SafeTogether: Personal Safety and Situational Awareness using Mobile Devices

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ABSTRACT
Mobile devices have become popular for personal communication during emergencies as has been observed by researchers from public behavior during crisis situations in the past few years. People mostly use standard text and voice services on mobile devices to communicate during emergencies. However, free form text or voice may not always be the best means of communication due to operational or situational constraints in emergencies. Moreover, current devices are equipped with sensors that can capture rich situational context beyond what text and voice can convey, which can help responders make informed decisions during emergencies. In this paper, we present the design of a system that takes advantage of these features to enhance personal safety by capturing situational information and enables simultaneous communication with groups of people during critical and minor emergency situations. The design focuses on the ability to use the tool without prior training and to learn through usage during minor emergency situations. We developed a prototype, called SafeTogether, based on these design principles and performed a study to evaluate the usability of our system. Results of the study showed that we met our design objectives and helped identify certain usability issues.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation (e.g., HCI)**]: User Interfaces – *Interaction styles, Screen design, User-centered design;*

General Terms
Design, Human Factors.

Keywords
Mobile device, safety, situational awareness, personal emergency.

1. INTRODUCTION
Emergencies and disasters are marked by high levels of information need and low levels of information availability [23]. Research in "Crisis Informatics" shows that during such situations, a "backchannel" communication [25] emerges and becomes more popular among the public because it provides information that affects the public locally as opposed to generic news broadcasts [19]. These communications tend to focus first on individuals and families and then on the community [23]. As such, initial communication after an emergency is usually related to the safety and security of the affected family and friends as can be seen in the Facebook groups created after the shooting incident at Virginia Tech [29] and from twitter activity during the Mumbai terrorist attack [28]. While mobile technology, social networking websites, and discussion bulletin boards seemed to emerge as the most important means of communication, people perceived mobile phones as central to their ability to stay in touch, despite problems with phone services during crises. Many of them even reported that text messaging was their only form of communication after disasters such as the Hurricane Katrina [23].

These observational studies suggest the following. First, the immediate reaction of people during any emergency is to ensure their own safety followed as soon as possible by that of the people they are concerned about. Second, most of the people resort to mobile phone as the primary means of communication during emergencies. Third, in emergencies, people use tools and technologies that they have become familiar with by using them for routine communication in non-emergency situations (such as SMS, Facebook and Twitter). Therefore, it is desirable to have a system on a mobile device that can be used to enhance safety and to communicate easily with other contacts during an emergency and can be learned easily by frequently using it for minor emergency or non-emergency situations. In our current work, we propose a design that combines these desired functionalities into a prototype system called SafeTogether (Figure 1a).

SafeTogether is originally designed to be a mobile front-end to a larger system called Microsoft Vine [17]. Vine is a platform for routing communications between different systems during emergency situations. It is built to know the various ways there are to reach anyone using it, and tries multiple methods through multiple clients until it gets the message through. Its server can interface with clients such as PCs, mobile devices, satellite phones and cars. Communication methods are tailored to appropriate clients. On this platform, users can register their mobile clients, and create customized profiles (specifying information such as contact groups, pre-determined messages, and commonly visited locations). Moreover, this system coordinates with emergency personnel during emergencies to route appropriate communications via the system to all connected people. Our prototype system focuses on the mobile client that has the unique advantage of acquiring additional contextual information aiding in better emergency response. In this paper, we simulated the server side functionalities (especially message routing between devices) in order to focus on the mobile client-side interface development.

Emergency situations arise infrequently and are associated with significant time and resource constraints. Therefore, SafeTogether is designed to need minimal user interactions and attention. Furthermore, the system is designed to handle not only critical but also minor emergency situations so that users do not entirely forget about its existence. Frequent use of SafeTogether in minor emergency situations will help users use the system in critical emergencies without much trouble. It uses built-in sensors such as GPS and camera to provide real-time information to emergency personnel as well as contacts, enabling them to be aware of the users' current situation and take knowledgeable actions. The system enables users to ask for immediate help, receive instructions from the emergency personnel, report their current condition and location, and receive status updates from their contacts. Through a qualitative study, we evaluated the usability of the system in various scenarios and received positive feedback with some suggestions for improvement.

