Mobile agent systems to aid in Emergency Situations

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Abstract

Mobile devices are pervasive in peoples' daily life. Between phones, tablets, and portable gaming systems people are nearly always connected to a sophisticated computing device. Additionally, almost all of these devices are connected to one another through Wi-Fi, Bluetooth and Satellite networks. This amazing resource of networks and devices has been instrumental in allowing people to communicate, but we have only scratched the surface of what all this interconnectivity is capable of. More specifically, this array of devices and networks could provide tremendous resources in an emergency situation. This paper will survey the different three different mobile agents that can assist in emergency situations. By surveying what is currently available conclusions will be drawn on what can be available, what issues are present, and what improvements can be made.

Introduction

In the United States there are 86.7 mobile phones subscriptions per 100 inhabitants. Despite the US being a technology leader it is far behind many European nations. Germany has 128.27, Portugal 139.64, France 93.45, and Latvia 98.90 [6]. These figures prove that mobile phones are part of our everyday life. While mobile phones have done much for our ability to communicate we are only scratching the surface of what is possible with the technology each person carries on a daily basis. A modern smart phone will generally contain, a camera; accelerometer; microphone; speakers; and Wi-Fi, Bluetooth, and cellular connectivity. These sensors have been exploited for countless mobile applications, but a majority of these application are for entertainment. This technology and interconnectivity should be used for more than entertainment.

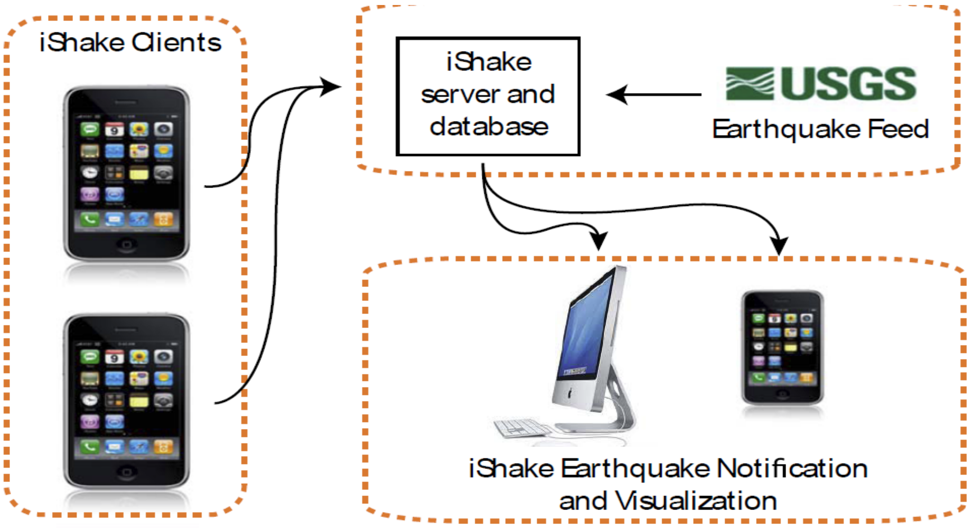
There has been research to this end. For example iShake is an iPhone application that collects accelerometer data to map an earthquakes intensity and location. This earthquake data is collected on a central server and used to help emergency services coordinate relief efforts. Additionally, there has been research in traffic collision detection and adhoc communication in the event of an emergency. Despite the success seen in these emergency applications, current research has failed to provide a robust system that integrates all the sensors and interconnectivity into one general purpose emergency detection system.

This paper will analyze three mobile phone based systems to see what they are capable of and where improvements can be made. A discussion of three different systems will give perspective on what is available, and what can be available in the realm of mobile based emergency agents.

