ERWear: Wearables System Design through the Lens of First Responders

Edwin Chan [1]
chane@ucalgary.ca

Yuxi Wang [1]
yuxwang@ucalgary.ca

Teddy Seyed [1]
teddy.seyed@ucalgary.ca

Frank Maurer [1]
frank.maurer@ucalgary.ca

[1] University of Calgary
2500 University Drive NW
Calgary, Alberta, Canada

ISS '16, November 06-09, 2016, Niagara Falls, ON, Canada
ACM 978-1-4503-4248-3/16/11.
http://dx.doi.org/10.1145/2992154.2996880

Abstract
We explore the design of a wearable computing solution for first responders. Wearable devices have many uses, but commercial devices are not suitable for emergency response. First responders face high risk and volatile situations, and wearables possess significant potential to keep responders safe. A lack of understanding exists when designing wearables for first responders. Existing research focuses on the physical implementation of various sensors, rather than usability. Combining literature and extensive interviews, we devise design guidelines for responder-oriented wearable systems. We propose a prototype system, and discuss early feedback from responders.

Author Keywords
Wearable devices; first responder; emergency management; head-mounted display.

ACM Classification Keywords
H.5.2 [Information Storage and Retrieval]: User Interfaces---User-centered design; H.5.3 [Group and Organization Interfaces]: Computer-supported cooperative work

Introduction
Emergencies happen frequently and unpredictably, with potentially devastating results. First responders are

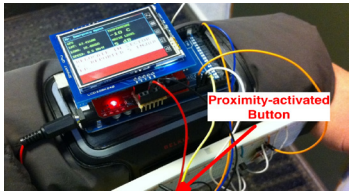

Figure 1: An early wearable prototype for emergency management, by Cernea et al. [1], was found to be too heavy and bulky for practical use.

tasked with gathering information during volatile situations, and protecting the safety of impacted victims. Despite constantly being exposed to risk, responders are often ill-equipped for the task, relying on aging technology with limited capabilities. In recent years, wearable devices have proliferated, becoming easily accessible in many form factors. Despite the potential of wearables to keep users safe, most existing wearables are designed for everyday use, not suitable for emergency situations.

Wearable computing enables the constant and automated collection of information, keeping dispatch informed of a responder's health status, location, and surrounding environment. Head-mounted displays can help visualize mission-related information, increasing situational awareness of responders. Cameras embedded in various wearable devices help responders convey information quickly and accurately. To bring these benefits to responders, we carry out extensive interviews over the course of a year to understand their needs. From the resulting design guidelines, we propose a prototype wearable system made for responders. We then discuss early critique and feedback from responders.

Related Work

Lachner et al. found that mission-related data, information about incidents, clinical data, medical treatments, and spatial awareness data are necessary for emergency response [6]. Of these, health and spatial data play especially significant roles [3, 5].

Magenes et al. introduced ProeTEX, a wearable system for field operators that detects physiological and environmental status [7]. The study demonstrated the use of many sensors, without investigating how they can benefit responders. Cemea et al. developed a wearable device with a color display, which tracked GPS location, ground speed, and ambient noise levels [1]. The system lacked user involvement in the design phase, and was too heavy and bulky for practical use (Figure 1). Curone et al. used sensor data to classify responders' activities, showing that sensor data can help dispatch monitor responders to improve safety and awareness [4].

User Requirements

Interviews with 21 emergency responders were conducted in three stages, over the course of one year [2]. The first two stages helped us identify four themes to designing wearables for responders, while the last stage elicited early feedback to our prototype. The first theme, *System Usability*, provides context about the operating conditions of responders and presents several requirements for such a system to be feasible. The remaining three themes relate to the collection, exchange, and presentation of data. *Responder Safety* describes the types of information the EOC needs to receive from responders, in order to monitor and maintain their safety and well-being. Next, *Responder Awareness* is about how responders can be supported in their tasks through a greater understanding of their surroundings. Finally, *Media and Communications* discusses several tools which can help better convey information, as an alternative to traditional communications via radio.

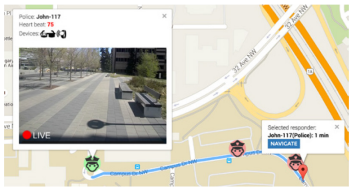

Figure 2: EOC operators can see geotagged photos and live video captured by first responders, displayed directly on the map.

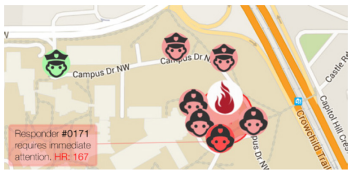

Figure 3: Color indicators alert EOC operators to abnormal heartrates, helping operators monitor the status of responders and ensuring backup can be dispatched in a timely manner.

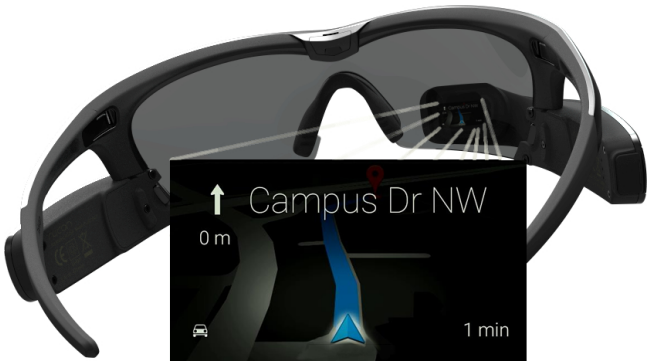

Figure 4: The Recon Jet eyewear used in *ERWear* provides always-on and hands-free access to visual and geographical information, such as navigation support.

