
TravelThrough: A Participatory-based Guidance System for Traveling Through Disaster Areas

Lucy T. Gunawan

Delft University of Technology
Mekelweg 4, 2628 CD
Delft, The Netherlands
l.t.gunawan@tudelft.nl

Siska Fitrianie

Delft University of Technology
Mekelweg 4, 2628 CD
Delft, The Netherlands
s.fitrianie@tudelft.nl

Zhenke Yang

Delft University of Technology
Mekelweg 4, 2628 CD
Delft, The Netherlands
z.yang@tudelft.nl

Willem-Paul Brinkman

Delft University of Technology
Mekelweg 4, 2628 CD
Delft, The Netherlands
w.p.brinkman@tudelft.nl

Mark A. Neerincx

Delft University of Technology
Mekelweg 4, 2628 CD
Delft, The Netherlands
m.a.neerincx@tudelft.nl

Abstract

This paper focuses on decentralized individual self-help in the aftermath of a disaster, instead of the traditionally adopted model of centralized disaster response management. It presents the results of a controlled field experiment that compares a new disaster response model involving civilians participating with smartphones with the traditional centralized model. In the new system, the affected people lead themselves to safety, and at the same time serving as distributed active sensors that share observations of the disaster area. The results show that the proposed system is more effective, preferred, and reduces the workload in guiding affected people safely to their destinations.

Author Keywords

Multimedia-enriched system; human participatory; self-help; disaster response; empowering citizen; crowdsourcing

ACM Classification Keywords

H.5.2 [Information interfaces]: user-centered design.
D.2.2 [Software Engineering]: Design Tools and Techniques – User interfaces.
H.5.m [Information interfaces and presentation] (e.g., HCI): Miscellaneous.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

CHI'12, May 5–10, 2012, Austin, Texas, USA.

Copyright 2012 ACM 978-1-4503-1016-1/12/05...\$10.00.

Introduction

Natural and man-made disasters have resulted in tremendous damages and costs of human life. Typically, in such situations, disaster responders quickly become overwhelmed with the emergency response provision [28]. Kean & Hamilton [17] and Tierney et al. [31] pointed out that the lack of knowledge and overview of the situation is one of the major factors impeding an informed response at critical points. This, partially, was resulted from these few factors: (1) the dynamic nature of the event, (2) the complexity and inefficiency of the disaster management organization model, (3) distributed information piecemeal across geographically distant locations [26], and (4) inaccurate exchange of location information due to the sole use of verbal communication to relay geo-spatial information [12].

The disaster response protocol currently used worldwide is still based on a centralized, closed system that was originally derived from the military [20]. Such an organizational structure is often chosen on the merits of the believed benefits of distinct authority and responsibility units [4, 30]. This protocol treats civilians as helpless victims that unable to cope with the situation. Civilians are therefore never considered as constructive parts of the system [5]. Consequently, while civilians can inform the authorities of the situation by calling emergency numbers, their reports are typically treated as less reliable, and require further verification from the professionally trained. This adds extra pressures, communication and coordination bottlenecks, and delays [29, 7], especially in mass-casualty disasters, when information centers are flooded with input and inquiries [17]. This does not only slow things down, but often renders situation

awareness incomplete and outdated, as depicted in Figure 1(a).

The present work is based on the assumption that, during a disaster situation, the affected people are capable of contributing timely and reliable information [3, 17, 20]. Here, we explore the capacity of this social unit by handing affected people devices and technology to lead themselves to safety, while at the same time, using them as distributed active sensors. The technical feasibility and limitations of this solution has been analyzed through critical literature study. This includes the possibility of setting up a mobile ad-hoc network and improvement in battery capacities when data communication and power network is down during a disaster [13]. In our proposed system, an affected person is equipped with a GPS enabled smartphone and software for sharing relevant information of the disaster area where the user is located in.

Related Work

For more than a decade, scientists have reported the interest that police departments, firefighters and paramedics showed in utilizing handheld communication devices for quick and efficient exchange of information with control rooms, headquarters and hospitals [15, 21]. SMS messaging has been used effectively during the China SARS epidemic in 2003 to inform others about the physical locations of diagnosed SARS victims [19]. Vieweg et al. [33] investigated microblogging (Twitter) as a medium to harvest information for improving situation awareness during the Oklahoma Grassfire and the Red River Flood in 2009. However, using textual messages it is difficult to describe geographical information, especially when it comes to pinpointing exact locations.

