Utilizing the Potential of the Affected Population and Prevalent Mobile Technology during disaster Response: Propositions from a Literature Survey

Lucy T. Gunawan[1], Siska Fitrianie[1], Willem-Paul Brinkman[1], Mark A. Neerincx[1,2]
[1]Delft University of Technology, [2]TNO Human Factor Soesterberg
{l.t.gunawan, s.fitrianie, w.p.brinkman, m.a.neerincx}@tudelft.nl

ABSTRACT

Despite the growing awareness of the untapped potential of the affected population in a disaster situation, their inclusion in a disaster management is extremely limited. This study aims to survey the literature to see whether utilizing the affected people and prevalent mobile technology can be used during disaster response. The idea is to provide the affected with a way to lead themselves to safety and empower them to serve as distributed active sources of information. This way, those people will reach safety by themselves, while at the same time helping to construct a clear image of the disaster situation without burdening the already overwhelmed emergency services. This study examines knowledge derived from disaster sociology, draws on experience from recent disasters, and extrapolates current technological solutions. By establishing that such a solution is feasible, it offers a basis for empirical studies on a mobile technology that can be used during disaster response.

Keywords

Literature survey, the role of community, post-impact of disaster response, crowdsourcing.

INTRODUCTION

In recent years, both natural and man-made disasters, including earthquakes, floods, wild fires, hurricanes, tsunamis, civil riots, and terrorist attacks have resulted in tremendous damages, disruptions, and threat to human life. In response to such inevitable situations, the priority is usually given to rescuing as many human lives as possible, and protecting them from the subsequent harm. In order to have an effective and efficient response to a disaster, the knowledge of a situation in the disaster area needs to be acquired as rapidly and as comprehensively as possible. This, for example includes the extent of the damage, potential hazards, dangerous and safe areas, casualties, and the availability of emergency facilities. It is, however, a complicated task to generate a complete and comprehensive knowledge of a disaster area. This is not only due to the dynamic nature of the event. It is also partially caused by the complicated and inefficient structure of the centralized disaster management model that is commonly adopted worldwide. This model puts an unnecessary burden on the limited emergency services, overlooks the potential resource available in the affected population, and incorporates an extended hierarchical information chain.

Not only does this model excessively rely on the limited emergency services for the rescue actions, it also makes them responsible of acquiring information on the ground. During disasters, the local emergency services typically receive a surge of demand in rescue work exceeding their normal operational capacity. They, therefore, become quickly overwhelmed with the response provision. The civilians, who are treated as helpless victims unable to cope with the incident, do not play any significant role in the system. While civilians can provide the authorities with information about the situation by calling emergency numbers, their reports are typically treated as less reliable, and require further verification by trained professionals. This adds extra workload and delays on emergency services, especially during mass-casualty disasters, when information centers are flooded with input and inquiries. As a result of all that, the knowledge of disaster situation tends to be incomplete and outdated.

The study of how humans behave during times of collective stress showed that the affected population in a disaster are actually capable humans, who tend to act rationally and exhibit a great deal of pro-social behavior. They are most likely to be proactive and are usually the first to provide help on the ground, since individuals and groups typically become more cohesive and unified during situations of collective stress. Despite the growing awareness of their untapped potential in a disaster situation, their inclusion in a disaster management system is still extremely limited.

The challenge of understanding the impact of a disaster and the resulting situation can be analogically compared to the story of the blind men and the elephant. In the story, a group of blind men touch an elephant to understand its physical shape. Each one feels a different part, but only one part, such as the trunk, the tusk, or the tail. They then compare notes and learn that they are in complete disagreement, leaving them with an inaccurate mental model. Now, imagine if these blind men were equipped a 3D tracking and positioning system while feeling the elephant's shape. If they were then also allowed to communicate and combine their findings, and provided with a computer numerical control (CNC) machine to print the resulting 3D shape (such as RepRap), they can print a miniature of an elephant that resembles the real elephant, resolving their previous disagreements. By using the same analogy, it is useful to use the affected people as distributed reporters all over the disaster area, who are experiencing the disaster first hand. In addition, utilizing advances in smart-phone technology with GPS and data connectivity, makes the affected population a potentially vital element in a system that can constructs an emerging overview of the disaster situation.

