Springer

Journal of Mechanical Science and Technology

Journal of Mechanical Science and Technology 23 (2009) 2776~2779

www.springerlink.com/content/1738-494x
DOI 10.1007/s12206-009-0729-1

The development of a visual system for the detection of obstructions for visually impaired people †

Mitsuhiro Okayasu*

Department of Machine Intelligence and Systems Engineering, Akita Prefectural University, 84-4 Ebinokuchi, Tuchiya-aza, Yurihonjo-city, Akita, 015-0055, Japan

(Manuscript Received October 23, 2008; Revised February 19, 2009; Accepted February 19, 2009)

Abstract

In this paper, the author presents a new visual system that can aid visually impaired people in walking. The system provides object information (that is, shape and location) through the sense of touch. This visual system depends on three different components: (i) an infrared camera sensor that detects the obstruction, (ii) a control system that measures the distance between the obstruction and the sensor, and (iii) a tooling apparatus with small pins (ϕ1 mm) used in forming a three-dimensional shape of the obstruction. The pins, arranged on a 6×6 matrix, move longitudinally between the retracted and extended positions based on the distance data. The pin extends individually, while the pin tip reflects the object's outer surface. The length of the pin from the base surface is proportional to the distance of the sensor from the obstruction. An ultrasonic actuator, controlled at a 15Hz frame rate, is the driving force for the pin movement. The tactile image of the 3D shape can provide information about the obstruction.

***Keywords*: Blind; Visual system; Infrared camera sensor; Ultrasonic actuator**

1. Introduction

According to the World Health Organization [1], there are 314 million visually impaired people in the world, 269 million of which have poor vision, while 45 million are blind. These visually impaired people lead difficult lives. One of the difficulties they face is on mobility particularly when crossing streets or riding in buses or trains. Many blind people use white canes measuring about 1 m, but such canes provide little spatial information. This lack of information often leads to vehicular and traffic accidents.

To address this issue, an attempt has been made to improve the white cane [2, 3]. Particularly, mechanical and electrical systems are added to provide an aural navigation system. A sound message is generated as the blind person moves closer to the obstruction. Admittedly, the old cane system is widely accepted in Japan, but this technology has limited use for visually impaired people. The cane is still considered unreliable and does not guarantee safety in walking. Therefore, this current work provides a new design for a visual system that can support visually impaired people.

2. Principle of the visual system

Fig. 1 displays the visual system developed in this work. With this system, the information about the obstruction, such as the shape and the distance, can be provided. The visual system has three components: (i) an infrared camera sensor that detects obstructions [Fig. 1(a)], (ii) a control system that measures the distance between the obstruction and the sensor [Fig. 1(b)], and (iii) a tooling apparatus with small pins (ϕ1 mm) used in forming a three-dimensional shape of the obstruction [Fig. 1(c)]

† This paper was recommended for publication in revised form by Associate Editor Hong Hee Yoo
*Corresponding author. Tel.: +81 184 27 2211, Fax.: +81 184 27 2188
E-mail address: okayasu@akita-pu.ac.jp

Table 1. Specification of the infrared camera sensor.

Parameter	
Detectable distance	1.2 m - 7.5 m
Emission Angle	Vertical direction: ±30deg.
	Horizontal direction: 22.5°
Number of active pixels	128×123
Frame rate	15Hz
Resolution	20 mm/m
Peak wavelength of LED	870 nm ±20 nm

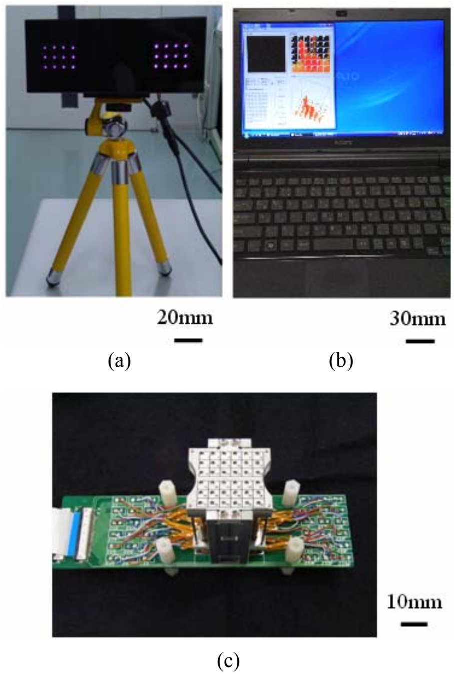

Fig. 1. Visual system for the detection of obstruction; (a) infrared camera sensor, (b) control system, and (c) apparatus for forming a 3D image of the object using many small pins.

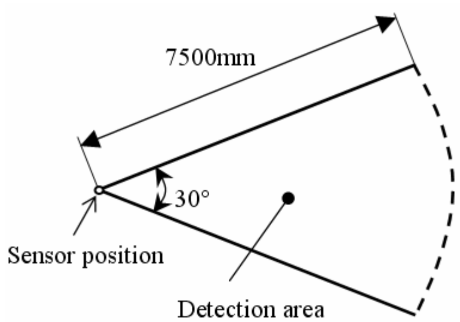

Fig. 2. Detection area available to find the obstacle by the infrared camera sensor.

