DEVELOPMENT OF THE NAVIGATION SYSTEM FOR THE VISUALLY IMPAIRED BY USING OPTICAL BEACONS

Kazushige Magatani[1], Koji Sawa[1], Kenji Yanashima[2]
[1]Department of Electrical Engineering, Tokai University, Kanagawa, Japan
[2]National Rehabilitation Center for The Disabled, Saitama, Japan

Abstract Our objective of this study is the development of the navigation system which is used in the indoor space(eg. underground shopping mall, hospital, etc.) and supports activities of the visually impaired without help of others. This system is composed of optical beacons which are set on the ceiling and emit the position code as infrared signal, an optical receiver which receives signal from beacons, and a navigator which guides a user by artificial voice.

Three subjects with low vision werer tested in the hospital with our navigation system. 49 optical beacons were set on the ceiling, and the subject equipped with an optical receiver and a navigator. Each subject walked from the start point to the destination following the guidance voice. From these experiment, the following characteristics became clear. **1)** On a pathway where a subject can feel the wall, every subjects could follow the navigation voice. **2)** Some subjects couldn't go across the wide pathway straight, and then the system lost their position. Therefore, if the problem of crossing the pathway is improved, our navigation system will be a very valuable one to support activities of the visually impaired.
Keywords- visually impaired, navigation, optical beacons

I. INTRODUCTION

It is possible for the most of visually impaired persons to behave in daily activities by using a white cane. However, if they want to go unknown place, they need the assistance of others. Therefore the navigation system by using GPS which supports the independent activities of the visually impaired is being developed[1][2]. A visually impaired user can get useful information from this navigation system and can walk freely, if GPS works normally. But, this system cannot use in the indoor space, because in these places we cannot receive the information signal from GPS satellites.

Our objective of this study is the development of the navigation system which is used in the indoor space (e.g. underground shopping mall, airport, hospital, etc.) and supports activities of the visually impaired without help of others. This system is composed of optical beacons which are set on the ceiling and emit the position code as infrared signal, an optical receiver which receives and demodulates infrared signal from optical beacons, and a handy personal computer which is called navigator and guides a user by artificial voice. Fig.1 shows the conception of our navigation system by using optical beacons. A visually impaired user of this system carries an optical receiver and a navigator. If an user enter the service area of an optical beacon, the optical receiver receives the area code from optical beacons which are set on the ceiling, and the navigator announce the map information and the route to the destination using pre-recorded voice. Following these navigation, an user can reach the destination.[3][4]

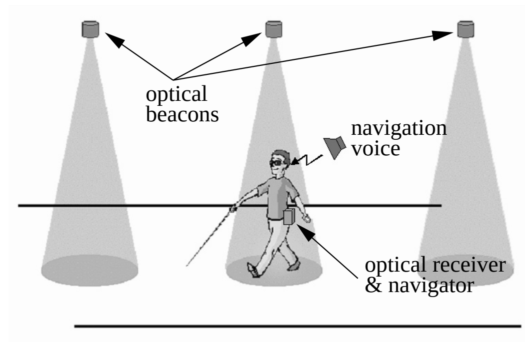

Fig. 1: Conception of the navigation system which uses optical beacons

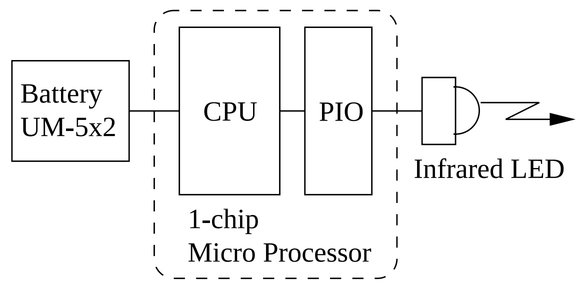

Fig. 2: Block diagram of an optical beacon

II. METHOD

Fig.2 shows the block diagram of an optical beacon. Fig.3 shows the block diagram of a infrared signal receiver and a navigator which are equipped by a visually impaired user. As shown Fig.2, the optical beacon which is composed of an one-chip microprocessor and a infrared LED is very simple and small. The infrared signal which is emitted from the optical beacon is pulse frequency modulated signal (carrier frequency of this signal is 38kHz). This signal includes the information which is composed of start code, 8 bit position code and stop code. The generation of area code and modulation are operated by software. A period of infrared signal is 50ms. Therefore we can receive the area code 20 times a second. The

