The Heroes' Problems: Exploring the Potentials of Google Glass for Biohazard Handling Professionals

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Abstract
In "white powder incidents" or other suspicious and risky situations relating to deadly diseases or chemicals (e.g., Ebola investigation), those who handle the potentially hazardous materials are the heroes who spearhead the first responder's operations. Although well trained, these heroes need to manage complex problems and make life-or-death decisions while handling the unknown and dangerous. We are motivated to explore how Google Glass can facilitate those heroes' missions. To this end, we conducted contextual inquiry on six biohazard-handling, Personal Protective Equipment (PPE)-wearing professionals. With an inductive thematic analysis, we summarized the heroes' workflow and four groups of "Heroes' Problems". A unique "A3 Model" (Awareness, Analysis, Action) was generated to encapsulate our qualitative findings and proposed Glass features. The findings serve as the groundwork for our future development.

Author Keywords
user study; Google Glass; PPE, personal protective equipment; biohazard, HazMat suit; contextual inquiry; thematic analysis; wearable technology

ACM Classification Keywords
H.5.2 [User Interfaces]: User-centered design

Figure 1: A PPE wearer with a detector

Introduction

In addition to being deadly, the spread of infectious diseases have a greater social impact. The recent Ebola outbreak in West Africa exemplifies such diseases' spreading ability and fatality [2]. From time to time those deadly infectious diseases can, in the wrong hands, be used to create a means of terror, causing social issues such as fear, panic, and confusion, with or without the actual existence of the pathogen. For example, after the Anthrax attacks in the United States ("Amerithrax") in 2001 [11], several unknown packages containing white substances were reported found in office buildings or residential areas. Some of them were real threats, some merely hoaxes. Whichever it was, the phrase "White Powder Incident" was coined [11] to describe such suspicious scenarios that led to mass disturbance.

Yet, with the presence of villains, comes the rescue from heroes. Besides the medical professionals who treat patients infected by the diseases in medical facilities, there is another group who work as the first line of defense. Those first responders are trained to deal with with unidentified bio-hazardous materials (often referred as "HazMat": Hazardous Material) while wearing PPE (e.g., mask, suit, gloves, and oxygen tank) to isolate themselves from the exposure.

Recently, a number of wearable devices have become available on the commercial market. Google Glass (referred to as *Glass*), an "eyewear computer", is one of the devices that has caught much attention. It has a micro-computer, a small display located in front of the (right) eye, sensors to detect the user's movements, a camera for taking pictures or videos, wireless transmission modules, and can be controlled with voice commands, or via touchpad interactions.

We posed these questions to start the investigation: Are the operations really always a smooth ride for the heroes? What can be improved for them with the possible use of wearable technology? We are motivated to explore and implement how Glass can be integrated with PPE wearers' work in handling HazMat. This research describes our qualitative user study using contextual inquiry and inductive thematic analysis to understand our potential users: the heroes who fight against bio-hazardous incidents. Here we present our findings, which we believe can benefit our future design and implementation, or other related projects in the research community.

Background

Wearable Technology for Special Professions

Recent technology has benefitted certain, special professions (e.g., police, soldiers, and firefighters), making their equipment more portable, wearable, and smart. Examples include: a vest for police with communication functionality developed by the MIThril Platform [3]; wearable augmented reality system for military usages [5]; firefighter Patrick Jackson's Glasware (application developed for Glass) [1], which was mentioned in National Fire Protection Association's (NFPA) research initiative for smart firefighting [10].

Job Role
■Job position/rank ■Daily routine ■Substances and equipment involved in the tasks ■Work environment ■Team organization
Wearing & undressing PPE
■Steps and time needed ■Issues of comfort, mobility, dexterity
Information provision/retrieval
■Information needed to provide/retrieve in the phases of before/during/after an operation ■In what forms should the information be? – paper or digital, visual or auditory? ■The potential risks or penalties when failure to provide/retrieve such information happens ■How does wearing PPE affect the provision/retrieval of the said information?
Communication
■Communication with the team ■Distance/presence issues ■The need to follow a certain hierarchical command structure
Training
■How were you trained to use the PPE? ■How to get refreshed with existing knowledge? ■How to learn knowledge about new equipment?
Glass Trial
■Play around with Glass ■Share your first impression. ■Encouraged, but not required, provide some potential uses of Glass.

