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# Development of the navigation system for the visually impaired by using white cane

Yoshiaki Hirahara*, Yusuke Sakurai*, Yuriko Shiidu*, Kenji Yanashima** and Kazushige Magatani*
* Department of Electrical Engineering, Tokai University, Japan
** National Rehabilitation Center for the Disabled, Japan

*Abstract:* A white cane is a typical support instrument for the visually impaired. They use a white cane for the detection of obstacles while walking. So, the area where they have a mental map, they can walk using white cane without help of others. However, they cannot walk independently in the unknown area, even if they use a white cane. Because, a white cane is a detecting device for obstacles and not a navigation device for there correcting route [1].

Now, we are developing the navigation system for the visually impaired which uses indoor space. In Japan, sometimes colored guide lines to the destination is used for a normal person. These lines are attached on the floor, we can reach the destination, if we walk along one of these line. In our system, a developed new white cane senses one colored guide line, and makes notice to an user by vibration. This system recognizes the color of the line stuck on the floor by the optical sensor attached in the white cane. And in order to guide still more smoothly, infrared beacons (optical beacon),which can perform voice guidance, are also used.

[key words: white cane, colored line, RGB color sensor]

## I. Introduction

A white cane is a typical supporting device for the visually impaired. The visually impaired can sense some obstacles around him/her. And they can walk safely by using this cane. Therefore, the area where they know well, they can walk safely using white cane. However, they cannot walk independently in the unknown area, even if they use a white cane. Because, a white cane is a detecting device for obstacles, and not a navigation device. In such cases, helping of others are necessary. From these reasons, The research and development of a supporting instrument to help an independent walk of the visually impaired is done at various places. For example, a navigation device which used GPS like car navigation system is developing[2]. However, most of these devices are for outdoor space, and are not for indoor space.

In order to solve this problem, we are developing the navigation system for the visually impaired that uses indoor space. In Japan, sometimes colored guide lines to the destination is used for a normal person. These lines are attached on the floor, we can reach the destination, if we walk along one of theses lines. In our system, a developed new white cane senses one colored guide line, and make notice to an user by vibration. This system recognizes the color of the line stuck on the floor by the optical sensor attached in the white cane. And in order to guide smoothly, infrared beacons

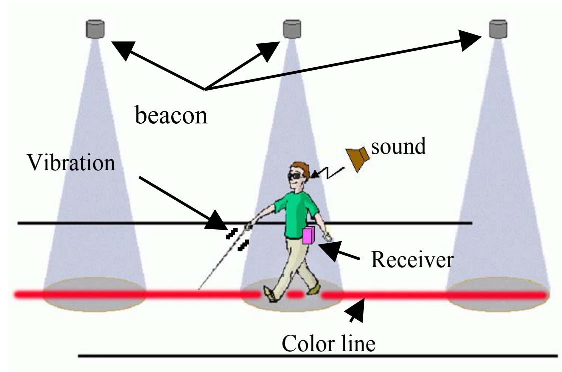
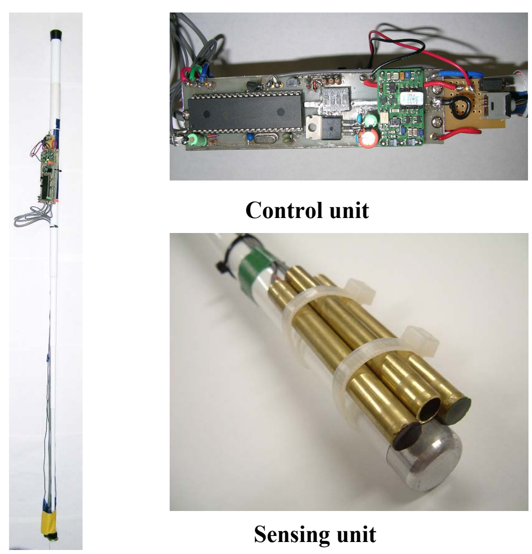



**Fig.1 The conception**

(named optical beacons) that can perform voice guidance, are also used.

