Digital Volunteers in Disaster Response: Accessibility Challenges

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Abstract. The emergence of the Digital Humanitarian Volunteer (DHV) movements when disaster strikes have drawn the attention of researchers and practitioners in the emergency management and humanitarian domain. While there are established players in this rapidly developing field, there are still unresolved challenges, including accessibility of their digital tools and platforms. The purposes of this paper are twofold. First, it describes the background, impact and future potential of the DHV movement, and discusses the importance of universal design for the digital tools and platforms used for crowdsourcing of crisis information. Second, this paper shows how lack of concern for universal design and accessibility can have significant negative impact on the practical use of these tools, not only for people with disabilities, but also for anyone and in particular the DHVs who may be affected by situational disabilities in the field in an emergency situation. The insights from the findings serve as feedback on how to improve digital humanitarian response by broadening the base of potential volunteers as well as making the related tools and platforms more reliably usable in the field.

Keywords: crisis mapping, digital humanitarian volunteer, crowdsourcing, accessibility.

1 Introduction

Collective action from the grassroots has changed response operations in a disaster [1]. Alexander [2] has noticed the shift on humanitarian response post-Indian Ocean Tsunami disaster due to the mass ownership of receiving devices, quicker international response to disasters. The author believes that existing scientific and technical know-how are promising to solve the global disasters issues. Rapid ICT technologies development have changed the landscape of humanitarian response [3], and have empowered non-first responder players to take an active role in responding crisis virtually. One of the fast-developing phenomena with respect to the shifting in the response operations is the presence of the digital humanitarian volunteers. They represent voluntary and technical communities, non-governmental organizations, expert groups, universities, research institutions and the private sector. Well-integrated emergency planning maps is a key device in promoting interagency and cross-jurisdictional coordination of emer-

gency response [4]. Meier [5] describes this ICT role entering the humanitarian response domain as the shifting of humanitarian space from a traditional unipolar system to a more multipolar world order, allowing new actors to join and participate in providing additional support for crisis response.

Many approaches have been used worldwide to engage the digital humanitarian volunteers in the collection or analysis of crowdsourced data. Microblogging, crowdsourcing, citizen journalism, social-media sharing, and mapping are examples of popular DHVs' methods of activities. In this paper, we try to look at specific examples, i.e. mapping and crowdsourcing-types of DHVs.

The aims of this paper are twofold. First, to provide a solid overview for the phenomenon of DHVs, including history, terminology, and current state of the art; and second, to discuss challenges with the phenomenon from a universal design point of view.

This paper is organized as follow: Chapter 2 gives an overview of the terminology, history and early development related to DHVs. Chapter 3 elaborates different aspects of current DHVs. Chapter 4 examines the phenomenon from the perspective of challenges concerning accessibility and universal design. Conclusions and future directions are revealed in Section 5.

2 Digital Volunteering

Prior to explaining further both the competing views on the role of DHVs and our standpoint on perceiving these issues (Section 3), clarification on some basic terms is necessary as there are many different names which actually refer to the same meaning. The following terms are identified from the literature: Volunteered Geographic Information-VGI [6], crisis mappers [5, 7], digital volunteers [8], digital humanitarian organizations [1, 5], humanitarian cyber-space [9], and participatory mappers [10, 11]. These DHV actors can be mapper professionals and non-mappers. It can be recognized by observing if the organizations provide the geospatial or geographic information where mapping skills are obligatory, or they mostly harvest information and provide service digitally such as Tweet-based information, other crowdsourcing activities where cartographic knowledge is not always necessary, although eventually they may visualize their findings in a map. The VGI, for example, is referred to a phenomenon, where people without the cartographic skill of knowledge can report their geographic position and even make thematic maps [12].

The map platforms or map products are the core of the application of the digital volunteerism which are then used to communicate disaster information. Digital humanitarian organizations are grassroots organizations that mobilize a large number of individuals that share a set of open tools, practices, and ethical standards to create collective intelligence for providing information as aid [1]. Many of these organizations join a network called DHN (Digital Humanitarian Network), although admittedly some organizations do not fully operate in a digital fashion as they combine working remotely

and working in the field such as MapAction[1] or CODE[2]. Phillips [13], however, differentiate Digital humanitarian networks (DHNs) and Digital Activist Networks. The former network creates maps, assesses building damage, builds missing person lists, monitors, and aggregates big crisis data, while the latter focuses on advocacy that relief who share text, video, and images about situation "on the ground" or uses petitions, email campaign or even hacking activities.

Regardless the terms used in the literature, there are a set of specific properties all authors want to point out: it is about information collected by digital volunteers which can be substantial and complementary to the data collected by official sectors, and it is concerning mobilization of digitally connected citizens and volunteers regionally or worldwide in acquiring specific crisis information. Hurricane Katharina response in 2005 has frequently used as an example, where DHVs impacts was more visible than ever. The volunteers bypassed official agencies and established a spontaneous digital assistant such as Katharina People Finder [12]. In the rest of our paper, we use the term Digital Humanitarian Volunteers as defined by Crowley [1]. In the next sections, we start briefly with the initial practice of Digital volunteering, the development, and the crowdsourcing practices.