It is important to note that SafeTogether is not meant to be a substitute for emergency services such as "911." It is most effective in scenarios where any situational information can be immediately captured by the built-in sensors. It is also not designed to be used as a public warning or alert system or as a substitute for personal messaging systems such as Short Messaging Service (SMS). Moreover, the system is designed in a very simple way considering non-professional users and therefore, is only minimally useful for professional emergency personnel.

The paper is organized as follows. Section 2 discusses previous related research. Section 3 describes our system design along with scenarios. Section 4 introduces the system interface and Section 5 describes our usability study. Section 6 concludes our work with some directions for future work.

2. RELATED WORK

2.1 Mobile Social Systems

People use mobile devices and social networking systems to stay connected with their family and friends every day. Facebook and Twitter offer text and image based communication on mobile devices, while systems such as Dodgeball, Loopt and Whrrl offer location-aware services. However, all of these systems are designed for casual every day communication rather than for safety or emergency situations during which people might be incapacitated to type messages or perform routine actions. Moreover, these systems do not yet utilize the rich information provided by other sensors on these devices such as cameras to provide better situational awareness.

2.2 Emergency Response on Mobile Devices

Communication technology usage is prevalent among people during emergencies [19]. Palen's research studies have shown, through surveys and interviews of people who witnessed the 2007 California Wildfires [25], Virginia Tech shootings [29], and Hurricane Katrina [23], that the majority of the people used mobile phones to get in touch with their friends and family during the events apart from using online social networking services.

Mobile devices can provide enhanced situational awareness in real-time. Therefore, they are increasingly being used in the field for enhancing safety and security during emergencies. Researchers have developed and evaluated prototype mobile systems for health care emergency [5], emergency evacuation [4] and emergency response and training [14]. While these prototypes have been designed to work with the limited resources of a mobile device, they do not take specific advantage of all their built-in sensors. Moreover, they are too sophisticated to be used by non-professionals for personal safety during emergency situations. Some researchers have demonstrated the use of cameras and location sensors to augment the physical world with virtual information [11][24]. However, they do not demonstrate use of the tool during emergency situations, even though they mention a possible emergency scenario where the tool can be used [11].

There are a few commercial emergency alerting systems such as "BMW Advanced eCall" [3] and "GPS.SOS!" [12] that are simple and effective to use for personal safety during emergencies as they involve some amount of automated operation. However, the former system is specific to automobile accident emergencies and the latter is limited to location determination of a user.

2.3 Representation of Critical Information

Critical situational updates have to be frequently delivered to the user during emergency scenarios. Situational information notification can be passive (e.g., for casual social situations) or active (e.g., for emergencies). The Whereabouts Clock [22], Scope [6], and peripheral interfaces [30] are examples of the former, where situational updates are provided with the least disruption to users' activities. Active notifications should be adapted to the end users' situational context [13][27] based on attention-grabbing notification cues such as visual pop-outs [20], audio [12] or tactile [13] responses.

Many researchers have worked on representing critical information for emergency and crisis situations. While some were designed for the desktop platform [1][16], others were designed for in-field activities on a mobile platform [9][10][14][18]. However, sophisticated visualizations require prior training to be used effectively during emergencies. In other words, they are all designed to be used by professional responders rather than by non-professionals for personal safety. Since a non-professional user may not use a safety or emergency tool very often [15], it has to be designed intuitively making it easily usable even for intermittent usage.

2.4 Emergency Mobile System Evaluation

Designing and evaluating a mobile system for emergencies is not straightforward. Traditionally, researchers have proposed user-centered design techniques based on role-playing and low-fidelity prototyping [26]. They also have suggested moving evaluation into realistic scenarios by performing field tests [8]. However, given the unfeasibility of visiting and observing all possible usage settings and contexts, some have stressed the importance of scenario-based design and evaluation [7]. Systems designed for safety during emergencies are even harder to evaluate using field tests since replicating such real-world conditions are hard [15]. Therefore, usability studies for SafeTogether were performed using role-playing under simulated laboratory settings.