In this paper, we'll describe about our developed instrument that supports the independent walking of the visually impaired in the indoor space. Fig.1 shows the conception of our system. This instrument is composed of a map information system and a navigation system. In map information system, optical beacons and a receiver of them are used. Optical beacons are set on the ceiling and emit the position code as infrared signal. A receiver receives the signal form a beacon and inform a map information by pre-recorded voice. The navigation system can follow the colored guide line on the floor, and informs a visually impaired user that he is on the guide line by vibration. Fig.2 shows the our white cane system.



**Control unit**

**Sensing unit**

**Fig.2 General view of the system**

## II. Methodology

The block diagram of our system is shown in Fig.3. As shown in this figure, line color is sensed by a RGB color sensor. This sensed color signal is analog to digital converted at the A/D converter that is included in one chip microprocessor. Digitized color information is analysed in a

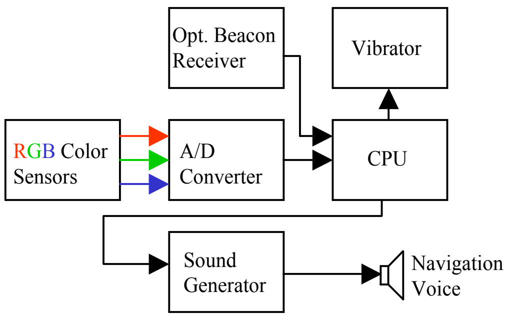
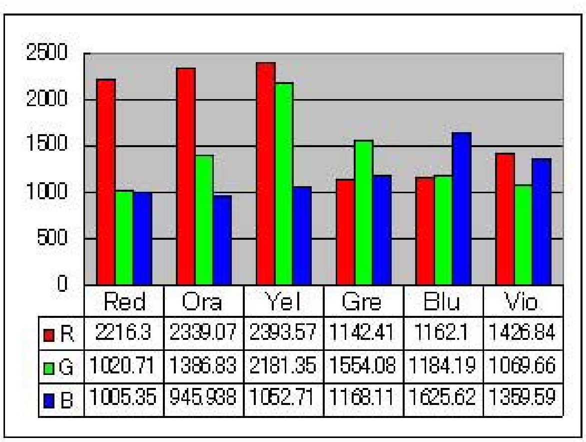



**Fig.3 A block diagram of the digital system**

CPU and color of the guide line is decided. If the sensor senses the selected color, CPU make the vibrator on. In our system we can select 6 or more colores. Another role of this system is for optical beacons. As mentioned earlier, some optical beacons are set on the ceiling of the target space, and they emit their own area code as a infrared signal. In our system, an user have to equip with the optical receiver. This receiver receives the infrared signal from an optical beacon, and demodulated code is send to CPU. This code is analysed in CPU and suitable guidance voice is selected and informed to the user.

II-I. Color identification.

In this part, we will talk about the color identification method of our system. In our system , a color sensor that outputs analog RGB value is used. These three signals are analog to digital converted by 8bit A/D converter. So, we can obtain the 8bit digitised R,G,B value as the floor color information. If we express this value (R,G,B), we can obtain the color data from (0,0,0) to (255,255,255). In case we use this expression in order to indicate sensed color, if the ratio R:G:B is fixed, these tone are same, only brightness are different. Fig.4 shows the example of RGB value of 6 types of




| | Red | Ora | Yel | Gre | Blu | Vio |
|---|---|---|---|---|---|---|
| R | 2216.3 | 2339.07 | 2393.57 | 1142.41 | 1162.1 | 1426.84 |
| G | 1020.71 | 1386.83 | 2181.35 | 1554.08 | 1184.19 | 1069.66 |
| B | 1005.35 | 945.938 | 1052.71 | 1168.11 | 1625.62 | 1359.59 |