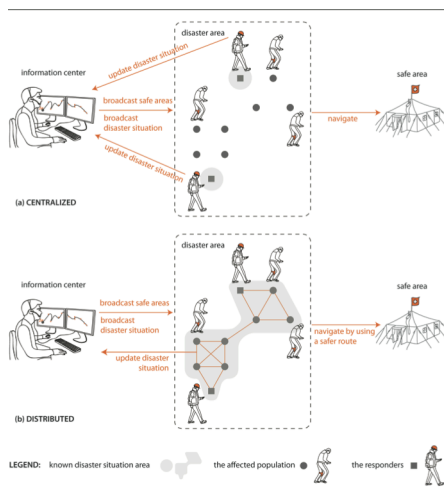


Figure 1. Comparison of the outcomes of centralized and distributed systems to situations of a disaster area; (a) a about the disaster situation only known if the emergency services are present and (b) achieve a bigger coverage of the knowledge by sharing information among civilians and emergency services in the field and operators in the information center.

Another development is that multimedia enabled smartphones have become widely available to be used during disasters. For example, after the underground bombings in London, UK, citizens used camera phones with MMSs to capture photos and videos of structural damage in places of underground surroundings. During the Indian Ocean Tsunami in 2004, Hurricane Katrina in 2005 and the Haiti earthquake in 2010, people used social networks, Wikipedia, blogs, photo and video sharing, call centers and sites to report the situation and offer shelter, jobs, information and emotional supports [22, 23].

Usahidi [32] and Sahana [27] are two examples of crowdsourcing systems on map platforms used for coordination of relief efforts that have been deployed in several countries. OpenStreetMap [8] was used as collective effort during the Haiti Earthquake in 2010 for mapping the earthquake's impact within a very short period of time. It was reported that a complete map of Port-au-Prince was constructed within 48 hours after the earthquake by collaboration of hundreds of mappers around the world [16]. The resulting digital map was used extensively for disaster response, damage reports and transportation purposes by emergency services, humanitarian organizations, and search and rescue (SAR) missions.

The TravelThrough System

In this paper, 'Affected people' is defined as the group of disaster victims that require guidance for displacement or evacuation. Affected people are, in numbers, the largest category of disaster victims, amounting up to 94% [9]. The remaining 6% includes casualties and injured people who need physical assistance. Most of this affected group consists of

healthy people able to help themselves to safety and help others. However, proper coordination between information center operators, rescuers in the field and civilians is a must for achieving an effective mobilization process [10]. The proposed TravelThrough system is designed to enable affected people during a disaster event to use their handheld device for navigating to a safe location. Figure 1(b) shows a schematic view of a disaster event at a given location. At any point in time, each affected person is associated with a spatial location. The affected people now become effective distributed reporters in the field. While on the move, they may report their state to their surroundings. All data from the affected people's handheld devices (including the automatic tracking of their routes) arrives at the information center, where it can be acknowledged, filtered, and used for marking specific areas. Finally, the relevant data can be broadcasted to all other affected people in the area. Such real-time information sharing supports the immediate usage of newly found routes to safety as they emerge, and is useful not only for affected people, but for emergency services, SAR missions, and humanitarian organizations as well.

A novel aspect of the proposed system is the participatory-based guidance for traveling through disaster areas. The system is equipped with features for: (1) navigating the mobile users to a certain location, (2) sending useful incident field reports, (3) sharing up-to-date information about the current situation with other users, (4) (information center) marking dangerous areas based on the received incident field reports. Figure 2 illustrates the users task of the TravelThrough system. The system takes into account that the environment during a disaster is non-



Figure 2. The main interactions of actors of the TravelThrough system.