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
25 Oct 2001	N/A	-

Title and Subtitle Development of The Navigation System for The Visually Impaired by Using Optical Beacons	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Department of Electrical Engineering Tokai University Kanagawa, Japan	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes Papers from 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom.	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 3	

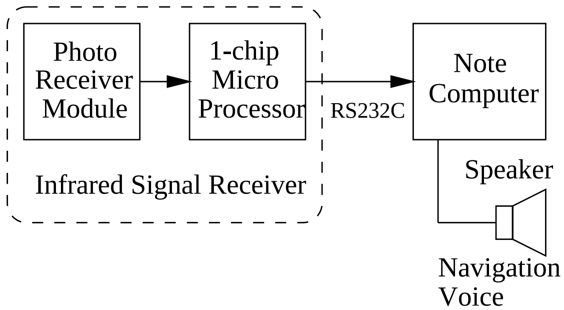

Fig. 3: Block diagram of an optical receiver and a navigator

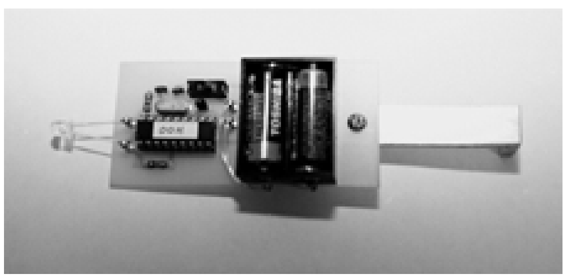

Fig. 4: A picture of an optical beacon

infrared signal receiver receives and demodulates the signal from a beacon, checks up this signal with error, and then sends position code to the handy computer which is called the navigator. The navigator calculates the route to the destination based on the user's position and map information, and then guides a user using pre-recorded voice. This navigator works on the Windows98, and guiding voice is saved in the hard disks as wave formatted files. The communicable maximum distance between an optical beacon and a receiver is about 6m. And this distance is proportional to the power consumption of the beacon. In our default setting, an optical beacon can work for about 3 weeks continuously. Fig.4 shows the picture of an optical beacon.

III. EXPERIMENT

Three subject with low vision were studied in the hospital with our developed navigation system. The round trip route between the entrance of the hospital and the low vision clinic was set, and 49 optical beacons were set on the ceiling along this route. An outline map of the testing field and the arrangement of optical beacons are shown in Fig.5. Subjects equipped with a infrared signal receiver and a navigator. Fig.6 shows a subject who equips with our system. In this picture, an infrared signal receiver and a speaker were set on a belt of the shoulder bag. A handy computer (navigator) was in the shoulder bag.

Each subject walked from the start point to the destination following the guidance voice which was based

