Utilizing the Google Project Tango Tablet Development Kit and the Unity Engine for Image and Infrared Data-Based Obstacle Detection for the Visually Impaired

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Abstract: A novel image and infrared data-based application to assist visually impaired (VI) users in detecting and avoiding obstacles in their path while independently navigating indoors is proposed. The application will be developed for the recently introduced Google Project Tango Tablet Development Kit equipped with a powerful graphics processor and several sensors which allow it to track its motion and orientation in 3D space in real-time. It will exploit the inbuilt functionalities of the Unity engine in the Tango SDK to create a 3D reconstruction of the surrounding environment and to detect obstacles. The user will be provided with audio feedback consisting of obstacle warnings and navigation instructions for avoiding the detected obstacles. Our motivation is to increase the autonomy of VI users by providing them with a real-time mobile stand-alone application on a cutting-edge device, utilizing its inbuilt functions, which allows them to micro-navigate independently in possibly unfamiliar indoor surroundings.

Keywords: Obstacle detection, obstacle avoidance, Unity, Project Tango, blind, visually impaired.

1. Introduction

One of the major challenges faced by visually impaired (VI) individuals during navigation is detecting and avoiding obstacles or drop-offs in their path. RGB image and infrared data-based systems have emerged as some of the most promising solutions for addressing this issue; however, currently such systems fall short in terms of accurately localizing the user and providing real-time feedback about obstacles in his path.

The Project Tango Tablet Development Kit [1], recently introduced by Google Inc., is an Android device, equipped with a powerful graphics processor (NVIDIA Tegra K1 with 192 CUDA cores) and several sensors (motion tracking camera, 3D depth sensor, accelerometer, ambient light sensor, barometer, compass, GPS, gyroscope), which allow it not only to track its own movement and orientation through 3D space in real time using computer vision techniques but also enable it to remember areas that it has travelled through and localize the user within those areas to up to an accuracy of within a few centimeters. Its integrated infra-red based depth sensors also allow it to measure the distance from the device to objects in the real world providing depth data about the objects in the form of point clouds. The depth sensors and the visual sensors are synchronized, facilitating the integration of the data from these two modalities.

Our project aims to utilize the Project Tango tablet to develop a system to assist VI users in detecting and avoiding obstacles in their path during navigation in an indoors environment. The system will exploit the inbuilt functionalities of the Unity engine in the Project Tango SDK to create a 3D reconstruction of the surrounding environment and to detect obstacles in real-time. The user will be provided with audio feedback consisting of obstacle warnings and navigation instructions for avoiding the detected obstacles. Our motivation is to increase the autonomy of VI users by providing them with a real-time mobile assistive stand-alone application on a cutting-edge device, utilizing its inbuilt functions, which allows them to micro-navigate independently in possibly unfamiliar indoor surroundings.

The rest of the paper is organized as follows: Section 2 provides a brief overview of existing image and infrared data-based obstacle detection and avoidance systems for the VI. Section 3 describes the application and outlines the plan for its development and evaluation. Section 4 concludes the paper.

2. Related work

Newly emerging sensor technologies, such as Microsoft’s Kinect, Occipital’s Structure Sensor, and, most recently, Google’s Project Tango Tablet Development Kit [1], are making it possible to exploit infrared light to extract 3D information about the environment without the need to install any equipment in the surroundings. Recent development work on obstacle detection for the VI has specially focused on Kinect, either utilizing the data from its depth sensor alone or from both its RGB and depth sensors. However, since Kinect is not designed to be a wearable or handheld device, affixing it to the body or clothing results in bulky and aesthetically unappealing contraptions; furthermore, the Kinect sensor needs to be connected to a
backend server making systems based on it vulnerable to communication and speed performance issues. The Project Tango tablet appears to have a distinct advantage over Kinect in that it is an aesthetically appealing, handheld, mobile device equipped with a powerful processor enabling it to execute computationally intensive code in real-time without the need to connect to a backend server. Moreover, it has several additional embedded sensors and in-built functionalities, which can be utilized for extending and improving the obstacle detection application in the future. A few preliminary applications for the Tango tablet have already been proposed for obstacle detection and avoidance for the VI: The system presented by Anderson [2] collects depth information about the environment, saves it in a chunk-based voxel representation, and generates 3D audio for sonification which is relayed to the VI user via headphones to alert him to the presence of obstacles. Wang et al. [3] cluster depth readings of the immediate physical space around the users into different sectors and then analyze the relative and absolute depth of different sectors to establish thresholds to differentiate among obstacles, walls and corners, and ascending and descending staircases. Users are given navigation directions and information about objects using Android’s text-to-speech feature. However, both these applications need further development and are yet to be tested with the target users [4].

3. Application Development

The application is being developed for Google’s Project Tango Tablet Development Kit which is a 7” Android-based tablet. It will utilize the Project Tango Unity SDK [21] to acquire a 3D reconstruction of the surrounding environment in the form of a mesh which is created and updated in real-time. A character object in the 3D reconstruction will represent the user’s position in the real world. Obstacle warnings will be issued if the distance between the character object and any object in the 3D reconstruction becomes less than a certain threshold (initially, this will be set to 0.5 meters; however, this value may be modified or a user-controlled customization option may be provided based on the results of our interviews with the target users).

Feedback to the users will be provided by playing pre-recorded audio files via an open-ear bone conduction Bluetooth headset. The feedback will include warnings about approaching obstacles - potentially including some details about their sizes and their positions relative to the user - and navigation instructions to avoid the obstacles (bear right, bear left, etc.). For users with some residual vision, a visual display option may also be provided in addition to the audio output.

Adopting a user-centered design approach, we are planning to conduct semi-structured interviews with VI individuals in Athens, Georgia, USA in order to gain some insight into their preferences for the user interface of the application and to procure their suggestions for what features should be included. The results of the interviews will inform the design of the system during its development.

Once an initial prototype has been developed, the two main parts of the system - the obstacle detection component and the user interface – will be empirically evaluated. The performance of the obstacle detection component will be tested for obstacles of various sizes at various positions with respect to the user and under different lighting conditions. The user interface will be designed in accordance with the users’ preferences (acquired via the interviews) and will then be evaluated by conducting usability tests with VI users.

A similar system, being developed in parallel for obstacle detection and avoidance for the VI using the Project Tango Tablet Development Kit, was introduced in [4]. However, this system employs a different approach for detecting the obstacles by directly segmenting the point cloud data acquired from the scene. We aim to eventually conduct a comparative evaluation of the proposed system with this one to study any differences in terms of speed, accuracy and general usability.

4. Conclusion

A novel image and infrared data-based application to assist VI users in detecting and avoiding obstacles in their path while independently navigating indoors has been proposed in this paper. The application will utilize the functionalities of the Unity SDK of the Google Project Tango Development Kit to provide an aesthetically acceptable, cost-effective, portable, stand-alone solution for this purpose. A user centered approach would be adopted for the design and development, with semi-structured interviews being conducted with VI users at the initial stages of the development cycle to inform the interface design and usability testing with the target users being carried out at later stages with the initial prototype in order to identify any usability problems and to better adapt the system to the users’ needs.

References

[1]“Google Project Tango (https://www.google.com/atap/project-tango/).”

