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A navigation system for the visually impaired using colored navigation lines and RFID tags

First Tatsuya Seto Tokai University, Japan and Second Kazushige Magatani Tokai University, Japan

Abstract— **In this paper, we describe about a developed navigation system that supports the independent walking of the visually impaired in the indoor space. Our developed instrument consists of a navigation system and a map information system. These systems are installed on a white cane. Our navigation system can follow a colored navigation line that is set on the floor. In this system, a color sensor installed on the tip of a white cane senses the colored navigation line, and the system informs the visually impaired that he/she is walking along the navigation line by vibration. The color recognition system is controlled by a one-chip microprocessor and this system can discriminate 6 colored navigation lines. RFID tags and a receiver for these tags are used in the map information system. The RFID tags and the RFID tag receiver are also installed on a white cane. The receiver receives tag information and notifies map information to the user by mp3 formatted pre-recorded voice.**

Three normal subjects who were blindfolded with an eye mask were tested with this system. All of them were able to walk along the navigation line. The performance of the map information system was good. Therefore, our system will be extremely valuable in supporting the activities of the visually impaired.

I. Introduction

There are approximately 300,000 visually impaired persons in Japan. Most of them are not stone-blind, and most of them are low-vision. They can feel light, however they cannot walk independently without some supporting devices. A white cane is a typical supporting device for the visually impaired. They use a white cane while walking for the detection of obstacles around them. In their known area, they can walk independently using a white cane. However, they cannot walk without help of others in their unknown area, even if they use a white cane. Because, a white cane is a detecting device for obstacles around them and not a navigation device that gives them a route to the destination. Therefore, a navigation system that supports independent activities of the visually impaired is required.

Many navigation systems for the visually impaired are developing [1][2]. However, these supporting devices are usually useless in the indoor space (e.g. underground shopping mall, hospital, airport, etc.) and cost a lot of money to spread. In addition, most of the visually impaired in Japan are old and they probably cannot use complex supporting systems. Therefore, our objective is the development of a simple and inexpensive navigation system for the visually impaired which can use in the indoor space.

In Japan, navigation line system is used for the normal person. This system is composed of some colored tapes that are set along the walking route. These color lines are called colored navigation line. Each color is assigned for each destination. If we walk along one of these navigation lines, we can arrive the destination that is indicated by the color of line easily. Fig.1 shows an example of the navigation line system. In our navigation system, a visually impaired user can follow the colored navigation line and reach the destination by using a developed white cane.

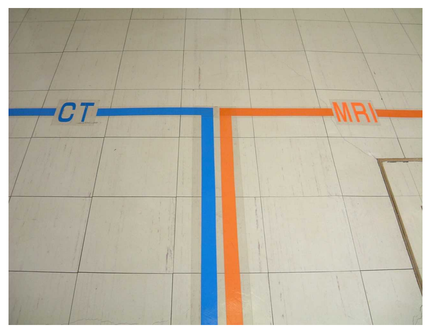

Fig. 1. Example of colored navigation lines

II. Methodology

A. Conception

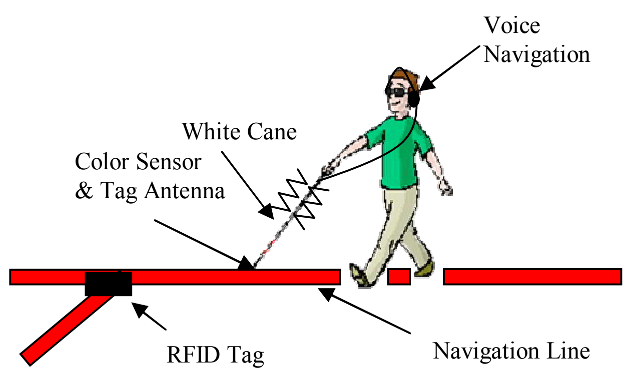

Fig. 2. A conception of the navigation system

The conception of our navigation system is shown in Fig.2. As shown in this figure, our developed system is composed of colored navigation lines, RFID tags and an intelligent white cane. An intelligent white cane includes a RGB color sensor, a transceiver for RFID tags, a vibrator and a voice processor.