Therefore, this paper raises an idea to utilize the potential capacity of the affected and the widespread mobile technology during disaster response. By providing these people with a way to lead themselves to safety while, at the same time, empowering them to serve as distributed active sources of information. This way, those people will be better off in a safer place by themselves, while at the same time helping to rapidly construct a clear image of the disaster situation without burdening the already overwhelmed emergency services. With better knowledge of the disaster situation, the humanitarian aid and rescue activities may be assisted more effectively, and potentially save the injured in a shorter amount of time. To investigate this issue, a literature survey from the available knowledge was done to substantiate whether this idea can potentially be implemented. Results found from the literature survey will be summarized in this paper.

HYPOTHESIS

The main hypothesis to be investigated in this paper is formulated as follows:

Can the affected population be guided safely in traveling through disaster area effectively and efficiently through a participatory mechanism by collaboratively sharing geo-spatial information among professional and non-professional actors during the disaster response?

To answer this question, it is first divided into four sub-questions or claims. The four claims are formulated as follow: (1) The affected population are capable human beings able to a large extend to take care of themselves and help others during the time of collective stress. (2) In a disaster area without a map available, the affected population can be guided to reach a destination by using mobile navigation technology that constantly points to the direction of the destination and provides elementary navigation cues. (3) Using (audio) visual communication channels to collaboratively share geo-spatial information across people in the disaster area increases the accuracy and completeness of the disaster situation map. (4) By collaboratively sharing geo-spatial information between the affected population and professional actors on-and-off location: (a) the affected population will be guided in a safer manner and (b) a more accurate disaster situation map will be constructed, which in term will better facilitate the relocation of the affected population, in comparison to the commonly used system.

This study only examines the participation of the affected population in the disaster response stage, in which the disaster has already struck (post-impact). This paper is organized by paragraph for each claim followed by the evidence that support it.

SUBTANTIATIONS OF THE HYPOTHESES

In order to establish background support for all hypotheses, it is important to first understand that the affected population is often not a group of helpless victims. Instead, *the affected population, often, are capable humans beings able to a large extend to take care of themselves and help others during the time of collective stress,* and who even possess unique characteristics which can serve as a valuable resource during disaster response. The claim that an affected population are capable humans is supported from the field of disaster sociology and the experience of the past humanitarian operations experience. These reports show that the affected population in a disaster is actually capable humans. People tend to act logically and rationally with calm behaviors (Quaratelli, 1986; Lomnitz, 1999). Instead of too shocked and helpless to take responsibility for their own survival, the affected population, on the contrary, many find new strength during an emergency (WHO, 1989). Disaster victims are more immune to the disaster shocks, more innovative in resolving their problems and more resilient in the wake of severe challenges that they are given credit for (Fisher,1998; Quarantelli & Dynes,1972). Instead of reacting in an anti-social manner, individuals and groups typically become more cohesive and unified during situation of collective stress. (Quarantelli, 1986; Drabek & McEntire, 2003). Generally, those affected by disaster are most likely to be proactive, rather than wait for emergency personnel to arrive at the scene, the affected persons, organizations and communities are the first to help and take care of themselves and others (Quarantelli, 1999; Wenger et al., 1986; McEntire, 2006; Tierney et al., 2001; Kean & Hamilton, 2004). By analysing the numbers and experience learned from past disasters, it becomes apparent that the affected population is a massive potential resource, accounted for 94% of the population (Guha-Sapir, 2010). Furthermore, by having the special property of being distributively located all over the disaster area and experiencing the disaster themselves, they are valuable resource to collect the first hand information about the disaster.

The second hypothesis states that *in a disaster area without a map available, the affected population can be guided to reach a destination by using mobile navigation technology that constantly points to the direction of the destination and provides elementary navigation cues*. Support for this hypothesis is explored by looking at the motivation of citizen physical movement post-disaster impact, looking at how people use and adopt technology during a disaster situation, and examining successful navigation technology used by less technology adept or handicapped individuals. Most citizen physical movement post-disaster impact is typically to ensure the protection and survival of oneself or close relatives (traveling to get home or get to shelter, collecting of close relatives, seeking for assistance, or doing rescue) (Provitolo et al., 2011). Recent disaster and other emergency events showed that the experience of a disaster catalysed creative uses of available technologies during disasters, especially for information seeking (Boyle et al., 2004). They are able to utilize familiar technology, or quickly adopt new unfamiliar ones for their purpose, such as: the use of text messaging, mobile phones, twitter, blog, conference call, photo and video sharing, and forums (Shklovski et al., 2010; Procopio & Procopio, 2007; Fox et al., 2002; Hughes & Palen, 2009). Handheld navigation technology has been successfully used to support individuals with cognitively impaired (Chang et al., 2010, Liu et al., 2006, Fickas et al., 2008) and elderly people (Goodman et al., 2004, Kawamura et al., 2008). Since it is technically possible to have a mobile navigation device to successfully guide such users, then it should also be possible to use similar system for guiding the affected population.

