A Vision of Augmented Reality for Urban Search and Rescue

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Figure 1: In this design fiction for future search and rescue operations: On the left is the view of where a house of interest is located through the goggles of a search and rescue team member. On the right is a painted target from the perspective of the team that is marking areas of interest with color-coded tags (e.g. green for potential human residents, yellow for areas with potential danger such as packs of animals, red for remains in the open).

ABSTRACT

Search and rescue (SAR) operations are often nearly computer-technology-free due to the fragility and connectivity needs of current information communication technology (ICT). In this design fiction, we envision a world where SAR uses augmented reality (AR) and the surplus labor of volunteers during crisis response efforts.

Unmanned aerial vehicles, crowdsourced mapping platforms, and concepts from video game mapping technologies can all be mixed to keep SAR operations complexity-free while incorporating ICTs. Our scenario describes a near-future SAR operation with currently available technology being assembled and deployed without issue. After our scenario, we discuss socio-technical barriers for technology use like technical fragility and overwhelming complexity. We also discuss how to work around those barriers and how to use video games as a testbed for SAR technology. We hope to inspire more resilient ICT design that is accessible without training.

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CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; **Collaborative and social computing**; *Ubiquitous and mobile computing design and evaluation methods*; Interactive systems and tools; Ubiquitous and mobile computing systems and tools; • **Applied computing** → Cartography.

KEYWORDS

disaster response, search and rescue, augmented reality, crowdsourcing, volunteers, drones, video games, design fiction

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1 INTRODUCTION

This design fiction establishes a near-future scenario within which augmented reality (AR) is used in search and rescue (SAR[1]) operations in concurrence with an assemblage of currently separate, yet existing technologies. We say existing technologies because current information technology is not typically seen as resilient

[1]The abbreviation is commonly read as a word “sar” by responders in the USA.

to the types of conditions a SAR operation experiences [20, 22]. As a result, SAR operations tend to use more robust and reliable technologies like radios, paper maps, handheld GPS maps, and paper documentation [1, 9, 27]. This technology is juxtaposed against the rapid development of information communication technology (ICT) in society writ large [8].

The resulting expectation that crisis response should embrace the use of ICTs in addition to digital mapping technologies, cellular technology, and connectivity that can connect to crowdsourcing platforms [11, 20, 22]. We are inspired by video games, crowdsourcing disaster, and current technology needs in crisis response [2, 7, 22, 29]. Our spaces of inspiration lead us to urge mobile ICT (e.g., smartphones, wearables) developers to use extended battery life and the ability to withstand the physical rigors as selling points.[2] This will foster more robust ICT design and use in SAR operations. Once ICT use is common in SAR, the connection between existing crowdsourcing efforts [23] in crisis response to AR is inevitable, as one of the most significant barriers to this new design trend is access. By working toward this common goal,[3] the resilience of humankind within, during, and after disaster will be increased.

2 DESIGN FICTION

The first footage of the aftermath of the hurricane[4] began to creep into social media and online community feeds shortly after the rains had weakened enough for unmanned aerial vehicles (UAVs or drones) to take flight [12, 14, 17]. Drone operators – recently outsourced and certified by FEMA,[5] much like NASA[6] began to rely on SpaceX [5, 13] – began to fly over and photograph the impacted areas. The image feed was examined in nearly real-time as these satellite-connected drones sent images to public mapping platforms [25]. Members of this certificate-gated community (see: [7]) began to pour over the assembled map of a vast metropolitan region that had been devastated by flooding, winds, and intense rain [12, 17, 25]. It was the biggest hurricane anyone had seen that year; the hurricane, combined with mandatory evacuations, had made this coastal city seem post-apocalyptic.

Hurricanes' courses can be somewhat predicted, so, in advance of the incident,[7] SAR teams were stationed outside the expected area of impact. As the drone operators did their work, their first task was to identify an area for the *base of operations* (*BOO*[8]). With candidate locations tagged by the community, the incident commander identified an appropriate location. The convoy of tractor trailers and personnel began to move in and establish the BOO.

The drone operators continued their work by starting to identify areas of interest. Online mapping communities also began processing and preparing information for the SAR teams for their initial deployment. They deployed a connectivity balloon – a lightweight drone equipped to provide wireless network communication – over the center of the area of interest to provide a direct data feed from the mapping drones to the BOO [3, 15].