Table 1 indicates the specification of the infrared camera sensor. With this camera sensor, images of the obstruction can be taken at a frame rate of 15Hz. The camera sensor can clearly detect obstructions within an area of 7500 mm radius and covering 30 degrees elevation from the base point of the sensor (Fig. 2). The obstruction information can be obtained anytime as long as the sensor is attached to the person. The object's image can be translated into a large number of image pixels, that is, 128×123 = 15744. Each pixel can also indicate the distance data via the control system. The data are measured through the time of flight (TOF) principle with an accuracy close to a few percent. This principle uses a method that measures the time it takes for an object to reach a detector while traveling over a known distance. The measurement depth is proportional to the time needed for the light to travel from the camera to the object. The pins, arranged in a 6×6 matrix, make longitudinal movements between the fully retracted and fully extended positions based on the distance data. The end or tip of each pin represents a point on the outer surface of the object, with the length of the pin from the base surface proportional to the distance of the sensor to the object.

Fig. 3 shows the infrared image of (a) the object (a clock) and (b) the depth data from the object. The depth data are indicated with color density, that is, the darker the color, the closer the distance. Fig. 3(c) displays the 3D image of the object formed by the pin tips. The 36 pins, arranged in a 6×6 matrix with a 3.5 mm pitch, make longitudinal movements between the retracted and extended positions. The position of each pin is controlled by the average depth data in its specific area, each pin representing 1/36 of the entire area [Fig. 3(b)].

The value of the pin position is calculated to be 1/1000 of the true depth data, in which the higher the pin level, the closer the position of the object to the sensor. For instance, if the depths measured are 3m and 7m, the values of the pin position are 7mm and 3mm, respectively. An ultrasonic actuator is the driving force for the pin movement, and a tactile image of the object's shape is formed by the pin tips. The overall process for this visual system is summarized in the flow chart [4] in Fig. 4.

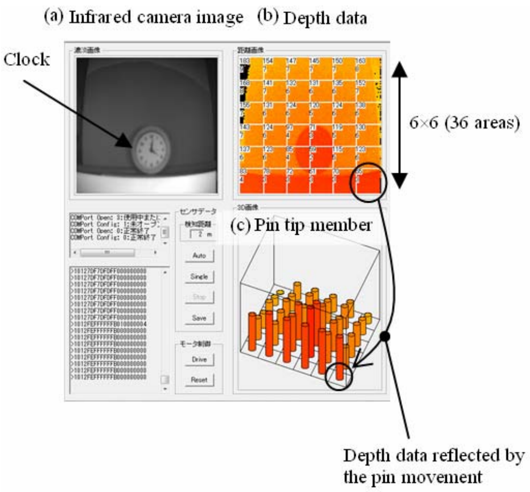

Fig. 3. Control system showing (a) the clock, (b) depth data from the object, and (c) image from the 6×6 pin array.

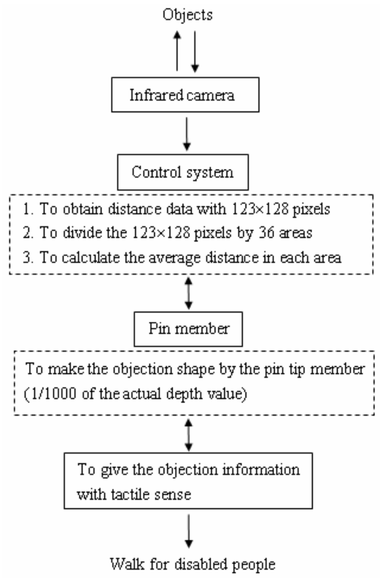

Fig. 4. System flow chart for the visual system.

3. Experiments

The mechanical performance of the visual system was examined, and an attempt was made to see whether or not the obstruction information provides a clear three-dimensional shape formed by the pins. Several objects such as a chair, a pot, and a person were used in the examination; the results are shown in Fig. 5. These indicate that the camera images of these objects are represented by a pin tip image of the outer surface. A walk trial was conducted using the system

