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시각장애인을 위한 이동보조시스템의 장애물 감지 특징 조사+

(Survey on Obstacle Detection Features of Smart Technologies to Help Visually Impaired People Walk)

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(Seonghee Min and Yoosoo Oh)

요 약 본 논문에서는 시각장애인을 위한 이동보조시스템을 비교 분석하고, 6개의 장애물 감지 특징을 정리한다. 전통적으로, 시각장애인은 흰 지팡이를 사용하거나 안내견과 함께 보행한다. 최근 IoT 기술의 발달로 시각장애인의 보행을 보조하는 스마트 이동보조시스템이 개발되었다. 이러한 스마트 이동보조시스템은 장애물을 감지하고, 경로를 안내하는 역할을 수행해야 한다. 특히 스마트 이동보조시스템은 장애물인지 판단하고, 햅틱 피드백을 통해 장애물 정보를 제공한다. 그리고 스마트 시스템은 서버를 구성하여 장애물의 정보를 저장하고, 다른 사용자에게 정보를 공유한다. 또한 저장된 장애물 정보를 통해 사용자 중심의 최적의 경로를 생성하여 시각장애인에게 장애물을 회피할 수 있는 경로를 안내한다. 스마트 이동보조시스템은 기계학습과 인공지능 기술을 적용함으로써 더욱 빠르게 발전할 것이다.

핵심주제어: 스마트이동보조시스템, 장애물감지시스템, 사용자 중심의 최적 경로, 장애물 정보, IoT시스템

Abstract In this paper, we compare and analyze smart technologies and present six obstacle detection features to help visually impaired people walk. Traditionally, visually impaired people walk with the white cane or a guide dog. With the development of IoT technology, various smart walking aids systems have been developed. Those intelligent walking aids systems have obstacle-detecting systems and route-guidance systems. Many researchers are developing the walking aids system, which detects an obstacle and provides the obstacle information by haptic feedback. Also, they are designing the database server system to share the obstacle information. Particularly the composed system can quickly give an obstacle-avoidance route using shared obstacle information. Smart walking aids systems for visually impaired people will advance more rapidly by applying machine learning and intelligent systems.

Keywords: Smart walking aids system, Obstacle detecting system, User-centered optimal route, Obstacle information, IoT system

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1. Introduction

Visually impaired people identify peripheral obstacles or geographic changes using a white cane or a guide dog. They widely use the white cane for their walk. However, visually impaired people need professional education on touch techniques to use it. Moreover, they must get used to the white cane through adequate practice (Chung In Wook Human Service Foundation, 2014). It is still difficult for visually impaired people to walk alone. For example, according to the disabled real-condition investigation in Korea (Korea Institute for Health and Social Affairs, 2014), 44.8% of visually impaired people surveyed answered that problems outside the home were inconvenient (very inconvenient 20.5%; little difficulty 24.3%). Notably, the reasons for their answers included an absence of convenient facilities (40.6%), and lack of guardians when going out (50.5%). Walking is necessary for visually impaired people because only 26.9% report having use of a car.

The World Health Organization (2017) counted 285 million visually impaired people in the world in August 2014, and it is gradually increasing.

As the economy grows, there is a growing movement to enhance their quality of life and welfare. However, they still lack convenience facilities or walking aids systems for safe walking. In 1990, the United States enacted the Americans with Disabilities Act (ADA). Each country (e.g., United Kingdom, Australia, Sweden, etc.) has independently passed the Anti-Discrimination Act, which was expected to eliminate the public's prejudice against visually impaired people. These activities helped them to improve their life.

Therefore, in this paper, we look into walking aids systems for visually impaired people. The walking aid system for visually impaired people is a form of detection and guidance of obstacles. We survey and analyze our developed system for them (Ko et al., 2014; Ko et al., 2015; Min et al., 2015; Lee and Oh, 2016; Min and Oh, 2016; Min and Oh, 2017a; Min and Oh, 2017b; Lee and Oh, 2017). Also, we summarize six features for detection obstacles based on the survey. Six features are the form of obstacle detection device, the method of obstacle detection, the feedback of obstacle information, the obstacle map, the obstacle guidance system, and the obstacle evaluation method. Lastly, we describe how to develop smart aids systems in intelligent system environments.

2. Background

In this chapter, we analyze various existing smart walking aids systems for the visually impaired. Table 1 is analyzing the existing smart walking aids system. We chose existing research activities related to obstacle-detecting systems and route-guidance systems for visually impaired people for our strategy. Obstacle-detecting systems replace the white cane. So, if visually impaired people use this system, the users can know external obstacles without knocking or dragging the ground with a cane. It detects obstacles around the user with an ultrasonic sensor or vision recognition technology, using a camera.

