Artificially Intelligent (AI) Drones for First Responders

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Abstract (Required only in final camera ready version)

Keywords

Artificial Intelligence, First Responders, Drones, Responder Drone, Traffic Accidents.

Introduction

According to the World Health Organization, approximately 1.35 million people die as a result of road traffic accidents every year. Supporting first responders and decreasing response time for traffic accidents has been a major goal towards improved road safety. However, increased traffic makes it difficult for emergency services to respond to traffic related accidents in a timely manner than they might want to. In the meantime, unmanned aerial vehicles (UAVs), or drones, have been proposed as an assistive technology ranging from helping with indoor errands to serving as outdoor assistants for surveillance, delivery, and companionship. The advancement of artificial intelligence (AI) (such as computer vision) and unmanned aerial vehicles (UAVs), or drones, such as delivery drones, have provided opportunities for assisting first responders in emergency situations. Companies have started to discuss the variation of drones and package delivery where drones might be adopted. However, to the best of knowledge, there is a lack of study to investigate drones for first responder tasks. This research study aims at investigating the opportunities and requirements of using computer vision and delivery drones to support emergency services. In particular, we aim to answer the following questions:

- What are the *opportunities* of using computer vision in a responder drone?
- What are the *strengths* of computer vision in a responder drone?
- What are the potential *challenges* of computer vision in a responder drone?

To understand the opportunities and concerns of using drones to assist first responders in traffic accidents, we conducted semi-structured interviews with 20 participants who are regular commuters and drivers in the Silicon Valley. We found that drones are promising in providing accessibility to first responders in tight situations, timeliness of alerting emergency services, and real time traffic management information. The benefits would allow for a speedy basic medical response until services arrive, have a means for two-way communication between motorists and responders and be able to deliver aid in remote areas. Meanwhile, such technologies should take into account privacy, weather, and utility needs.

Related Work

In a recent survey, Mirri et al. categorized the role of drones as personal devices, motivators, companions, and helping devices in case of emergency and search and rescue tasks (Mirri and Salomoni 2019). For example, Teledrone was proposed as a design with video conferencing technologies to provide a sense of social presence and companion during outdoor activities with remote friends or family members (Shakeri 2019). DroneNavigator was proposed as a social companion for visually impaired people to find their way and locate objects(Avila et al. 2015). In a follow-up study, the same group of researchers (Soto and Funk 2018) investigated the social acceptability issues companion drones for blind travelers in public spaces, and indicated the public audience might have concerns about the safety aspects (e.g., drones hitting passersby) and privacy issues (flying over private properties). On the other hand, reservations of drones from the public should not be a reason to block the development of assistive technologies for the visually impaired individuals. Drones are also explored as companion devices (Kim et al. 2016) and found that participants would expect to receive practical support from drones enabled by the unique properties of drone's flying or filming functions. Such support includes delivery service, doing errands, and navigating service. They further categorized participants' perception of the social roles of drones as a servant, a pet, a friend, and in rare cases, as a bully. Another study explored the opportunities of social drone companions at home and

found that participants are generally supportive of drone companions for tasks such as fetching items and cleaning (Karjalainen et al. 2017). Meanwhile, the main concerns of drones include the privacy and fear of drones in the public area, as raised by Uchidiuno et al. (Uchidiuno 2018), who also proposed privacy-preserving technologies including capturing data in non-sensitive areas. The closest to this study was conducted by Khan et al. (Khan and Neustaedter 2019) who explored the use of drones for assisting firefighters during an emergency situation. They also conducted qualitative interviews with 20 participants and summarized the following scenarios of potentially deploying drones: fire emergencies, hazardous materials, vehicle accidents, and in-home medical emergencies. The work, however, specifically focuses on how drones might be used in vehicle accidents.

Prototype

System Design

As one of the artificial intelligent technologies, computer vision uses deep learning to analyze images for objects and scenes [10]. In our project, we adopt computer vision to analyze the accident scene through the aerial photos and footage. Figure 1 demonstrates an example of the application of computer vision in an aerial filming. As a first step, we developed a prototype to 1) detect vehicles, pedestrians, and other roles, and 2) recognize and analyze vehicle plates.

To be able to identify accidents, the first step is to detect vehicles, pedestrians, the roles (such as first responders). The best way to identify with the highest confidence level is by using bounding boxes as well as segmenting each object as different from one another. By using both bounding boxes and segmentation, computer vision is able to identify objects with high confidence to facilitate the decision making.

