]

\centering

\includegraphics[width=.35\textwidth]{fig/optimalp.eps}

\caption{ Calculation of nearest shelter place. }

\label{Figure:optimal}

\end{figure}

%For partitioning, it should be maintained two properties (i) preciseness, means the difference between a path and a set of its trajectory partitions should be as small as possible and (ii) conciseness means the number of trajectory partitions should be as small as possible. These two properties are contradictory to each other so more challenging issues is to find the optimal tradeoff. To find the optimal tradeoff between preciseness and conciseness the minimum distance length (MDL) principle widely used that cost consists of two components: $L(H)$ and $L(D|H)$ \cite{grunwald2005advances}. Here, H and D means the hypothesis and the data. The two components are informally stated as follows: $L(H)$ is the length of the distance of the hypothesis; and $L(D|H)$ is the length of the distance of the path. The best hypothesis $H$ is one that to clarify $D$ and minimizes the sum of $L(H)$ and $L(D|H)$ \cite{lee2007trajectory}.

\begin{figure}[ht]

\centering

\includegraphics[width=.5\textwidth]{fig/trajectory.eps}

\caption{Calculate Minimum distance function for path shelter}

\label{Figure:MDLCOST}

\end{figure}

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 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 \ref{eq:perpend} to measure the perpendicular distance where $(m,n)$ is the co-ordinate 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 with 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. In figure \ref{Figure:MDLCOST}(b) $P3$ trajectory partitioned in two parts. Again we measured the perpendicular distance for the both partition. 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. Figure \ref{Figure:MDLCOST}(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.

Algorithm \ref{alg:mindistance} and \ref{alg:distance} shows the procedure to determine the distance of the trajectory path from staring point to ending point. In algorithm \ref{alg:mindistance} 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 \ref{alg:distance}. Then we recommend shelter distance to subscriber $u$.

In algorithm \ref{alg:distance} 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 would call the $distance$ function twice for the left and right partition. And if the perpendicular distance is lower than the limit we took the approximate solution and store the result. And lastly it would calculate the total distance from the two partition or with the approximate distance for each trajectory and return the result in the algorithm \ref{alg:distance}.

\begin{equation}

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

\label{eq:perpend}

\end{equation}

%Figure \ref{Figure:MDLCOST}(a) shows the formulation of $L(H)$ and $L(D|H)$. Suppose a trajectory $TR\_i = p\_1p\_2p\_3 \cdots p\_j \cdots p\_{len\_i}$ and a set of characteristic points = $\left\{p\_{c\_1} , p\_{c\_2} , p\_{c\_3} , \cdots , p\_{c\_{par\_i}} \right\}$. Then the formula $L(H)$ and $L(D|H)$ is defined by equation \ref{eq:LH} and \ref{eq:LDH} respectively \cite{lee2007trajectory}.

%

%\begin{equation}

%L(H) = \sum\_{j=1}^{par\_i-1}{log\_2(len(p\_{c\_j}p\_{c\_{j+1}}))}

%\label{eq:LH}

%\end{equation}

%

%

%\begin{eqnarray}\nonumber

%L(D|H)&=& \sum\_{j=1}^{par\_i-1}{\sum\_{k=c\_j}^{c\_{j+1}-1}} \left[log\_2\left\{d\_{\bot}(p\_{c\_j}p\_{c\_{j+1}}, p\_k p\_{k+1})\right\}+\right.\\

%&& \left.log\_2 \left\{d\_{\theta}(p\_{c\_j}p\_{c\_{j+1}}, p\_k p\_{k+1})\right\}\right]

%\label{eq:LDH}

%\end{eqnarray}

%

%\begin{equation}

%Min Distance = L(H)+L(D|H)

%\label{eq:MDL}

%\end{equation}

%

%

%

%where, $len(p\_{c\_j}p\_{c\_{j+1}})$ denote the length of a line segment $p\_{c\_j}p\_{c\_{j+1}}$ that is the Euclidean distance between $p\_{c\_j}$ and $p\_{c\_{j+1}}$. Hence, $L(H)$ represents the sum of the length of all trajectory partitions and $L(D|H)$ represents the sum of the difference between a trajectory and a set of its trajectory partitions.

