Designing a Smartphone-Based Assistance System for Blind People to Recognize Intersections and Obstacles in Indoor Corridors*

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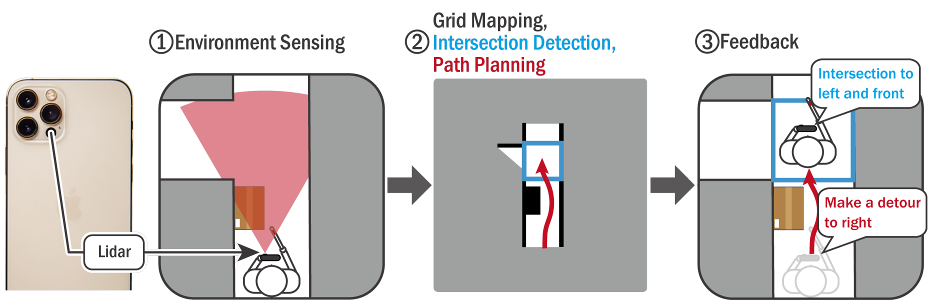

Fig. 1. The overview of our system.

1 Introduction

People with visual impairment face significant difficulties when navigating in indoor corridors. As an indoor corridor may contain obstacles (*e.g.*, boxes, chairs), blind people need to be aware of them to avoid accidents. In addition, they also face another challenge when they have to turn in an intersection. Detecting an intersection may be challenging for blind people, as they may not notice its existence even if they are in it. For example, when an obstacle is in front of an intersection, blind people may walk past it as they cannot walk along the wall. Therefore, We aim to navigate blind people safely in an indoor corridor using only one smartphone by assisting them to avoid obstacles and detect intersections.

To detect intersections in indoor corridors, Garcia *et al.*proposed to use a quadcopter to capture RGB images and perform the detection using a convolution neural network. As photos taken by blind people may contain motion

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blur [11], their method may not have robust detection results when applied to people with visual impairment. Therefore, we present a robust method to detect upcoming intersections for blind people. As for obstacle avoidance, previous research used wearable devices [5, 2] and robots [7, 8]. Since such systems require blind people to carry heavy devices [3, 4] and have expensive operation cost [3, 4, 6], smartphones, which are widely used by blind people [9], can be considered as an alternative solution. This paper aims to utilize a single iPhone 12 Pro to assist blind people with these two tasks.

2 System Overview

We propose a smartphone-based navigation system for blind people to detect intersections and avoid obstacles in an indoor corridor safely. The system first utilizes the built-in Lidar sensor to acquire a point cloud of the surrounding environment, containing the 3D-position and the normal vector for each point. Based on each point's position and normal vector, the system distinguishes each point between floor and obstacle and constructs a grid map. Figure 1–2 illustrates an example of the grid map. Each cell in the grid map is classified as either obstacle (black cells), floor (white cells), or not occupied (gray cells).

Intersection detection. The system detects an upcoming intersection using the YOLOv3 [10] detector. To avoid motion blur of RGB images, we instead use the image of the grid map as the input of the detector. For training, we constructed a data set by gathering the images of the grid maps and by annotating them. When the detector first detects an intersection, the system will vibrate to notify the existence of an upcoming intersection. Then, once the user is in the intersection, the system will convey which way the intersection leads to by audio feedback (*e.g.*, *"Intersection to left and front."* [Figure 1–3]).

Obstacle avoidance. The system performs path planning so that the user can avoid obstacles. First, the system sets the path planning destination to a point in the middle of the corridor 3.5 meters away. Then the system plans an obstacle-avoiding path using the A* path planning algorithm [12]. When the user is following the generated path, the system will remain silent. The system will provide spatialized audio feedback via a bone-conducting headset when the user is veering from the path. The user is required to point the smartphone to the orientation in which it does not give any feedback. Also, when the system detects an obstacle, the system will tell the user to make a detour to a specific side to avoid collision (*e.g.*, *"Make a detour to the right"* [Figure 1–3]).

3 Conclusion and Future Work

In this paper, we present a system to assist blind people to detect intersections while avoiding obstacles using only one smartphone. For future work, we plan to conduct a user study to evaluate the validity of the system.

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