3. SAFETOGETHER DESIGN

Designers of tools for emergencies need to consider the end users and their tasks and goals [15]. Since SafeTogether is designed for personal non-professional emergency response, we started by considering various emergency scenarios where individuals can capture contextual information to better assist first responders (emergency personnel, family, friends, etc.). A set of key characteristics were formulated from these scenarios which informed the design of SafeTogether.

3.1 Emergency Scenarios

The first two scenarios describe relatively critical emergency scenarios either with need for immediate help or lack of enough time to capture important situational information. The remaining scenarios are of medium or minor emergency, although some of these could still escalate to critical emergencies depending on the severity of the situation. Most scenarios of usage of SafeTogether fall into this second category where the circumstances can either be false alarms or may potentially lead to a critical emergency situation if not checked at the appropriate time.

Scenario 1 - "Severe Accident": Accident victims who are either partially physically disabled or in precarious situations can use SafeTogether to get help by sending a picture of their situation if possible and location information to obtain timely help from emergency services. The situational information can help the emergency personnel determine the location and also provide immediate instructions for the victim's safety before help can arrive at the scene well prepared to face the emergency.

Scenario 2 - "Robbery Witness": SafeTogether can potentially be used for critical emergency situations arising due to the fleeting nature of situational evidence. For example, if users witness a robbery, they can use SafeTogether to take a picture of the robber and send it to emergency personnel, who can forward it to law enforcement personnel. It not only helps them automatically determine the location of the incident, but also gives them a picture of the accused involved instead of relying on eye witness accounts.

Scenario 3 - "Suspicious Object": People may encounter unclaimed objects in a public place or dangerous objects such as snapped wires after a storm on the road. SafeTogether can be used to take pictures of these suspicious objects and inform emergency personnel. These personnel may be able to decide from the picture whether the object is potentially harmful, and can either provide instructions for the user's safety or suggest an alternate route to avoid the dangerous object. The users and their contacts can also use the system to communicate each others' status in case the suspicious object turns out to be potentially dangerous.

Scenario 4 - "Minor Accident": SafeTogether can also be used for emergency situations arising from injuries sustained from minor accidents. In such situations the victims can take a picture of their injuries and request help from emergency personnel. Emergency personnel can send instructions to the victims to go to a nearest medical center or arrive at the scene with necessary first-aid depending on the estimated gravity of injuries from the picture and location information. Moreover, the victims can use the system to inform their family and friends about their situation.

Witnesses to injured people can also use SafeTogether to provide pictorial and location information to emergency personnel while asking for help. These personnel, in turn, can make necessary arrangements or decisions before arriving at the scene to attend to the injured victim.

Scenario 5 - "Toxin leak": Another emergency scenario affecting people at a larger scale is a chemical leak. Such a scenario has potential to turn into a critical emergency depending on the nature of the leak. Users who witness such leaks can request help from emergency personnel using SafeTogether by providing them with a picture of the source of the leak. Potentially using advanced sensors such as temperature and pressure sensors on a mobile device and techniques such as indoor location positioning, additional information can be forwarded to building security personnel. Users stuck in an emergency evacuation can notify family and friends about their status using SafeTogether.

Scenario 6 - "Separated from a group": SafeTogether can be used in the event of getting separated from a group to locate group members. Location information can be provided either from the GPS coordinates or by taking a picture of a familiar landmark allowing group members to determine the location easily.

3.2 Design Considerations

We identified key characteristics of emergency contexts from the aforementioned scenarios which formed the basis for our interface design. These characteristics are described below.

Infrequency of use: Emergency tools are used infrequently. However, when the need arises, they must be quick, not prone to error, and easy to use [15]. Therefore, one of our main goals was to make the system interface intuitive so that a user can use it without much difficulty for the first time even without any prior training. Moreover, we also made the system usable for both critical and minor emergency scenarios so that the experience of using it in the latter case can help in more critical emergencies.