Table 1. Contextual inquiry topics

Google Glass for Medical Uses
Several studies have demonstrated how Glass can be integrated to regular medical workflow to enhance collaboration and information exchange. Feng et al. [4] implemented a rapid diagnostics testing (RDT) Glassware, coupled with QR code and a backend system, to support hands-free test strip identification for examiners. Monroy et al. [9] developed a platform that provides optical coherence tomography (OCT) imaging data to doctors while they were examining patients. Glass has also been used in live surgeries, such as showing patients' vital signs during percutaneous transluminal angioplasties (PTA) [12], or broadcasting the doctor's point of view to medical school students during a knee operation [7]. Additionally, user studies on how acceptable Glass can be were conducted on people with Parkinson's disease [8] and upper body motor impairments [6].

We found that there was a shortage of studies on how HazMat handling professionals, a profession that requires unique knowledge and special PPE, can benefit from wearable technology. More specifically, we also found that although many Glass explorations have been made for medical applications, there lacks the use of Glass for HazMat handlers. Therefore, we believe it is not only original but also practical to explore how an existing device, Glass, can go along with present PPE and first-responding operations to benefit our HazMat fighting heroes.

Method

We performed contextual inquiry interviews to discover how PPE wearers behave and work in incidents of biohazards. Six interviewees were recruited (two females and four males). They were first responders, industrial health specialists, and epidemiologists, who all shared the experience of wearing HazMat equipment while proceeding with their inspecting and treat neutralizing tasks; tasks that may involve carrying portable instruments (lab tools or detectors) and communication devices. Some of the participants were in managerial positions who organize and oversee biohazard response operations. Each interview was structured for 45 minutes to one hour. After a quick briefing, they were asked to provide information with these questions listed in Table 1. The contextual inquiry interviews were conducted in a conversational style and the questions were not asked in a particular order. We then conducted inductive thematic analysis to find emerging patterns from the interview. Our findings are as follow.

Findings

The first part of findings is a temporal summary of how the heroes proceed with an operation. Their operational challenges are summarized in the second part.

The Heroes' Mission: Workflow of Fighting the Villain
Normally a first responder for biohazards works in an office or control center. After receiving the notification about an incident, the team prepares the equipment then moves to the scene. Upon arrival, they listen to the briefing from the commander, get equipped with PPE, and carry needed tools and detectors. As they approach the biohazard they report what they see through radio transceiver to the rest of team. Once they start to handle the hazardous substances, they might ask the team for additional or updated information. They then exit the scene if the situation is

neutralized, undress the PPE, and return to the team for a debriefing session. The team, leaving the site, keeps its members and other personnel (police, media, medical facilities, or local government) informed about the further development.

The Heroes' Problems
No matter how smoothly (or not) an operation ends up, each of our interviewees mentioned that they always expected for the worst during the onset of the operation because there were always these potential Heroes' Problems, as listed below.

Fear for the Unknown: It is not uncommon at all that the heroes do not always know what and how exactly they should do to handle the hazards even after the situation is analyzed. They are trained as a "specialized generalist", but there are just too many unknowns, e.g., the substance is well concealed (with the intention of not getting found or opened), not documented in detail (e.g., smuggled by criminals, or not well recorded by the party responsible, e.g., the lab or hospital), or forms unexpected reactions (mixed with weather or other substances, exposed to humans and animals). Often they can only rely on an iterative "guesstimate" method with the support team. The novices' biggest fear is facing the unknown, while the seasoned also often caution themselves for the strange.

Limited Dexterity: PPE is meant to be durable and protecting. The tradeoff is they are heavy and thick to wear. The heroes in question struggle to delicately manipulate the detectors and tools with limited dexterity or discomfort from poor ventilation. This problem worsens when they sacrifice manual availability to carry and operate many detectors (as a result of guesstimation) and communication devices, while wearing, say, a Level A suit and a self contained breathing apparatus (SCBA) as heavy as 40 pounds.

Communication & Information Insufficiencies: Many still rely on radio transceivers to communicate with the support team. Before entering the scene, they are shown information about the environment. But often they need to deal with the environmental changes on their own once they begin (e.g., finding a way in/out a big and complex building, or responding to drastic weather changes on the fly). Not only does radio communication fail to clearly describe the information, its limitation in transmission distance also constrains the teams' spatial strategy.

