Chapter 1
RFID and Dead-Reckoning-Based Indoor Navigation for Visually Impaired Pedestrians

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ABSTRACT

This chapter presents an indoor navigation solution for visually impaired pedestrians, which employs a combination of a radio frequency identification (RFID) tag array and dead-reckoning to achieve positioning and localisation. This form of positioning aims to reduce the deployment cost and complexity of pure RFID array implementations. This is a smartphone-based navigation system that leverages the new advancements of smartphone hardware to achieve large data handling and fast pathfinding. Users interact with the system through speech recognition and synthesis. This approach allows the system to be accessible to the masses due to the ubiquity of smartphones today. Uninformed pathfinding algorithms are implemented onto this system based on our previous study on the implementation suitability of uninformed searches. Testing results showed that this navigation system is suitable for use for the visually impaired pedestrians; and the pathfinding algorithms performed consistently according to our algorithm proposals.

INTRODUCTION

Pedestrians who are visually impaired face numerous challenges whenever they are required to step out of their dwellings to move to another location. Assistive technologies exist to alleviate the mobility challenges faced by visually impaired pedestrians by utilising modern electronic innovations to guide the visually impaired user. With the advent of ubiquitous mobile and wireless technologies, there is a growing demand for assistive technologies from the visually impaired community. This is especially true whereby automotive navigation systems, along with many mainstream and modern pedestrian naviga-

tion systems implemented (e.g. on wearable technologies and smartphones) are evidently designed and developed for the sighted pedestrian, with little or no regard for the visually impaired. This, along with and other challenges faced in the mobility of the visually impaired is highlighted in (Williams, Hurst, & Kane, 2013), with extensive reviews and case studies. These reviews include those of assistive mobility aids for the visually impaired, where case studies are conducted by interviewing a selected group of visually impaired pedestrians across the United States. The authors queried the participants regarding their usage of smartphone-based assistive technologies and gathered that only 13% of the users do not use assistive navigation technologies. There is, therefore, a clear demand for assistive technologies.

According to (Dakopoulos & Bourbakis, 2010), navigation assistive technologies provides a form of visual substitution for the visually impaired. It can be categorised into three types of devices/aids:

1. Electronic travel aids (ETAs) for mobility and displacement,
2. Electronic orientation aids (EOAs) for orientation and bearings, and
3. Position locator devices (PLDs) for positioning and localisation.

The ETA is usually the main component in a navigation system for these pedestrians, and it is typically connected to an EOA and a PLD (aka ETA system). The ETA handles more vital processes for the system, which includes pathfinding computation and user guidance, among others. This chapter emphasises on pathfinding algorithms and their roles in ETA systems for blind pedestrians. An ETA system, like other pedestrian navigation systems, follows the process in Figure 1 to function.

ETAs remain an area of popular research interest, the growing smartphone adaptation rate, along with the ubiquity of navigation systems, catalysed the need of ETA systems for the visually impaired. These days, the processing capabilities of smartphones are improving immensely, with octa-core processors finding a commonplace within new smartphone launches. Hence, many current works on ETA systems proposed are smartphone-based (Au et al., 2013; Guy & Truong, 2012; Kamiński & Bruniecki, 2012; Uddin & Suny, 2015), where they are versatilely used to provide route calculation, speech input via speech-to-text, and speech output via text-to-speech, which is used in guidance (Ceipidor, Medaglia, & Sciarretta, 2010; Uddin & Suny, 2015). Alternative methods to guidance may involve external devices, such as a haptic device (Ando, Tsukahara, Seki, & Fujie, 2012; Todd, Mallya, Majeed, Rojas, & Naylor, 2014). ETA Route calculation (pathfinding) requires that the smartphone communicates with PLDs and EOAs such as a GPS receiver and a compass to localise and position the user before it can commence, as

Figure 1. Process of navigation in an ETA, texts on arrows depict the procedure for navigation
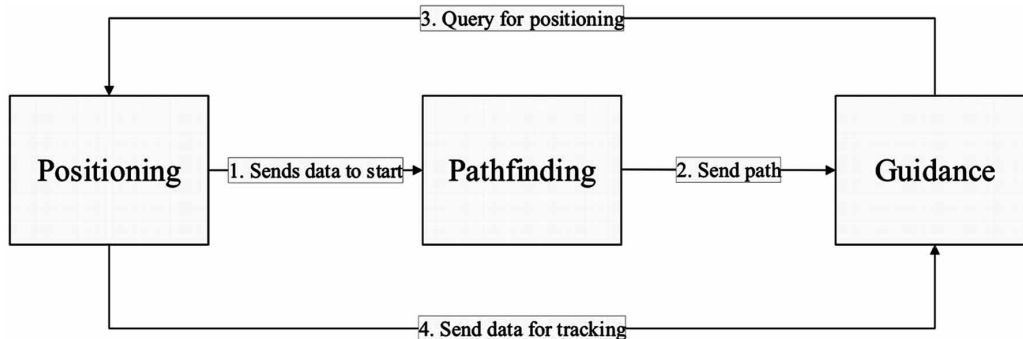
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