ERWear

The *ERWear* wearables prototype tries to address the requirements of emergency responders, and consists of the Recon Jet eyewear and the Motorola 360 smartwatch.

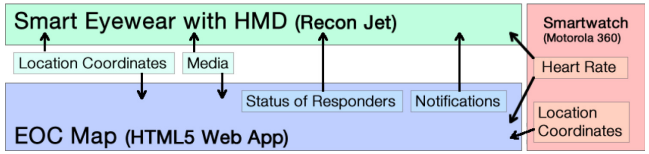

Figure 5: Information exchange between *ERWear* components.

The Recon Jet is a pair of wirelessly connected sunglasses, equipped with a head-mounted display positioned over the right eye (Figure 4). It is always on and hands-free, allowing responders to focus on their tasks. Responders' locations are always tracked by GPS, as part of the safety requirements. Using the built-in camera, responders can record and stream videos to dispatch (Figure 2). Compared to traditional bodycams, a head-mounted camera reflects exactly what the user sees, which is important when presenting video evidence in litigation. On the display, responders can visualize spatial and graphical information, which is difficult to convey verbally over the radio. Maps and navigation guide responders to objectives or fellow responders, increasing situational awareness and efficiency. The Recon Jet is extendable with numerous sensors by connecting to ANT+ peripherals.

The Motorola 360 smartwatch is used primarily for its heart rate sensor, and compliments the Recon Jet (Figure 3). The built-in GPS sensor acts as a backup to Recon Jet's positioning system, providing redundancy for tracking responder locations to ensure their safety.

We also implemented a simple EOC Map, to demonstrate how dispatch operators could interact with and monitor first responders through the equipped wearables.

Early Discussion and Critique

Responders were able to operate the devices with minimal help. Walking with the HUD equipped, participants found the device usable for prolonged use. "*The weight, it's very comfortable, I think you could wear it for several hours.*" However, they expressed some discomfort due to the small size and position of the display. Having located the controls, users were able to respond to notifications and start navigation with ease. Although interactions were simple, users still emphasized the need for minimal interactions during emergency scenarios.

Users appreciated navigation support, and particularly liked knowing locations of other responders. Recording and sharing geotagged photos and videos was seen as

Figure 6: A participant tries on the Recon Jet during an interview.

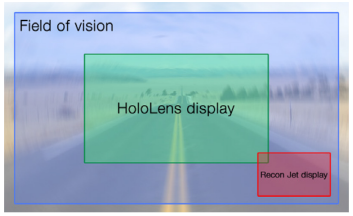

Figure 7: Content overlaid in the center of a user's field of vision allows them to stay focused on a task, without shifting their focus.

a necessity to provide elevated situational awareness to decision makers.

Heavy emphasis was placed on designing a minimalistic interface, with only critical information being shown during operations. Functionality and comprehensibility were prioritized over aesthetics, as the system must remain operable by responders under stress, when cognitive ability may be reduced.

Future Work

From our interviews, it became apparent that wearable devices can help first responders be safe and efficient. We discovered significant enthusiasm for bringing wearables into emergency response.

A continuation of our *ERWear* prototype may use augmented reality displays like the Microsoft HoloLens [7], as suggested by many participants. Showing content directly in a user's view will prevent responders from having to repeatedly shift their focus (Figure 7). It will also be crucial to investigate how information should be visualized to responders, in a clear and concise manner.

Conclusion

We addressed the lack of understanding in designing wearable devices for first responders. We extensively interviewed responders and supporting roles in three stages over a yearlong period. Resulting design guidelines led to our *ERWear* wearables prototype for first responders. We conducted usability testing with responders, and presented early feedback. We hope to extend our prototype to include augmented reality HUDs in the future, while refining the visual elements to be clearer for responders. We hope this initial work will encourage greater use of wearables in emergency response, as a powerful and versatile tool to support responders and keep them safe.

References

[1] Cernea, D., Mora, S. and Perez, A. et al. Tangible and Wearable User Interfaces for Supporting Collaboration among Emergency Workers. *Lecture Notes in Computer Science*, (2012), 192-199.

[2] Chan, E. and Pratte, S. Integrating Wearables in Emergency Management. 2015.

[3] Chang, J., Henry, M., Burtner, R., Love, O. and Corley, C. The Heroes' Problems. In Proc of. *33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '15*, (2015), 1531-1536.

[4] Curone, D., Tognetti, A. and Secco, E. et al. Heart Rate and Accelerometer Data Fusion for Activity Assessment of Rescuers During Emergency Interventions. *IEEE Transactions on Information Technology in Biomedicine 14*, 3 (2010), 702-710.

[5] Fischer, C. and Gellersen, H. Location and Navigation Support for Emergency Responders: A Survey. *IEEE Pervasive Comput. 9*, 1 (2010), 38-47.

[6] Lachner, J. and Hellwagner, H. Information and Communication Systems for Mobile Emergency Response. *Lecture Notes in Business Information Processing*, (2008), 213-224.

[7] Magenes, G., Curone, D., Lanati, M. and Secco, E. Long-distance monitoring of physiological and environmental parameters for emergency operators. In Proc. of *2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, (2009), 5159-5162.