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A navigation system for the visually impaired an intelligent white cane

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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, this sensor senses a color of navigation line and the system informs the visually impaired that he/she is walking along the navigation line by vibration. This color recognition system is controlled by a one-chip microprocessor. RFID tags and a receiver for these tags are used in the map information system. RFID tags are set on the colored navigation line. An antenna for RFID tags and a tag receiver are also installed on a white cane. The receiver receives the area information as a tag-number and notifies map information to the user by mp3 formatted pre-recorded voice. And now, we developed the direction identification technique. Using this technique, we can detect a user's walking direction. A triaxiality acceleration sensor is used in this system. Three normal subjects who were blindfolded with an eye mask were tested with our developed navigation system. All of them were able to walk along the navigation line perfectly. We think that the performance of the system is good. Therefore, our system will be extremely valuable in supporting the activities of the visually impaired.**

I. INTRODUCTION

There are approximately 45,000,000 visually impaired persons in the world, and 300,000 visually impaired persons in japan. In japan, many of them are using a white cane while walking. 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 can't walk without help of others in their unknown area, even if they can use a white cane very well. Because, a white cane is a detecting device for obstacles and not 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 system for the visually impaired are developing [1][2]Some navigation systems for the visually impaired using GPS are experimentally developed in some laboratories. These systems are typical examples of the supporting systems for independent activities of the visually impaired. However, these supporting systems are usually useless in the indoor space (e.g. underground shopping mall, hospital, airport, etc.) and cost a lot of money to spread. Most of the visually impaired in Japan are old and they probably cannot use a complex support system. Therefore, our objective of this study is the development of a simple and inexpensive navigation system for the visually impaired which can use in the indoor space.

II. METHOCOLOGY

A. *Conception*

In Japan, the navigation line system is used for the normal person. This system is composed of some colored tapes that are set on a floor 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 corresponds the color of line easily. Fig.1 shows an example of the navigation line system. In our system, this colored navigation line is used for the visually impaired.

The conception of our system is shown in Fig.2. 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 a one-chip microprocessor.

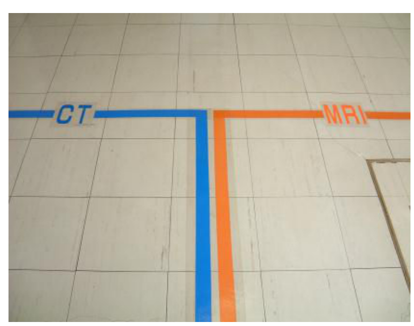

Fig.1. An example of colored navigation lines

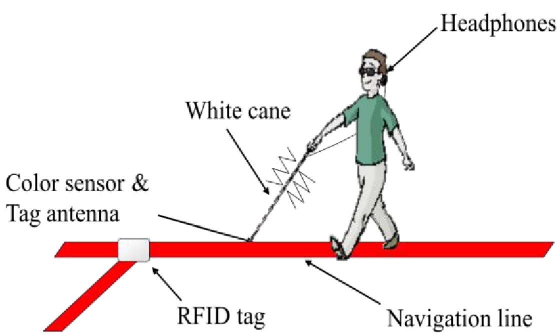

Fig.2. A conception of the navigation system

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 land mark 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. A visually impaired user swings the white cane left to right or right to left in order to find a target navigation line. If this sensor catches the target color, the white cane informs the visually impaired that he/she is walking along the correct navigation line by vibration. The white cane also makes communication with a RFID tag at the land mark 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 reach the destination, only walking along the selected navigation line by using an intelligent white cane.

B. Color sensing system

A block diagram of a colored line sensing system is show in Fig.3

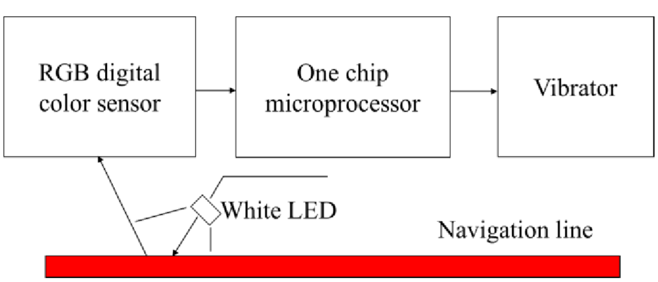

Fig.3. A block diagram of the color system

In this system a RGB color sensor installed on the tip of a white cane senses the floor color. RGB sensor outputs RGB signals by digital value, and these are analyzed by a CPU (one chip microprocessor). The value of RGB changes as the circumferential brightness, even if the sensed color is same. However, the ratio of RGB does not change under same color sensing. In our system, RGB values are transformed to the Yxy notation. A point of one color in x-y coordinate of Yxy notation is located a same point at any condition. A x-y coordinate of the color is acquired as linear transform of the RGB values. The following formula shows this linear transformation.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} 2.7689 & 1.17517 & 1.1302 \\ 1.0002 & 4.5907 & 0.0600 \\ 0.0000 & 0.0565 & 5.5943 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