Current Research

Below is a summary of three different mobile emergency applications.

iShake



Above is a diagram visualizing all the pieces of the iShake system.

iShake is a project developed by researchers at the Department of Civil and Environmental Engineering University of California, Berkeley. The iShake system uses the technology incorporated into the iPhone to create a seismic sensor that, combined with other iPhone's data, is able to quickly and accurately measure and map an earthquake's intensity[6].

iShake uses the accelerometer integrated into the iPhone to drive a state machine[6]. There are three possible states--wait for stillness, buffer mode, and streaming mode[6]. The first state, wait for stillness, is necessary because a mobile phone is often in a state of motion and will be unable to detect earthquake movement. To solve this issue, researchers at Berkley programmed the phone to wait until the accelerometer is in a still state before monitoring for earthquake movement. Once the phone remains still for some period of time it will transition to the next state, buffer mode. In buffer mode the phone is waiting for an earthquake event to trigger the next state. This trigger is an acceleration event that may be an earthquake. Once a possible earthquake is detected the phone will enter streaming mode. In this state the phone is transmitting accelerometer data to iShake's servers.

The iShake server looks for similar acceleration events across multiple phones, and looks for a correlation of data with high quality USGS sensors in order validate the data seen from individual iPhones[6]. Once a correlation is made across multiple iPhones and USGS data the server aggregates the data and creates an intensity map of the earthquake. After extensive testing and development the researchers found that system is definitely feasible[6]. Despite the successes the researchers at Berkley achieved there are still some issues that needed to be dealt with in order to make this system more robust.

As one might have surmised this system has a high chance of false positives. A phone that is in the buffer state and then gets picked up has a high chance of detecting the acceleration of the pickup event as an earth quake. Researchers at Berkley are able filter out some of these false acceleration events locally. For example, the acceleration of getting dropped on the ground is too great for an earthquake to act on a phone resting on the ground[6]. In that case the iShake would filter out that acceleration event, and not stream it to the server[6]. In addition to false positives there are other issues to consider. For example, the researchers found data discrepancies due to manufacturing variances in accelerometers and they found variances in the acceleration reported due to different resting surfaces of the phone[6]. These issues were overcome with additional testing and logic, but there is one big issue with this system that was not overcome, communication.

An iPhone that is unable to communicate with the central server is useless in aiding earth quake detection, and often times this is the case in a large earthquake, and the reasons for this are twofold. The first reason is the physical damage that an earthquake creates destroys the cell phone infrastructure. Secondly networks are based on the random distribution of data [14]. When a natural disaster occurs peoples communication habits are no longer random and this will bring cause many cell phone networks to fail. What is needed is a more intelligent system. A system that is able to adapt to the loss of communication will be much more robust in a real earthquake event, and this will be discussed further in the analysis section.

WreckWatch

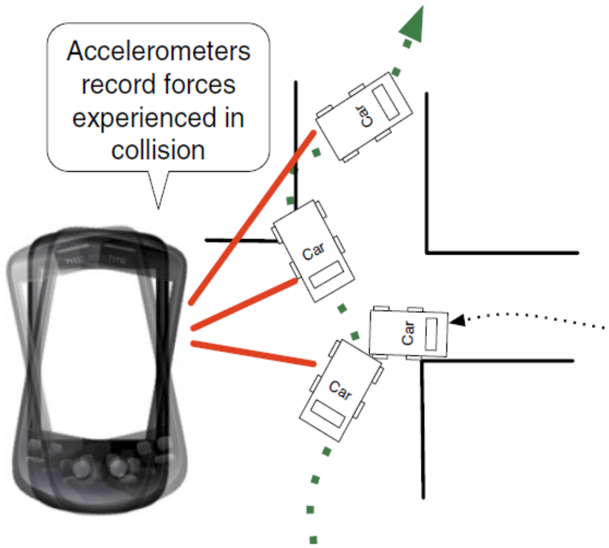


Diagram of WreckWatch

Decreasing the time it take for first responders to show up to an accident can reduce the mortality rate by 6% [12]. To help increase response time researchers at Vanderbilt University came up with WreckWatch. WreckWatch is an Android application that uses the accelerometer and microphone in modern smart phones to detect traffic accidents. Detection of traffic accidents is not new in fact collision detection already exist in some vehicles such as GM OnStar equipped vehicles. A vehicle integrated crash detection system will be able to provide more accurate results than smartphone, but there are still some significant advantages of using a smartphone[12]. First is the install base, over 325 million smart phones have been sold in the US[12]. Secondly, smart phones are easily upgraded over the air (OTA) [12]. This is important when one considers that GM had to make obsolete over half a million vehicles traffic detection because of communication infrastructure changes[12]. Thirdly, smart phones are low cost compared to integrated detection within a vehicle[12]. Finally, smart phone detection offers traffic collision detection in any vehicle opposed to vehicle integrated collision detection.