The ultrasonic sensor can detect obstacles at night, but it only knows presence or absence. The vision recognition technology using a camera recognizes kinds of obstacles. However, it is challenging to detect obstacles at night.

The route guidance system for visually impaired people is similar to navigation. This system guides the path to the destination using an easily understood word. It uses RFID, GPS, or camera to know the current location of the user.

The system using GPS in a smartphone application was recently developed. The system in indoor environments tracks the user's location, using RFID or Bluetooth, because it is challenging to know the location of the user through GPS.

Table 1 Existing Smart Walking Aids Systems

The system	Output method	Method detecting location of user	Method detecting obstacles	Remarks
The PERCEPT (Tsirmpas et al., 2014)	Voice	RFID	Ultrasonic sensor	Route guidance in indoor by minimap
The SmartWand (Kim, 2007)	Vibration		Ultrasonic sensor	The color of things, ambient light
The walking guidance system by tactile display (Yoon et al., 2007)	Haptic feedback		Ultrasonic sensor	3D obstacle information
The human action recognition system (Ko et al., 2015)	Voice		Camera	Human action information
Hahn's study (Hanh et al., 2010)	Voice(HRTF)		Camera	
The walking assistant device (Kim et al., 2008)	Voice, Vibration	GPS	PSD sensor	
The M2M based intelligent walking assistance system (Kang et al., 2011)	Voice, Vibration	GPS	Ultrasonic sensor	Dangerous situations information
The haptic sight (Yang, 2012)	Haptic feedback	RFID, Activity marker		Minimap of building
The indoor localization and guidance system (Bae, 2016)	Voice	Beacon		Route guidance indoor by beacon
The smart cane navigator (Kim and Seo, 2015)	Voice	GPS	Ultrasonic sensor	Route guidance outdoor
The smart guiding glasses (Bai et al., 2017)	Voice	Image	Camera	Route guidance indoor by AR Rendering
The wearable smart system (Ramadhan, 2018)	Buzzer, Vibration	GPS, Cellular Communication	Ultrasonic sensor	The form of wrist band

3. Features for Obstacle Detection

In this chapter, we summarize six features of the smart aids system for visually impaired people to detect obstacles.

3.1 The Form of Obstacle Detection Device

When we consider a smart walking aids system design, we could adopt a form of a white cane. Traditionally, visually impaired people walk with the white cane. The white cane, a symbol of them, is used to detect obstacles. Moreover, it is inexpensive. Primarily, people feel that unfamiliar equipment is unnatural to use instead of the familiar white cane. Therefore, the smart system should adopt this form of a rod by reducing rejection from the new system (Ko et al., 2014).

3.2 The Method of Obstacle Detection

The smart aids system should use a distant sensor and camera to detect obstacles. The system also provides various types of information with the presence, location, size, or description of an obstacle to the user. The related sensors are attached to the system to detect obstacles around the user. In recent years, with the development of deep learning, it has become easier to identify the type of obstacle through the camera. Depending on the device's performance, it is possible to classify the type of obstacle without going through the server (Ko et al., 2015; Lee and Oh, 2016).

3.3 The Feedback of Obstacle Information

Providing obstacle information to the user in voice form is not appropriate because the visually impaired person recognizes the surrounding environment by sound. Therefore, data on obstacles should be provided to the user through tactile feedback. The actuators providing the tactile feedback are vibrators or haptic devices. Notably, the vibrator is a valid actuator because it is simple to implement and inexpensive. However, it is challenging to present the direction of the obstacle when the vibration spreads throughout the system. So, the obstacle-detecting system should provide obstacle information using the haptic device. The haptic feedback cane can detect obstacles and guide to the location of barriers, using the ultrasonic sensor, the haptic feedback equipment, and the vibrator (Min et al., 2015).

3.4 The Obstacle Map

Visually impaired people can walk more safely if a system guides the user-centered walking route. Therefore, we should gather obstacle information obtained from the smart system and save it in the database. Also, the information can be presented on a map. If new obstacle information appears in the obstacle database, the obstacle database updates the obstacle information. This process is essential because the obstacle information acquired in the smart walking aids system changes quickly. Moreover, the reliability of obstacle information should be high to prevent wrong guiding information for a user. If the obstacle information is clustered and stored, the loading speed can be improved (Min and Oh, 2016).

3.5 The Obstacle Guidance System

The obstacle guidance system consists of the server, the smart cane device, and the smartphone app. The server creates the obstacle map based on obstacle information acquired in the smart walking aids system. The data stored in the obstacle map is big data because it is all obstacle information currently on the road nationwide. Therefore, a server is needed to manage this data efficiently. The system generates the route, integrating the general walking route to the destination and the obstacle avoidance path when the user inputs the destination. This system provides both obstacle information and walking routes to help visually impaired people walk safely. Fundamentally it generates a user-centered walking route, unlike existing navigation. Because it consistently learns obstacles in walking paths and then makes guidance for the safe walking route. Besides these kinds of guiding methods, a system can regulate the direction by using braille or vibration (Min and Oh, 2017a; Min and Oh, 2017b).