These devices included in a white cane are controlled by one-chip microprocessor.

A navigation line is set on the floor along the walking route to the destination. If there are many destinations, different color is assigned for each route. At the each landmark point of the walking route, an RFID tag that indicates area code is set on a navigation line. A color sensor installed on the tip of a white cane senses the color of a navigation line. In our system, a visually impaired user swings the white cane left to right or right to left in order to find a target navigation line for him/her. If this sensor catches the target color, the white cane informs a visually impaired user that he/she is walking along the correct navigation line by vibration. The white cane also makes communication with a RFID tag at the landmark point of walking route. If the white cane finds a RFID tag, a voice processor notifies area information that corresponds to the received area code by pre-recorded voice. Therefore, a user of this system can obtain the area information and can reach the destination, only walking along the selected navigation line by using an intelligent white cane.

B. Color sensing system

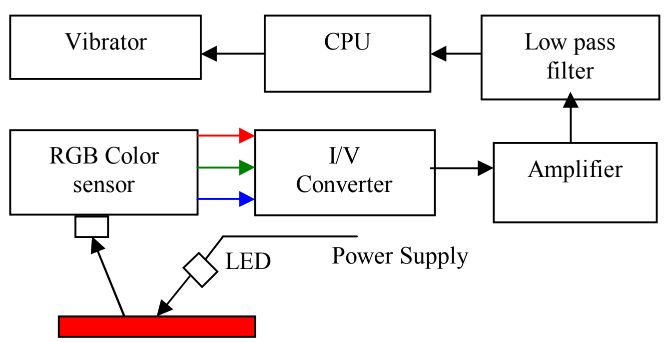

Fig. 3. A block diagram of the color detecting system

A block diagram of a colored line sensing system is shown in Fig.3. In this system, a RGB color sensor installed on the tip of a white cane senses the floor color. RGB outputs of this sensor are current to voltage converted, amplified and noise reduced by a low pass filter. Then these processed signals are analog to digital converted by 10 bit resolution, and analyzed by a microprocessor. As shown in Fig.3, white color LEDs are also installed on the tip of a white cane, and these LEDs shine on the floor.

Generally, ratio among R, G and B intensity are used for detecting color. However, R, G and B signal intensity will change according to the surrounding brightness, and detecting color technique using RGB raw signals will be complicated. In our system, Yxy notation of color is used for detecting color. The x-y coordinates of Yxy notation shows the color, and Y shows brightness. Therefore, if colors are same, x-y coordinates of colors are same in any brightness. In our system, digitized RGB values are transformed to the Yxy notation, and the inputted color is evaluated whether target color or not by using x-y coordinates of Yxy notation. Fig.4 shows an example of x-y coordinates. Some x-y values that were measured for same color navigation line under different brightness are mapped in this figure. As shown in this figure, if line colors are same, x-y coordinates of these data are almost same. If a sensed color is the target color, one chip microprocessor turn on a vibrator while 500ms to notify that the user is on the right route. This system discriminate 6 or more colored line on the floor stably.