WreckWatch is based on an 11 parameter algorithm that includes GPS data, timing data, and other system data, but the two most important parameters to this algorithm are microphone data and accelerometer data[12]. The WreckWatch algorithm continually runs on a smartphone, and as data enters the system the algorithm will result in two states--an accident happened or accident did not happen. The two main factors that decide if an accident happened are a high decibel sound event (greater than 160db) and a high g-force event (greater than 4gs) [12]. To reduce false positives speed from the GPS sensor is also used, or in other words the phone needs to detect movement prior to the wreck[12]. If there was no speed and then high g-forces were present this could be somebody dropping their phone. Although this precondition does open the door to missed detection in the case someone is stopped at a stop light and they get rear ended.

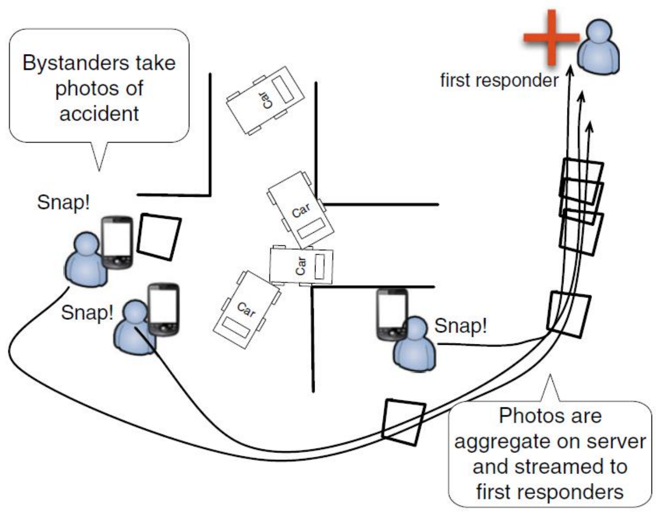
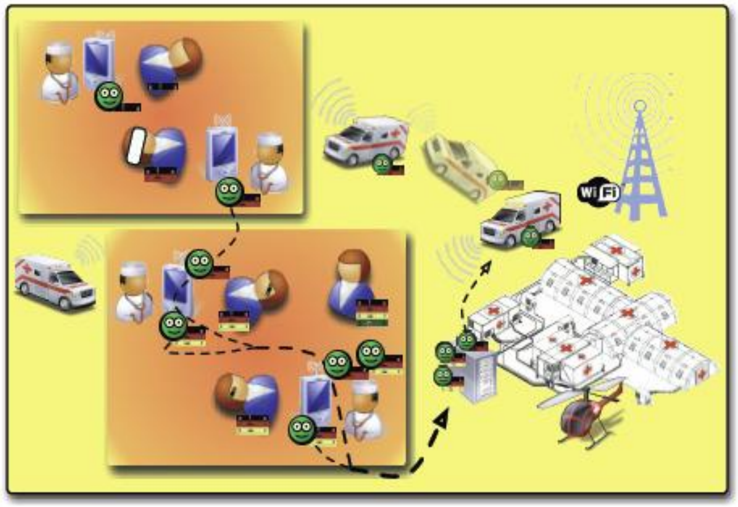


Diagram depicting situational awareness.

As depicted above, WreckWatch offers more than accident detection it offers situational awareness. Situational Awareness is defined as "being informed of the environment of a specific area at an instant in time[12]." When accident is detected an event is created on a WreckWatch server that other users of WreckWatch can attach data to[12]. For example, if a bystander witnessed a wreck they could load the WreckWatch application, take a picture of the accident, and send that image over to the server. From there emergency services could not only be notified an accident happened they could have information about that accident before they arrived on scene. Situational awareness and accident detection could be improved with inter-agent communication, and will be discussed below.

