Safe Swarm

Preemptive and Rapid Response Countermeasures for Public Safety in the 21st Century

Heather Kemp
University of Iowa
Iowa City, Iowa
heather-kemp@uiowa.edu

Theo Linnemann
University of Iowa
Iowa City, Iowa
theo-linnemann@uiowa.edu

Yusuf Sermet
University of Iowa
Iowa City, Iowa
muhammedyusuf-sermet@uiowa.edu

ABSTRACT

This paper describes the Safe Swarm drone application for Mobile Computing and proposes a method of development and testing for the system.

CCS CONCEPTS

• **Computer systems organization** → **Robotics**; • **Computing methodologies** → *Robotic planning*; • **Hardware** → *Wireless devices*;

KEYWORDS

Drones, wireless networking

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1 INTRODUCTION

In June 2014, SSH and GfK carried about a national survey of 2,000 people in the USA about harassment as people walked the streets. They found that 65% of women experienced street harassment, 23% had been sexually assaulted, and 20% had been followed, while 25% of men reported to being harassed as well. Enter the Safe Swarm, a fleet of autonomous drones that will deploy to a mobile application users location and follow them so they are not alone on the streets. The Safe Swarm drones would, at full production capability, be able to follow users, stream the video activity of what is happening, notify nearby friends of the situation, and keep the user in a well lit area with their flashlight. With the Safe Swarm supporting people as they walk the streets alone, decreased harassment rates will facilitate a feeling of safety as users walk home, and increase the probability of perpetrators being caught through the live video footage.

2 APPROACH

In this project, we propose the utilization of a fleet of relatively small drones to navigate and accompany users to a safe location of their choice. The fleet of drones are assumed to be stored in a convenient location while being connected to the internet and waiting for a geolocation. A user requests a Safe Swarm drone as a companion through their mobile device (e.g. Android) using the Safe Swarm app. Once the request is made, mobile app assigns the first available drone to the user and feeds the geolocation (i.e. altitude, longtitude, latitude) measured by the Global Positioning System (GPS) sensors every second. Additionaly, the elevation model of the region of interest is also planned to be integrated into the system in the future to better assess potential obstacles and barriers along the route as well as to compensate for the error rate of the altitude calculation from the GPS sensors. Last known location of the user is saved and periodically updated in the database in case of battery issues on user's end.

Once the drone is navigated to the user, there are 2 main objectives needs to be achieved; (1) accurately detecting the user (2) tracking the user despite obstacles. Both tasks could be achieved if GPS sensors provide a precise and dependable geolocation information. However, readings from the GPS are known to be prone to get affected by the magnetic environment and are easily disturbed or interfered by surrounding elements (i.e. metal). GPS sensors hosted in smartphones are generally accurate to within a radius of 4.9 meters under good environmental conditions. This accuracy can easily deteriorate in cases of signal blockage, indoor use, and signal reflection, due to surrounding structures and plants. Signal quality can also get affected by the number of available satellites for given time and location, though it constitutes a less likely risk. Therefore, an additional method (i.e. visual recognition) for identifying and tracking the user can prove to be useful to increase the confidence. In the future, app can ask for user's photo during sign up so that it can differentiate from other people nearby. Once locked, object tracking algorithms can be used to follow the user in addition to the GPS readings.

2.1 Social Mechanism

There can be different variables that can affect the functionality and accuracy of the system (e.g. dead battery of the phone or the drone, variance in the sensor readings due to environmental conditions, vandalization). To be able to assure a safe and comfortable walk even when the drone is out of use for any reason, a social network of trusted friends will be integrated in the app. User can choose to notify her/his nearby friends to have them manually track the user.

3 EXPERIMENTAL PLAN

System evaluation will be based on the completion of the drones primary objective in 3 different scenarios.

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3.1 Primary Objective Definition

The primary objective is defined as the drone, in an automated manner, successfully deploys upon request, positions itself within the goal cylinder, and tracks the user until either the user sends the dismiss command or the drones energy supply is depleted. A successful rapid deployment is defined by the drone taking no longer than the expected travel time to the location plus the average time to target lock with a tolerance of 10%. The goal cylinder is defined as a right circular cylinder described by the location of the user where the users longitudinal axis defines the cylinders central vertical axis. The goal cylinder consists of 3 parameters, the radius from the user, the maximum altitude bound, and minimum altitude bound. The three scenarios we consider are described in sections 3.2, 3.3, and 3.4.

3.2 Static Target Scenario

In the static target scenario, we consider the unmoving user standing at a distance of 100 meters from the point of deployment. Both the user and deployment point are at approximately the same elevation. There are no obstacles within the shortest path between the drone and the user. In this scenario, the goal cylinder is defined by a radius of 1.85 meters, a maximum bound of 8 meters and minimum bound of 6 meters. This is our minimum baseline and the first among our initial high level goals. We evaluate the drones performance based on its successful completion of the primary objective as defined in section 3.1 and the drones ability to maintain its position for up to 60 seconds.

3.3 Low Velocity Dynamic Target Scenario

In the low velocity dynamic target scenario, we consider the moving user at an average adult walking pace of approximately 5.0 kilometers per hour. Initial conditions are similar to the static scenario in that altitude is approximately the same upon deployment and there are no obstacles between the user and the drone. We define the goal cylinder to have a radius of 2 meters, a maximum bound of 9 meters and minimum of 6 meters. A successful execution of this scenario requires completion of the primary objective, in addition to the following. The drone must track the target continuously for a minimum of 60 seconds while the target starts and stops moving and takes a minimum of eight 90 degree turns, with at least two left turns and right turns.

3.4 High Velocity Dynamic Target Scenario

In the high velocity dynamic target scenario, we consider the moving user at an average adult running pace of approximately 16 kilometers per hour. Initial conditions are again similar to scenarios 3.2 and 3.3, however the user may be in movement at the time of deployment. In this scenario, we define the goal cylinder to have a radius of 2.5 meters, a maximum bound of 10 meters and a minimum bound of 6 meters. In addition to the primary objective, the drone must track the target continuously from the time of initial target lock for 60 seconds. The users path shall contain no less than four 90 degree turns consisting of at least one left and right turn.

3.5 Target Metrics

During the three testing scenarios, we will use a custom scoring rubric out of 80 points defined as follows.

(1) One point for each second that the drone maintains target lock within the goal cylinder, up to sixty points.
(2) Ten points for a successful rapid deployment.
(3) Ten points for a successful deployment termination, which is defined as returning to the point of deployment when its primary objective is complete.

3.6 Midterm and Final Demonstration

The goal for the midterm demonstration will be to have the drone successfully complete scenario 3.1 with a perfect score based on our previous rubric. The goal for our final presentation will be successful execution of all three scenarios with a minimum score of seventy points.

4 RELATED WORKS

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5 LOGISTICS

The Safe Swarm team consists of Heather Kemp, Theo Linnemann, and Yusuf Sermet. To realize the proposed application, a smartphone with Android Nougat operating system, and a Wi-Fi enabled drone with a high-resolution camera is required. Both devices needs to be equipped with a GPS sensor. For testing purposes, Google Nexus 7 smartphone and DJI Mavic Pro drone is planned to be used. In addition to the fact that each team member will work on the development and deployment, Heather will be responsible for networking, Theo will be responsible for setting up the application, and Yusuf will be responsible for the drone. This project will allow us learn in-depth how a sensor-focused Android application that integrates Internet of Things (IoT) devices can be developed. Having a real-life use case will likely to present many obstacles and errors which will result in a valuable experience.