In order to make navigation technology work more effectively and efficiently for disaster response, an up-to-date representation of the post impact situation is required, especially in the case when the environment is altered thus rendered existing maps useless. The traditional centralized mechanism of gathering this kind of information might not be efficient due to limited emergency resources that collect this kind of information (Schneider, 2005) and the hierarchical reporting structure in command-and-control organization of disaster management (Drabek, 1985, Kean & Hamilton, 2004, Ramaswamy et al., 2006, U. S. House of Representatives, 2006b). Therefore, a distributed approach that utilizes the affected population for collecting situation data in the field is arguably more effective and efficient. The mechanism to do so in a distributed manner is outlined in the third hypothesis. It claims that *using (audio) visual communication channels to collaboratively share geo-spatial information across people in the disaster area increases the accuracy and completeness of the disaster situation map*. Support for this hypothesis is argued by considering the theory of rumour transmission, where communication in the networked structure is superior to the chained structure (such as in the Chinese whisper game) due to the cross verification of transmitted information (Buckner, 1965). To argue that map and GPS coordinates could be better at pinpoint exact location, examples of inefficient current practises in sharing geo-spatial information through the exclusive use of voice communication was studied. In the examples, emergency services were sent to the wrong address and could have lead to terrible consequences (WDR Online, 2008, Firegeezer Blog, 2008). These are some examples of successful collaborative map-making for disaster response. In the Great East Japan Earthquake and Tsunami of 2011, traffic information maps based on real-time passable route data was collected via navigation systems and used to generate maps to assist people inside the impacted area (METI, 2011). In Haiti Earthquake 2010, OpenStreetMap (Goodchild, 2007) was used substantially for a massive mapping in a very short period of time since Haiti did not have a digital map before the disaster. It was reported that within 48 hours after the earthquake, a complete map of Port-Au-Prince and Carrefour were drawn by collaborating of hundreds of volunteer mappers around the world using the post-quake aerial imagery (ITO World, 2010). The resulting digital map was used extensively and largely for the disaster response, damage reports and transportation purposes by emergency services, humanitarian organizations, and search and rescue missions.

Good coordination is needed for an effective response (Gao et al., 2011). Even though the command and control model was criticized by disaster sociologists for its inflexibility (Neal & Phillips, 1995; Comfort, 1985), this thesis does not dismiss its eminent role. This leads to the fourth hypothesis, *by collaboratively sharing geo-spatial information between the affected population and professional actors on-and-off location: (a) the affected population will be guided in a safer manner and (b) a more accurate disaster situation map will be constructed, which in term will better facilitate the relocation of the affected population, in comparison to the commonly used system*. The collaboration between the emergency services and the affected population is necessary. This is due to the two different kinds of information which both parties possessed, that may compliment each other: (1) the affected population have the knowledge of going on in the field, while (2) the emergency services have the knowledge such as: population data, emergency facilities, shelter locations, and vulnerable infrastructures. Support to this claim is provided by looking at examples of successful crowdsourcing systems through popular and social media (Gilmor, 2004, Palen & Liu, 2007) and cross-sector collaborations (Simo & Bies, 2007, Maon et al., 2009, van der Vijver et al., 2009).

CONCLUSION

This paper investigated the idea that the affected population in a disaster can safely travel through a disaster area effectively and efficiently through a participatory mechanism by collaboratively sharing geo-spatial information among professional and non-professional actors during the disaster response. Through critical analysis of relevant literatures, it was shown that the affected population in a disaster consists of capable human beings who form an enormous potential resource for helping disaster response effort. It was shown that they are able use technology at hand creatively both familiar and new unfamiliar ones. At the same time, the mobile technology trend becomes prevalent, not only equipped with GPS but also cameras and mobile data access. The combination of distributed affected population, experiencing the disaster first hand, and technology, make the affected population perfect active sensors to emergent situation awareness. And at last, it was shown from lessons learned from past disaster that collaboration between professional and non-professional actors in disaster response can make the disaster response more efficient and effective. Therefore, these form the theoretical foundation to support the idea, the main hypothesis, and as the basis for empirical studies for designing ICT solutions that utilize the participation of the affected population and prevalent technology that may be used in disaster response (Gunawan, 2012).