%

%As mentioned before, find the optimal partitioning by equation \ref{eq:MDL} is exactly the tradeoff between preciseness that is represented by $L(H)$ and conciseness that is represented by $L(D|H)$. The cost of finding the optimal partitioning is considered minimum distance. This process is so much faster then Dijkstra's algorithm.

%

%The main idea of this proposed method is to consider the set of local optima as the global optima. Let $MDL\_{par}(p\_i,p\_j)$ denote the MDL cost = $L(H)+L(D|H)$ of the trajectory between $p\_i$ and $p\_j$ where $p\_i$ and $p\_j$ are only characteristic points and $(i<j)$. Let $MDL\_{nopar}(p\_i,p\_j)$ denote the MDL cost when assuming the there is no characteristic point between $p\_i$ and $p\_j$ means $L(D|H)$ in $MDL\_{nopar}(p\_i,p\_j)$ is zero. A local optimum is the longest trajectory partition $p\_ip\_j$ that satisfies $MDL\_{par}(p\_i,p\_j) \leq MDL\_{nopar}(p\_i,p\_j)$ for each value of k such that $i < k \leq j$. Those points where this condition do not follow it should be partitioned and add $k\_1$ at a characteristic points. Figure \ref{Figure:MDLCOST}(b) shows the approximate partitioning of a trajectory where $p\_3$ is a characteristic point and partitioning trajectories are $p\_1p\_3$ and $p\_3p\_5$. Figure \ref{Figure:MDLCOST}(c) shows three kinds of distance $d\_\bot$, $d\_|$ and $d\_\theta$.

\begin{table}[htp]

\centering

\caption{Alert Classification}

\begin{tabular}{|l|c|c|}

\hline

Disaster & SMS & Voice Alert \\

\hline

Rainfall & Yes & Yes \\

\hline

Heavy Rainfall & Yes & Yes \\

\hline

Cyclone & Yes & Yes \\

\hline

Wildfire & Yes & Yes\\

\hline

Flood & Yes & Yes\\

\hline

\end{tabular}

\label{tab:alertclass}

\end{table}

\subsection{Sending notification}

After getting update from website and calculating the minimum distance then it will send notification to the subscriber whose data are already in database. This notification can be both audio and text message because subscriber could be blind.

\begin{figure}[htp]

\centering

\includegraphics[width=.49\textwidth]{fig/floodjs.eps}

\caption{ Weather Update statistics view. }

\label{Figure:rainfall}

\end{figure}

\begin{figure\*}[htp]

\centering

\includegraphics[width=.95\textwidth]{fig/scrnn.eps}

\caption{ Application Demonstration. }

\label{Figure:application}

\end{figure\*}

\subsection{Location tracking of victim}

In the time of disaster, subscriber could be in the middle of it. Then for rescue, this application will determine the victim’s location by using GPS for android or triangulate location using mobile network tower for non-android phone and send back the data to the rescue centre.

\section {Implementation}

\label{implementation}

In our implementation we have used android based smart technology. For alerting people we first insert their data into the application’s database. In database, subscriber locations are also saved. Then the application communicate with the server. Determining the kind of situation server response with a JSON file containing the weather information. This application reads the JSON file and convert the data into a message which would be sent to the people whose data are in the database. If JSON file get some disaster like as Cyclone, Flood, Wildfire it sends SMS or voice call to the subscribers.

\begin{table}[htp]

\centering

\caption{Shelter Co-Ordinate Table}

\begin{tabular}{|l|c|c|}

\hline

District & Shelter Co-ordinate & Trajectory Co-ordinate \\

\hline

\end{tabular}

\label{tab:sheltertab}

\end{table}

\subsection{Database Design}

This is an android application so we used Sqlite database\cite{junyan2009application}. This database contains three attributes which are subscriber name, mobile number and region. The attribute mobile number acts as a primary key because only mobile number is unique for subscribers because there can be more than one subscriber with same name and same location.

Also in the weather server we had created database tables for storing the weather status and to store the shelter position. Table \ref{tab:sheltertab} shows the architecture of the shelter co-ordinate table of the database.