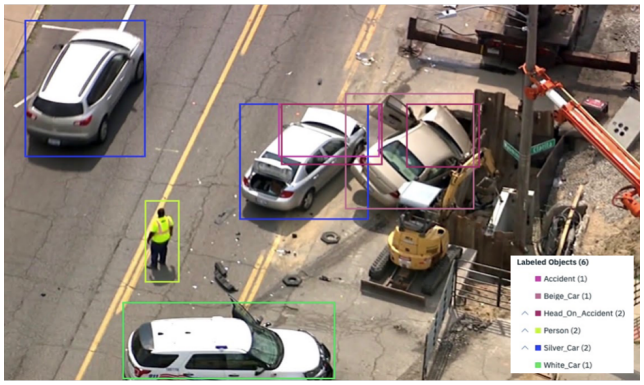

Figure 1. Screenshot of prototype Computer Vision model for responder drones.

To provide more comprehensive support, it is essential to detect license plates on vehicles. By reading license plates and text, computer vision powered drones would be able to identify vehicles; by connecting to the public vehicle database, it could provide more detailed information about the vehicles involved in accidents.

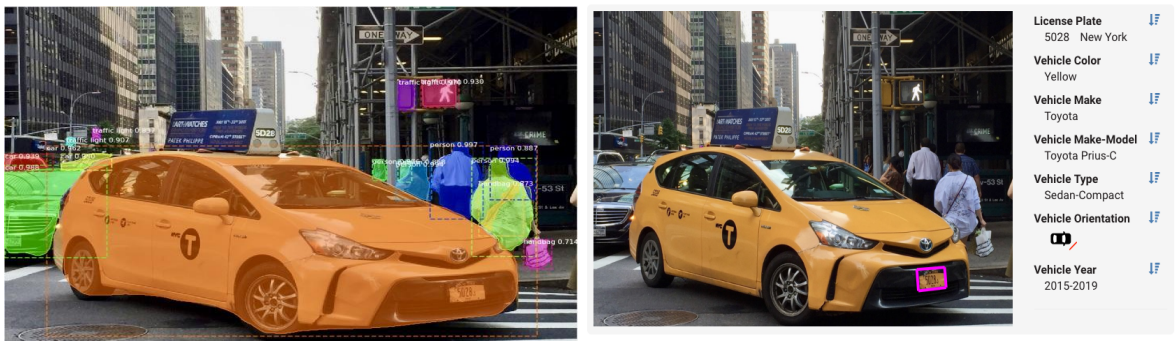

Figure 2. object detection and segmentation model (left) and license plate reader and identifier model (right)

Service Design

We then propose three services that drones could provide to assist first responder tasks: 1) detecting accidents, 2) delivering basic medical supplies and 3) remote tele-conferencing.

With the application of computer vision applied in aerial images, it is feasible for drones to provide surveillance on traffic situations and detect traffic accidents when it happens. By reporting traffic accidents with filming footage, supplemented with contextual information, first responder could be more prepared in providing rescue services.

Similar to prior research researchers that adopted drones to deliver packages, it is possible to use drones to deliver first-aid medical supplies. The amount of supply delivery is dependent on the accident situation and the carrying capacities, but sending the very basic supplies might be able to provide more timely medical care before the medical staff arrive.

Equipped with cameras, microphones and mobile Internet, drones could help medical staff observe the injury and provide timely medical support through video-conferencing capabilities. This would provide professional medical instructions before the arrival of an ambulance.

Study

We interviewed 20 candidates based on a semi-structured interview method for three purposes. First, semi-structured interviews allow interviewees to express their unsolicited opinions in the conversation allowing to better understand public understanding and opinion; second, concepts can be clearly conveyed and ensured by both parties in a non-formal way establishing if messages are understood or not; third, new ideas can be discussed if presented to understand better. We developed the focused goal of the interviews by having open ended questions about experiences and opinions to better engage the participants. The participants chosen in this study were students and professionals acquainted with us who have lived in the San Francisco Bay Area, yet have no prior knowledge of the study to be able to engage better.

Results

The collected responses from twenty participants included, 11 students and 9 professionals, 14 male and 6 female. We then conducted a thematic analysis using a grounded theory (Strauss and Corbin 1998) approach, which is a well-established qualitative data analysis method. The analysis was conducted around each of the three main topics we collected in the interviews, which are presented below.

Q1: What are the opportunities of using computer vision powered drone?

To create a responder drone powered by computer vision, the needs of motorists must be understood at first. The participants were asked about their driving experience and conditions of roads in the United States as well as their experiences in traffic accidents. Participants expressed the opportunities of using computer vision in a responder drone to provide tangible support, and informational support.