2.1 Initial Practices

Meier [14] and Crowley [1] have discussed the historical development of DHVs extensively. Apparently, initial use of digital volunteering in a disaster was often associated with the mapping. Meier [5] recounts, crisis mapping itself is not new and dated back to the year 1668 as Louis XIV of France commissioned three-dimensional scale models of eastern border towns allowing his personnel plan realistic maneuvers. In several greatest crises in the history, however, the crisis map represented "the view from above" or the view from "who hold the control".

There is not so much information, when exactly the crisis mapping from grassroots representing "the view from below" started. We found, for example, an article from Dymon and Winter [4], elaborating the emergency mapping in the grassroots in the exercise context, when GIS technology was still expensive, not fully established part of emergency management practices as the stakeholders still tried to familiarize themselves with the technology. Indeed, the initial participatory, grassroots-based mapping approach was non-digital, non-real time and was a combination between a crude site sketch on-site and mental maps (mental images that have spatial attributes) of the evacuees. The process of on-the-spot map production during a disaster was considered as a new type of cartographic effort, a so-called "crisis mapping". The initial notion of crisis mapping activities is to supply critical information about the spatial dynamics dimension of the disaster. These crisis map sketches were made to: 1) help emergency managers to understand and learn the geographical setting in order to control the disaster conditions, 2) help to inform the media of risks, 3) help agencies to document history

[1] MapAction, http://www.mapaction.org
[2] CODE, Connected Development, http://connecteddevelopment.org

of an incident for better record keeping, and 4) help agencies to reconstruct the incident in order to establish lessons learned [4].

Meier [14] points out that new technologies are key enablers, facilitating both organization and collective action to be more rapidly deployed and provide more scalability than ever before. Citizens are more involved in putting crisis information into the map, and the citizen-produced maps began to appear. This new way of mapping is often referred as Neogeography [15-18], which can be summarized as a geography for everyone made by everyone [17]. Baker [19], however, has started using the NeoGeography term in relation to a space that is created by virtual communities formed of individuals who are far away from each other physically. As mentioned by Goodchild and Glennon [20], the technologies allow average citizens to determine position accurately without professional expertise; anyone gains has the ability to make maps with a cartographic design that previously possessed only by trained cartographers.

The launch of the Google Earth and Google Maps (2004) and broader access to satellite imaginary has brought further this new cartography direction to unlimited possibilities of making use of the map. In the meantime, the Harvard Humanitarian Initiative (HHI) at Harvard University launched a Crisis Mapping and Early Warning programme to study the potential use of live mapping technologies in humanitarian response, in 2007 [14]. Furthermore, in 2009, the HHI initiated the International Network of Crisis Mappers, a global network of members who are actively interested in the application of real-time mapping for crisis situations. Partnerships between traditional humanitarian actors and new informal networks became an important topic for discussion in the International Conference of Crisis Mappers 2010.

Another phenomenon frequently cited as an important milestone for live crisis mapping was the emergence and use of the web-based platform Ushahidi Map 2008 for reporting human rights violations during the post-election unrest [21]. Witnesses submitted these reports via web-form, email, and SMS. Reports from the mainstream media were also mapped. This enabled the 'crowd' to participate as witnesses and collectively uncover violence across the country [14]. Initially published as a free, open source software, Ushahidi becomes a popular live crowdsourcing mapping platform for crisis. Meier [5], Meier [14] presents exemplary deployment of crisis maps in the following disasters: Haiti, Chile, Pakistan, Russia, Syria, Tunisia, Egypt, New Zealand, Sudan, Libya, and, Somalia. Up to now, Ushahidi claims to have more than 90,000 deployments. Beginning from 2015, while keeping Ushahidi as an open source software, it is also offered as an easy to deploy service platform with elevating fees, depending upon the customer's feature preferences. From this brief explanation, apparently, the initial DHVs have a strong link to the mapping practices. However, the next question, should one really need to contribute in the mapping to be called digital volunteers? To put it differently: Are DHVs really about bottom-up driven crisis mapping only? The next section will discuss this development further.

2.2 Further development of DHVs' practices

While the use of a map is still the most popular DHVs' practices, tool variations, and the methods how to do it is developing into different directions. For example, when

Malaysian Airlines flight MH370 was missing in 2014, the Tomnod MH370 website was set up[3], dedicated for uploading satellite imagery which was then used for searching for the wreckage in crowdsourced mode. It attracted approximately 2.3 million people who participated in the search mission by scanning more than 24,000 square kilometers of areas suspected as the incident location [8]. Since then, in 2015, apparently, Tomnod has been active in several disasters, i.e. Capetown wildfire, Nepal and Chile Earthquakes. Digital volunteers in the Tomnod network work together to identify and tag important objects in satellite images, e.g. burned building, damaged roads, fires, tents or shelters, major destruction, and so on.