Figure 3. Examples of visual symbols used on the interfaces of the TravelThrough system: (a) types of new incident reports: unstable building, fire, blocked road, broken bridge, and victim; (b) user's position; (c) destination point;

deterministic, and existing communication infrastructures tend to get overloaded or break down. Consequently, the mobile users' communication can be based on distributed mobile ad-hoc networks, allowing a wireless network of handheld devices without a central base station. Social studies have shown that, during a disaster, individuals and groups typically become more cohesive and unified [24, 3], people naturally pull together and form small support groups in response to disasters [17]. These groups usually consist of family, friends, neighbors, coworkers and other people, who happened to be at or near the scene at the time of impact [25]. We assume that at least one member of such an emergent group is capable of operating the TravelThrough system, and may be able to lead the group to safety.

System Design

The TravelThrough system consists of a server (master client) located in the information center and a set of mobile application clients on handheld devices. The system supports two-way data exchange. Observation maps allow a user to view relevant information of the disaster area including dangerous places in the neighborhood, the user's current location and walked track. In addition, the user is allowed to attach new information relevant to a particular location of the disaster area. This information is shared with the information center. At the same time each mobile device receives route trails and incident reports, which are symbolically displayed (Figure 3), from information gathered from all other users, and external data sources by the information center.

INFORMATION CENTER APPLICATION

Figure 4 shows the map-interface of the server at the

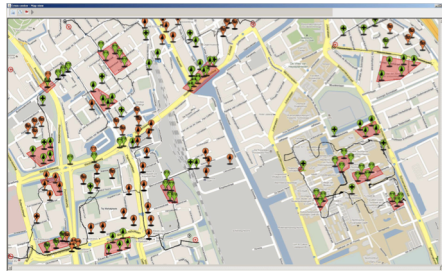


Figure 4. The interface of the information center.

information center. It provides options for: (1) selecting objects on the map, (2) marking dangerous areas, and (3) creating reports. When the server receives a report from a mobile users, the application automatically displays them as new reports on the map. Additionally, the application displays the walked tracks of all mobile users in real-time. Data may also be reported by other actors, e.g. disaster responders, authorities, or other institutions.

MOBILE APPLICATION

The handheld device consists of two main views: the navigation view (Figure 5.above) and the event-reporting view (Figure 5.below). The user can switch between views by tapping on one of the two options:

Navigation view. The navigation view is used to guide an affected person in a disaster area to a safe destination point. It consists of an arrow that dynamically points towards the destination and an interactive digital map (Figure 5.above). This arrow conveys necessary and sufficient information to aid navigation for short distance navigation [11]. The map shows the following information (see Figure 3, 4 & 5): (1) incident reports from all users in the vicinity shown by pin-like markers. Orange indicates new reports, while green represents reports which have been acknowledged by the information center, (2) the user's position is represented by a blue blinking dot, (3) a designated nearest destination point is shown by a green pin, (4) danger areas are drawn in the shape of red shadowed polygons and (5) the trails of all users are displayed using green lines. The user can zoom in-and-out of the map using the pinching action.

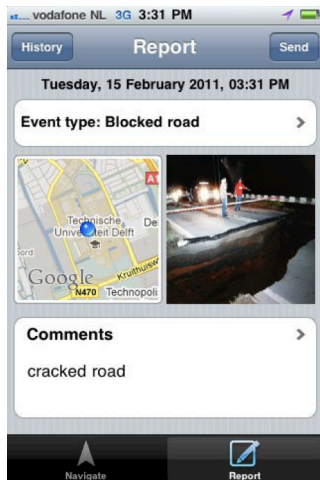
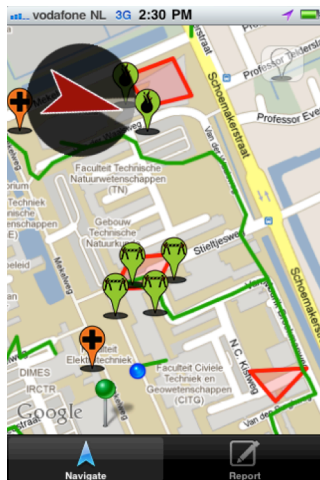


Figure 5. Mobile application interface: (above) the navigation control interface with situation updates and walked routes, (below) the report event control interface filled with incident report.

Event reporting view. The event reporting view is used to report events or incidents encountered by the user. The user is required to enter the location and the type of incidents and optionally provide a photo of the incident with a brief description (Figure 5.below). After filling in a report, the user may send it and receive its confirmation.