3.6 The Obstacle Evaluation Method

The obstacle-evaluation method can be applied to a customized route-guidance system to induce safe walking for the visually impaired. This method identifies the surrounding obstacles by utilizing a wearable device designed for the visually impaired. It consists of regional obstacle classification, peripheral obstacle detection using the wearable device, and classified obstacle determination. The local obstacle classification categorizes obstacles in advance by region, to select the barriers around the current movement route of visually impaired people. The peripheral obstacle detection is the process of recognizing obstacles by the sensed data (obstacle location, direction, and size) using wearable devices. The classified obstacle determination acquires the classified obstacles from the database and compares them with the currently recognized barriers. The obstacle database manages the classified constraints in the form of an obstacle DataFrame (Pandas data type) of the ontology model (Lee and Oh, 2017).

4. Discussion

Smart walking aids systems for visually impaired people have been rapidly growing, combined with IoT technology. The IoT technology can communicate with an object by establishing a network environment. Gartner (2019) expected that the IoT market will grow every year, and the proportion of healthcare providers will be increased. The IoT technology for visually impaired people provides healthcare services by analyzing data not only inside the body but also outside the body for the user.

To implement IoT technology for visually impaired people, we should efficiently accumulate personal quantified data. A method for analyzing the user from the personal quantified data is expected to develop into essential technologies (Lee and Oh, 2017). A biological sensor can be used to analyze the user's current status by collecting quantified behavior data. For example, a wearable device for visually impaired people can guide a user-centered route by collecting both obstacle data around the user and biological data of the user.

It is essential to discuss how to collect significant data from wearable sensors. In particular, the most central topic is the study of how to extract user characteristics from data. Such characteristics extraction is possible with ontology modeling and inference by using wearable devices. A lifelog-based ontology management technique can provide customized services by extracting user characteristics.

In the future, smart technologies for visually impaired people are expected to evolve into a scenario in real environment. Smart technologies can promote to develop walking aids systems and route-guidance applications. The smart walking aids system can detect a size, kind, and shape of obstacles. The route-guidance application can generate and guide the user-customized optimal route, based on the user's preference. By utilizing the smart systems, visually impaired people can safely walk using the smart system. The following scenario describes the user's life in the case that above smart system are developed.

"Visually impaired John woke up in the morning and checked a new smart walking aids system. It fit well with John's keys and hand grips. Also, it is equipped with IoT technology to control the device in the home. John went home with the smart walking aids system and a smartphone, to go to a bank. Because John has never been to the bank, he ran the route-guidance app on his smartphone. When he set up a destination, the app began to guide the route, including obstacle information from his location to the bank.

Because a general route has a construction site, this system generates a way to consider safety. John's system detected the obstacle that another user found a few minutes ago and registered in the database. The system quickly guides a path to avoid the barriers so that John can walk safely, avoiding an obstacle. At this time, the system informs that the sidewalk is crowded with people in the front, so John selects another route. The system starts to guide the bypass in real-time.

A new obstacle not stored in the database appears. The system saves the obstacle in the database and guides an avoidance route for John to arrive safely at the bank. When John goes back home, he selects the obstacle-guidance mode. Because John knows the path, he does not need the mode. He can go back home safely using the smart walking aids system."

In the future, smart walking aids systems for visually impaired people will be developed more rapidly. Also, smart walking aids systems will be accelerated by applying machine learning and intelligent system. For example, the intelligent walking aids system with machine learning can guide a safe route by analyzing the preferences of the user. It can provide not only an obstacle's presence or absence but also the barrier's kind. It can even predict the user's destination, using the user's semantic information and context without input.

5. Conclusion

In this paper, we compared and analyzed smart technologies and presented six obstacle detection features to help visually impaired people walk. Six functions are the obstacle detection device, the method of obstacle detection, the feedback of obstacle information, the obstacle map, the obstacle guidance system, and the obstacle evaluation method.

Many researchers are developing the walking aids system, which detects an obstacle and provides the obstacle information by haptic feedback. Also, they are designing the database server system to share the obstacle information. Particularly the composed system can quickly give an obstacle-avoidance route using shared obstacle information. Smart walking aids systems for visually impaired people will advance more rapidly by applying machine learning and intelligent systems. In the discussion section, we discussed topics that need to be focused on developing smart aids systems.

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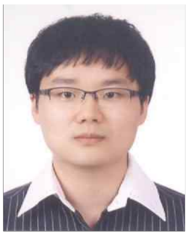

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