The use of social media in disasters is another direction of recent DHVs practices [22, 23]. The exploitation of Twitter for crisis management has been growing in the last decade using different methods and various applications, ranging from natural disasters such as earthquakes or floods to major political conflicts. Although the attitudes towards the use of Twitter in formal emergency management still vary among scholars and practitioners [24], especially about the credibility of the information [25], the need for browsing and visualizing social media [26], in real-time and application of artificial intelligence [27] increases. In Haiti earthquake 2010, New York's 2012 hurricane Sandy, and Oklahoma's 2013 tornado humanitarian organizations and the networks of volunteers established platforms for crowdsourced information including those from social media which were furthermore transformed into live-web-based crisis maps. For longer term crisis such as Syrian [28] or refugee crises [29], advanced sentiment analysis is a popular approach. In this case, many scholarly works focus more on the development of analysis method than presenting social media as crowdsourced data for direct use as crisis decision support. By and large, organizations joining the DH-Network are good examples to grasp, what kind of activities that have been offered as a part of digital volunteering activities.

To see further development of DHVs activities, the next sections describe the DHVs Landscape and Players, Crowdsourcing technique, Technologies, Decision maker needs and deployment techniques.

3 DHVs Today

There are numerous DHV players worldwide, but people can easily identify the big players or strong network ones. Humanitarian Practice Networks, Digital Humanitarian Networks, Crisis Mappers, Standby Task Force (SBTF), and MapActions are just a few examples of DHVs joining DH-Network. Established in 2010, SBTF has partnerships between traditional humanitarian actors and new informal networks. Recently SBTF has over 1800 members in 100 countries[4].

Professionally, the DHV actors can be technology professionals (web and mobile developers, data scientists, social media analysts, wifi-network/vsat experts, geo-coding), geographers (infrastructure mapping, satellite imagery analysis, GIS analysts, spa-

[3] http://www.tomnod.com/

[4] http://www.standbytaskforce.org/

tial analysts, ground mappers), seasoned humanitarian practitioners, journalists, professional crowdsourced translators, and scholar. The output from the digital volunteering works can be map visualization, technical reports, social media monitoring and analysis, social media strategy, training, community's urgent needs, situational information, real-time online updates, and some other variants intended for decision supports and improving situational awareness.

We try to capture the landscape of DHVs as depicted in the charts in Fig. 1. The charts present a simplification of current approaches to digital humanitarian volunteering in a crisis. In the left figure, the horizontal axis represents the two opposite ways of operation of information collection, i.e. operating on-site and operating remotely. The vertical axis denotes the types of information sources preferably collected by different humanitarian actors which are simplified as:

1) *Humanitarian aid workers* as a part of formal organizations sent in humanitarian missions in a disaster site; it could be affiliated to United Nations (UN) and government agencies, or NGO workers that are a part of network of collaborative partnerships to assist with humanitarian relief operations e.g. IFRC (International Federation of Red Cross and Red Crescent Societies). In short, this group consists of in-situ volunteers;

2) *Emergency decision makers* are local, national or international authorities who responds directly on-site, and shall monitor overall crisis development, or those who operate slightly remotely e.g. in a command and control room to provide decision supports. These two formal actors are represented in the below part of the chart to indicate their working tendencies to make use of authoritative information sources.

3) *Community volunteers* can be networks of affected communities. As a group identified as well by Phillips [13], the people directly affected by the disaster seek help to locate missing people, medical treatment, identify shelters, aid, and inaccessible zone, share information about the crisis to enhance situational awareness and seek for ways to provide support to those affected.

4) *Digital volunteers* are representing two types of crowd. The first type is local citizens or geographically affected crowd who provide raw information directly. The second type is a remote volunteer crowd that coordinate and manage information to support a humanitarian response [12, 30]. They can be crisis mappers, like the so-called "Voluntweeters" [31] who were acting remotely to help the process, verify and direct information during the crisis, creating a mesh of interconnected volunteers from all over the world, or other humanitarian initiative organized digitally. The dashed line in the middle dividing the chart depicts the approach to humanitarian mission that much more grounded approach in the left side and more ICT supported on the right side and tendencies to work based on remote information, such as making use of non-authoritative information with the assistance of ICT technologies.