Implementation

The client is an iPhone application that runs on iPhone 3GS with IOS 3.2. GPS and compass information are retrieved from the device's hardware. The navigation view of the client displays information overlaid over a Google maps view (Figure 3). The server is implemented in Java, and uses Google map overlays for displaying the crises area. Data types are grouped in different overlays, enabling the operator to filter his views. The server is able to calculate the best destination for the client and responds with relevant information in its neighborhood and along the intended route. Communication between the clients and the information center are based on XML-RPC using both the Internet and the 3G network.

Experiment

A controlled experiment in a field setting has been conducted to evaluate the proposed system. In particular a comparison is made between the distributed participatory model (TravelTrough) and the centralized coordinated model based on the current practice in disaster response [20]. Table 1 summarizes the differences between the two systems. The experiment was set up to answer 3 questions: (1) can the affected people be guided to a safer location by using the TravelThrough compared with the centralized system? (2) Do TravelThrough users have a lower

workload than the centralized system, and (3) how do users perceived the usability of the TravelThrough system.

Method

The experiment was setup to mimic an earthquake disaster with multiple incidents simulated around some part of Delft, The Netherlands (area $\pm 5.4 \text{ km}^2$). It used a one way within subject design in which the independent variable consists of two conditions: (1) the TravelThrough and (2) the centralized system. Each experiment session involved 3 participants: 2 affected persons who walk in the field and 1 operator sitting in an information center. The role of all participants remained the same throughout the experiment session. The task of an affected person was to navigate safely from a predefined location to a designated destination as fast as possible, imitating a victim in a disaster area who was searching for a safe shelter. On the way, the participant was asked to report relevant incidents he might find, and to avoid dangerous areas (revealed to him on the smartphone as he went along). For the two conditions, the participants used two different predefined sets of starting point and destination pairs. These sets were the same for both participants. However, the first participant started the task 5 minutes earlier than the second one. The order of the conditions administered and routes were counterbalanced to eliminate the learning effect and route differences.

To simulate the intense nature of a crisis situation, 15 additional virtual affected people were spread around the city. The operator in the information center had no knowledge of the fact that only two real affected persons were taking part in the experiment. All virtual

	Centralized	TravelThrough
Protocol	Centralized Command and Control Model [21, 4, 5, 29]	Distributed Participatory Model
Main actors	Emergency services (local government) [2, 34].	The affected population and the emergency services.
Situation map	Unshared map [11]	Shared map across actors
Affected population	Seen as helpless victims [4, 5, 2]	Seen as empowered citizens
Communication media	Audio communications [17, 18]	Visual + Audio communication
Navigation tools	Paper maps, not integrated GPS-based navigation system [18]	Interactive maps, integrated navigation system.
Situation update	Radio broadcast to all [18]	Targeted broadcast
Walked trails	-	GPS logs, walked route
Map maker	A plotter [11]	Everyone participating
Main source of incident reports	The responders + civilians report through emergency call number [7]	The responders + direct report of the affected population
Dependency on technology infrastructure	Less dependent on technology: radio and (mobile) phones [28, 6]	More dependent on technology: data connectivity, smart phone with GPS

Table 1. The difference settings and conditions in the TravelThrough session and the Centralized session.

persons produce realistic data, except for the fact that their location was kept separated from a predefined area where the “real” affected persons walked, to keep from interfering with them. The task of the operator was to assist the affected people in the field to reach their destination safely by (1) receiving, inspecting and acknowledging incident reports, (2) recognizing patterns and sizes of dangerous areas around similar reports, (3) marking dangerous areas, and (4) broadcasting the latest situations. The incoming reports were a combination of reports from the real participants in the field and the virtual affected persons.

In the TravelThrough condition, all reports were synchronized and displayed directly on both the mobile application of the affected people in the field and the information center application. In the case of the centralized condition, an additional operator is used to act as an emergency service number relaying reports from the real affected people to the participant in the information center, a role that was filled by one of the experimenter; while reports from the virtual persons were directly sent to the information center. Also in this condition, the situation updates were not done automatically; therefore the operator had an additional task of announcing new information on the radio, imitating a radio broadcast during a disaster.