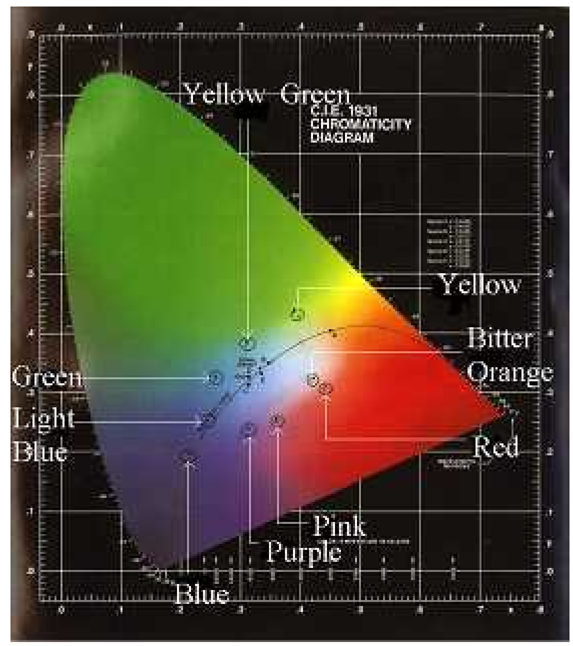

Fig. 4. xy-Chromaticity diagram

C. RFID tag system

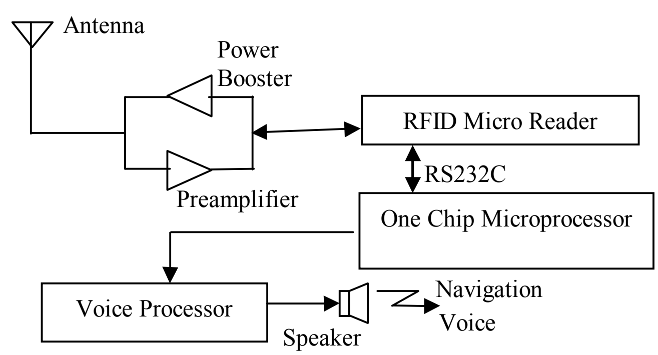

Fig. 5. A block diagram of a RFID tag transceiver and a voice processor

A block diagram of RFID tag information system is shown in Fig.5. In the navigation route, there are some landmark points where the system has to notify a user of the area information. For example, a corner to turn left or right, an entrance to the elevator, stairs are typical landmark points for the visually impaired. In our previous navigation system, optical beacons that were set on the ceiling and a receiver for the beacons were used for this objective [3][4]. From experiments, it is confirmed that the optical beacon system works very well. However, an optical beacon consumes electric power continuously to emit the area code as infrared signals. And a user has to have a receiver for the beacon besides the white cane. Therefore, passive type RFID tags (TEXAS INSTRUMENTS, RI-TRP-x4FF) are used in our system. It is not necessary to have own power source for used RFID tag. The power of RFID tags are supplied from a RFID transceiver that can make communication with RFID tags as radio frequency wave of 135kHz. Therefore, no energy is consumed while these tags don't work. This is the benefit for using RFID tags and this point is better than our previous system that used optical beacons. This RFID transceiver is installed on a white cane and an antenna for the transceiver is also installed on the tip of a white cane. The size of a used RFID tag is 8.5cm x 5cm, and an example of a used RFID tag is shown in Fig.6.

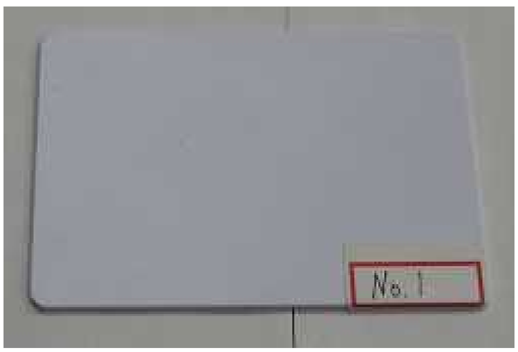

Fig. 6. An example of used RFID tag

Both receiving sensitivity and output power of ordinary RFID transceiver are too small for our system. If ordinary transceiver is used, communicable distance between a cane and a RFID tag is about 5cm. About 20cm or more communicable distance is necessary in our system. So, a pre-amplifier for the receiver and a power booster for the transmitter are developed and installed in our system. Using these amplifiers, communicable distance is enlarged to about 50cm.

The voice processing unit is also necessary for RFID tag system. At the landmark point, it is necessary to notify area information by voice. In our system, the one-chip microprocessor analyzes an area code from a RFID tag, and selects the navigation voice data, then the user can hear the area information from the bone conductive earphone. Navigation voice is useful for the visually impaired. However, if a speaker is used for navigation voice, it is loud for other person. Generally, a visually impaired person use sound to understand his/her circumstances. Because of shutting off the sound around him/her, an earphone is not used for voice navigation. Therefore, a bone conductive headphone is used in our system. This headphone doesn't shut off sound around him/her. Navigation voice is MP3 encoded and saved in a SD memory chip. A used voice processor (microtechnica, STL-2000) is shown in Fig.7.

