INTRODUCTION

This work introduces a wearable system to provide situational awareness for blind and visually impaired people. The system includes a camera, an embedded computer and a haptic device to provide feedback when an obstacle is detected. The system uses techniques from computer vision and motion planning to identify walkable space, plan step-by-step a safe motion trajectory in the space, and recognize and locate certain types of objects. These descriptions are communicated to the person wearing the device through vibrations. We present results from user studies with low- and high-level tasks, including walking through a maze without collisions, locating a chair, and walking through a crowded environment while avoiding people.

SYSTEM FRAMEWORK

The system includes a depth camera, an embedded computer, a vibration belt for haptic feedback, and a refreshable braille display for scene descriptions. Perception of the environment is achieved through a structured-light depth camera, which provides a point cloud that represents the measured depth of the field of view.

DETECTING OBJECTS

The objects of interest, such as chairs, tables and other furniture, are adjacent to the ground plane. We use pre-trained models for the objects we want to recognize, based on their distinct geometry. The object classes include “chair,” “table,” “stair up,” “stair down,” and “wall”. We can see the wall and chair detection below.

USER STUDIES

The chair-finding task was intended to measure the system’s ability to help a user find a specific target in an environment. In this case, the target was an empty chair, with non-target distractors consisting of an occupied chair or a tall recycling bin. The task serves as a representative example of a general object detection task. Overall times to completion were comparable across conditions, but the user incurred significantly fewer non-target contacts and accidental collisions when using the system, either by itself or together with a cane, compared to using the cane only. Comparing the use of a cane only with the use of the system only suggests that even with relatively little practice, the system is better at facilitating navigation to a target among distractors while reducing contacts.

CONCLUSION

We presented a real-time wearable system, which includes a camera, an embedded computer and a belt with embedded vibration motors that provides vibration feedback to signal obstacles to its users. Using depth information from a camera, the system distinguishes walkable free space from obstacles and can identify a few important types of objects such as the location of a chair. These descriptions of the surroundings are communicated to the person wearing the device and translated into safe navigation directions. Haptic devices provide a high frame rate and low-latency feedback, which is desirable for navigation tasks, including walking through a maze or finding an empty chair. Braille displays offer richer high-level feedback in a discrete way, but with longer reaction times due to sweeping of the fingers on the braille cells. Audio feedback was deemed undesirable given the low refresh rate and long latency, as well as potential obstruction of other sounds, a major source of environmental cues for blind people.

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