www.irbas.academyirmbr.com July 2023
International Review of Basic and Applied Sciences Vol. 11 Issue.3

Prediction of Natural Disasters by Assessing Animal Behavior Using Crowd-Sourcing

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Abstract

This research is based on predicting the earthquake using unusual animal behavior. Multiple researches have been carried out in predicting the quake using abnormality in animals but this research focuses on designing the mobile app "Early Alert Disaster Management System" that could predict earthquakes using crowdsourcing and ICT. ICT has evolved rapidly and it is still evolving, there are so many technological revolutions going on in this field. It has influenced the behavior of consumers, their daily lifestyle, marketing, and business activities. Besides smartphone technology which is growing exponentially, there is another concept known as "Crowdsourcing", this concept has touched the sky in a very short time, and it is being adopted and used by almost all disciplines wherever there is a need to acquire data. Crowd-sourced enabled systems are modernizing the tactic for confronting hitches and allowing us to monitor and act upon almost anything, anywhere in real time. In EADMS, crowd-sourcing will be used in gathering the data. The gathered data will be analyzed and based on this analysis, certain statistics will be generated. Once the statistics meet the threshold level, different alerts will be sent to the registered users, and on the sending of the last alert, the shortest route to the safest location will also be sent to the registered user so that they can evacuate the place to be affected. Besides that, EADMS also allows its registered users to transmit messages to other people who are not registered with the system. We have used the Girls Gossip model to transmit the information so that our app can alert as many people as possible.

Keywords: *Intelligent Systems, Crowd-Sourcing, ICT, Earthquake, Seismic Activity.*

Introduction

Earthquake is the one that threatens mankind the most. An earthquake can transmute into many other disasters, if it befalls underwater, it becomes the root cause of TSUNAMI, if it befalls in an area full of mountains it becomes the reason for avalanches or volcanic eruptions, or even if it ensues on the land, it has enough power itself to shake the land for destruction. Many researches have proved the possibility of

predicting the earthquake using unusual animal behavior but none of those researches state the transmission of information to the people. Although there are different devices installed in the developed countries that can predict the earthquake 3rd world countries like Pakistan are not rich in hi-tech, and underdeveloped countries like Pakistan cannot afford these instruments. But ICT technology has been accepted by users Worldwide, as a part of their lifestyle which shows its success in raid changing technologies (Aldhaban, 2012). Currently, the prediction analysis system of such countries relies on the equipment that works on its precursors without focusing on the others, and the channel of dissemination for the disaster is based on media, which involves T.V, radio, etc. A person gets to know about any disaster through such mediums and by the time he or she gets to know about the disaster is almost too late for them to take action. Even after the disaster, the situation remains in chaos. People got stuck in the Debris, unable to escape from the situation. Paths to reach the affected region get blocked. Volunteers and emergency services got struck as well, thus unable to reach the desired location on time for the aid of the affected ones. The after-effects pushed the affected countries 10 to 12 years; their economy was weakened, agriculture was ruined, the physical environment was affected and people's precious lives were lost. Therefore, this serious, unkind, hostile, and hazardous tremor must have some controlling measures that help underdeveloped countries protect their nation from cataclysm.