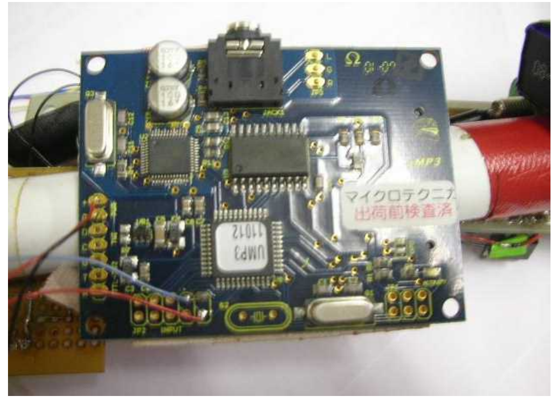

Fig.7. A MP3 voice processor

III. EXPERIMENT

Three normal subjects who were blindfolded with an eye mask were tested with our developed system. Fig.8 shows the schema of experiment route. As shown in this figure, there were two experiment routes.

One was used blue navigation line. The subject started from A point and turn left at the B point. RFID tags were set at the B and C point. A subject heard "Turn left" at B point. In this route, point C was destination, and at the C point a subject heard "Here is the destination".

The other was used red navigation line. A subject started from A point, turn right at the D point and turn left at E point. RFID tags were set at the D, E, and F point. At the D point, a subject heard "Turn right", and "Turn left. A curved angle is an acute." At E point. In this route, F point was destination. All subjects were tested with both routes.

All subjects could walk along the navigation line correctly, and all colored lines were continuously detected stably. From previous experiments, most of subject lost their route without voice navigation at the point B and E [3]. In all cases of this experiment, the intelligent white cane found RFID tag and notify the subject of turning information, and all subjects turned right or left and found the line to the destination. Fig.9 shows one subject under experiment.

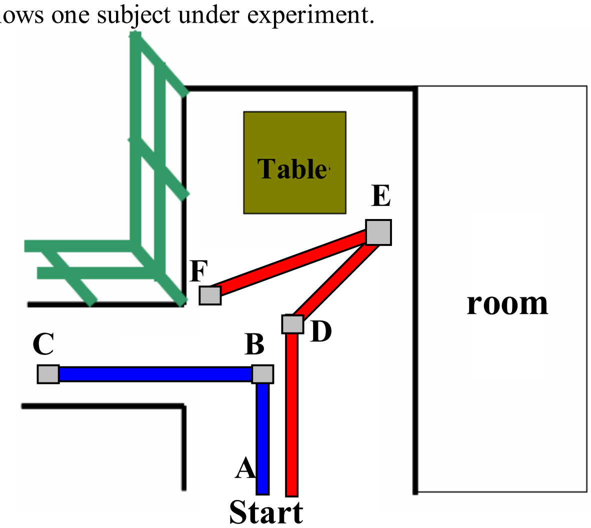

Fig. 8. The schema of experiment route

Fig. 9. A subject of the experiment

IV. CONCLUSION

In this paper, we described about our new navigation system using colored navigation lines and RFID tags for the visually impaired. In our system, an intelligent white cane detects target navigation line and notifies that a user is on a target line by vibration. And at the landmark point, a white cane also notifies area information by pre-recorded voice. Therefore, only following vibration of a white cane and navigation voice, a user can reach the destination.

Three subjects were studied with our navigation system. All subjects could use our system and reach the destination. From these experimental results, our system worked perfect. However, our system has one problem that our system cannot detect user's direction. For example, when a white cane detects blue line between point A and B in Fig.8, our system cannot detect whether a user walks from A to B or B to A. Now, we are developing a new method to detect user's direction using an acceleration sensor. Therefore, if this problem is improved, our system will be a very valuable one to support activities of the visually impaired.

REFERENCES

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