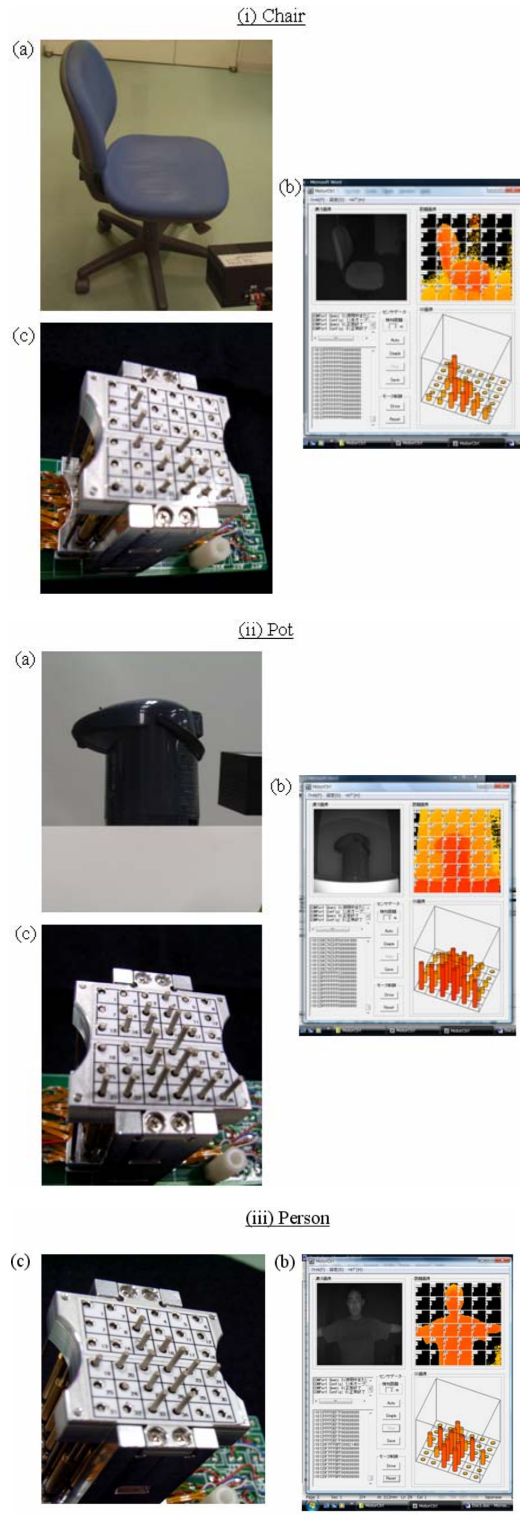

Fig. 5. Visual system showing various objects: (i) chair, (ii) pot, (iii) person.

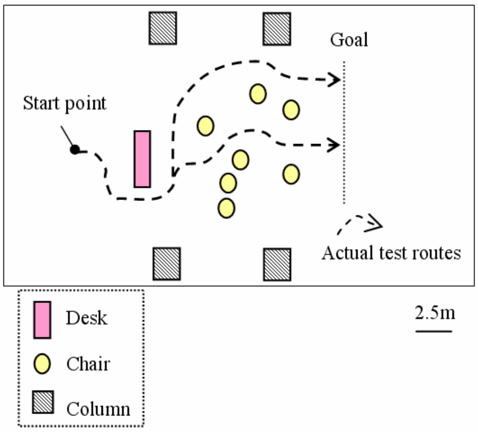

Fig. 6. Schematic illustration of the test field with various obstructions such as a desk, chair, and column.

in a field to further examine the performance of the visual system. In this case, the participants were completely blindfolded and were kept away from the obstructions. They were ordered to reach a specific goal in the shortest time. Various obstructions, for example, a desk, chair, and column, were put on the test field as displayed in Fig. 6. The start and end points are positioned to the right and left-hand sides, respectively. There are two walkways for the participants as indicated by the dashed line in Fig. 6. In the walk trial, the participants successfully found the goal in less than 5 min without any major collision with any of the objects. This experiment clearly shows that the system could be an effective walking aid for visually impaired people.

4. Conclusions

In this study, a new visual system has been developed to aid the walking of visually impaired people. The system can provide clear information about the shape and distance of an obstruction. Information about the surrounding objects is obtained using touch rather than vision. This system has three components: (i) an infrared camera sensor that detects the obstruction, (ii) a control system that measures the distance between the obstruction and the sensor, and (iii) a tooling apparatus with small pins (ϕ1 mm) used in forming a three-dimensional shape of the obstruction. The pin tip represents part of the outer surface of the object. The pins can go up and down depending on the distance of the sensor to the object; their movement is driven by a small actuator. With a tactile image of the pin tip array, information about the shape of the object can be obtained.

Acknowledgements

The author would like to acknowledge the financial support of the government of Akita prefecture. The author would also like to acknowledge the technical support of Mr. Mitsuo Ishizuka and the many visually impaired people of Akita Association on Visual Disability.

References

[1] WHO, Available online at : http://www.who.int/mediacentre/factsheets/fs282/en/ (accessed 27-7-2009).
[2] Miya, Support system for visually handicapped people. Japan Patent, 2001-319289 (2001).
[3] J. Ogawa and K. Aonuma, White cane for visually handicapped people. Japan Patent, 2003-265559 (2003).
[4] G. Wei, C. Zongyu and L. Congxin. Investigation on full distribution CNC system based on SERCOS bus. Journal of Systems Engineering and Electronics 19 (1) (2008) 52-57.

Mitsuhiro Okayasu received his Ph.D. degree from the University of Toronto in 2006. Dr. Okayasu is currently an Associate Professor at the Dept. of Machine Intelligence and Systems Engineering at Akita Prefectural University in Japan. He has engineering experience of more than 10 years in industries both in Japan and Canada.