Exploring Drones to Assist Firefighters During Emergencies

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ABSTRACT

In the near future, emergency services within Canada will be supporting new technologies for 9-1-1 call centres and firefighters to learn about an emergency situation. One such technology is drones. To understand the benefits and challenges of using drones within emergency response, we conducted a study with citizens who have called 9-1-1 and firefighters who respond to a range of everyday emergencies. Our results show that drones have numerous benefits to both firefighters and 9-1-1 callers which include context awareness and social support for callers who receive feelings of assurance that help is on the way. Privacy was largely not an issue, though safety issues arose especially for complex uses of drones such as indoor flying. Our results point to opportunities for designing drone systems that help people to develop a sense of trust with emergency response drones, and mitigate privacy and safety concerns with more complex drone systems.

INTRODUCTION

Since the late 1960s, people in the USA and Canada have had to place a telephone call to the number 9-1-1 to share details about an emergency [11]. In the next few years, Canada will move towards Next Generation 9-1-1 (NG9-1-1) where callers and 9-1-1 services will increasingly use additional technologies [13]. One such technology is a drone which is a small-scale aircraft remotely controlled and provide video recording and/or streaming features. We have chosen to explore drones given

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Emergency calling; firefighters; drone; surveillance

Figure 1: Fire from top

Figure 2: House fire (close-up)

their likely ability to provide important contextual information about an emergency situation [4]. For example, if an emergency is called in to a 9-1-1 call centre, one could imagine a drone flying to the emergency (either automatically or controlled by an operator) and providing a birds-eye view of the situation and sharing it with 9-1-1 call takers and, subsequently, first responders. In our work, we have chosen to focus on *firefighters* as they handle and respond to a range of emergency situations, including car accidents and hazardous material situations, in addition to fire response.

To date, there has been limited research into how drone systems should be designed to best match firefighters' needs when responding to 9-1-1 emergency calls nor the benefits and challenges that might be raised by citizens about drone use during these situations. We explored this topic through an interview and scenario-based study of emergency situations with firefighters and people who have experience in calling 9-1-1 to report emergencies. We focused on 'everyday emergencies' such as automobile accidents, fires, and injuries that a citizen might call in to 9-1-1, as opposed to disaster response, crisis management, or search and rescue. Our goal was to answer several research questions. For firefighters, how might firefighters make use of drone footage in an emergency? And, how should drone systems be designed to aid firefighters during an emergency? For 9-1-1 callers, what benefits and challenges do they feel exist for drones that capture video of an emergency situation?

Our results show that drones could provide a number of benefits to 9-1-1 callers and firefighters, including knowledge of the context of an emergency, which could save valuable time. Drones can be thought of as 'non-human firefighters' which have the ability to reassure people that 'help is on the way' and provide additional perspectives to the firefighters to help them size-up an emergency scene. Privacy and surveillance were largely not an issue in our study for participants unless they were at fault for an incident or doing something illegal. Together, these results illustrate design opportunities for emergency response drones with an emphasis on designs supporting trust by the public; communication between dispatchers and those on scene; appropriate and useful camera work; and multiple drones and possibly indoor drone usage.

RELATED WORK

Information about an emergency is shared with firefighters in textual form through a computer aided dispatch system (CAD) when they are travelling to the scene with additional information being shared over radios [8]. Firefighters attend emergencies ranging from fires to hazardous material incidents to motor vehicle accidents [5]. Previous research looked into the needs of information sharing between firefighters and emergency control centres [7], mobile applications to enable text messaging between firefighters [1]. However, drones were not explored. Drones have the potential to be effective for emergency situations by providing a bird's eye view [4]. A study suggests that drones can be socially adapted and accepted [2]; however, a lack of regulatory frameworks calls for an investigation into how drones should be used [6]. People's privacy perception of drones was explored by Yang et al. [10] who found privacy concerns around inconspicuous data collection and inaccessible controllers of the drone. This work explored civil, government, and recreational drones

Figure 3: Apartment complex

Figure 4: HAZMAT from ground level

while our study aimed at understanding people's perception of drones in emergencies. Chang et al. explored privacy and security issues involving drones [3]. While they did not find any new concerns, they found out that the drone design itself can shape people's privacy and security concerns. Other work in this area explored how the registration of drone owners could reduce people's privacy concerns [12].

USER STUDY

We conducted an exploratory study with 9-1-1 callers and firefighters to understand how firefighters could make use of drone footage during everyday emergencies; how drone systems should be designed to aid firefighters during such emergencies; and what benefits and challenges everyday citizens feel exist for drones that capture video of an emergency situation. Our study was approved by our university research ethics board.

Participants
We recruited twenty participants in total through snowball sampling (word-of-mouth), social media (posts on Facebook), and contact directly with emergency response centres within our city. Participants were in two groups.

Everyday People: We interviewed twelve everyday people (six males, six females) who were experience with calling 9-1-1. Their age range was within 18 to the late 60s. They were experienced with calling 9-1-1 for diverse situations including gas leak, house fire, medical emergencies, police emergencies etc.

Firefighters: We recruited eight firefighters with the age range of 36 to 65. They had firefighting experience ranging from five to forty years. Three of them had extensive experience with using drones for emergencies.

Method
We conducted semi-structured interviews with each participant. Interviews were conducted in-person with local candidates living in Metro Vancouver, Canada. Other participants were interviewed through Skype. Interviews lasted between 25 and 75 minutes. Questions were different for everyday people and firefighter groups given their backgrounds and needs. We structured the interview in two phases.