REFERENCES

1. Boyle M. P., Schmierbach M., Armstrong C. L., McLeod D. M., Shah D. V., and Pan Z. (2004) Information seeking and emotional reactions to the September 11 Terrorist Attacks. Journalism and Mass Communication Quarterly. Spring. 81, 1, Humanities Module, 155-167.
2. Buckner H. T. (1965) A Theory of Rumor Transmission. Public Opinion Quarterly, 29,1 (Spring), 54-70.
3. Chang Y.-J., Peng S.-M., Wang T.-Y., Chen S.-F., Chen Y.-R., Chen H.-C. (2010) Autonomous indoor wayfinding for individuals with cognitive impairments. Journal of NeuroEngineering and Rehabilitation. 7(45).
4. Comfort L. K. (1985), Action research: A model for organizational learning. Journal of Policy Analysis and Management, 5, 100–118
5. Drabek T. E. (1985) Emergency Management: The Human Factor. Washington, DC: Federal Emergency Management Agency, National Emergency Training Center.
6. Drabek T. E. and McEntire D. A. (2003) Emergent phenomena and the sociology of disaster: lessons, trends and opportunities from the research literature. Disaster Prevention and Management. 12(2), 97-112.
7. Fickas S., Sohlberg M., and Hung P.-F. (2008). Route-following assistance for travelers with cognitive impairments: A comparison of four prompt modes. International Journal Human Computer. Study. 66, 12, 876-888.
8. Firegeezer Blog (2008) Canada. http://firegeezer.com/2008/05/02/ambulance-sent-to-wrong-city.
9. Fischer H. W. III (1998) Response to disaster, fact versus fiction and its perpetuation: the sociology of disaster. Lanham, Maryland: University Press of America, Inc.; www.univpress.com
10. Fox S., Rainie L., and Madden M. (2002) One year later: September 11 and the Internet. Pew Internet and Americal Life Project. http://www.pewinternet.org/reports/pdfs/PIP_9-11_Report.pdf.
11. Gao H., Wang X., Barbier G., and Liu H. (2011) Promoting Coordination for Disaster Relief - From Crowdsourcing to Coordination. In Proc. of SBP. 197-204.
12. Gillmor D. (2004). We the Media: The Rise of Citizen Journalists. National Civic Review. Fall, 58-63.
13. Goodchild M. F. (2007) Citizens as sensors: the world of volunteered geography. GeoJournal, 69, 4, 211-221.
14. Goodman J., Gray P.D., Khammampad K., and Brewster S.A. (2004) Using Landmarks to Support Older People in Navigation. In Proc. of Mobile HCI, 38-48.
15. Guha-Sapir D., Vos F., Below R., and Ponserre S. (2011) Annual Disaster Statistical Review 2010: The numbers and trends. Centre for Research on the Epidemiology of Disasters (CRED).
16. Gunawan, L.T., Fitrianie, S., Yang, Z., Brinkman, W.-P., Neerincx, M. TravelThrough: A Participatory-based Guidance System for Traveling through Disaster Areas. In Proc. of CHI 2012 (In Press).
17. Hughes A. L. and Palen L. (2009) Twitter adoption and use in mass convergence and emergency events. International Journal of Emergency Management, 6, 3, 248–260.
18. ITO World. Mapping the Crisis - OpenStreetMap Response to Haiti Earthquake (2010). http://itoworld.blogspot.com/2010/01/mapping-crisis-openstreetmap-response.html
19. Kawamura T., Umezu K. and Ohsuga A. (2008) Mobile Navigation System for the Elderly - Preliminary Experiment and Evaluation. In Proc. of UIC. 578-590