Preparations

In the TravelThrough condition, the affected person use the developed application on the iPhone 3GS. The affected person in the centralized condition use paper maps and normal mobile phones. One mobile phone was used to report incidents to the information center and the other was used as a radio receiving all updates about the situations. To simulate disaster incidents and

dangerous areas around the city while the affected people were walking, some prominent landmarks were used as triggering instruments for this experiment, accompanied by a booklet of instruction of triggered events. The booklet has mainly two parts: (1) a matrix of 12 landmarks spread around the experiment area with unique numbers (Figure 6.above) and (2) corresponding instructions triggered by the numbers obtained from the matrix (Figure 6.below). The affected persons were asked, when they spot a specified landmark (± 25 m from the landmark), to (1) open the instruction corresponding with the unique number, (2) try to understand the situation, and (3) report the incident to the information center using the provided information.

Participant

The experiment involved 24 groups of 3 participants (15 female and 57 male) within the age 18-57 years old ($M = 29$, $SD = 7.8$). They were recruited from different faculties at the Delft University of Technology with completed secondary school, undergraduate and post-graduate level of education. 81% of them had experience with navigation devices.

Measurement

Measurements for the affected person are: accuracy (the frequency and the duration entering dangerous areas), efficiency (the completion time, the walking distance and the workload on performing tasks), preferences, and perceived usability of the mobile application.

Measurements for the operator are: workload on performing tasks, preferences, and perceived usability. Workload was measured by using the Rating Scale Mental Effort (RSME) [35] (administered 8 minutes after the experiment started of each condition) and the



NASA Task Load Index (NASA-TLX) [14] (administered after each condition). The higher scores indicate greater workload. The (user) preferences were self-rated and indicated on a Likert scale from 1 to 7 anchored by bipolar descriptors from “totally disagree” to “totally agree”. Finally, the usability of the TravelThrough system was measured using Component-Based Usability Questionnaire (CBUQ) [1].

Result and Analysis

THE AFFECTED PERSON

Accuracy. The accuracy was analyzed in both conditions using a paired-sample *t*-test. The overall trespassing was relatively low in both conditions therefore analysis focused on those cases where the trespassing occurred. The test results indicated that the second participant in the TravelThrough condition ($M = 7059$, $SD = 12558$) was spending significantly less time (seconds) in dangerous areas compared to the second participant in the centralized condition ($M = 49144$, $SD = 63384$), $t(13) = 2.38$, $p = 0.03$. Although there was no difference on frequency data, $t(13) = 1.53$, $p = 0.15$, the significant duration in the dangerous area was promising. This result demonstrated that in the TravelThrough condition, the subsequent affected person could be helped by the shared situation updates and the safe trails reported by the prior affected person. Additionally, one of the participants commented that, when spotting a red dangerous area on his mobile, “I just remembered to avoid this area. But it is very good because it reminds me some areas I can’t go through”

Efficiency. The following three measures (efficiency, preferences, and the perceived usability of the mobile application) take the average score of the two affected

persons in each experiment session. The efficiency of the affected people was analyzed using a one-way within-subject MANOVA. The independent variable was the two system conditions (the TravelThrough and the centralized), while the dependent variables were the RSME score, the NASA-TLX score, walking distance, and walking time. The test revealed a multivariate main effect for system, $F(4, 20) = 4.32$, $p = 0.01$. The univariate analysis results (Table. 2) show that the TravelThrough condition led to a lower workload compared to the centralized condition. The affected people mentioned that in the TravelThrough condition, they were able to receive better and faster situation updates. In case of the centralized condition, the affected people had to continuously keep track of new situation updates by radio, which were mostly not really clear. Additionally, they needed to mentally create the situation map of the dangers around.

Preferences. A MANOVA with repeated measure was conducted with as dependent variables updating preferences, reporting preferences, navigation preferences, and general preferences. The results shows an significant overall main effect, $F(4,20) = 18.72$, $p < .001$, between TravelThrough and centralized conditions. This effect was also found back in univariate analyses of all the dependent variable measured (Table 3). Examining the mean scores showed that TravelThrough was consistently preferred to the centralized system. This might have been caused by the mechanism of getting real-time situation updates, as consistently supported by earlier workload analysis.