Cognitive resource constraints: Emergency situations are usually scenes of chaos, confusion and fear for safety. To accommodate limited cognitive resources during such situations, we focused on an interface with minimal, simple user interaction. For example, we used pre-determined messages instead of free-form typing as it would have made the system more complicated. We designed two levels of information detail so that all important notifications can be shown as an overview and detailed information provided on demand.

Physical operational constraints: Considering the limited capacity to physically operate a device during emergencies, we focused on designing an interface with large clickable widgets which would be easy to use even with a finger or thumb. The application itself can be easily started during an emergency by mapping it before-hand to a hardware button or by adding it as a home screen plug-in.

Lack of response time: With a lot of information to process and little time available during emergencies, the system should not freeze up waiting for information or updates. Therefore, our design also focused on fluidity of interaction by making time consuming processes (such as map download) asynchronous.

4. SAFETOGETHER INTERFACE

The "Microsoft Vine" project structure and our design considerations determined the types of data to be captured and transmitted, necessary functionality and general interface design of the client system. To keep the interface simple, we focused only on a touch-screen based interface.

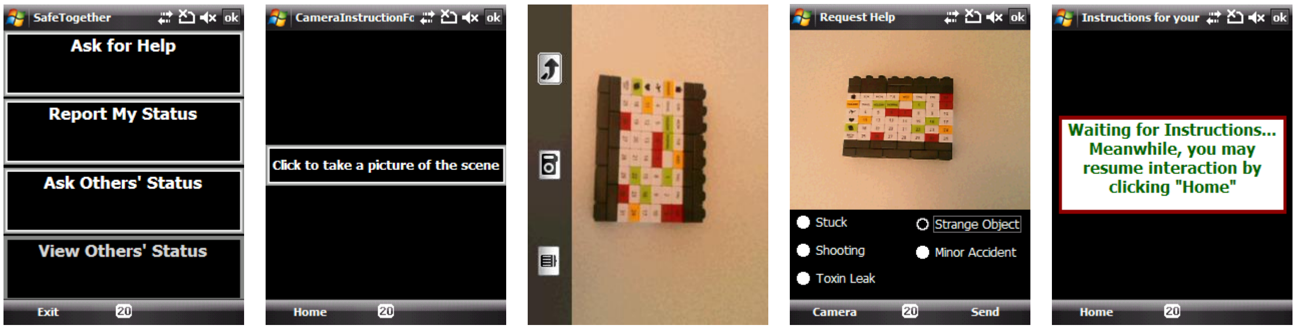
4.1 Data

The following types of data are captured and transmitted.

Situational Information: Location information from the built-in GPS receiver is polled every minute and automatically sent with every communication. Scene information can be captured by the user using the built-in camera.

Safety Instructions: Instructions from "emergency service" can be received and displayed in the form of maps (showing routes to safe destinations), text (showing turn by turn directions), and audio or video files (such as first aid administration).

Users' Status: As mentioned earlier in our design considerations section, we provided the following pre-determined messages to report the users' status: "I am OK," "Minor Injury," "Major Injury (Helped)," "Major Injury (Help on way)," "Major Injury (Need Help)." To request others' status, we decided to use a single default message, namely, "Are you OK?" since most



(a) (b) (c) (d) (e)

Figure 1: Sequence of screenshots showing the usage of "Ask for Help" functionality

status requests in emergencies are primarily concerned with the safety of people at the other end.

Contact Groups: For the current implementation, we included the two most important groups of contacts, namely, family and friends. To keep the interaction simple, we do not allow users to select individuals within a contact group to communicate with.

4.2 Interface

A Home/Notification screen (Figure 1a) provides access to the three major capabilities of the system that are described in detail below. This screen is updated with messages based on available information (Figure 2c, Figure 3b). Notifications of new instructions, requests or responses are shown in red (Figure 3b) and time elapsed since most recent action is shown in yellow.