20. Kean T. H., and Hamilton T. H. (2004) The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States, W.W. Norton & Company Ltd, New York.
21. Liu, L., Hile, H., Kautz, H., Borriello, G., Brown, P. A., Harniss, M. and Johnson, K. (2006). Indoor wayfinding: Developing a functional interface for individuals with cognitive impairments. In Proc. of Computers & Accessibility, Assets, 95-102.
22. Lomnitz C. (1999), Henry W. Fischer, III: Response to Disaster: Fact Versus Fiction and Its Perpetuation. The Sociology of Disaster. Natural hazards. 19, 1, 79-80.
23. Maon F., Lindgreen A., and Vanhamme J. (2009). Developing supply chains in disaster relief operations through cross-sector socially oriented collaborations: a theoretical model. Supply Chain Management An International Journal 14, 149-164.
24. McEntire D. A. (2006) Anticipating Human Behavior in Disasters: Myths, Exaggerations and Realities. In Wiley Pathways Disaster Response and Recovery. John Wiley & Sons.
25. METI (2011), Japan Portal: Good Design Grand Award 2011 goes to "Traffic Information Archive Map," Honda's project based on its "internavi" system in response to the Great East Japan Earthquake, November. http://www.meti.go.jp/english/press/2011/1109_01.html.
26. Neal D. M. and Phillips B. D. (1995) Effective Emergency Management: Reconsidering the Bureaucratic Approach. Disasters, 19, 4, 327-337.
27. Palen L. and Liu S. B. (2007) Citizen communications in crisis: anticipating a future of ICT-supported public participation. In Proc. of CHI. ACM Press, 727-736.
28. Procopio C.H. and Procopio S.T. (2007) Do You Know What It Means to Miss New Orleans? Internet Communication, Geographic Community, and Social Capital in Crisis. Journal of Applied Communication Research, 35, 1, 67 - 87.
29. Provitolo D., Dubos-Paillard E. and Muller J.-P. (2011) Emergent Human Behavior During a Disaster: Thematic versus Complex Systems Approach. In Proc. of EPNACS within ECCS'11: Emergent Properties in Natural and Artificial Complex Systems. Vienna, Austria, 47-57.
30. Quarantelli E. L. (1986) Research findings on organizational behavior in disasters and their applicability in developing countries, Preliminary Paper #107, Newark, DE: Disaster Research Center, University of Delaware.
31. Quarantelli E. L. (1999) Disaster Related Social Behavior: Summary of 50 Years of Research Findings. DRC Preliminary Papers, Disaster Research Center.
32. Quarantelli E. L. and Dynes R. R. (1972) When disaster strikes (It isn't much like what you've heard or read about). Psychology Today, 67–70.
33. Ramaswamy S., Rogers M., Crockett A. D., Feaker D., and Carter M. (2006) WHISPER – service integrated incident management system. International Journal of Intelligent Control and Systems, 11, 2, 114–123.
34. Schneider S. K. (2005) Administrative Breakdowns in the Governmental Response to Hurricane Katrina. Public Administration Review, 65, 515-517.
35. Shklovski I., Burke M., Kiesler S. and Kraut R. (2008) Use of communication technologies in Hurricane Katrina aftermath. Position paper for the HCI for Emergencies workshop CHI 2008, Florence, Italy.
36. Shklovski I., Burke M., Kiesler S. and Kraut R. (2010) Technology adoption and use in the aftermath of hurricane Katrina in New Orleans. American Behavioral Scientist Online 1st. February 18.
37. Simo G., & Bies A. L. (2007). The role of nonprofits in disaster response: An expanded model of cross-sector collaboration. Public Administration Review, 67(Suppl. to Issue 6), 125- 142.
38. Tierney K. J, Lindell M. K, and Perry R. W. (2001) Facing the Unexpected: Disaster Preparedness and Response in the United States. Washington, DC: Joseph Henry Press.
39. U.S. House of Representatives (2006b), One Year Later... Katrina's Waste: A Report Detailing Contracting Fraud, Waste, and Abuse in the Aftermath of Hurricane Katrina, U.S. House of Representatives, August 28.
40. Van der Vijver K., Johannink R., Overal K., Slot P., Vermeer A., van der Werff P., Willekens H. en Wisman F. (2009) Burgernet in de Praktijk. De evaluatie van de pilot van Burgernet, Stichting Maatschappij, Veiligheid en Politie, Dordrecht. Volkskrant
41. WDR online (2008) (German only): http://www.wdr.de/themen/panorama/brand03/toenisvorst_wohnungsbrand/index.jhtml.
42. Wenger D., Quarantelli E. L., and Dynes R. R. (1986) Disaster Analysis: Emergency Management Offices and Arrangements, Final Project Report #34. Newark, DE: Disaster Research Center, University of Delaware.
43. WHO. (1989) Coping with Natural Disasters: The Role of Local Health Personnel and the Community.