Literature Review

China started their research on the unusual behavior of animals for predicting any impending natural disaster and succeeded in their research. Chinese began to study systematically the unusual behavior of animals. They established an operational network in different cities and closely studied the behavior of animals. Several reports of abnormal animal behavior were received based on which they evacuated the suspicious city. The earthquake caused considerable damage to the fields and land but the successful evacuation saved 100,000 human lives (Bhargava et al., 2009). While researching the unusual behavior of animals in Peru, scientists encountered that animals in Peru such as Pumas and Razor-billed curassow birds moved for the cover, a few days before the Earthquake which struck in 2011. They believe that due to the airborne ions in the atmosphere, animals predict the occurrence of an Earthquake and move for cover (*Animal Tracking Could Help Predict Earthquakes | Discover Magazine*, n.d.). According to Friedman T. Freund, Animals possess capabilities to sense any changes that occur in the environment, thus looking at the unusual behavior of animals; can help people to identify any change in the environment, which could lead to the fact for an incoming Earthquake (Woith et al., 2018). (*Nepal Earthquake | Tech Times*, n.d.) An earthquake hit Nepal in April 2015 with a 7.8 magnitude. Immediately before an earthquake, many animals started behaving strangely. They started leaving their homes to seek shelter. This could be because they detect small, fast-traveling waves or because they sense chemical changes in the groundwater from an impending earthquake. An unusual animal behavior can be converted into something that can be understood by us. Many studies have shown that putting biotelemetry devices on animals can have seriously detrimental effects on their welfare, changing their behavior, and by doing so, data is collected. Another way of collecting data is to monitor changes in the animal's behavior using motion detectors. The detectors could be used to automatically detect any deviation from normal behavior patterns. The wisdom of the crowd can be a great help (Tucker et al., 2019). Through crowdsourcing, a diverse range of users can give input. (*Animal Tracking Could Help Predict Earthquakes | Discover Magazine*, n.d.) ICT and crowdsourcing (Tong et al., 2020) can be used with unusual animal behavior before the disaster and these all factors, together can help a lot in predicting a seismic activity (*Did Animals Sense Tsunami Was Coming?*, n.d.). Researchers has shown that mobile phones can be a great help in detecting tremors and other health diseases (Aldhaban, 2012). Japan employs an advanced early warning system consisting of over 1000 seismometers tactically placed across the country, which proved instrumental in saving lives during the 2011 magnitude 9 earthquake. Researchers conducted a study to assess the precision of mobile phones by subjecting them to simulated shaking and comparing their accuracy with more reliable scientific instruments. Subsequently, the researchers validated their system using actual data from the Tohoku earthquake. Employing a network of 462 GPS stations distributed throughout Japan, the team approximated the data that would be generated by mobile phones. The system demonstrated the capability to detect the