As they did, those same drone contractors and their respective communities painted 75 targets. These targets would be areas that needed investigation by teams on the ground. Their targeting and connectivity was dependent on the connectivity balloon. The contractors and communities used a set of heuristics to develop targets, including:

- how changed the area was from its most recent aerial photograph (e.g., buildings that had collapsed or been washed away);
- places that looked like they had been particularly flooded (e.g., collections of cars and other debris, buildings surrounded by water);
- locations that appeared to no longer be reachable by safe paths (e.g., places where someone might have sheltered, but would now no longer be able to leave);
- locations with messages from people trapped (e.g., with "HELP!" painted in an obvious place);
- locations with human or animal bodies in the open; and
- locations that seem to be sheltering humans or large numbers of animals.

Those 75 targets covered 400 square miles of what used to be an urban area. Both workers in the BOO and search and rescue operatives are able to make use of the marked targets.

This aerial perspective is not perfect, however, and a ground search still needed to be carried out. In some cases, areas are obscured from drones' views; in other cases, connectivity is insufficient to support moving the necessary data around. In the latter case, observations were delayed until the drone could move back into a connected area.

The BOO consists of a set of tents, mobile bases, and equipment depots that support operations and planning. A command base serves as the main gathering point within the BOO; out of this building, command decisions and plans are made, incorporating information from the field and from the *incident command post*, a permanent installation that is remote from the incident. This vehicle has been equipped with a light table [9], in addition to antennae that could accept the signal from the balloon. The light table displays all 75 targets, in addition to the signals for each of the SAR team gathered at the edge of the territory waiting for the go ahead to begin their activity.

Judging from the expected coverage circle, it seemed like there would be few dead areas as the SAR teams attempted to get to each of the investigation sites. Each SAR team member would note and triage other objects of interest along the way.

Each member of the team wore their standard gear; the targets would be visible at the BOO as well as in the real world through specialized goggles that the SAR team used. Each had personal protective gear (e.g., helmet, rescue boots), radio, and backpack with a first aid kit, rain gear, a shovel, some rope, and enough

[2]We want to mention the growing competition surrounding battery life [30], answers to common repair needs for mobile devices [24], and the current socio-political climate around the right-to-repair movement [26] as ways in which this goal is currently manifesting.
[3]We specifically use the term "goal" here with reference to Reeves et al.[21] within which we cite an idealized future that you can help be created.
[4]"…cyclones of diameter of from 50 to 1000 miles, wherein the air moves with a velocity of from 80 to 130 miles an hour round a central calm space, which with the whole system advances in a straight or curved track…" [19].
[5]The United States Federal Emergency Management Agency, which manages disaster response at the federal level.
[6]The United States National Aeronautics and Space Administration (NASA), which handles government space flight.
[7]"An occurrence, natural or manmade, that requires a response to protect life or property. …" [28].
[8]Pronounced as "bee-oh-oh".

water for them and any potential rescues they might find [10]. In addition to their kit, each member of the team wore a pair of goggles that could display any signal within a mile of their location. These signals looked like giant pillars of color in the horizon (Figure 1) and, as the SAR member got closer, thinned until it pointed at the ground. As each team member got to the point, they could use their small tablet to mark the target as either A). clear or B). one of eleven possible response scenarios, along with their priority. Each of these scenarios would change the icon of the paint at the table as well as any SAR team member within a mile of the target; high-priority scenarios would be pushed to nearby responders immediately, to provide situation awareness and provoke action, if needed.

3 DISCUSSION

In this design fiction, we presented a SAR scenario that is just barely a fantasy. Everything within our fiction is separately available, but not for SAR. . . yet. What we blended together was:

- SAR operations as they are organized now;
- concepts from map interfaces in video games;
- crowdsourced mapping technologies;
- drone operations;
- and crisis informatics.

The most surprising inclusion here, we feel, is using concepts from game design to explore how wearables and AR can be used in the context of disaster response. Video games at present often feature large, highly detailed virtual worlds that require resource gathering. These SAR-compatible systems are often well-designed and meant to provide a bridge between places where things are and those who are searching for them. Yet they are often ignored due to being for entertainment purposes.

Our discussion expands on the implications of our design fiction. Specifically, we want to address the barriers to use these technologies simultaneously. Next, we want to discuss workarounds for getting these technologies over their barriers. Finally, we point toward the value of video games as a means for testing emergency response interfaces.