(Re) Training: Whenever new biochemical threats and diseases emerge, or new equipment is released, the heroes are required to receive relevant training. They are also scheduled for regular refreshing courses for existing equipment and protocol. These training sessions take hours to complete, but do not provide a close-to-real experience due to the lack of the presence of real hazards, or integration of all needed equipment and personnel.

Design Opportunities

We are motivated to design and implemented Glass features to address the aforementioned challenges. Glass has many types of sensors and wireless communications capabilities, making it a good wearable context-aware device to function differently in varying statuses. Per our inductive thematic analysis, we present our A3 model (Figure 2) to encapsulate our findings and proposed features that may come useful for the heroes.

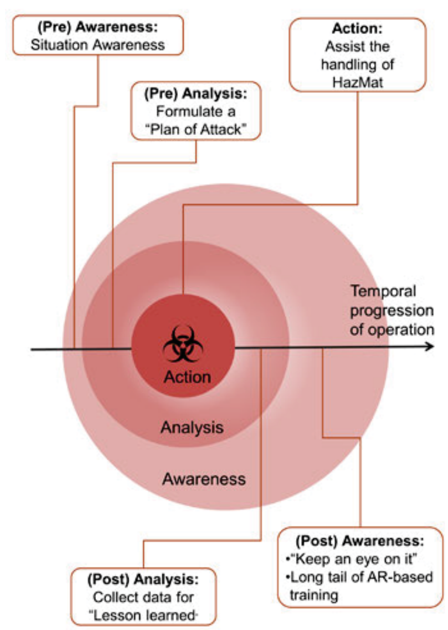

Figure 1: A3 model & each mode's goal

(Pre) Awareness: On their way to the scene, the heroes can use Glass as a supplementary GPS navigator to guide them with the best routes to the scene per traffic, weather, or evacuation progress. It can also update the heroes with news notifications or messages from the control center.

(Pre) Analysis: Arriving at the scene, while getting suited-up and briefed, the team can formulate analysis by finding and sharing site-specific information to Glass, such as maps, detailed environmental updates (e.g., temperature, wind directions), currently available equipment/personnel, or initial images and videos taken from exterior to or far from the hazard. All of these analyses can help the team to devise a "plan of attack".

Action: Wearing PPE to enter the scene, the heroes, whose faces are covered by the masks (making Glass's touchpad inaccessible to fingers), can pose gestures in front of Glass to trigger certain commands. While handing the hazard, Glass can display abstracted information for the equipment. This would include remaining oxygen amount or quick readings from the detectors. Glass can send images and videos to the support team to better describe what the hazard is like. This can better relieve the heroes from dealing with the unknown, e.g., they can use Glass to take and send pictures of the unknown substance's MSDS or UN number to the support team, and have the team send back the bullet points of protocols on Glass.

(Post) Analysis
After the Action is finished, the heroes retreat to the team's gathering spot. Through Glass they can share images or data gathered from different locations. They can (using voice command) to take notes of the shared information to collectively draft a "lesson learned". Some of the information can be shared to the media or other departments for archiving or further analysis.

(Post) Awareness: The heroes undress the PPE and return to their normal offices. Similar to the Pre-Awareness mode, in this mode Glass can provide more macro-level information about the incident so that the heroes can "keep an eye on it", e.g., follow-up news stories, or updates from the cleaning crew. Training is also included in this mode. Glass, coupled with augmented reality, location detection, and integration with to the equipment, should provide a more vivid and real learning experience. The bigger region on Figure 2's (Post) Awareness area shows training features as a long tail (required regularly in later times but with less intensity compared with real incidents).

Design Considerations: Compared with PPE that are made to be strong and durable, Glass might not always withstand quick and rough movements from its wearers. Also, battery life will be an issue, especially if it runs many computation-intensive features or if the hero's work goes longer than planned.

Conclusion

To explore potential uses of Google Glass for PPE-wearing, biohazard-handling professionals (the heroes), we conducted contextual inquiry interviews with six participants, followed by an inductive thematic analysis, to understand the workflow and difficulties for the heroes. Those "Heroes' Problems" can be summarized as Fear for the Unknown, Limited Dexterity, Communications & Information Insufficiencies, and

Training Issues. We then formulated an A3 model to encapsulate the findings with proposed Glass features. The A3 model also serves as a framework for context-aware switching mechanisms. We hope this study can further our design and implementation to help the heroes with Glass (or in a broader sense, wearable technology), and provide inspirations for the research community in smart eyewear or head-mounted displays.

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