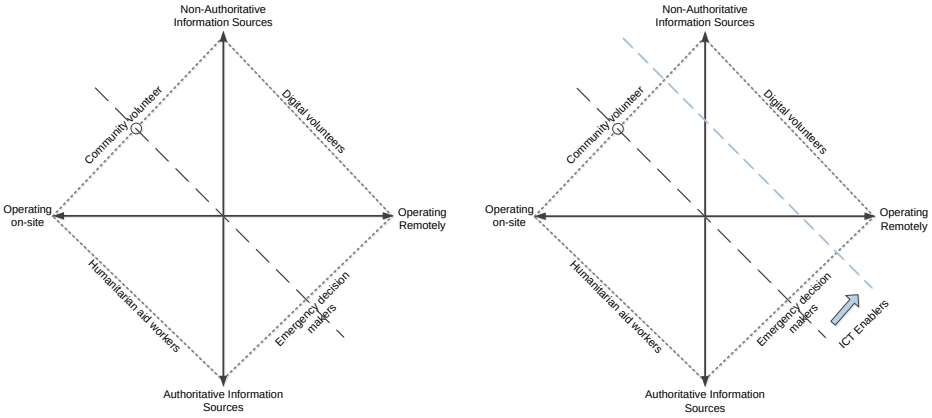

Fig. 1. Approaches to digital volunteering.

3.1 On techniques and technologies for DHVs

The most popular way of conducting digital volunteering is a crowdsourcing technique [32]. The term crowdsourcing describes a web-based business model that harnesses the creative solutions of a distributed network of individuals. Web2.0 technologies facilitate interactive information sharing, interoperability, and collaboration. Proponents of this approach assume that crowds of people can solve some problems faster than individuals or small groups, and rapidly generate data [33]. The term crowdsourcing itself used to be interpreted as:

"The act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large, group of people in the form of an open call." In the mapping field, UNOOSA [34] defines crowdsource mapping as *"Reaching out to the unknown crowd for help in gathering geospatial information, visualizing that information on a map and gaining further insight by analyzing the data. Such a crowd would be supporting not only humanitarian and emergency crises but also all the phases of the disaster risk management cycle: prevention, preparedness, early warning, response, early recovery and reconstruction."*

As we see in the initial development, the smartphones, open-source software, GIS technologies and web-based platform are consistently used for conducting DHVs activities. Mobile and web-based applications, participatory maps & crowdsourced event data, aerial & satellite imagery, geospatial platforms are among the exploited technologies. The use of advanced visualization, live simulation, and computational & statistical models for early warning and rapid response are additional techniques can be applied in DHVs efforts. In addition, Meier (2011) suggests GIS analysis, machine learning, pattern recognition and spatial econometrics as additional core skills to handle the big data stream originating from crowdsourcing activities. Ushahidi[5] and Kricket[6] are examples of open-source platforms for crowd-mapping. On information gathering,

[5] Ushahidi, https://www.ushahidi.com/
[6] Kricket, http://kricket.co/

DHVs believe that the information should be real time, and specifically for DHV mappers, it is important that the data have spatial component (Meier 2011) for visualization, besides for analysis and decision support.

In addition, social networking platforms and social media especially Twitter gain popularity for collecting data. As information scientists we also attempt to extract meaning from mass volumes of real-time data exhaust. Furthermore, the combination of Twitter and machine learning [35], real-time remote coordination, Twitter data mining, data analysis and mapping, Social Network Analysis have further developed. However, most of the time, the geographical component is most important for humanitarian information in the form of maps.

3.2 On Decision Makers' Information Needs

There have been extensive discussions on what information is actually needed by the decision makers in the humanitarian mission. It has been highlighted in the literature that crowdsources information is not intended to replace the work already being carried out by established organizations and the private sector but rather as an additional support to the emergency management process and decision-making. It is also have been discussed elsewhere that information collection needs to be in line with the specific information needs of the end-user community who actually affected by the disasters and emergency response managers dealing with the problem. Specifically, these should be a clarity how that community was able to access and use the information provided by the volunteer and technical communities. Gralla, Goentzel and de Walle [36] and Kuusisto, Kuusisto and Yliniemi [37] has proposed a framework for information needs of decision makers in crisis.

3.3 On Deployment

In a more organized/ coordinated digital volunteer deployment, there are several stages to enable the digital volunteering, as seen in the Figure 3. We will use two big DHV organizations as an example to explain the volunteering operation, i.e. MapActions and StandBy Task Force (SBTF). Member recruitment is typically conducted voluntarily, e.g. by signing-up. Some organizations will provide their services upon request from formal humanitarian organizations. For example, MapAction has deployed two volunteers to map the Ecuador earthquake based on a request from the United Nations. Meanwhile, activation of SBTF can be based on the request of international agencies, local stakeholders operating in disaster setting or active support from SBTF to humanitarian organizations. However, a set of criteria has been outlined prior to fulfillment of SBTF activation request. These criteria are ranging from the capability of the organization to respond to disasters, its presence in the field, clear need for SBTF support, to clear plan of data collection, sharing and privacy, sustainability plan, monitoring and evaluation plan for SBTF support and understanding of potential risks for local people and the digital volunteers. Maximum two weeks is the typical duration of activation period, although an extension can be decided through a meeting between SBTF and Activating

Organizations on day 10[7]. Note that SBTF also encourages its members to volunteer in deployments as individuals without any official engagement from SBTF.