4.2.1 Ask for Help

SafeTogether allows users to request help from an "emergency service." Figure 1 shows a typical sequence a user may follow while using this capability. Users can initiate this process by clicking on the Ask for Help button from the Home/Notification screen (Figure 1a). To enable users to provide their current situational context, the system automatically captures the location information and allows users to take a picture of the scene. Since we were limited to HTC Touch Cruise's default software interface (Figure 1c) for camera operation which takes a while to start, we added an additional screen (Figure 1b) to inform users that they need to take a picture. Once they finish capturing a scene (Figure 1c), users can describe the scene using our pre-defined descriptions (Figure 1d). If none of these describe the scene, users need not select any. After finishing this process by clicking on the "Send" menu, users can either wait for the instructions from the emergency service (Figure 1e) or go to the Home screen to use other functions of the system. Meanwhile, instructions from the "emergency service" in the form of maps (to show safe routes), text (directions and other instructions) and audio or video files can be received and displayed.

For extremely urgent emergencies, we can have a lighter version of the system with just the functionality to ask for help mapped to a hardware button for fast and direct access.

4.2.2 Report My Status

Users can report their status using SafeTogether. This can be initiated by selecting the Report My Status button from the Home/Notification screen (Figure 1a). Then users can select a message from the pre-existing messages that best matches their current status and a recipient group from the existing contact groups (Figure 2a). Optionally, they can also enquire about the recipients' status indicating the response priority. Once they send it to the selected recipient group by clicking on the "Send" menu, users are notified of the success status of this communication and the Home/Notification screen is updated accordingly (Figure 2b).

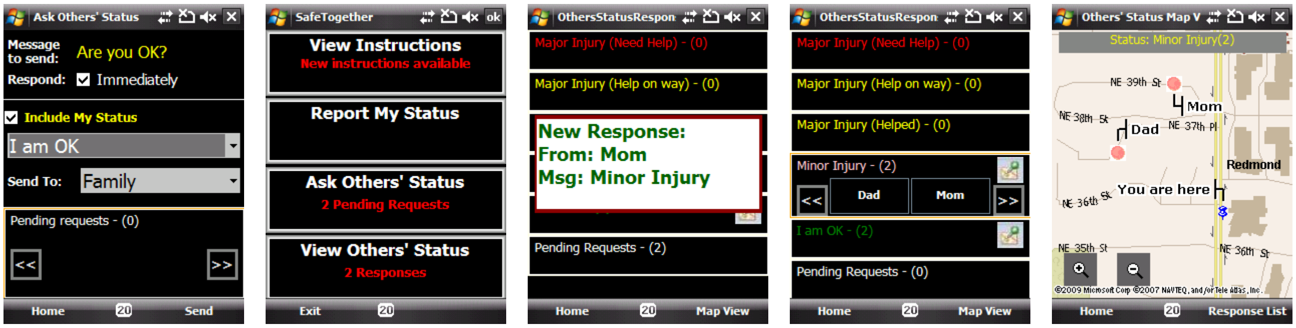
Users can also respond to status update requests from their contacts. The number of such requests is shown on the Home/Notification screen (Figure 2c). In this case, when users select the Report My Status button, they get to the reporting screen (Figure 2d), which shows the list of people who asked for the status. In addition to the status message, users have the option to respond either to everyone in a group or to only those people in a group who requested the users' status as shown in Figure 2d.

4.2.3 Ask Others' Status / View Others' Status

SafeTogether allows users to request status updates from people in their contact groups. Users can start this process by clicking on

(c) (d)

Figure 2: Sequence of screenshots showing the usage of "Report My Status" functionality



(a) (b) (c) (d) (e)

Figure 3: Sequence of screenshots showing the usage of "Ask/View Others' Status" functionality

the Ask Others' Status button from the Home/Notification screen (Figure 1a). They can then send the request with the default message: "Are you OK?," optionally set a response priority and include their current status (Figure 3a). The message is delivered to the selected recipient group by clicking Send menu. They are then automatically redirected to the Home/Notification screen, where the arrival of new responses is indicated with the number of responses as shown in Figure 3b. The View Others' Status button in this screen is enabled once new responses arrive. Then users can click on the View Other's Status button, to view the responses grouped by their category of criticality as shown in Figure 3c and Figure 3d. Responses arriving in real-time are shown using a pop-up message with the details as shown in Figure 3c. Clicking on a category displays the names of people in that category (Figure 3d). The corresponding map icon shows locations of people in that category on a map, color-coded by the criticality of their status (Figure 3e). Alternately, users can view locations of all the people who responded, using the Map View menu in Figure 3e.