Perceived usability of the mobile application. Theratings of the CBUQ for interactive components on the users’

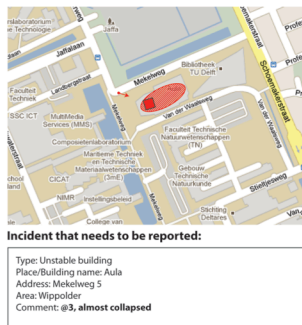


Figure 6. Participant booklet: (above) the matrix of 12 landmarks (below) an example of the corresponding instruction.

Indicator	Travel-Through		Centralized		F	p
	M	SD	M	SD		
	Getting updates	5.9	0.9	3.7		
Reporting task	6.0	0.7	5.0	1.0	16.17	10 ⁻³
Navigating task	5.9	0.7	4.1	1.0	42.23	<10 ⁻³
General preference	5.9	0.7	4.2	0.9	73.39	<10 ⁻³

Table 2. Efficiency of the affected person, N = 24, dfs = (1, 23)

Indicator	Travel-Through		Centralized		F	p
	M	SD	M	SD		
	Getting updates	5.9	0.9	3.7		
Reporting task	6.0	0.7	5.0	1.0	16.17	10 ⁻³
Navigating task	5.9	0.7	4.1	1.0	42.23	<10 ⁻³
General preference	5.9	0.7	4.2	0.9	73.39	<10 ⁻³

Table 3. The average of user preferences of the affected people and the operator, N = 24, dfs = (1, 23).

Indicator	Travel Through		t	df	p
	M	SD			
Navigation view	6.0	0.7	5.37	23	<10 ⁻³
Event reporting view	6.1	0.4	10.54	23	<10 ⁻³
General	6.2	0.5	9.95	23	<10 ⁻³

Table 4. The component usability of the mobile device application (TravelThrough) for the affected person

handheld device were analyzed by using one sample *t*-test with break-even point of the CBUQ (test value = 5.29) [1]. The interactive components analyzed were event reporting view, navigation view, and general interaction. The tests show that the means of all interactive components scored significantly above the break-even point (see Table 4). This means that all interactive components of the TravelThrough mobile application used by the affected person were consistently considered to be more usable compared to components of the norm data [1].

THE OPERATOR

The workload. The workload of the operator was analyzed using a one-way within-subject MANOVA. The independent variable was the two system conditions (the TravelThrough and the centralized), while the dependent variable was the workload of the operator measured by the RSME and the NASA-TLX questionnaires. The test revealed that the system had a main effect on the workload of the operator, $F(2, 22) = 21.84, p < .001$. From the univariate analysis and examining the means (Table 5) it can be seen that the TravelThrough gave less workload compared to the centralized system. This might be the result of the automated situation update throughout the system in the TravelThrough. In the centralized case, many of the participants had difficulties in finding locations of the incident reports on the map based on their address. The high number of incoming reports had overwhelmed them. Consequently, they often forgot to broadcast the updated situations.

Preferences. Operator's preferences were analyzed using a one-way repeated-measures MANOVA, with the preference items of the operator as the dependent

variables. The test revealed that the system had a main effect on the preference of the operator, $F(3, 21) = 33.54, p < .001$. This agrees with the univariate analysis, showing that the participants gave a higher rating value for the TravelThrough than for the centralized system in the three component measures (see Table 6). Few participants commented that by placing each report on the map, they could have more situation awareness. On the other hand, the automation offered them a better overview of the situation. This is consistent with the previous findings of this experiment.

Perceived usability of the information center. The general rating of CBUQ for the TravelThrough and the centralized system was compared using a paired sample *t*-test. The TravelThrough showed a significant, $t(23) = -5.01, p < .001$, higher ratings ($M = 5.2, SD = 1.3$) in this measure compared to the centralized system ($M = 3.5, SD = 1.3$).

