Exploring the Use of a Drone to Guide Blind Runners

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ABSTRACT

People with visual impairments have a hard time getting consistent physical exercise, as they can not do some exercises, such as running outside, without a sighted guide. People with visual impairments have been shown to have higher spatial localization skills than sighted people, which lead us to believe that they could follow a drone on a running-track environment. This paper presents a feasibility study where we investigate the ability to localize and follow a low-cost flying drone in people with visual impairments. A Wizard of Oz style study was conducted with 2 blind participants. Our results indicate that blind individuals can accurately localize the drone and follow it. Qualitative results also indicate that the participants were comfortable with following the drone and had high efficacy when it came to following and localizing the drone. The study supports future development of a fully functioning prototype.

Keywords

Exercise; Obesity; Health disparities; Drones; Running;

1. INTRODUCTION

Obesity has become one of the biggest drivers of preventable chronic diseases and health care costs in the United States. The problem is of a higher significance on people with visual impairments due to their fewer opportunities to be physically active. Even with the few options available to the visually impaired, they require a sighted guide for such options to be accessible [5]. Our project aims to explore the usage of low-cost unmanned aerial vehicles (drones) as autonomous guides for individuals with visual impairments. Drones can maintain a speed that is fast enough to keep up with a runner, and can ignore uneven ground surfaces. This paper describes a pilot study where we evaluate the feasibility of using a consumer-level drone as a guide in a track-like situation. In our design, the drone flies ahead of the blind individual, who follows it using the sound of the rotors. We test how accurately blind individuals can localize the drone, try to determine the optimal distance to keep the drone for the most accurate localization, and see how accurately blind individuals can follow the drone.

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Figure 1: Our project explores the use of a low cost quadrotor drone as a substitute for a sighted guide.

2. RELATED WORK

Past research has explored the assistive capabilities of robots for the visually impaired. Most of this research has involved slow, grounded robots that are attached to the user with a leash. Mori and Kotani [6] created a robotic travel aid that was mounted onto a wheelchair using a camera and sonar for collision detection and a GPS for localization. Kulyukin [4] created a guide robot for indoor environments that used radio frequency identifier (RFID) tags to localize the robot. Some non-robotic research into helping blind athletes has also been done. Several studies have explored electromagnetic walls where two transmitting units are positioned to create 2 walls of detectable radiation patterns on either side of the user, forming a corridor between the walls [7, 2].

Utilizing drones as running companions have been demonstrated via Joggobot [3], but it was meant for sighted runners. For blind users, Avila et. al conducted a few small experiments where a blind participant followed a drone piloted by the experimenters [1].

3. EXPERIMENT

Our primary goals for this experiment were to determine whether further development on a guide drone for blind athletes was worthwhile by evaluating three main questions. First, can people with visual impairments accurately localize and orient towards a drone using only the sound of its rotors? Second, can people with visual impairments accurately follow a drone and stay within a running-track width lane? Third, will people with visual impairments trust the drone and feel that they are accurately tracking and following the drone?

We recruited 2 blind participants (males, 35 and 36 years old), one of whom was legally blind. Each subject participated in two tasks: a localization task and a navigation task. The goal of the localization task was to test the participants ability to accurately locate a drone using the sound of its rotors. Participants were asked to estimate the location of the drone after it was flown to 10 predefined locations organized in 2 semicircles of radii 3 and 4 meters, respectively. Participants wore a video recording helmet from which their estimation accuracy was determined. The goal of the navigation task was to test the participants ability to to walk in a straight line by following the sound of the drone's rotors. Participants were asked to walk in a straight line within a track of 12.6 meters long and 1.22 meters wide in two conditions: one without drone guidance and another with drone guidance. In the latter, the drone was distanced at 3 meters from the participant. Participants were asked to walk at any speed that they felt comfortable with, and they were told that the track was simply a straight line with no obstacles. All participants were asked to perform the task without their cane. Participants continued to wear the video recording helmet for their safety and to video record the trials for our reference. Two experimenters, one on each side, walked next to the participant to ensure his safety. Each participant performed a total of 10 trials, 5 for each condition. A stopwatch was used to record the overall trial time and the amount of time the participant spends outside the walking lane. The order of two the conditions was counterbalanced among participants with the first participant assigned to the With-Drone condition. The Bebop drone [1] and the Contour Roam 3 [2] camcorder were used in this experiment. When both tasks were completed, participants were asked to fill a post-experiment questionnaire to provide demographic information in addition to their qualitative feedback.

4. RESULTS

For the localization task, results show that the drone was never far from the center of the camera frame for any of the trials, indicating that blind individuals can accurately localize the drone from the sound of its rotors. We found no difference between the data for locations at 3 meters and 4 meters. For the navigation task, we divided the error time by the total time for each participant for both conditions and Table 1 shows the results. For the post-experiment questionnaire, both participants had relatively similar responses. Both felt extremely confident that they were able to accurately localize the drone, that the sound of the drone was sufficient for localization, and that they were able to accurately follow the drone. They both felt relatively comfortable following the drone and were mostly confident that they were walking in a straight line with assistance from the drone. However, they were uncertain about their ability to follow the drone while running, and uncertain about the role that drones might play in assisting them with their own physical activity.

Condition	Participant 1	Participant 2
With Drone	10%	0%
Without Drone	28.51%	2.86%

Table 1: Average percentage of time that participants 1 and 2 were out of the lane for the conditions with drone and without drone

5. CONCLUSION AND FUTURE WORK

We acknowledge that this experiment had several limitations that we plan to overcome in future studies. We mention the major ones here for brevity. The study was performed in an indoor space that had no windows opened, resulting in a high level of echo that amplified the drone's sound cues. We ran our experiments in a walking track of 12.6 meters long which we believe was too short to reliably measure blind people's ability to maintain walking in a straight line. While performing the navigation experiment with the second participant in the condition without the drone, we noticed that the participant was able to maintain walking in a straight line almost perfectly and were able to predict the end of the track. Because the experimenters were walking next to the participant on both sides, we suspect that the participant could have used their walking steps as sound cues to help him stay on track. Our experiments were conducted with only 2 participants which is not sufficient to perform effective statistical analysis and arrive at reliable conclusions. Each participant covered a total distance of 126 meters at the navigation task, which we believe is too short compared to the relatively few participants that we were able to recruit. Both experiments tasks were carried out in a Wizard-of-Oz style where one of the experimenters controlled the drone manually, which may have introduced some inaccuracies to the experimentation procedure.

Future work will involve a working prototype with a low-cost drone, such as the Parrot AR.Drone 2.0[3]. The AR drone has built-in tag detection that can determine the distance from it to a specific tag that could be worn on a participant's shirt. It also has a downward facing camera, which with computer vision techniques could be used to automatically orient and move along the lines of a normal running track. Ideally, this would be done with an Android application that could be run on the user's phone, and physical feedback via vibration on the phone could be explored as an additional channel of feedback. We also will do user studies to determine how blind users feel about following the drone at a running pace.

6. ACKNOWLEDGMENTS

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[1]http://www.parrot.com/products/bebopdrone/

[2]http://contour.com/cameras/roam3

[3]http://www.parrot.com/usa/products/ardrone-2/