On the Activation stage, the operation can be varied as well: onsite or remotely. MapAction will mobilize data collection and base map data gathering of the affected country, as well as field base deployment as a part of United Nations Assessment and Coordination (UNDAC) mission. In the SBTF operation, the members will get the notification when the activation starts, via email and the activation is announced in SBTF website (See for example the activation for Refugee Crisis [8]).

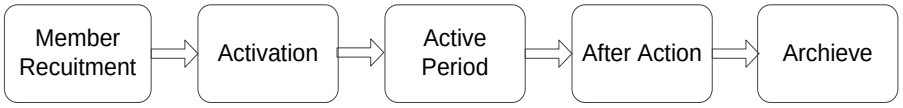

Fig. 2. Typical Digital humanitarian Deployment Life Cycle.

In the active period, the Map Action team will map the most crucial operational questions in the field such as movement of people affected by the disasters or the logistic capacity to reach them. During this time the situation maps will be circulated and updated, both as printed map or electronic distribution via websites. While in the SBTF deployments, the operation varies, but the volunteers gather data, put the collected information in a centralized workspace. The information collection does not only focus on those that can support map visualization, but also other sources including pictures in specific social media. Depending upon the crisis development, some updates might be sent in between the deployment, such as occurred in Refugee Crisis case.

At the end of the mission, MapAction will hand over the maps and collected data to UN organizations signify the completion of one digital volunteering mission. Archiving the maps of completed missions is a normal final sequence to preserve all results of each volunteering activities. In the case of SBTF, the collected data is handed over to the activating organization, and archiving public information in the website.

Finally, we return to the question if DHVs are really about bottom-up driven crisis mapping only. The explanation above has provided a clear answer that digital volunteering is not only about the mapping, but wider than that. However, map visualization is apparently the heart for digital humanitarian volunteer activities as it is the best way to communicate the location of all information being collected, gathered and analyzed during the disasters. To put it differently, spatial data is always an advantage to any crisis and any DHVs efforts that include spatial information will provide benefits to the affected people.

[7] SBTF, Our Activation Criteria, http://www.standbytaskforce.org/for-humanitarian-agencies/our-activation-criteria/

[8] SBTF, Refugees in the Balkans. Activation Starts 16 September 2015. http://www.standbytaskforce.org/2015/09/13/refugees-in-the-balkans-activation-starts-16-september-2015/

3.4 On DHVs' Role

The influential DHVs are well organized, have a huge number of members and strong connections to the formal humanitarian organizations such as Red Cross or UN agencies, and professional map producers and research institutions. However, we have also observed that the presence of strong network and players does not stop smaller players or newcomers (institutions and individuals, whether or not the initiators have experience with digital volunteering) to deploy their initiatives.

The majority of crisis maps are actually not launched by humanitarian organizations or digital volunteer networks; sometimes just ordinary individuals launching they own maps. Experienced organizations may have a better way of handling several issues when activating the DHV movements such as: ethics, security, liability and data protection; handling misinformation and propaganda in political crisis and maintaining the circle of volunteers.

Some other classical issues identified by UNOOSA [34] will also be challenges and unknown to newer players such as preparedness and prioritization regarding to the need for geospatial data to be readily available for support during any disaster event; data licensing, which ensured that satellite imagery was made available to the volunteer and technical communities; data scramble, or contribution to the definition and compilation of available geospatial data during a crisis; decision maker's needs; impact evaluation, and bringing together all those willing to volunteer their time and involving them in meaningful activities that contributed to the decision-making process.

4 Accessibility of Tools and Platforms for DHVs

From earlier sections, we learn that DHVs require a lot of considerations to make a great contribution on improving crisis communication and information sharing. We also see that DHVs rely on the ICT technologies both for digital volunteers (information collectors) and target groups (humanitarian workers and general public). In this case, the perspectives of accessibility and universal design are often missing in the DHVs' technology requirements or needs. As in most domains, the introduction of digital tools and ICT provide both opportunities and challenges, in particular for people with disabilities. A well-developed universally designed platform can provide access to information and means of communication, work and other productive activities that has made life for people with disabilities much easier. On the other hand, ICT can also bring potential barriers, if a system design process is not taking accessibility into account. In many digital systems, even those targeting the general public, lack of awareness of accessibility and even basic usability can be severely limiting the potential user base.

When the digital volunteers are primarily working through digital platforms, the usability and accessibility of these platforms are very important. However, the awareness of the importance of these factors among experts in ICT for emergency management is relatively low [38, 39].

