Chapter 7
Indoor Navigation Aid Systems for the Blind and Visually Impaired Based on Depth Sensors

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ABSTRACT

This chapter focuses on the contributions made in the development of assistive technologies for the navigation of blind and visually impaired (BVI) individuals. A special interest is placed on vision-based systems that make use of image (RGB) and depth (D) information to assist their indoor navigation. Many commercial RGB-D cameras exist on the market, but for many years the Microsoft Kinect has been used as a tool for research in this field. Therefore, first-hand experience and advances on the use of Kinect for the development of an indoor navigation aid system for BVI individuals is presented. Limitations that can be encountered in building such a system are addressed at length. Finally, an overview of novel avenues of research in indoor navigation for BVI individuals such as integration of computer vision algorithms, deep learning for the classification of objects, and recent developments with stereo depth vision are discussed.

DOI: 10.4018/978-1-7998-6522-3.ch007

INTRODUCTION

The World Health Organization (WHO) reports that globally the number of blind or visually impaired (BVI) individuals amounts to roughly 2.2 billion, of which at least 1 billion are in conditions that could have been prevented or are still pending to be addressed (a.e. uncorrected refractive errors or cataracts). Moreover, with a vast majority of vision impaired individuals being of 50 years or over (World Health Organization 2013). Bourne et al. (2017) provides estimates on how these numbers conditions were for each condition, for instance: 36 million people were blind, 188 million had mild visual impairment, 1,095 million people aged 35 years and older had functional presbyopia, and 667 million of those were 50 years of age or older. Blindness and visual impairment are growing problems that go side-by-side with an increasing aging world population (He, Goodkind, and Kowal 2016). Estimates suggest that by 2050 the total population will amount to 9.7 billion with almost 22% having a form of visual impairment (Ackland, Resnikoff, and Bourne 2017).

In a review from Köberlein et al. (2013), the authors set to calculate the economic burden (per person) of treating a BVI individual, they achieve this by doing a systematic analysis of publications on the subject. Results suggested that the direct cost were attributed to the hospitalization and medical services used for diagnosis and treatment; and most indirect cost were attributed to the use of caregivers (often pay by the hour). Noteworthy, to mention that both costs were increasing proportionally with the degree of visual impairment.

Traditionally the most popular methods to assist the visually impaired people are the use canes and guide dogs. However today there are several technologies that can be used to provide information about the environment and assist their navigation. These technologies are grouped under the umbrella term *assistive technologies* (AT), which can represent any software system or hardware device that is used to maintain or improve the functionality and promote the general well-being of an individual by augmenting or enhancing their possibilities due to a disability (World Health Organization 2018; Cook and Polgar 2014).

Research in assistive technologies for BVI is a very open and dynamic. Contributions and new developments come often from the engineering, computational (software) and electronic (hardware) fields. The main objective of this field is to provide technologies to bring comfort to the individual in their daily lives, assessing their own limitation and enhancing their re-entrance to normal life (Cook and Polgar 2014; Assistive Technology Industry Association 2020).

For instance, assistive technologies for BVI encompasses different aspects of the daily life of an individual. Tasks include the continuous monitoring of the progress of the condition, also attention is given to mobility and navigation issues, legislation on the adequation of the environments (a.e. appropriate buildings access), but also information retrieval and presentation (including digital and traditional braille readers, and digital enhancements to normal monitors), adaptation of devices to daily life activities (a.e. adaptation to the use of kitchen utensils) and enhancement of human-human interaction (Hersh and Johnson 2010).

The field of assistive technologies for BVI is very broad, however, our main objective in this document is to review general ideas and implementations on the subject of navigation aid systems for the BVI, first focusing on generals research ideas found in literature and then presenting results from an indoor navigation aid system based on Microsoft Kinect depth sensors.

The structure of this document is as follows: in Section 2, background information about assistive technologies for BVI, describing the most used technologies and examples of aids developed are given.