Electronic Triage Tag and Opportunistic Networks in Disasters



A Diagram Depicting the Electronic Triage Tag System

As was briefly discussed above in the iShake discussion there is the possibility of losing communication in a disaster. The next system that is analyzed offers a possible solution to this potential communication problem. This system is the Electronic Triage Tag System (ETTS). ETTS was developed by researchers at the University of Barcelona, and Cambridge University, and in the event of an emergency ETTS creates an adhoc network for emergency service personnel.

In a disaster, emergency services set up a base station and from there emergency workers head into the disaster and classify the severity of the victims, a process known as triage (depicted above) [4]. Currently, this is a manual process where workers physically tag victims with a card that ranks the severity of their injuries, and then when feasible communicate this information to the base station[4]. The problem is that cell towers could be down, and the worker wouldn't be able to communicate with the base station. Additionally, it may be the case a victim is out of radio coverage from the base station or next available worker. In which case the worker will have to head back to the base station to communicate the needs of his/her victim. These issues can be solved by the ETTS[4].

ETTS uses mobile phones to aid in this process of triage. Essentially, ETTS creates an adhoc network using mobile agents. More specifically, instead of physically tagging victims emergency workers would enter the triage information into their smart phones and then the Mobile Agent Emergency Triage Tag (MAETT) will try and communicate with the base station or a nearby MAETT[4]. More specifically, the MAETT will first try and communicate directly with the base station, but if that fails it will try and communicate with nearby MAETT. Once a MAETT is communicating with another MAETT they determine who will return to the base station first (this information is entered in to the smart phone before emergency workers head into the disaster). Whichever agent is scheduled to return first will have neighboring agents jump to that phone. Eventually, the MAETT will make it back to the base station[4].

The one drawback to this system is that it assumes all agents will eventually be returning to the base station. Which isn't an issue in this particular domain, triage, but if we wanted to integrate this system into other scenarios additional work would need to be done.

Analysis

The applications discussed above are important in their respective area, but even so there is lots of potential improvement. iShake needs a way to communicate in the event cell networks fail; WreckWatch needs to communicate with nearby agents to make a more useful traffic collision event; and ETTS is a useful system on its unknown but could provide benefits to additional application. What it boils down to is that all of these systems would benefit from an important concept--multi agent systems .

iShake is balancing on the line of being either a multiagent system or a distributed system. On one hand you have a system is only able to work with multiple agents. On the other hand there is no inter-agent communication. In order to push iShake into a more qualified multi agent system it would need interagent communication. With this ability it would help eliminate false positive by correlating/filtering data before passing it on to the server. Additionally this communication channel could be used to establish and ad hoc network. In much the same way the ETT system works earthquake data could hop through multiple agents until it reached an emergency base station. Additionally, the multiple percepts used in WreckWatch to determine a traffic accident could be used in iShake to better determined if an earthquake was occurring. For example, iShake could listen for crashing glass or other sounds that have some correlation to an earthquake.

WreckWatch is a network of autonomous agents making decisions in isolation. Improvements could be made if each WreckWatch agent communicated with nearby WreckWatch agents. The situational awareness system that WreckWatch implemented could be further automated. In the case of an accident WreckWatch could communicate with nearby agents to find any information they know about the accident. For example, if there was a smartphone in each car of a multiple car accident all the WreckWatch agents could communicate and compile their data. This could be used to determine who was at fault in an accident or who needs the most help.

Furthermore instead of only having a one way dialog to emergency responders these systems could provide more benefit if they relayed important information back to the user. Such as where disaster help centers are located; where the center of the disaster is located; or estimated time of arrival of emergency services. Many of the complications that each system presented (false positives, network failures) could be solved with a more robust system.

Conclusions

When the VCR first came on the market in the 70's it was an amazing technology that allowed people to record television in their home and play it back later. But people soon realized that they can more use out of their VCR if it had a clock. Individuals would be able to program the time when they wanted to record shows. So some ingenuous engineer married the clock and the VCR and all was well for home recorders. This scenario illustrates where current mobile emergency systems are, they are in need of integration. Currently, there are many important mobile phone based applications that can help in certain emergencies, but none of them do it all, and are not robust enough to be reliable in an actual disaster. In the future a more robust agent could be developed that could offer real benefits to a disaster scenario.

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