Swing Type Obstacle Sensing for Remote Internet Controlled Substitute Robot

Yoshihiko Takahashi and Takayoshi Yatsumonji

Dept. of System Design Eng.
Kanagawa Institute of Technology
1030, Shimo-Ogino, Atsugi, Kanagawa, 243-0292, JAPAN
ytaka@sd.kanagawa-it.ac.jp

Abstract

A swing type obstacle sensing for a remote Internet controlled substitute robot is proposed in this paper. The substitute robot can, for example, act as a substitute for a child who is staying in a hospital room. Also, a person can take care of his/her elderly parents from foreign countries using the substitute robot. The two personal computers of the robot and an operator are connected using the Internet. Using a CCD camera, a speaker, a microphone, and a PC display, both persons can communicate with each other. A swing type obstacle sensing with an easy graphical human interface are proposed in order to ease the difficulties of remote operation. The designs of the swing type obstacle sensing have the advantage of cutting down the sensor numbers and the system cost. The system concept, obstacle sensing, human interface, and some of the experimental results are presented. The validity of the robot system was confirmed by the application experiments with the assistance of elementary school children and a bedridden person.

1. Introduction

It will be possible to spend a comfortable and convenient life using a remote Internet controlled robot. The remote controlled robot can be a substitute for many people in many situations.

For example, a bedridden child who is staying in a hospital room can attend a class room using the substitute robot. There is a possibility that a bedridden child will feel left behind, and he/she cannot go back to his/her school again. Such a student is called a "Fu-tou-kou" student (a student who refuses to go to school) in Japan. Using the substitute robot, a bedridden child can look around the inside of his/her classroom, and can talk to other people. The proposed substitute robot will encourage a bedridden child to maintain his/her study habits. The next example is to help a son/daughter who lives away from his/her aged patients. A son/daughter can communicate with his/her parents from foreign countries using the substitute robot. Many other applications are possible.

The proposed substitute robot is a mobile robot with a personal computer, a display, a CCD camera, a microphone, and a speaker. An operator also uses a personal computer with a display, a CCD camera, a microphone, and a speaker. The two personal computers are connected using an Internet service. A wireless LAN is used to move the mobile robot without a connection wire.

A lot of researches on remote controlled robots and network robots have been conducted [1-5, for example]. We are proposing a swing type obstacle sensing for the remote controlled robot in order to ease the operational difficulties. An ultrasonic sensor is used in this study. We are also proposing an easy human interface to operate the remote controlled robot. Comparing with a fixed type sensor [6, 7, 8], the designs of the swing type sensing have the advantage of reducing the sensor numbers and the system cost. The system concept, obstacle avoidance, human interface, and some of the experimental results are presented. The validity of the robot system was confirmed by the application experiments with the assistance of elementary school children and a bedridden person.

2. Concept of the remote controlled robot

Fig.1 shows the concept of how to use the proposed remote controlled robot. An operator can manipulate the remote controlled robot by monitoring the picture from a CCD camera of the robot. The manipulation can be conducted wherever an operator can connect a personal computer to the Internet. The remote controlled robot is connected to the Internet through a wireless LAN in order to enable it to move around easily in the room.

Fig.2 shows the mechanical system of the remote controlled robot. A personal computer is installed inside the robot's main body, and controls the robot system. A PC display, a CCD camera, a microphone, and a speaker are also installed in the robot for communication. In order to move as a stand-alone system, the robot system uses a battery, and a wireless LAN. The robot system can be moved by a tire system actuated by DC motors.

3. Signal flow of operation commands

Fig.3 shows a signal flow of the operation commands. By clicking a control bottom on the operator side display, an operation command is sent from the operator side computer to the robot side computer through the Internet and the wireless LAN. After receiving the operation command, the robot side computer conducts the DC motor control. The DC motor control is conducted using A/D and D/A converter boards.