$$x = X/X + Y + Z$$
$$y = Y/X + Y + Z$$

The x-y coordinates of colors of used navigation lines are shown in Fig.4. If a sensed color is the target color, a CPU turns on a vibrator to notify that the user is on the right route. This system can discriminate 6 or more colors of the navigation line.

C. RFID tag system

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][5]. From experiments, it is confirmed that the optical beacon system worked well.

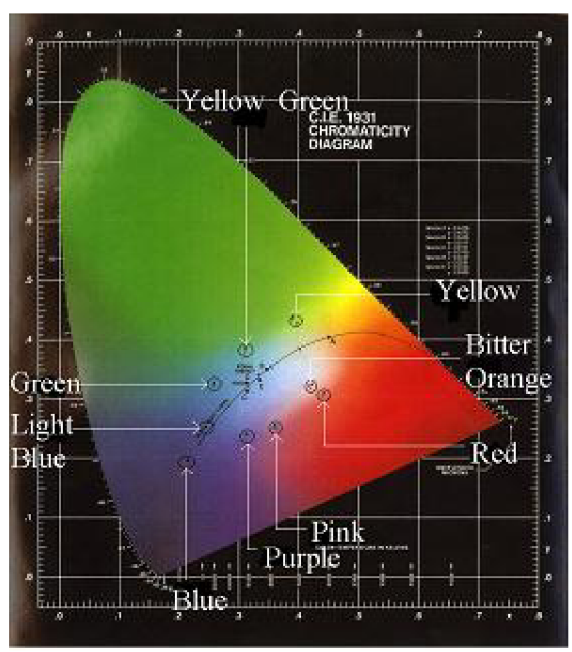

Fig.4. xy-Chromaticity diagram

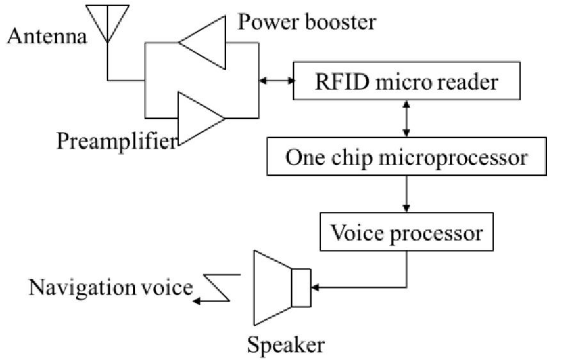

Fig.5. A block diagram of a RFID tag transceiver and a voice processor

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 in addition to a white cane. Therefore the passive type RFID tags are used in our new system. It is not necessary to have own power source for passive type RFID tag. The dimension of RFID tag is 8.5cm x 5cm, and the communication frequency is 135 kHz. The power of RFID tag is supplied from the transceiver that can make communication with RFID tag as radio frequency wave. And RFID tag system can be installed in a white cane. These are the benefit for using RFID tags.

Both receiving sensitivity and output power of ordinary RFID micro reader (transceiver) are too small for our system. In order to solve these problems, a preamplifier for the receiver and a power booster for the transmitter were developed and equipped in our system. An antenna for the transceiver is also installed on the tip of a white can. By using this system, communicable distance between a RFID tag and a white cane is about 50cm. Fig.6 shows an RFID tag that is used in our system. The voice processing unit is also necessary for RFID tag system. At a landmark point, it is necessary to notify area information by voice. In our system, a CPU selects and outputs the pre-recorded phrase that corresponds with a received area code. Pre-recorded phrases are encoded in mp3 format and saved in the memory. Our developed white cane is shown in Fig.7 and a picture of enlarged tip of this cane is also shown in Fig.8.