earthquake a mere 77 seconds after its initiation, providing a critical lead time of 10 seconds before the seismic event. (Conover, 2015). However, the deficiency of such a system is that it does not give much lead time to evacuate the place. For detecting the motion of animals before the quake, Motion-triggered cameras were located in Yanachaga National Park in Peru, scientists found significant changes in animal behavior more than three weeks before the earthquake of magnitude 7. The cameras recorded 5 to 15 sightings. After 23 days, fewer animals were sighted and 5 to 7 days before the earthquake, no animal movements were recorded. According to Dr. Rachel Grant, positive ions in the air generated in large numbers when rocks below the surface are stressed in the build-up to an earthquake may hold the key to the animal's unusual behavior. According to her animals don't like positive ions. She further elaborated that among all species in the zoo, rodents were the first ones to disappear, they have vanished 6 days before an earthquake (*Can Wild Animals Help Us Predict Earthquakes? | CNN Business*, n.d.). Although the idea and approach were great based on their zoo research, scientists haven't made any smart and efficient system. Bangladesh has designed an early disaster warning and evacuation system. It provides vital support in a multitude of ways. Location-based disaster preparedness system made for Bangladesh. The system consists of a Disaster management server, and GPS supports Android mobile phones. The database of the system stores the disaster-prone areas and the details about users in its database. Regional weather offices can also access the database to update the disaster-prone areas. Through GPS, the mobile phone gets the current location of its user and sends it to the server. Utilizing the user's present location, the system assesses whether the user is situated in a potential disaster-affected area. This determination is made through the application of the Ray Casting Algorithm. Users receive timely disaster warnings through visual and audio messages displayed on the application's map. Additionally, the application provides users with the most efficient route to the nearest safe area or shelter zone. The regional evacuation control authority monitors evacuation progress preemptively using Disaster Management Systems (DMS), facilitating a swift evacuation process prior to the onset of a disaster. (Rahman et al., 2012) Predictions about Earthquakes can be achieved by observing the unusual behavior of animals, as animals are much more capable than humans of perceiving certain kinds of geophysical stimuli that could lead to earthquakes (Kirschvink, 2000). Animals can change their reproductive behavior when they feel any change in nature, this includes natural disasters like earthquakes or tsunamis, etc. It has been observed that animals abandon their spawning because of the Earthquake and then delay it until the Earthquake ends (Grant & Halliday, 2010). Animals show unusual behavior before the huge waves strike the coasts of India and Sri Lanka, many wild and domestic animals escape to safety ten days earlier, as it seems that they already know that some disaster is about to occur. According to some eyewitnesses, the following events happened; Dogs refused to go outdoors, Elephants screamed and ran for a higher ground, Zoo animals quickly moved into their hideouts and refused to come back out and flamingos left their low-lying spawning areas. Thus, after the disaster relatively very few animals have been reported dead, hence it was assumed that animals somehow sense an imminent disaster (*Radio Sound Effects: Who Did It, and How, in the Era of Live Broadcasting - Robert L. Mott - Google Books*, n.d.). The behavior of birds and animals is also an indicator of the nature of forthcoming rainfall and the probability of droughts (Magomelo et al., 2014). The animal's unusual behavior is observed repeatedly for predicting the Earthquake, these behaviors seem to have no rational explanation until the ground shakes. Animals like snakes, earthworms, and frogs reach the surface before an Earthquake; similarly, catfish batter violently before an Earthquake. The change in the composition of water, underwater sounds, and electric radiation is perceived by Numazu through a very sensitive system of nerve cells in the feeler on the sides of the body, thus it is suggested that the nervous system of fishes acts as a registering tool, which reacts with far greater sensitivity than seismograph (Bluestone, 2010). Animal sensitivity is linked to the long-distance signals spread by the energy (Cao & Huang, 2018). The signals of animals are usually produced in multiple forms including acoustics, chemical, and electromagnetic signals. The nearby Earthquake can easily be recognized with the help of these signals (Hussain & Asif, 2012). Working principle of EADMS. Three types of users can interact with the EADMS i.e. General users, Volunteers, and Zookeepers. Three types of alerts will be sent to the users. Alert A will be a wake-up call. Alert B will be the "Be ready" call and Alert C will be the last alert that will tell the people to empty the place then the Girls Gossiping model has been used to transmit the information to the unregistered users.

Methodology

EADMS works on the principle of ICT and crowdsourcing. The data for the research in phase 1 is collected through crowdsourcing. It is, gathering information from a group of people on a common topic (Alsever, 2007; Allen et al., 2018). The information that is gathered is, "for the people and by the people". The system includes three types of users who interact with the application. They include (1) zookeepers, (2) general users, and (3) volunteers. For registration and to become a part of a system, the general user(s) must have pets. Volunteers can be anyone such as hospital workers, social workers, etc., and general users can register as volunteers as well, only, if they want to register and don't own any pets. Zookeepers and general users are the ones who interact with the system (as soon as they encounter any unusual behavior of animals) by uploading the data using the questionnaires presented as a form in an Android application. Amongst all the users, the zoo keeper's input will have a higher priority. The form is available as a questionnaire containing 8 to 10 questions that are asked by the user. After filling out the questionnaires, the form is uploaded to the server where it is analyzed and stored according to the respective zones. Early Alert Disaster Management System has been designed and developed to predict earthquakes using unusual animal behavior. There will be three types of users interacting with our app general users, zookeepers, and volunteers. General users must have pets. Data will be collected through crowdsourcing. General users and zookeepers will be given input by filling form. Forms will have 8 to 10 questions related to the pets. Based on the user's form input, statistics will be generated. There will be a threshold level set. Once the threshold is met, alerts will be generated text messages will also be sent to the registered users, and multiple routes to the unaffected region will be generated. Volunteers will get the shortest route to the unaffected area so that they can help the people evacuate from the unaffected area.