3.1 Socio-Technological Barriers to Use

We already know from our preliminary data that there is resistance to the incorporation of technology that is not yet reliable and robust. Until human-carried battery capacities enable such designs to work seamlessly all-day and until such gear can survive the rigors of search and rescue (e.g., water-, shock-, heat-, dust- proof), such devices are unlikely to find a home in search and rescue practice [16]. This barrier could also be referred to as the barrier of time or the barrier of capitalism. Hearty, low-power, single-purpose devices with long battery life could be available but there is simply no incentive to do develop or sell them yet.

In addition, there are issues within design trends. *Crisis informatics*, the study of human information behaviors during disaster, has been attempting to use current computational techniques without much success over its fifteen-year existence [20, 22]. The reason for this is that there is an imbalance between the usefulness of computer technology and the knowledge required to use it. While related to the physical fragility of ICT, this relates more to when the technology *is functioning*. The knowledge of and endless packages necessary to install to make data useful requires a skillset that very few people in the crisis response world possess.

3.2 Seamful Workarounds

There are numerous workarounds for these issues of fragility, access, and training. First, technological resilience can be increased by decreasing certain kinds of *seams* – breaking points in technological systems caused by combinations of events, sensor capabilities, network coverage, etc. [4, 6]. In our scenario we imagined removing as many of these as we could.[9]

The SAR team all had goggles that could do one thing: show potential areas of interest within a mile. Everything else in our scenario is outside of the crisis zone and outsourced to people who will either be sitting in the comfort of their homes or within an EOC in a stable, bunker-like room with robust protections for infrastructure. Our scenario reflects an approach to seamful design [6] that advocates for avoiding seams.

In other cases, the seams created by the fragility of the technology are worked-around. The connectivity balloon only needs to float where it is deployed. The transponder and broadcast of the signal is still delicate, but deploying it above a zone after an event with potential power needs being partially offset by solar power will increase the lifetime of these balloons; they can be replaced as needed. Areas of dead connectivity are filled in by drones using local storage and deployed responders, who use their alternative viewpoint and personal gear to gather nearby data.

The most imaginary piece of technology for this design fiction are the goggles. We based this concept off of the video game *The Legend of Zelda: Breath of the Wild* [18]. This game actually places the functionality we want to see put to use in crisis within a tablet that the main character carries around. By placing this on goggles, a more hearty piece of technology than a tablet, power, heat, and connectivity needs can be minimized. This minimization is necessary as the battery needs for a tablet will force the tablet to be a bit larger than necessary. Additionally, a tablet would allow designers to cram more potential technology inside of it and this is unnecessary.

3.3 Games as Testbeds

Video games are a rich source of inspiration that is oft-ignored. In this case, *The Legend of Zelda: Breath of the Wild* [18] contains a feature for placing digital pins through a tablet that the character carries around. This feature continues to inspire us and, based on our experience as disaster-response researchers, we connected this component of game design to work practice [9, 27], developing new designs. While this game has inspired us, we believe that this moment of inspiration points to the value of using games as not only a way to inspire designs, but also to consider the ways in which certain designs do and do not work. This too, is a form of a workaround in that, while these technologies are expensive to create and difficult to deploy due to physical and training limitations, they

[9]By seams, we begin by referring to the physical weaknesses of technology. We then refer to the skill set and expertise needed to use computer software, computer hardware, and multi-device, multi-platform, multi-tool collaboration. By stripping SAR technical needs to their essential components, we attempt to interweave design and theory [6] to an accessible foundation for all stakeholders to engage. SAR team members can suggest new tools they need without worrying about invisible systems.

can still be examined from a use perspective within their digital environments.

4 CONCLUSION

In this design fiction, we presented a near-future setting for SAR operations. By using developments from drone-technology spaces, crowdsourcing, wearables, and video games, this assemblage of technologies could almost be pieced together now if it were not for their individual fragilities. The consideration of more hearty and robust technologies for consumers is urgently needed. By fostering more resilient technology, emergency response can better integrate these technologies into their toolkit. Additionally, we further urge designers to look to virtual exercises like resource gathering in video games as an inspirational space for future development. By looking to the present with an eye on how easily it could be destroyed by natural forces, the resilience of humans everywhere will increase.

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