Conclusion and Discussion

The present study is based on earlier findings of how humans behave in times of crisis, and aims to utilize modern advances in personal mobile devices. This is the first empirical study to examine that in a controlled condition. The experimental results show that the TravelThrough system in the distributed setting can successfully help subsequent affected people in avoiding danger (provided the first affected person shares his findings). Furthermore, the results also show that the system reduces the mental effort and workload for both the affected people and the operator significantly. This is an important point since the application will be used in highly stressful conditions. The results also confirm that TravelThrough was

Measures	Travel Through		Centralized		F	p
	M	SD	M	SD		
RSME	7.7	2.2	10.5	2.5	43.32	<10 ⁻³
NASA-TLX	58.4	15.9	76.0	17.6	16.43	<10 ⁻³

Table 5. Univariate analysis of the workload for Travel-Through and Centralized condition with N=2, dfs = (1, 23).

Indicator	Travel Through		Centralized		F	p
	M	SD	M	SD		
Registering reports	5.3	1.0	2.3	1.2	98.17	<10 ⁻³
Broadcasting situation	5.5	1.2	2.9	1.3	43.51	<10 ⁻³
General preference	5.1	1.1	2.5	1.1	87.19	<10 ⁻³

Table 6. User preferences of the operator, N = 24, dfs = (1, 23).

perceived more usable for both navigation and sharing information in a disaster event. Moreover, this system was preferred for traveling through disaster area more than the traditional system. The navigation task did not seem to have large negative effects on time or walking distance compared to the current centralized system.

Like any other empirical research, this study still suffers from some limitations. (1) Since the experiment was done in the controlled setting, important factors that play a role in real disasters, such as emotions, social issues, multitasking and task interruptions, could not be investigated, (2) All participants of this study were highly-educated people, which only reflects one segment of the population. (3) The operator participants of the information center were not trained professionally. Proper training might have benefited their performance, which in turn also influenced the affected people in performing their tasks. Nevertheless, we believe that the results of this study can potentially be extended to other domains within the disaster management. Different intelligent systems, such as user behavior and stress analysis could be added.

REFERENCES

- [1] Brinkman, W.-P., Haakma, R., & Bouwhuis, D.G. Theoretical foundation and validity of a component-based usability questionnaire, *Behaviour and Information Technology* (2009), 2, no. 28, 121 – 137.
- [2] Cronan, K. Foundations of Emergency Management. *The Australian J. of Emergency Management* (1998), 13(1), 20-23.
- [3] Drabek, T. E. and McEntire, D. A. Emergent phenomena and the sociology of disaster: lessons, trends and opportunities from the research literature. *Disaster Prevention and Management* (2003), 12(2), 97-112.
- [4] Dynes, R.R. Problems in Emergency Planning. *Energy* (1983), 8, 653- 660.
- [5] Dynes, R. R. Community Emergency Planning: False Assumptions and Inappropriate Analogies. *International Journal of Mass Emergencies and Disasters* (1994), 12(2), 141-158.
- [6] Farnham, S., Pedersen, E., Kirkpatrick, R. Observation of Katrina/Rita Groove Deployment: Addressing Social and Communication Challenges of Ephemeral Groups. In *Proc. ISCRAM 2006*, (2006).
- [7] Gates, D. G. Executive Analysis of Fire Service Operations in Emergency Management (2007), <http://www.usfa.fema.gov>
- [8] Goodchild, M. F. Citizens as sensors: the world of volunteered geography. *GeoJournal* (2007), 69(4), 211-221.
- [9] Guha-Sapir, D., Vos, F., Below, R., and Ponserre, S. Annual Disaster Statistical Review 2010: The numbers and trends. Centre for Research on the Epidemiology of Disasters (CRED)(2011).
- [10] Gunawan, L. T. Collaboration-Oriented Design of Disaster Response System. *Proc. of CHI, ACM Press* (2008), 2613-2616.
- [11] Gunawan, L. T., Oomes, A. H. J., Neerincx, M., Brinkman, W-P., and Alers, H. Collaborative situational mapping during emergency response. *Proc. of ECCE* (2009), 6:1-6:7.
- [12] Gunawan, L. T., Alers, H., Brinkman, W-P., Neerincx, M. Distributed collaborative situation-map making for disaster response. *Interacting with Computers* (2011), 23(4), 308-316.
- [13] Gunawan, L.T., Fitrianie, S., Brinkman, W-P., Neerincx, M. Utilizing the Potential of the Affected Population and Prevalent Mobile Technology during Disaster Response: Propositions from the Literature. In *Proc. of ISCRAM* (2012) (In press)
- [14] Hart, S. G. and Staveland, L. E. Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock and N. Meshkati