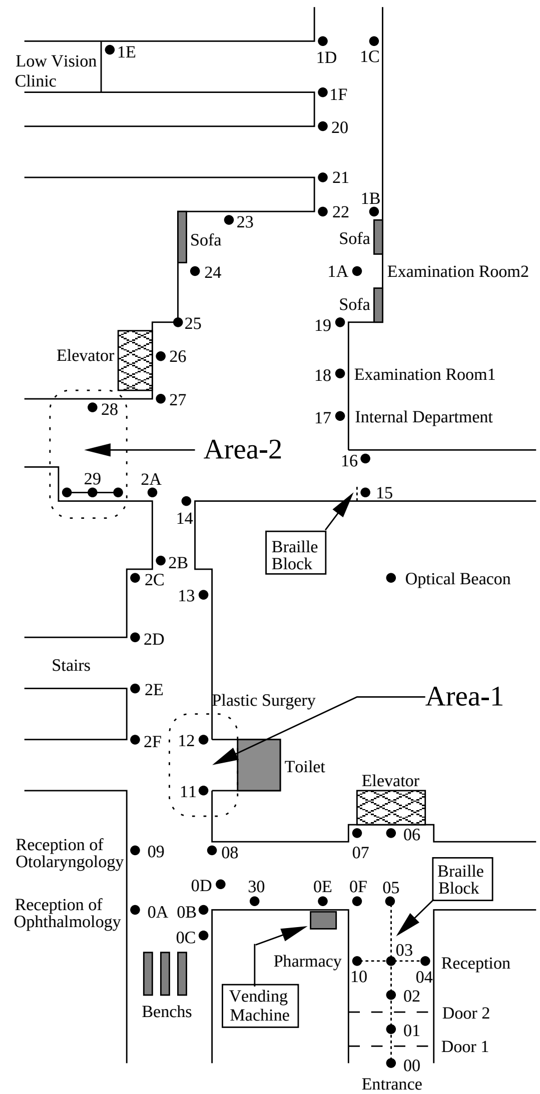

Fig. 5: An outline map of the testing field and the arrangement of optical beacons

on the training of the walking with a white cane. All of subjects were blindfolded and walked along right side wall of the route with a white cane. One subject was well trained in walking with a white cane, and other two subjects were not experienced in using white cane.

IV. RESULTS

Form these experiment, the following characteristics became clear.

1. On a pathway where a subject can feel the wall by a white cane, every subjects could follow the navigation voice, and the system worked perfect.

2. On occasion subjects lost the guidance voice. In such cases, the guidance was too complex and too long.

Fig. 6: A picture of the equipped navigation system

3. The subject who was well trained could follow the navigation and walked perfect. However, other subjects couldn't go across the wide pathway straight (especially Area-1 and Area-2 in Fig.5). At these places their trace were winding widely, and then the system lost their position.

V. DISCUSSION

As mentioned earlier, on a pathway where a subject can feel the wall, all subjects could walk following guidance of the system. However, some guidance voice is too long and complex, for example "Turn right, and then you will find a bench. When you find the bench, you should turn left and go straight." For these message, subjects started walking before understanding the messages, and then they bumped with a obstacle. Therefore, all guidance messages should be simple and based on many experiment. In this navigation system, the navigator announces some information under every optical beacons. Not all announcements are necessary for an user who is well trained in walking with a white cane and has a mental map of the walking area. Therefore, it is necessary to adapt navigation messages to user's walking ability. And a mechanism which navigates only when a user demands navigation is also necessary.

Subjects who were not experienced in walking with white cane couldn't go across the wide pathway straight. For example, there is a wide pathway in Area-1 (crossing from No.11 beacon to No.12 beacon) and Area-2(crossing from No.28 beacon to No.29 beacon) which are shown in Fig.5. In these area, subjects cannot feel right side wall by their cane and lost hand hold. In such cases, most of visually impaired persons who are not experienced in using white cane cannot walk straight. Then, at these places, their trace were winding widely, and their position go out of service area of the navigation system. For example, setting of braille blocks solves this problem. However, braille blocks are useful for only visually impaired persons. For other disabled persons, braille blocks are usually obstacle. In order to solve this problem, we think that we should develop other methods, for example, using audio guidance sounds, using directional infrared beam which indicates the pathway to the other side of the crossing, and so on. And now, the method which assists the visually impaired in walking straight by using infrared beam is experimentally developing.

VI. CONCLUSION

Our developed navigation system using optical beacons were tested and assessed. If the problems which became clear from experiment are improved, our system will be a very valuable one to support activities of the visually impaired.

ACKNOWLEDGMENT

This research was partially supported by the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Scientific Research (C),12832056,2000.

REFERENCES

[1] K.Magatani, K.Yanashima et al. "The Navigation System for the Visually Impaired", Proceedings of the First Joint BMES/EMBS Conference, 652 (1999)
[2] H.Yamasaki, K.Magatani et al. "Development of the Navigation System for the Visually Impaired", Proc. of the World Congress on Medical Physics and Biomedical Engineering, WE-A305-01 (2000)
[3] K.Ikui, K.Magatani K.Yanashima, "Development of the Navigation System by Using Optical Beacons for the Visually Impaired", Proceedings 9th ICBME, pp246-248 (1997)
[4] K.Magatani, H.Hasimoto, K.Yanashima, "The Navigation System for The Visutally Impaired by Using Optical Beacons",Proceedings 10th ICBME, pp97-98 (2000)