<u>Context:</u> The first phase focused on the experience of both of the groups. We asked them to share details about the previous emergencies and asked how they would feel about drones capturing those situations; how they would want the drone to capture the scene; what they would not want captured etc.

Figure 5: HAZMAT from top

Figure 6: Accident (far-out)

Video Scenarios: The second phase of the study focused of understanding participant reactions to actual drone like footage of emergencies. We collected various footages of emergencies which were publicly available on YouTube (Fig. 1-7), clipped each footage to 30 seconds in length, and showed it to participants where we asked them to imagine themselves in the scene. The videos were categorized and purposely selected to be in four groups representing a range of emergency

situations: fire, hazardous material, vehicle accident, and injury in an apartment. These videos were a mixture of actual drone footages and smartphone footages. We started the interview by showing each participant a ten second video of a high-end commercial drone so they would understand what a drone was, if they were unfamiliar. Then, we showed them each of our video scenarios one-by-one and asked participants a series of questions about the video. Videos were shown in the order presented in Figures 1-7. Our questions sought to understand the benefits, challenges, and the usage of drones for emergencies.

Data Collection and Analysis
All interview data was transcribed and analyzed using thematic analysis to draw out main themes. The transcripts were read iteratively by one researcher to initially code the data to find similarities and differences across participants. Through frequent meeting with a second researcher, we explored the data for categories and central themes.

RESULTS

Benefits and Basic Usage
Our first responders pointed out how drones are already being used by some firefighters to get an overall view of the scene. Firefighters currently use drones for large scale structural fire emergencies or wildfires. A drone pilot controls the drone on the scene and shares the footage with them as per their request. They mentioned drones being inexpensive (compared to a helicopter) which provides high quality video stream. All participants talked about a number of benefits associated with using drones.

Participants thought drones would be most useful for fire incidents. They mentioned drones being able to locate nearest fire hydrants or provide a view from the top, for example. Firefighters thought drones could be useful to size-up the scene.

Firefighters thought drones could be particularly useful for situations involving hazardous materials with the ability to detect placards on vehicles. Drones were also seen to be useful in cases when it was dangerous for a human to come near a scene. Firefighters showed interest in having the drones equipped with different sensors to detect chemicals.

During vehicle accidents, participants thought drones could be useful to help regulate traffic and investigate the scene for evidence which might be helpful for post-investigation. For in-home medical emergencies, participants with children at home thought drones would be useful to assess the scene while two participants thought Google Maps would do the job well. Firefighters thought drones could help with traffic information, pointing out entry and parking areas in such scenarios.

Figure 7: Accident (close-up)

Design Needs and Challenges

Appearance and Location: Participants, both callers and firefighters, thought emergency service drones should have a prominent appearance which would make them feel more comfortable in the event of an emergency. Six callers and two firefighters suggested that a drone should be able to go inside buildings in case of emergencies. This would require the drone to be very small. Also, Firefighters suggested that drones could be equipped with different sensors such as gas or IR camera.

Locating the drones strategically around a vicinity is important because a drone should not take more than a minute to arrive to a scene during an emergency.

Capturing a Scene: Firefighters specifically wanted the drone to circle around a scene counter-clockwise starting from the address side of the building. They also mentioned capturing the scene from different height ranging from around 10metres to 200 metres. They also thought drones should be autonomous in part with manual controls since firefighters wanted to be able to request specific views.

Two-way Communication: We asked participants about the possibility of drones streaming or recording audio in addition to video. Callers felt that drones should not only have audio, but there should be two-way communication as well. Callers thought they would find it comforting if the firefighters would be able to provide instructions through the drones. That said, some participants thought two-way communication could distract firefighters from doing their work. Firefighters thought this could cause information overload and they would use it rarely. Still, they wanted the option to be available in case they ever had to use it.

Privacy and Safety: Two callers showed concerns related to privacy in terms of being captured by drone. These situations involved when the person is inside an apartment or a house or if the drone gets too close to the person. Other than that, all participants thought privacy was not important in the event of an emergency. Generally, firefighters did not have any privacy concerns but they pointed out unintentional data collection may cause privacy. For example, when looking for a victim, other people might be captured as well. They also showed genuine concerns in the event of seeing someone die on the drone footage when they cannot do anything to help that person.

Safety issues involved drone being stolen or getting hacked. Some participants thought drones could hit someone on duty or interfere with air traffic. Other concerns related to the possibility of firefighters neglecting their duties if drone does most of the work (for example, size-up a scene).

DISCUSSION AND CONCLUSION
Our study points to a range of design possibilities and challenges associated with drones and everyday emergency response. We explore these next.

Drones as a Trusted Companion
Callers showed a great deal of trust in emergency drones. Drones can be thought of as companions in emergencies. Compared to literature around public video streaming [9], we see a high level of public acceptance of drones. Therefore, emergency service drones should be clearly recognizable. Callers also talked about drones in a way that somewhat personified them as emergency responders in and of themselves. That is, they saw drones as a tool that might allow them to talk with actual 9-1-1 dispatchers or even first responders where the drone would act as an embodiment for a person. Although there is a possibility of information overload on call takers or first responders because of two-way communication.

Capturing an Emergency
Capturing an emergency starts with the challenge of initially locating drones. Most participants valued drones placed in areas of authority that resonated with notions of help and existing emergency services, e.g., fire halls. Once arriving at the scene, we see further design requirements around the camera work needed to adequately capture the scene. Desirable views involved a mixture of close-up and far-out video, with various flying patterns to size-up the scene, gain broad contextual awareness, and monitor situations on the go. Also, a combination of autonomous vs. manual control could ensure the capturing of right information. Image processing software might mark important object around the scene such as fire hydrants or damaged vehicle.

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