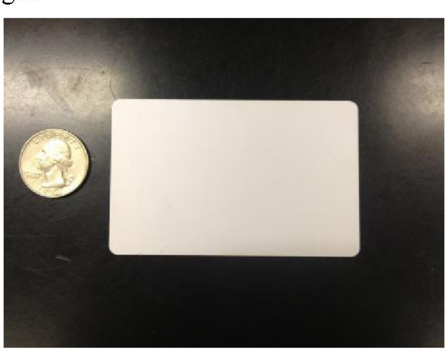

Fig.6. An example of used RFID tag

Fig.7. The white cane

Fig.8. The enlarged tip of white cane

D. Direction distinction system

This time, we developed the direction identification system. A block diagram of a direction identification system is shown in Fig.9.

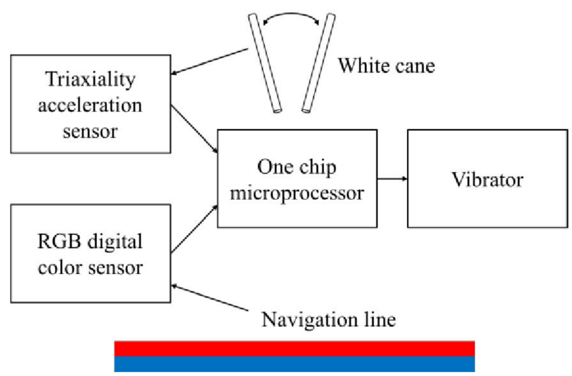

Fig.9. A block diagram of a direction identification system

Our previous system could detect the color of navigation line and could not identify user's direction. Therefore, there is a possibility that a user walks to the opposite direction. In order to solve this problem, we developed the direction identification system.

In this system, we use the colored navigation line as shown in Fig.10. This navigation line is consists of 2 colors. In Fig.10, blue and red are used. In this system a triaxiality acceleration sensor is installed on the white cane and we can detect swing direction of a white cane by using outputs of this acceleration sensor. As shown in Fig.10, if a cane swing left to right, a color sensor senses red and then blue. Conversely, if a cane swing right to left, a color senor senses blue and then red. In other words, we can know the user's direction by using in order of color of the navigation line.

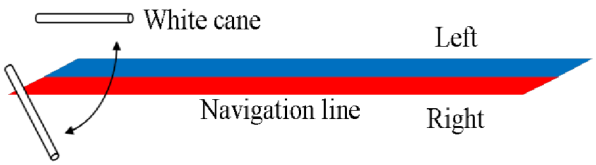

Fig.10. A conception of direction identification system

III. EXPERIMENT

Three subjects were tested with our developed system. All subjects were blindfolded by an eye mask and walked along the testing route. Fig. 11 shows the testing route. Two testing route were set on the floor and RFID tags were also set at the landmark point of these route. As shown in Fig.11, one navigation route consisted of red and blue color and another route consisted of green and blue color. Start point of both navigation lines were same. RFID tags were set on the navigation lines at the crossing and the destinations.

All subjects could walk from A-point to B-point, and B-point to A-point. In this experiment, the subject's directions were identified stably and perfectly. In all cases, a white cane found RFID tag and notify the subject of turning information, and all subjects turned right or left and reached to the destination. Therefore, we think that our navigation system for them visually impaired worked perfitct.

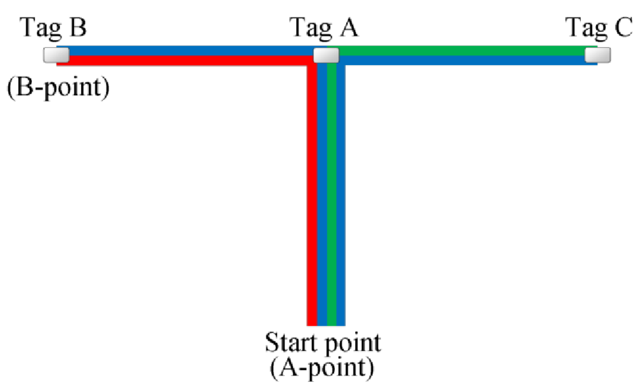

Fig.11. The testing route

IV. CONCLUSION

We described about our developed new navigation system for the visually impaired. A user of this system can obtain the area information and reach the destination by using a developed white cane. And because this system can detect user's direction, if a user turns opposite direction from destination, white cane can lead the user to right route.

In our previous navigation system, if a user turns to opposite direction from destination, he/she cannot arrive the destination. So, we developed a new system that can identify user's direction. From the results of the experiment, it is cleared that our system could detect user's direction stably. Therefore, we concluded that our navigation system will be a valuable one for the visually impaired.

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