4.3 Implementation

SafeTogether was developed and tested on a HTC Touch Cruise PocketPC Phone running Microsoft Windows Mobile 6.0 Professional. The interface was implemented using C#.NET and PocketPiccolo.NET toolkit [2][21] for creating custom interface controls. Map information was obtained using Microsoft MapPoint. The backend communication of a user with the emergency personnel and other contacts was simulated so as to focus our efforts on the system interface and functionality.

5. EVALUATION

Evaluation of emergency-based systems is hard as it is difficult to replicate the conditions existent during emergencies. People have used informal evaluation [14] or simulated settings [4][5] to evaluate systems designed for emergency. For our system, we performed a qualitative study using role-playing with simulated settings in a laboratory.

The major goal of our evaluation was to determine the system usability during emergencies. Apart from general usability issues, we focused specifically on answering the following questions:

1. Can the system be used easily without prior training?
2. Can the system be used easily with a single hand?
3. Can the system be used without difficulty in critical emergency situations based on the experience of using it in minor emergency situations?

To measure how quickly participants can finish the tasks, we recorded all user interactions including the start and finish of the task along with timestamps using an interaction logger. We also collected participants' subjective preferences using a questionnaire and three open-ended questions.

5.1 Tasks and Scenarios

We designed three tasks to answer the questions mentioned above. Each task was associated with a scenario described in the "Emergency Scenarios" section, and the scenarios progressed from minor emergency to critical emergency from task 1 to task 3. For all three tasks, we simulated instructions from the "emergency service" and messages from imaginary contacts at random time intervals (the time intervals, however, were same across different participants). Moreover, each task had multiple goals which the participants were encouraged to work towards simultaneously (although they were not required to). Participants were also free to determine whether they have finished the task.

5.1.1 Task 1

This task intends to test usability issues when operating the system for the first time. The participants are required to perform this task without any prior training in using the system. For this task, we used a minor emergency scenario: *"Suspicious Object."* Participants are instructed to accomplish the following goals:

Goal 1	1. Take a picture of the unidentified object (provided by the experimenter) and contact "emergency service." 2. Report the name of the safe destination where they direct the participant to go to.
Goal 2	1. Send request to all family members for their current status. 2. Report the locations of all family members who suffered minor injuries.

The task was completed when the participants reported the required information (by writing them down) from both goals.

5.1.2 Task 2

For the second task, we used the scenario: *"Fall from a ride."* The scenario was modified such that each participant's non-dominant hand was injured and they were instructed to use the system with their dominant hand. This task had the following goals:

Goal 1	1. Take a picture of their injured hand and contact "emergency service" for help. 2. Report the name of the medical center where they instruct the participant to go to.
Goal 2	Report their location and injury to all friends.

The task was completed when the participant achieved both these goals. The accuracy of the second goal was verified from the interaction logs and recorded videos.

5.1.3 Task 3

For the third and final task, we used the scenario: *"Toxin Leak."* To simulate the stressful conditions in a critical emergency, the participants were required to accomplish the goals within a time limit of three minutes (the time limit was determined using trials from a pilot study). For this task, the participants were free to use both hands and had to accomplish the following goals:

Goal 1	1. Take a picture of the pipe leak (setup by the experimenter) and ask for help from the "building security." 2. Follow the directions (on a raster image of a floor plan) provided by the "building security" and proceed towards a marked exit from the participant's current location.
Goal 2	Respond to only those friends who requested their status (with the message that they are safe).

The task was completed when the participant accomplished both goals. The goals were verified by the experimenter by following the participants until the exit and observing their actions.

