The Thirteenth International Symposium on Artificial Life and Robotics 2008(AROB 13th '08),
B-Con Plaza, Beppu, Oita, Japan, January 31-February 2, 2008

# Optical beam interface for mobile robot control

Tomoko Sakai and Shuji Hashimoto

*Dept. of Applied Physics, Waseda University*
*3-4-1, Okubo, Shinjuku-ku, Tokyo, Japan*
*tomoko@shalab.phys.waseda.ac.jp, shuji@waseda.jp*

*Abstract*: Today, we are using many types of control pads to control home electronic appliances or sometimes small mobile robots. These control modules are very convenient because we can send various control signals to each appliance. However, when those modules have so many control buttons, we have to learn the usage of them. Moreover, when the number of control modules increases as the number of appliances increase, we have to carefully select the a ppropriate controller for the appliance we want to control. In this research, we propose an optical beam interface, which can control all home electronic appliances in common. This interface consists of two parts. One is a luminescence part with a laser diode for user side. The other is a light detecting part with some light sensitive elements for electronic appliance side. We focus on a motion control of a home robot especially in this paper by introducing a structure of the proposed interface and the small mobile robot with experimental results.

*Keywords*: Optical beam interface, home robot control, intuitive interface, home electric appliances.

## I. INTRODUCTION

Today, our living environment is overflowing with a lot of electronic appliances such as air conditioners, televisions, audio players and so on. Additionally, with dissemination of home mobile robots of recent years, sometimes we control small robots in daily life. When we control such appliances, various remote control modules or pads are used as interface devices. These interface modules are convenient because we can send various control signals to the corresponding appliance from distant place. However, when the number of control modules increases with increasing of electronic appliances, the user has to learn the use of each control module to operate the appliance effectively, which is sometimes a time-consuming job.

In recent years, there are some new attempts to enable human to operate these electronic appliances intuitively. An attempt that user controls home electronic appliances and motion of a mobile robot only by intuitive gestures are reported by Umeda et. al. [1][2]. However, in this attempt, because gestures are recognized by camera images, it needs a rather long time to complete one operation. Furthermore, in control of a robot, it is difficult to obtain the robot location accurately if the robot is not at the center of the camera image because of the distortion of the camera lens.

There is another attempt to control a robot by laser beam [3]. In this work, the robot has a light detecting part to detect the laser beam, and moves according to the beam spot movement. However, many light detecting elements should be assembled into the robot to detect the beam spot with a small diameter, which makes the electric circuit and the processing complex.

In this paper, we propose a simple optical beam interface using a laser beam with a beam expander. Although the proposed interface can be used to control most of home electric appliances, we focus on the control of a small mobile robot in the experiments to examine the utility.

In Sec. Ⅱ, we describe the design method of the proposed interface. In Sec. Ⅲ, we describe about an application for robot control. And after describing about the overview of an experiment with an actual mobile robot in Sec. Ⅳ, conclusions follow in Sec. Ⅴ.

## II. OPTICAL BEAM INTERFACE

In this section, the overview of the proposed system is described. We have an assumption that the proposed optical beam interface is utilized in a room for many home electronic appliances and robots. Fig.1 shows a basic concept of a room with many home electronic appliances and mobile robots controlled by the proposed interface. The optical beam interface consists of two parts, a luminescence part and a light-detecting part implemented at the user side and the electronic appliance sides, respectively.

## 1. System design of the luminescence part

Fig.2 shows the system design of the luminescence part. As a light source, we utilize a green laser diode as the green color is most visible in usual room. The laser beam is expanded by a beam expander because the diameter of the beam from the laser diode is too small for users to light up the target easily. The control device in the luminescence part has two ON/OFF switches; a power switch and a signal switch. When the power switch is turned on, the laser diode is activated to emit the light continuously. While the signal switch is turned on the laser diode is derived with high frequency signal to make a high speed blinking. The light blinking is detected at the light detecting part as a signal under the environment where various lights, such as sunlight and fluorescent light, are mixed. The continuous light works to indicate the target that the user points.