Many of the online platforms in use for crowdsourcing of crisis information and crisis mapping among DHVs are Web-based. Web page accessibility can be evaluated

based on conformance to the Web Accessibility Content Guidelines (WCAG) 2.0[9]. The guidelines are based on 4 principles for accessibility:

1. Perceivable - Information and user interface components must be presentable to users in ways they can perceive.
2. Operable - User interface components and navigation must be operable.
3. Understandable - Information and the operation of user interface must be understandable.
4. Robust - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

There are several success criteria for each of these principles. that can be used to assess the accessibility of the digital platforms. Some success criteria can be automatically tested and others require human evaluation. In the previous study, automatic evaluation of a selection of typical web-based tools and platforms for crowdsourcing of information for DHVs have revealed that the tools and platforms tested are not accessible [39]. The main page as well as volunteer signup or information submission pages were tested as these typically are the first potential *barriers* (issues potentially blocking users from accessing some or all of the information or functionality of the web site) for new volunteers. Automatic testing showed that none of the tested tools[10] were fully compliant with WCAG 2.0. Common issues that were detected included:

- *Missing labels* that could affect screen reader users who rely on screen readers to understand the meaning and intention of the web elements (e.g. buttons).
- *Resizing issues* that affect users with visual impairments, making it more difficult to adapt the web site to their needs.
- *Lack of instructions or help* that are essential for users to learn how to use the web sites and get help when needed. They can also help users to prevent errors and understand error messages. Without appropriate instructions or help function, it is often difficult for users to understand what they should do and how to interact with certain functions.
- *Compatibility issues* - Lacking the robustness to ensure compatibility with current and future user agents, including assistive technologies.

To confirm the claims, we have examined three additional DHV-oriented websites for testing, all of them related to the ongoing refugee crisis. Two of the sites are map-based: The Refugee Project[11] providing information of refugees with origin and asylum country broken down by year, and The UN Refugee Agency (UNHCR)'s Refugees Operational Portal[12] providing maps and statistics regarding refugees. We have also tested one DHV-oriented site not related to mapping: Refugees on Rails[13] that aims «to help refugees to build and expand their qualification as software developers and provide them with valuable skills that will improve their chances on the labour market».

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[9] https://www.w3.org/TR/UNDERSTANDING-WCAG20/conformance.html

[10] Ushahidi Syria Tracker, Google Crisis Response Person finder demo, Quakewatch Prediction Center, Crisis Communication Wiki for professionals, and Emergency 2.0 Wiki.

[11] http://www.therefugeeproject.org

[12] https://data2.unhcr.org/en/situations

[13] http://refugeesonrails.org/en/

We find that both the Refugee project and the Refugees Operations Portal have many of the same issues as the previously tested sites, and in particular both are affected by *missing labels* on various elements. In addition, the quite low contrast on the Refugee project site (see Fig.3) can cause barriers for people with visual impairments as well as people attempting to use the site in poor light. Meanwhile, The Refugees Operations Portal has several cases of missing alternative text for images, so if the page is accessed using assistive technologies or blocking images for bandwidth reasons, the information carried by the images will be missed.

On the other hand, on the Refugees on Rails site, we detected only one significant barrier: a lack of explicit language identification code in the html source. Although this may seem like a non-issue, this can have consequences for people using assistive technologies. For example, screen readers are using this information to load the correct pronunciation rules.

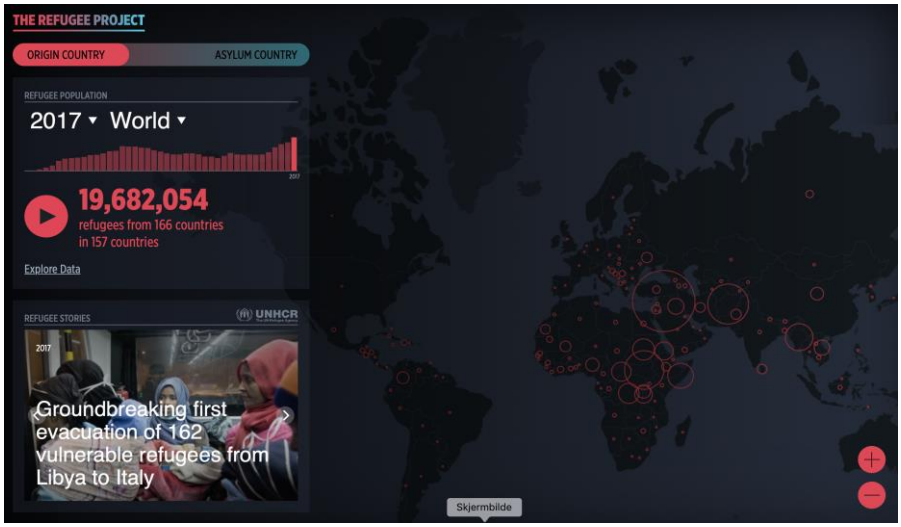

Fig. 3. The Refugee Project world map showing a lack of contrast.

To summarize the findings, the overall picture is that the majority of the tested sites have significant barriers, meaning that people with disabilities may be discouraged from joining the voluntary efforts.