5.2 Participants and Apparatus

Nine participants (seven males, two females) were recruited via e-mail from our institution for the study, with the restrictions that the participants were not color-blind, not disabled and had used a touch-screen device before. Their ages ranged from 21 to 53, with a mean of 30. Two of them (both males) were left-handed. One of them had never used text messaging on their phones. Only three of them had even given a thought about having a pre-determined plan during emergencies with family and friends and all of these involved mobile phones. The experiments were conducted in a laboratory setting using a HTC Touch Cruise PocketPC Phone running Microsoft Windows Mobile 6.0 Professional with a 128MB RAM, 400MHz processor and a screen resolution of 240x320 pixels. The phone had a built-in GPS receiver and a 3.15MP camera. Navigation was mainly supported by HTC's TouchFLO technology and a 4-way navigation wheel. The phone supported 3.6 Mbps 3G wireless connectivity for internet access.

5.3 Procedure

Participants were given an initial questionnaire to collect their demographics and prior experience with mobile device usage. They were briefed about the goals and background of the system. This was followed by a brief phone-specific training and the experimental tasks. All actions of the participant on the mobile device and their voices were recorded (except in task 3 where the participants have to move out of the lab) with their permission.

5.3.1 Phone-Specific Training

We envision that our system would be used by people on their personal phones. Therefore, we held this training session to familiarize participants with phone-specific features such as the 4-way navigation pad and the built-in camera. This training involved simple navigational tasks and a picture-taking task. The participants were allowed to explore the navigation of a map. They were also allowed to ask any questions related to the phone interaction. These training tasks did not involve any interface specific to our system as we wanted the participants to perform the experimental tasks without prior training.

5.3.2 Experiment

A printed sheet containing imaginary contact groups was initially given to the participants for reference through the entire session. For our study, we had two imaginary contact groups, namely, family (four members) and friends (eight members). Three printed task sheets were given to participants one at a time. For the second task, we handed out the appropriate task sheet according to the handedness (right or left) of the participant. Each task sheet consisted of a brief explanation of the associated scenario, instructions for the task, a set of goals to accomplish, and space to write down their answers to complete the task.

The participants were shown a "Task Menu Screen" which gave access to the tasks one at a time. They were instructed to read a task sheet completely before starting the task. Initially, only the first task is enabled. The task starts when the participant clicks on the corresponding "Start Task" button from the "Task Menu Screen" and ends when he clicks "Exit" from the application to come back to the "Task Menu Screen."

At the end of the experiment session, participants were given a questionnaire to collect their subjective opinions about the usability of the system. Following the questionnaire, the participants were briefly interviewed by the experimenter to collect further comments and suggestions.

5.4 Results

Most of the participants had a positive experience using the system and had only minor issues. The mean task completion times for tasks one, two and three were about 278, 156 and 132 seconds respectively. Even though the task times across different tasks are not comparable, participants in general were faster by the third task and were able to finish it in the given time limit of three minutes. Detailed results are described below.

5.4.1 Usability Issues

All of the participants except one were able to successfully complete all three tasks. The oldest participant could not complete the first task as he could not figure out how to ask for help after taking a picture of the unidentified object. However, he was able to successfully finish the subsequent tasks as he learned the system eventually. This participant mentioned he had used a touch-screen device only once or twice before. Therefore, he had difficulty using the device in general due to lack of experience.

One significant interaction issue we encountered was that most participants clicked on a contact's icon, instead of the provided map icon (Figure 3d), to view the contact's location on a map. Since a click on any location in a row caused the fisheye view to toggle, we had provided a separate map icon for each row. However, this caused confusion and repetitive interactions were recorded for this view. This problem can be resolved with a simple change in the behavior of the contact's display control.

Another usability issue involved taking a picture with a single hand. While our system was designed in a portrait mode, the device's default camera software operated in a landscape mode, making the rotation of the device with a single hand very difficult. However, it is to be noted that this is the current default behavior of the in-built camera software which is not trivial to modify. We argue that this will not be an issue with the availability of a customizable camera interface.

The two left-handed participants had some difficulty using a few of the default Windows form controls such as combo boxes and the scrollbar which are primarily designed for right-handed people. However, the custom controls developed by us using PocketPiccolo.NET did not pose such difficulties. Therefore, it would be beneficial to replace these default controls with custom controls that are usable with either hand.