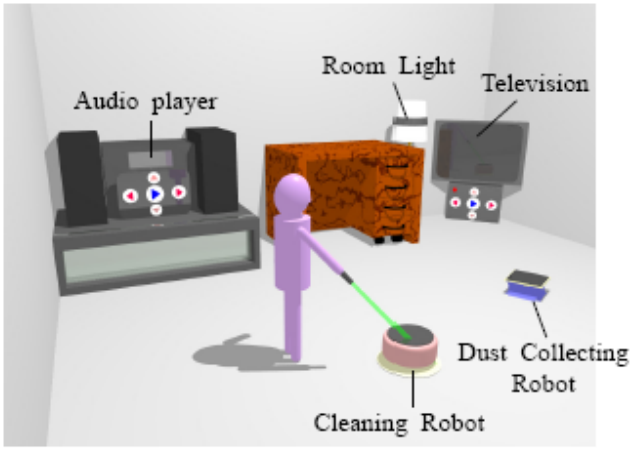



Fig.1 Basic concept of optical beam interface

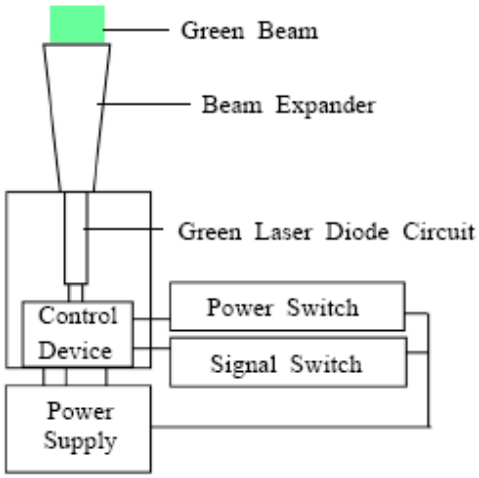



Fig.2 System design of the luminescence part

Fig.3 depicts a photograph of the luminescence part. Fig.4 shows a photograph of the interface when the light is ON.

Although the diameter of light beam from the laser diode is 3mm, it is magnified to 28mm the expander outlet. Although the beam diameter spreads to 60mm at 8.5m apart from the device, the luminous intensity is strong enough to be visible in an ordinary room.

## 2. System design of the light-detecting part

Fig.5 shows the system design of the light detecting part equipped on the small robot. The light detecting part consists of light detecting elements, band-pass filters, amplifiers, smoothing filters and a controller of the robot.

The details of implementation of the light detecting part for the small mobile robot is described in section IV.

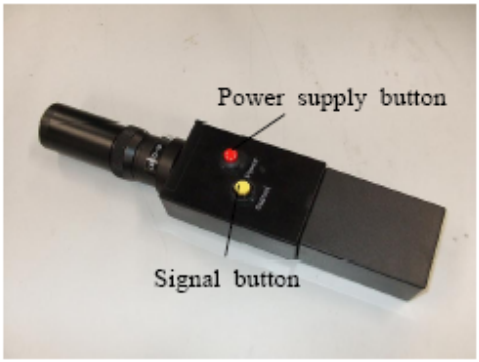



Fig.3 The luminescence part

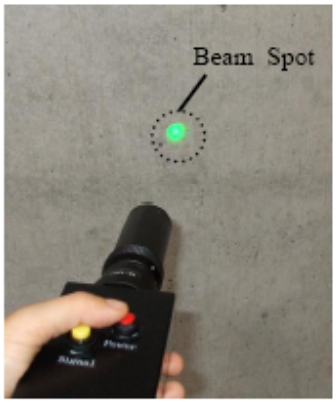



Fig.4 Light ON

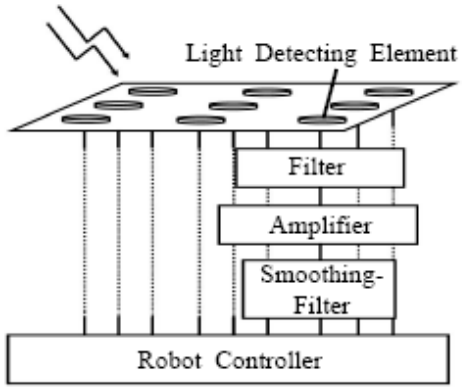



Fig.5 System design of the light detecting part

(a) Sweeping narrow space (b) Collecting dusts

Fig.6 The example of robot control by the interface

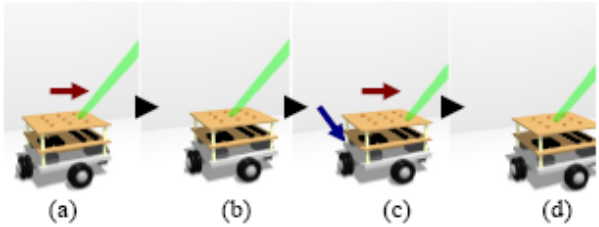
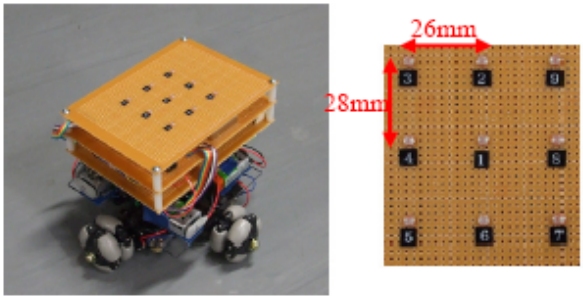



Fig.7 Motion of the robot




(a) The mobile robot (b) The light detecting surface

Fig.8 The mobile robot and the light detecting surface

## III. ROBOT CONTROL APPLICATION

In this section, we describe about an application of the proposed interface for robot control.. Because, in this interface, the luminescence part can send only two kinds of light beam, a continuous beam and a high frequency blinking beam, some artifices are needed for control of the robot. In this research, we employ 9 light detectors arranged in 3x3 as shown in Fig.5. As the robot moves to maintain the blinking beam spot at center of the detecting surface, the user can control the robot intuitively by shifting the beam spot to the desired direction just as pushing the robot with a stick. The robot can be used as a broom with a physical end effecter to sweep dust and push waste papers, while the optical beam works as a stick which can stretch and shorten freely. Fig.6 shows examples of application of the interface for mobile robots. In Fig.6(a), a cleaning robot controlled by the optical beam interface is sweeping in a narrow space, and in Fig.6(b), a mobile robot is collecting dusts at the distant place on a floor.
The appearance of a robot control sequence with laser beam is shown in Fig.7. If the blinking light points at the right element of the surface as shown Fig.7(a), the robot recognizes that signal light is pointing at right part of the surface and move small to right direction so that the light points at center of the surface again as Fig.7(b). In the same way, if the light points at another element as Fig.7(c), the robot moves and lights points at center again as shown Fig.7(d).