An exacerbating factor is that in disaster situations, people can be affected by situational disabilities that are making use of mobile digital equipment like smartphones more challenging than in normal day-to-day life, because of factors like stress, environmental factors like rain/heat/cold/wind, fear/panic, information overload, smoke, crowds, noise, etc. These factors can negatively impact the vision, hearing, cognitive abilities and not least the manual dexterity needed to manipulate a user interface on the small touch sensitive screen of a smartphone, and it may thus disrupt their situational awareness [38-40].

An additional challenge is that much of the work by DHVs relate to maps which by their nature are difficult to make accessible since they are very visually oriented, and may in addition be difficult to navigate on the small screen of a smartphone [41].

5 Conclusion and Future Work

This paper has provided a thorough overview of the phenomenon of DHVs, and also highlighted some challenges when it comes to accessibility and usability. Lack of attention to these factors has led to tools and platforms with barriers that make them inaccessible to many potential users. In a disaster situation, active DHVs in the field may also be affected by situational disabilities that makes the accessibility and usability of their tools even more important.

These highlighted issues deserve a much bigger focus, as they can make a big difference in the DHVs ability to provide quality information in the field, and can potentially open the field to a much broader diversity of DHVs in the future. One should not underestimate the value of motivated people armed with well-designed digital tools, and we firmly believe the advantages from this supplement to traditional emergency response can be tremendous. However, to make the impact as powerful as possible, universal design should be a non-negotiable part of the design process of the DHVs' digital tools.

Future and ongoing work that will be highly relevant for the DHVs, includes studies on the cause and effects of situational disabilities in disaster situations, and how these situational disabilities can affect the ability to gain and communicate situational awareness. Finally, studies on best practices on accessible maps and alternative representations of geographical data are also in the pipeline.

References

1. Crowley, J.: Connecting grassroots and government for disaster response. Commons Lab, Wilson Center (2013)
2. Alexander, D.: Globalization of Disaster: Trends, Problems and Dilemmas. Journal of International Affairs 59, 1-22 (2006)
3. Ferris, E.: Megatrends and the future of humanitarian action. Int. Rev. Red Cross 93, 915-938 (2011)
4. Dymon, U.J., Winter, N.L.: Emergency mapping in grassroots America: a derailment evacuation case study. Geoforum 22, 377-389 (1991)
5. Meier, P.: Crisis mapping in action: How open source software and global volunteer networks are changing the world, one map at a time. J. Map Geogr. Libr. 8, 89-100 (2012)
6. Haworth, B.: Emergency management perspectives on volunteered geographic information: Opportunities, challenges and change. Computers, Environment and Urban Systems 57, 189-198 (2016)
7. Ziemke, J.: Crisis Mapping: The Construction of a New Interdisciplinary Field? Journal of Map & Geography Libraries 8, 101-117 (2012)

8. Whittaker, J., McLennan, B., Handmer, J.: A review of informal volunteerism in emergencies and disasters: Definition, opportunities and challenges. International Journal of Disaster Risk Reduction 13, 358-368 (2015)
9. Sandvik, K.B.: The humanitarian cyberspace: shrinking space or an expanding frontier? Third World Q. 37, 17-32 (2016)
10. Plantin, J.C.: The politics of mapping platforms: participatory radiation mapping after the Fukushima Daiichi disaster. Media Cult. Soc. 37, 904-921 (2015)
11. White, J.I., Palen, L.: Participatory mapping for disaster preparedness: The development & standardization of animal evacuation maps. In: Palen, L.A., Comes, T., Buscher, M., Hughes, A.L., Palen, L.A. (eds.) 12th International Conference on Information Systems for Crisis Response and Management, ISCRAM 2015, pp. 214-224. Information Systems for Crisis Response and Management, ISCRAM (2015)
12. Hung, K.-C., Kalantari, M., Rajabifard, A.: Methods for assessing the credibility of volunteered geographic information in flood response: A case study in Brisbane, Australia. Applied Geography 68, 37-47 (2016)
13. Phillips, J.: Exploring the citizen-driven response to crisis in cyberspace, risk and the need for resilience. Humanitarian Technology Conference (IHTC2015), 2015 IEEE Canada International, pp. 1-6 (2015)
14. Meier, P.: New information technologies and their impact on the humanitarian sector. Int. Rev. Red Cross 93, 1239-1263 (2011)
15. Haklay, M., Singleton, A., Parker, C.: Web Mapping 2.0: The Neogeography of the GeoWeb. Geography Compass 2, 2011-2039 (2008)
16. Hudson-Smith, A., Crooks, A., Gibin, M., Milton, R., Batty, M.: NeoGeography and Web 2.0: concepts, tools and applications. Journal of Location Based Services 3, 118-145 (2009)
17. Rana, S., Joliveau, T.: NeoGeography: an extension of mainstream geography for everyone made by everyone? Journal of Location Based Services 3, 75-81 (2009)
18. Turner, A.: Introduction to neogeography. O'Reilly (2006)
19. Baker, N.: Weed- at talk at the library. In: Brook, J., Carlsson, C., Peters, N.J. (eds.) Reclaiming San Francisco: History, Politics, Culture, pp. 35-50. City Lights Publishers (1998)
20. Goodchild, M.F., Glennon, J.A.: Crowdsourcing geographic information for disaster response: a research frontier. International Journal of Digital Earth 3, 231-241 (2010)
21. Meier, P., Brodock, K.: Crisis Mapping Kenya's Election Violence: Comparing Mainstream News, Citizen Journalism and Ushahidi. Harvard Humanitarian Initiative, HHI. Harvard University, Boston (2008)
22. Middleton, S.E., Zielinski, A., Necmioğlu, Ö., Hammitzsch, M.: Spatio-Temporal Decision Support System for Natural Crisis Management with TweetComP1. Euro Working Group Workshops on Decision Support Systems, EWG-DSS 2013, vol. 184 LNBIP, pp. 11-21. Springer Verlag, Thessaloniki (2014)
23. Simon, T., Goldberg, A., Adini, B.: Socializing in emergencies—A review of the use of social media in emergency situations. International Journal of Information Management 35, 609-619 (2015)
24. Cameron, M.A., Power, R., Robinson, B., Yin, J.: Emergency situation awareness from twitter for crisis management. Proceedings of the 21st International Conference on World Wide Web, pp. 695-698. ACM (2012)
25. Mendoza, M., Poblete, B., Castillo, C.: Twitter under crisis: can we trust what we RT? Proceedings of the First Workshop on Social Media Analytics, pp. 71-79. ACM, Washington D.C., District of Columbia (2010)