The next usability issue concerned proper notification of incoming responses from other contacts. While we employed a pop-up message to notify users of a new incoming response, a few participants expected to hear an audio cue for such notifications. This issue can be resolved by employing more noticeable cues based on audio or tactile feedback for important notifications.

Finally, participants found the map slow to interact with. This was because of our reliance on web services to download map information, which is limited by available network bandwidth and connectivity. This problem can be reduced by pre-fetching map tiles to improve zoom and pan interaction performances.

5.4.2 User Satisfaction Ratings and Comments

Participants' ratings of subjective preferences varied between 5.3 and 6.3 (on a 7-point scale). Specifically they rated the ease of learning, ease of use and intuitivism of navigation at 5.5, 5.7 and 5.6 respectively. They rated the system's ease of use with a single hand at 5.3, primarily due to the camera orientation issue discussed above. Participants also highly preferred (6.2) a system such as ours over traditional phone and text communication during emergencies and indicated having relatively few privacy concerns disclosing their location for emergency purposes.

Participants had mostly positive comments about the system (including the participant who initially found the system difficult to use). They liked the fact that one could easily communicate simultaneously with a group of people. Some commented that it would be useful in emergencies where a person needs to be discreet and cannot speak. Several participants suggested that they would try it out for non-life threatening emergencies. One participant mentioned that it was easier for him to use the system with a single hand probably because of similar usage on his regular phone, in spite of the camera orientation issue.

We also asked three open-ended questions to our participants for further feedback. These responses indicated that even though the system was simple, the information was adequate and further information would make the system complicated and reduce usability of the system. Provision of an option to call a contact from within the system and audio cues to indicate the arrival of a response from other contacts were also suggested. One participant suggested that it could be used in biological scenarios to ask for help to determine diseases based on suspicious symptoms. Participants also suggested adding other useful contact groups including car-poolers and dynamically generated groups based on physical proximity during unforeseen incidents.

5.5 Discussion

The overall response to the system and its importance was encouraging. Participants mentioned that they are willing to try using such a system for non-life threatening emergencies because they rely on services such as "911" for immediate emergencies. This is expected since we did not intend to be a substitute for such services. Identification of some important usability issues (most of which can be resolved by simple modifications) will help improve the system. However, concerns about the speed and reliability of the system due to connectivity and GPS reception respectively cannot be resolved until their infrastructure improves to a point where it can be used and relied upon in emergencies. Even though this was not an exact simulation of intermittent usage in real life emergencies, participants became more confident as they learned how to use the system after one or two usages. Our studies demonstrated that the system was easily usable without training and easily learnable through multiple usages. This lends credibility to our assumption that using the system for relatively frequent personal safety situations can help users during critical emergency scenarios.

6. CONCLUSIONS AND FUTURE WORK

We have developed a prototype system called SafeTogether for enhancing personal safety and improving personal communication during emergencies. We modeled the system based on important design considerations for emergencies and on various possible usage scenarios. Users can overcome difficulties in usability due to infrequent usage since SafeTogether is designed to be easy to use without prior training and for both critical and minor emergencies. Through a usability study, we confirmed that the system was easy to learn and intuitive to use even without training. We also identified important usability issues, some of which require only minor modifications and others are related to infrastructural limitations. Nevertheless, users recognized the importance of such a system and liked specific advantages of the system over traditional messaging services on mobile devices.

We plan to fix usability issues identified from the study to make the system more effective. We would also like to incorporate situational data captured from other sensors such as orientation and temperature sensors when devices with these sensors become available. For the sake of interface simplicity, the current implementation of SafeTogether is designed only for emergency situations. We would like to extend the design to non-emergency scenarios to encourage use for frequent personal communication as well as occasional emergencies. Designing such a system entails careful trade-off between simplicity (for emergency scenarios) and flexibility (for everyday usage).

7. ACKNOWLEDGMENTS

We thank Amy Karlson, A.J. Brush, and Jim Holt for their feedback and advice on this work. We also appreciate our study participants for their time and comments.

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