- (Eds.) Human Mental Workload. Amsterdam: North Holland Press (1988).
- [15] IBM e-business case studies: Bullhead city police department (1999), <http://www.ibm.com/e-business/doc/content/casestudy/47405.html>.
- [16] ITO World. Mapping the Crisis - OpenStreetMap Response to Haiti Earthquake (2010). <http://itoworld.blogspot.com/2010/01/mapping-crisis-openstreetmap-response.html>.
- [17] Kean, T. H., and Hamilton, T. H. The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States, (2004), W.W. Norton & Company Ltd, NY.
- [18] Landgren, J. Designing Information Technology for Emergency response, Doctoral Dissertation, Gothenburg Studies of Informatics (2007), Report 39.
- [19] Law P. and Peng Y. Cellphone, Internet, and the SARS Epidemic. International Workshop on Mobile Technologies and Health: Benefits and Risks (2004). Udine, Italy.
- [20] McEntire, D. A. Anticipating Human Behavior in Disasters: Myths, Exaggerations and Realities. In Wiley Pathways Disaster Response and Recovery. John Wiley & Sons (2006).
- [21] Neal, D. M. and Phillips, B. D. Effective Emergency Management: Reconsidering the Bureaucratic Approach. *Disasters* (1995), 19 (4), 327-337.
- [22] Palen L. and Liu S. B. Citizen communications in crisis: anticipating a future of ICT-supported public participation. In Proc. of CHI (2007). ACM Press, 727-736.
- [23] Palen L., Vieweg S., Sutton J., Liu S. B. and Hughes A. Crisis Informatics: Studying Crisis in a Networked World. In Proc. of the Third International Conference on E-Social Science (2007).
- [24] Quarantelli E. L. Research findings on organizational behavior in disasters and their applicability in developing countries, Preliminary Paper #107, Newark, DE: Disaster Research Center (1986), University of Delaware.
- [25] Quarantelli E. L. and Dynes R. R. When disaster strikes (It isn't much like what you've heard or read about). *Psychology Today* (1972), 67–70.
- [26] Ramaswamy, S., Rogers, M., Crockett, A. D., Feaker, D., and Carter, M. WHISPER – service integrated incident management system. *International Journal of Intelligent Control and Systems*, (2006), 11(2), 114–123.
- [27] Samaraweera I. and Corera S. Sahana victim registries: Effectively track disaster victims. In Proc. of ISCRAM (2007).
- [28] Schneider S. K. Administrative Breakdowns in the Governmental Response to Hurricane Katrina. *Public Administration Review* (2005), 65, 515-517.
- [29] Sobel R. S. and Leeson P. T. Government's Response to Hurricane Katrina: A Public Choice Analysis, *Public Choice* (2006), 127(1), 55–73.
- [30] Tierney, K., Bevc, C., and Kuligowski, E. Metaphors Matter: Disaster Myths, Media Frames, and Their Consequences in Hurricane Katrina. *The ANNALS of the American Academy of Political and Social Science* (2006), 604, 57-81.
- [31] Tierney, K. J., Lindell, M. K., and Perry, R. W. *Facing the Unexpected: Disaster Preparedness and Response in the United States*. Washington, DC: Joseph Henry Press (2001).
- [32] Usahidi (2007) <http://haiti.ushahidi.com/>.
- [33] Vieweg, S., Hughes, A., Starbird, K., Palen, L. Microblogging During Two Natural Hazards Events: What Twitter May Contribute to Situational Awareness. Proc. of CHI, ACM Press (2010), 1079-1088.
- [34] Waugh, W. L. and Streib, G. Collaboration and Leadership for Effective Emergency Management. *Public Administration Review* (2006), 66: 131
- [35] Zijlstra, F. R. H. Efficiency in work behaviour: a design approach for modern tools. PhD Thesis, Delft University of Technology (1993).