**Fig.4 A histogram of color sensor output**

colored line. Usually, brightness of target space are variable. If the position is different, the brightness of these positions might not be same. So, one colored line has the approximately same RGB ratio at every position, but the RGB values are different. In our system, even if there are many difference of brightness in the target place, the color of line have to detect correctly. Of course, using RGB ratio is good idea for this purpose. This method is correct in the theory, however cannot work well in actually. Usually RGB ratios are not stable because of some noises.

$$\begin{pmatrix} Y \\ x \\ v \end{pmatrix} = \begin{pmatrix} \alpha & \beta & \gamma \\ \delta & \varepsilon & \zeta \\ \eta & \theta & \iota \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

**Fig.5 Transformation matrix**

Therefore, Yxy notation is used for color recognition in our system. In Yxy notation, coordinate x-y express only tone, and brightness is expressed as the value of Z coordinate. So, if we use Yxy notation, detection of colored line can be done without regarding of brightness. Fig.5 shows the transformation matrix that translate from RGB values to Yxy values. If Yxy notation is used in our system, it is necessary to decide all elements of this matrix.

In order to detect this matrix, RGB value under fixed brightness and Yxy values of some colored line are measured. From these set of RGB and Yxy values, all elements of transfer matrix are calculated. In our system, these obtained element data are used for color detection. 6 colors indicated in

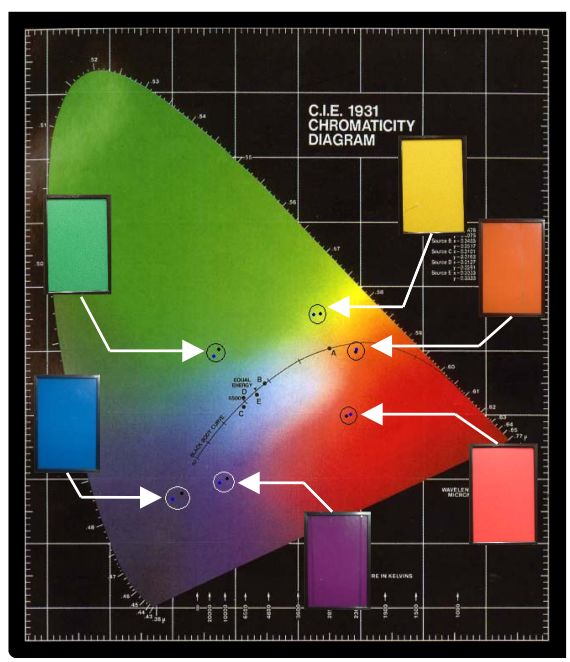



**Fig.6 xy-Chromaticity diagram**

Fig.4 are tested under different brightness. Yxy values of these colors under different brightness are mapped on the x-y coordinate. Fig.6 shows the results of this experiment. From this figure, we can observe that if color is same, mapping points under different brightness are approximately same.

### II-II The optical beacon

Fig.7 shows a block diagram of an optical beacon and Fig.8 shows the block diagram of an optical receiver which is equipped by an user. As shown in Fig.3, an optical beacon which is composed of an one-chip microprocessor and a infrared LED is very simple and small. This LED emits the pulse frequency modulated signal 20 times a second (carrier frequency of this signal is 38kHz). This signal includes the information which is composed of start code, 8bit position code and stop code.