Tangible support refers to delivering medical supplies. According to our participants the drones would be able to deliver medical supplies in remote and rural areas to extend the likelihood of survival. For example, if a motorist is involved in an accident on a mountain, far from other motorists, a drone in the area would be able to identify and deliver basic supplies while first responders arrive to provide additional aid. The second type of tangible support mentioned by participants is able to reach areas which may be hard to get to quickly during or after a natural disaster such as an earthquake or fire. As one participant said: *"There are many opportunities but depends on country to country, I believe a main opportunity in the US are to rural or remote areas and disaster relief, however in countries with high traffic there would be an even bigger need."*

Informational Support could be supported by drones equipped with cameras and microphones. This can be accomplished through first responders observing the situation and conveying instructions while

arriving on scene. Fire department and ambulance can receive real-time updates on situations as well as where they are in terms of arriving on scene. For example, *"The drone has to do more than just deliver medicine, if it has instructions of how to help, then that would be beneficial in saving lives."*

Q2: What are the strengths of computer vision powered responder drone?

Participants expressed the main strengths of using computer vision powered responder drone to be 1) accessibility, timeliness, and situational awareness.

Accessibility of using a drone with computer vision to be able to navigate into tight areas where first responders cannot. 60% of the participants emphasized that this could be potentially beneficial to understand the situation better and to provide first responders with more information on what is needed. Our participants were quick to establish that being able to fly above traffic, help could reach faster and provide help in areas where it would take time to get to, or even areas that have limited road access. This provides an extension to the capabilities of first responders and can help in hazardous situations such as wildfires for detection and delivering supplies to the front line stop further fire damage. One participant reflected: *"drones would be ideal in a remote area or areas hard to access to deliver help quickly but in no way should replace first responders."*

Timeliness means arriving on time quickly – a key objective of first responders to provide the best help in the shortest time frame. Participants asserted in their experiences during the traffic accidents they had been involved in, first responders arrived between 15 to 40 minutes. Timeliness can also be achieved by automatic reporting of traffic accidents. Our participants reported that during these instances the only method of getting professional help was by calling emergency services and explaining to them the situation before they could arrive. By using computer vision in drones, 25% of participants expressed emergency services can be notified of traffic accidents faster than calling, e.g., *"saving time, that would be something that drones can do by flying over traffic in a big city like San Jose, it could respond quickly."*

Situational Awareness – the intelligent understanding of traffic and road situation, it can be achieved through computer vision. From participant responses, 15% of them emphasize that there was a need for law enforcement and paramedics to receive live information about accidents for better integration for emergency response systems and by using computer vision in a responder drone, it would be able to provide emergency services with information about accidents and see what type of help is required as well. By being able to capture information it would automatically inform law enforcement, fire department and medical crew. This would also allow responders to receive analytics and live information about the current situation they would be responding to, so they are better prepared while en route. One participant reported: *"this could help out first responders with their jobs, more integration by being an eye in the sky for first responders to know where accident is, could potentially transport people if the drone is big enough."*

Q3: What are the challenges of computer vision powered responder drone?

Participants also expressed the concerns of using computer vision in a responder done: having privacy concerns about what is being viewed, airspace management against other flying objects, and operating in severe weather conditions.

Privacy Concerns. 50% of the participants explained how they personally feel that drones flying around with cameras around them recording interferes with their privacy. By using computer vision, visual recording is required to be able to detect and recognize objects and accidents. Due to data not being accessible to the public and having experience of the usage of the data, public perception will continue to be a concern on the ability of a responder drone, limiting its usability.

Airspace Management. 45% of interviewees noted that they believed drones could potentially be crashing into other objects. This would be detrimental to the efforts of a responder drone, whose task is to enhance the ability of first responders by delivering basic medical aid if a detected traffic accident requires. Until the drone can be ensured of being able to scan terrain and objects around it, both visually and with radar there will be a challenge of establishing public safety.

Weather. Participants also emphasized the issue of severe weather conditions such as heavy snow and rain, where computer vision would not be able to detect objects in a reasonable distance. This issue is detrimental as well in the general usage of a responder drone of detecting accidents in terrible conditions.

Until computer vision is able to detect in limited visibility conditions, it is a setback of a CV powered responder drone.

Conclusions

This research study aims to understand the opportunities and challenges of using computer vision in responder drones. We conducted a semi-structured interview study with twenty participants around these questions. Through the interviews, we found out that computer vision in a responder drone might have the potential in providing help quicker, be able to provide help in remote or rural areas, as well as communicate information through the vision to both first responders as well as what to do for motorists. Benefits of using computer vision equipped responder drones include the ability to respond quickly during traffic, provide two-way real-time information as well as deliver aid in remote areas. While the potential issues include privacy concerns, air traffic management against other drones and aircraft, as well as severe weather conditions limiting visibility.

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