\subsection{Application Testing}

Figure \ref{Figure:application} shows insider look 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. User also can edit or delete account information by choosing Edit Account Menu. After pressing the Edit Account button there are two option edit account or delete account. If user wants to edit account, then user have 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. Then system will search the database corresponding that mobile number and will delete that information. When apps requests for weather update, website calculate the situation of the disaster and make JSON report according to the condition of the weather. Figure \ref{Figure:rainfall}(a) shows that statistics of rain in 5 days. The heavy rainfall may cause flood and it could affect some area so the JSON file pointed to those possible affected area. Also if the statistics shows no promising situation of disaster then it will pointed to no warning in figure \ref{Figure:rainfall}(b). The system will search if there is anyone exist in affected region then it will send them the alert. By this only the affected people get alert, not all the people in the database. Table \ref{tab:alertclass} shows the overview of the alert classification.

%\section{Discussion}

%\label{discussion}

\begin{algorithm}

\caption{MinDistance (TR, U)}

\label{alg:mindistance}

\begin{algorithmic}[1]

\For{each $u$ \Pisymbol{psy}{206} $U$ }

\For{each $tr$($i$) \Pisymbol{psy}{206} $TR$ }

\State Find minDistance $u$ to $tr$($i$)

\State Select startPoint = $tr$($i$)$[pos]$

\State minDistance = Distance ($tr$($i$) , $SP$)

\EndFor

\EndFor

\State Recommand minDistance up to $u$

\end{algorithmic}

\end{algorithm}

\begin{algorithm}

\caption{Distance ($tr\_i$$[pos]$, SP)}

\label{alg:distance}

\begin{algorithmic}[1]

%\Procedure{CH\textendash Election}{}

\For{each $psoition$ \Pisymbol{psy}{206} $tr\_i$$[pos]$ }

\For{each $SP\_i$ \Pisymbol{psy}{206} $SP$ }

\State Check PD with the given limit/\* PD = Perpendicular Distance \*/

\State Distance ($tr\_i$$[pos]$, $i$)

\State Distance ($i$, $SP\_i$)

\EndFor

\State Calculate total distance

\EndFor

\end{algorithmic}

\end{algorithm}

\section {Result}

\label{result}

From table \ref{tab:resultclass} we can see that for every test case the euclidean distance is smaller than the trajectory distance. Because euclidean distance only calculate through the direct path using co-ordinate of two places. But there may not be direct path from those two places. In this case the trajectory distance is more accurate than the euclidean distance. So by this we can calculate the nearest shelter and recommend the subscriber.

\begin{table}[htp]

\centering

\caption{Trajectory Path Result}

\begin{tabular}{|l|c|c|}

\hline

Test Case & Euclidean Distance & Calculated Trajectory Distance \\

\hline

1 & 0.00195326 & 0.00513886 \\

\hline

2 & 0.000187697 & 0.000199476 \\

\hline

3 & 0.00107156 & 0.00139617 \\

\hline

4 & 0.00346705 & 0.0039669\\

\hline

\end{tabular}

\label{tab:resultclass}

\end{table}

\section{Discussion and Conclusions}

\label{conclusion}

Disaster does not consider any geographical boundary. To minimize the losses in these natural phenomenon we should prepare ourselves. Android technology allows us to get information from website easily. And disaster alert should be a solution to help and give necessary instruction to people that will save lot of human life. This application gives alert before disaster like heavy rain, flood, cyclone, wildfire etc. This also calculate the optimal route to the nearest shelter. In our future work we will solve this kinds of challenges. We also try to awareness of other unexpected disaster that happen very quickly and we can not find its information from website (like as Tsunami and earthquake).

\section\*{Acknowledgment}

The authors are grateful to the anonymous reviewers for their comments that improved the quality of our paper. This research was supported by the research fund of Bangabandhu

Sheikh Mujibur Rahman Science and Technology University, Bangladesh. Sajal Halder is the corresponding author.

% (used to reserve space for the reference number labels box)

%\begin{thebibliography}{1}

%

%\bibitem{IEEEhowto:kopka}

%H.~Kopka and P.~W. Daly, \emph{A Guide to \LaTeX}, 3rd~ed.\hskip 1em plus

%0.5em minus 0.4em\relax Harlow, England: Addison-Wesley, 1999.

%

%\end{thebibliography}

%\bibliographystyle{IEEETran}

\bibliographystyle{plain}

%\balance

\bibliography{myb}

\end{document}