26. Terpstra, T., de Vries, A., Stronkman, R., Paradies, G.: Towards a realtime Twitter analysis during crises for operational crisis management. Simon Fraser University (2012)
27. Imran, M., Castillo, C., Lucas, J., Meier, P., Vieweg, S.: AIDR: artificial intelligence for disaster response. Proceedings of the 23rd International Conference on World Wide Web, pp. 159-162. ACM, Seoul, Korea (2014)
28. Lynch, M., Freelon, D., Aday, S.: Syria's socially mediated civil war. United States Institute Of Peace 91, 1-35 (2014)
29. Coletto, M., Lucchese, C., Muntean, C.I., Nardini, F.M., Esuli, A., Renso, C., Perego, R.: Sentiment-enhanced Multidimensional Analysis of Online Social Networks: Perception of the Mediterranean Refugees Crisis. arXiv preprint arXiv:1605.01895 (2016)
30. Starbird, K.: Digital volunteerism during disaster: Crowdsourcing information processing. Conference on Human Factors in Computing Systems, Vancouver, BC, Canada (2011)
31. Starbird, K., Palen, L.: "Voluntweeters": self-organizing by digital volunteers in times of crisis. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1071-1080. ACM, Vancouver, BC, Canada (2011)
32. Madry, S.: The Emerging World of Crowd Sourcing, Social Media, Citizen Science, and Remote Support Operations in Disasters. Space Systems for Disaster Warning, Response, and Recovery, pp. 117-121. Springer New York, New York, NY (2015)
33. Barbier, G., Zafarani, R., Gao, H., Fung, G., Liu, H.: Maximizing benefits from crowdsourced data. Comput. Math. Organ. Theory 18, 257-279 (2012)
34. UNOOSA: Space-based information for crowdsource mapping Committee on the Peaceful Uses of Outer Space (2011)
35. Meier, P.: Next generation humanitarian computing. Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing, pp. 1573-1573. ACM, Baltimore, Maryland, USA (2014)
36. Gralla, E., Goentzel, J., de Walle, B.: Understanding the information needs of field-based decision-makers in humanitarian response to sudden onset disasters. Proceedings of the 12th International Conference on Information Systems for Crisis Response and Management (ISCRAM), pp. 1-7 (2015)
37. Kuusisto, T., Kuusisto, R., Yliniemi, T.: Information Needs of Strategic Level Decision-Makers in Crisis Situations. ECIW, pp. 187-194 (2005)
38. Gjøsæter, T., Radianti, J., Chen, W.: Universal Design of ICT for Emergency Management - A Systematic Literature Review and Research Agenda. International Conference on Universal Access in Human-Computer Interaction, pp. 63-74. Springer International Publishing, Las Vegas, USA (2018)
39. Radianti, J., Gjøsæter, T., Chen, W.: Universal Design of Information Sharing Tools for Disaster Risk Reduction. In: Yuko Murayama, P.Z., Dimiter Velev (ed.) ITDRR 2017. Springer, Sofia, Bulgaria (2017)
40. Gjøsæter, T., Radianti, J.: Evaluating Accessibility and Usability of an Experimental Situational Awareness Room. AHFE2018, pp. 216-228. Springer International Publishing (2018)
41. Tunold, S., Gjøsæter, T., Chen, W., Radianti, J.: Perceivability of Map Information for Disaster Situations HCII2019 (in press). Springer International Publishing, Orlando, Florida, USA (2019)