Transmission of Information

The gossiping girl approach is one of the excellent approaches to disseminating information. Like if one girl knows something unique, she will disseminate the information to the group of girls, she knows and also updates the other girls about the unique information. This technique is a great help to disaster management systems for instance if a disaster occurs at a lace, the information will be disseminated and gossiped about all over. It will help people evacuate from the affected place and will help volunteers reach out to the people who need help. The best practice in transmitting knowledge is through gossiping as people usually gossip as soon they get time or they hear very interesting news. The medium of Gossiping can be anything, it can be done at breakfast/ lunch or the dinner table, at parties, or over the phone. The main idea of gossiping is to share and exchange interesting information. In Disaster Management systems, gossiping will play an important role; not only the information will be shared amongst the registered users but will also be transmitted to others. In this way, EADMS will help mankind. To use gossiping in the system, there is a model known as the Gossiping Girls Model. According to this model, every girl holds unique information and they share their information with the other one in terms of gossip. The EADMS incorporates Gossip Girls phenomena. As The Gossip Girls illustrates knowledge is gossiped about amongst all the girls in the network, and the EADMS system will have the same mechanism, as soon as any volunteer or social service people receive any news regarding the disaster, they will transmit the knowledge to their friends. Their friends can also get registered to EADMS in no time and can reach the affected site using GoM. He then again can send this information to his/ her friends and thus they can also get registered and reach the disaster site. The cycle continues till the information is no longer transmitted. Thus using the Gossiping Girls model in EADMS helps to manage the Earthquake more efficiently. The network using Gossip Girl phenomena becomes volunteers and social service personnel which will help in transmitting the knowledge in their social circle.

Data Processing on the Server

The data processing on the server accepts the filled questionnaires sent through the Android application and stores them according to their respective zones. Each zone contains multiple areas. Based on the analyzed

data a graph will be bred which represents the statistics of the zones accordingly. A sample size of the questionnaires sent to the server plays an important role, as, the greater the sample size, the more authentic the data is. Three types of alerts are generated by the server, as soon as the received data becomes greater than the threshold. There is an administrator, who interacts with the system and can update the questionnaires via the admin panel on the server, he can set the zonal distributions and can also be able to set the threshold level for the comparisons.

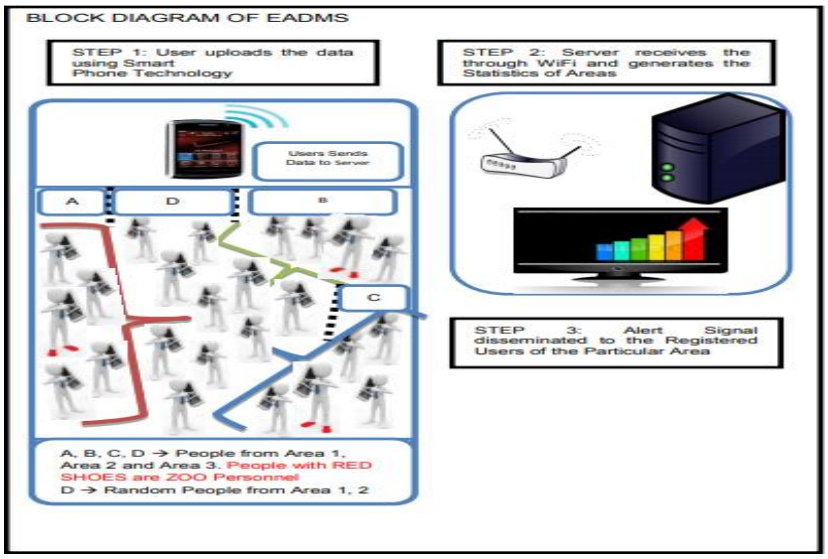

Figure No 1

Performance Evaluation

The form filled by the user has certain questions. Each question has a certain weightage out of 5. If the question has choices then each choice has a different weightage.