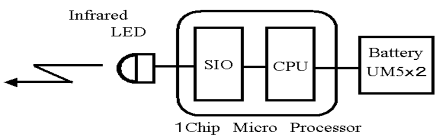



**Fig.7 The block diagram of an optical beacon.**

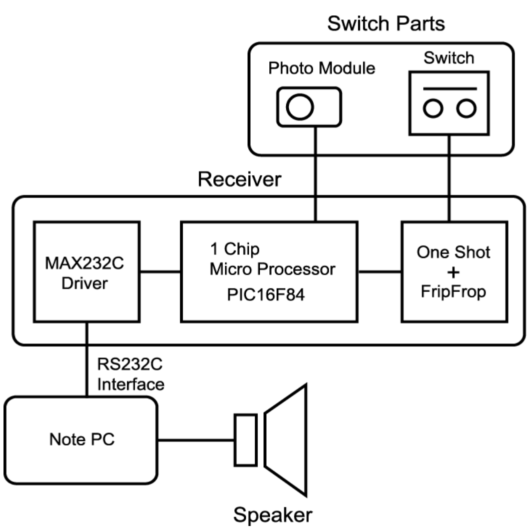



**Fig.8 The block diagram of a infrared signal receiver .**

A generation of area code and modulation are operated by software. As shown in Fig.8, a receiver for the optical beacon is composed of a signal receiving unit and a note computer. The receiver receives and demodulates the signal from a beacon, checks up this signal with error. And then a note computer calculates the route to the destination based on the user's position and map information.

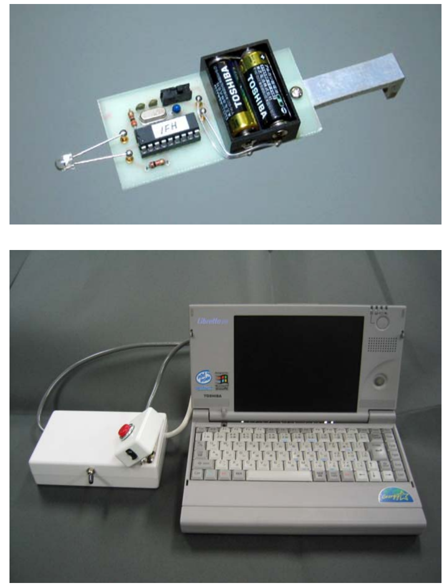


**Fig.9 Optical beacon & Receiver**

Finally, user can obtain the area information and the route information to the destination by pre-recorded voice. An optical beacon and their receiver are shown in Fig.9

### III. Experiment

The guidance experiment using our white cane and the infrared beacon was conducted in the our campaus. Five normal subjects were studied with our system. Six different colored lines were set on the floor. Distance from start point to destination is about 30m. This route was arranged right side of the floor. However, subjects couldn't feel the right side wall by a white cane, if they walk along with guide line

**Fig.10 Experiment**

correctly. And at the randmark point, optical beacons were set on the ceiling. At this points, our map information system announced turning information. All subjects were tested under blind folded by an eyemask. A subject under experiment is shown in Fig.10.

## IV. Discussion

All Subjects could walk from the start point to the destination following the guide line correctly. And all colored line are continuously detected stably. All subjects didn’t have skill for our system. And they didn’t understand how to use our system. However, after few trials they accepted usage of our system, and coulde use the system smoothly. In this condition, they could walk along a guide line for normal speed of their usually walking. Therefore, we think that our navigation system using a white cane worked very well.

However, there is one problem in our system. The system cannot detect the user’s walking direction and can only detect that he/she is on the navigation line. In order to improve this problem, new method that can detect walking direction is developing. A conception of this method is easy. Two colored navegation line that is shown in fig.11 is used in new method. One color expresses the route from start point to the destination, and the other is the color for detecting direction. And an acceleration sensor that is attached on the tip of a white cane is also used. This acceleration sensor detect the moving(swing) direction of a white cane. For example, if white cane sense color-1 first and color-2 next and swing of a white cane is from user’s left to right, then user’s direction is B. Our system can detect user’s walking direction as this way.


**Fig.11 Two colored navigation line**

## V. Conclusion

In this paper, we talked about our new guidance system for the visually impaired. Five normal subjects were tested with our system. From these experiments, our system can identify 6 colored guide line stably. And every subjects can reach correct destination by their natural waling speed. However, our system cannot detect user’s walking direction. So, the new method for detecting walking direction that is used two colored navigation line and an acceleration sensor is developing now. Therefore, we’ve concluded that if this problem is improved our navigation system that is used white cane will be a very valuable one to support activities of the visually impaired.

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