## IV. EXPERIMENTS

### 1. Structure of the experimental robot

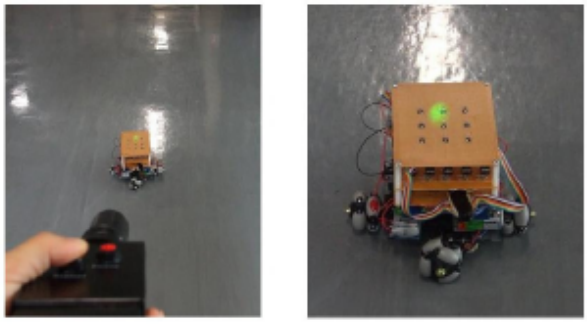
Fig.8(a) shows a photograph of the experimental mobile robot. The robot consists of light detecting part, mobile control part and mobile part. The size of robot is 220 × 220 × 140mm. Fig.8(b) shows the detecting surface of the light detecting part. Nine light detecting elements are arranged on this surface. The distance of between the elements is 26mm and 28mm, As the diameter of the blinking light is 28~60mm, the beam spot can cover at least one light detecting element when user lights the surface. The blinking signals detected at the light detecting surface are input to the controller through filters, amplifiers and smoothing filters. The control signals are sent to four motors through the H-bridge circuits. We employ PIC16F877 for the controller. Each motor is connected to an omni wheel. The robot

can move to the omni direction by the control of four omni wheels.

In this experiment, the forward direction of the robot is defined as the direction in which the No.2 detecting light element locates as shown in Fig.8(b). The robot goes forward if blinking light is pointing at the No.3, No.2 or No.9 element. The backward, left and right direction movements are actualized in the same way.

### 2. Experiment of robot control

The experiments were conducted in an ordinary room with sunlight from windows and fluorescent lights. We asked six experimenters to control the robot with the proposed optical beam interface. Fig.9(a) shows the photograph of the robot controlled by the user, and Fig.9(b) shows the zoomed up photograph of the robot lit by the beam interface.



(a) Controlling robot (b) Zoom of robot

Fig.9 The robot controlled by proposal interface

After the experiment, we got the experimenters' opinions as follows:

- It makes us feel secure because the robot does not move as long as constant beam is shot.
- As the user gets used to the interface, the robot can be controlled intuitively just by pointing at the area of the direction of movement on the light detecting part roughly without consciousness of the location of the light detecting element.
- It is interesting and strange such that we do not have to pay attention for posture of robot. All we just to do is pointing the relative direction on the surface to control.
- The laser pointer is little big and heavy. It does not allow me to keep pointing for a long time.
- It is difficult to point the robot if it is distant from me.

Although the quantitative evaluation is not finished yet, we had almost promising responses from the experiments. According to the negative opinions, the downsizing of the laser device may reduce most problems on the usability.

## V. CONCLUSION

In this paper, we proposed an optical beam interface for controlling home electronic appliances and small robots. Especially, we tried to control a mobile robot intuitively with the proposed interface. The user can control the robot by pointing the robot with the optical beam and can move the robot intuitively just as pushing the robot with a stick. The robot can be used as a broom with a physical end effecter to sweep the dust and to push the waste paper, while the optical beam works as the stick which can be expanded and contracted freely.

The future works include to reduce the interface size and to develop a standard detecting part for a variety of home electric appliances.

## ACKNOWLEDGEMENTS

This work was supported in part by "Establishment of Consolidated Research Institute for Advanced Science and Medical Care", Encouraging Development Strategic Research Center Program, MEXT, the 21st Century Center of Excellence Program, "The innovative research on symbiosis technologies for human and robots in the elderly dominated society", Waseda University Grant for Special Research Project and the research project of Waseda Research Institute for Science and Engineering.

## REFERENCES

[1]K.Irie, N.Wakamura, K.Umeda, Construction of an Intelligent Room Based on Gesture Recognition (Mechanical System), Transactions of the Japan Society of Mechanical Engineers. C, Vol.73, No.725, 2007, 258-265.

[2]K.Suzuki, M.Wada, K.Umeda, Improvement of Operation of Home Appliances in an Intelligent Room, 2006 JSME Conference on Robotics and Mechatronics Discouse papers, 2P1-E21, 2006.5.

[3]K.Hara, S.Maeyama, Y.Tanaka, Navigation Using a Laser for Mobile robot with Optical Sensor Array, Proceedings of the 25th Annual Conference of the Robotics Society of Japan, 3D14, 2007.9.