Ques #	Question	Weightage
01	Unusual behavior of pet (i-e cat) • Vocalizing • Hiding • Escaping • Fear • Scratching	 • 01 • 3.5 • 04 • 04 • 2.5
02	When did it start showing unusual behavior • Week ago • A day ago • 2-3hours • > a week	 • 4 • 2.75 • 3.75 • 4
03	Have your pet ever showed unusual behavior prior to earthquake • Yes • No	 • 01 • 0
04	If yes, has it showed the same unusual behavior? • Yes • No	 • 04 • 0
05	Has earthquake ever stroke into your locality? • Yes • No	 • 01 • 0
07	If yes, when did it last strike into your locality	01
08	Where were you, when it last hit into your locality?	01

Figure No 2

The A.M of these weights then be calculated and based on these means, statistics will be generated area-wise. A.M = ∑X / n Where n is the number of questions and ∑X is the sum of the weightage of questions.

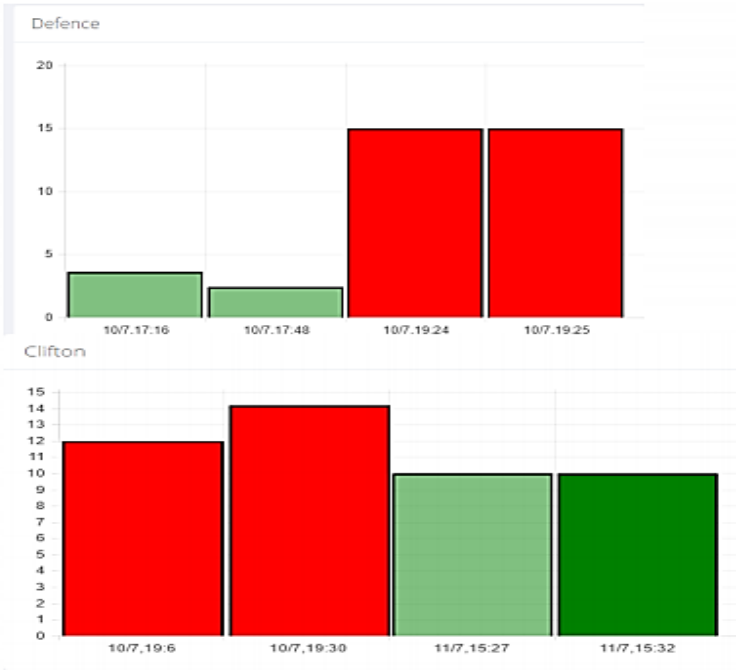

Figure No 3

Figure No 4

Once the threshold level is met, alerts will be sent to the registered users.

Results

Based on the statistics of considered regions of Karachi (i.e. Defense, Clifton, and North Karachi) and on meeting the threshold, three alerts were generated. Nearly 60% of the population of a particular area reports

an abnormality in animals, thus alert A is being generated. It alerts the people that there is something fishy going to happen, be prepared if th<=70% and th>60% then alert B is generated, and when th >70% then alert C is generated which alarms the people. With alert C, a route to the safest place is also being sent to the people. Volunteers receive the route to the affected area so that aid can reach the affected area soon. Registered users can then inform their loved ones via EADMS. Girls gossiping model has been incorporated with EADMS so that unregistered users can also make themselves safe.

Conclusion

The Early Alert Disaster Management System is intended to predict the earthquake using crowd-sourcing and ICT, as it takes data regarding the unusual animal behavior from three different sources including; random people from an area, social service personnel, and zoo keepers. As soon as the uploaded data reaches its threshold, an alert signal will be sent to all the registered users. As soon as they receive an alert signal, they could be able to view the shortest path from their location to the site where the Earthquake ensued. The information can be further disseminated to other people with the help of the Girl Gossiping Model which will be incorporated into the discussed system. Thus less developed countries can benefit from this system for predicting disasters and managing them within their confined boundaries.

Future Scope & Limitations

The future scope is to extend our project domain countrywide. Right now, it only focuses on Karachi city. Furthermore, we will be creating our data center which will include animals that can sense the earthquake before it. There will be motion-triggered cameras and sensors incorporated with a data center that will monitor the motion of animals and once the camera and sensors encounter any abnormality, sensors will transmit the data to the server and if 80% of the animals show unusual behavior at a time then alerts will be sent to the users. By doing so, our system will produce authentic outcomes and we can then contribute a society in a better way.

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