4. Obstacle avoidance using swing type sensing

An operator can avoid any obstacles by monitoring the picture from the CCD camera. It is, however, sometimes difficult to conduct the obstacle avoidance due to the remote control. Therefore, it is essential to develop a sensing system to detect obstacles. Fig.4 shows the mechanical structure of the proposed swing type obstacle sensing system. Two position sensors detect an obstacle in the upper and lower region, respectively. Identical sensing systems are installed in the front and the back of the robot system. In order to reduce the sensor numbers, the proposed system swings a position sensor. The swing motion is controlled using a DC motor and a potentiometer. The distance between an obstacle and the sensor is detected using the ultra-sonic position sensor, and the distance is classified into three levels; (a) safety distance, (b) attention distance, and (c) dangerous distance. When the dangerous distance is detected, the movement in the forward and backward directions is restricted.

5. Operation of human interface

Fig.5 shows the human interface used to operate the robot system. The center figure is the picture from the CCD camera of the robot system. The right figure is the picture from the operator desk. The lower figure is the operation panel. Fig.6 shows the expanded figure of Fig.5. Here, the definitions of each button are as follows.

1. Sensor Start, and Sensor Stop: Start and stop switches of sensor swing motion.
2. Forward, Backward, Left, Right, and Stop: Action Switches to move the robot system.
3. <Front>, and <Back>: Statuses of front and back sensors.
4. <Upper sensor>, and <Lower sensor>: Statuses of upper and lower sensors.

The robot system moves while pushing the action button. The color of the pushed action button is changed to yellowish green in order to understand easily. The sensor status is classified into the three levels by changing the color.

(a) Sky blue: safety distance, there are no obstacles in front of the robot system within 1[m].

(b) Yellow: attention distance, some obstacle is approaching to the robot system within 1[m].

(c) Red: dangerous distance, the sensor system stops the robot system when the distance is within 50[cm].

6. Confirmation experiments on swing type sensing system

Fig.7 shows the explanation figure of detection area using the swing type sensing system. Here, (a) and (b) are the conditions of non-swing motion and swing motion. Fig.8 shows the composition of the software used for communication; here NetMeeting and Desktop On-Call are used. Fig.9 shows the fabricated robot system used for the experiments.

Fig.10 shows the experimental results on the sensing linearity. The sensor was not swung, and the distance between the object and the sensor was changed. It was confirmed that the distance from about 20[cm] to 100[cm] could be detected. The sensor output at the distance of 50[cm] was about 5[v].

Fig.11 shows the experimental results on the sensing width. The sensor was not swung, and the object was moved right and left. By changing the distance, the experiments were conducted. Here, (a), (b), and (c) are the cases that the distances were 60[cm], 40[cm], and 20[cm]. It was confirmed that the sensing width was approximately ± 4[cm] at the distance of approximately 50[cm].

Fig.12 shows the experimental setup to confirm the sensing time response and speed. The plate of 1[cm] in width was rotated at the distance of 50[cm].

Fig.13 shows the experimental results on the sensing time response. The upper and lower figures show the results in the case of 0.8[rev/sec] and 4.4[rev/sec]. The detected voltage was about 5[v] in the upper figure. Therefore, it was confirmed that the upper case of 0.8[rev/sec] could detect the distance of about 50[cm]. However, the sensor output was about 6.5[v] in the lower figure. It was confirmed that the sensor could not detect correctly the distance in the higher speed case of 4.4[rev/sec].

The experiments of the sensing time response were conducted in the conditions from 0.8[rev/sec] to 4.4[rev/sec], and the results are arranged in Fig.14. It was confirmed that the sensor output was not correct at the higher speed. We decided that a sensor speed of around 1.4[rev/sec] was adequate for the swing speed of the sensor.

Fig.15 shows the experimental results on the object detection using the swing type sensing system. Here, (a), (b), (c), (d), and (e) are the sensor rotation angle, upper sensor output, lower sensor output, right motor actuate voltage, and left motor actuate voltage, respectively. The robot system was moved in the forward direction with a constant velocity of about 50[mm/sec]. The sensor swing speed was set at about 1.4[rev/sec]. The sensor rotational angle was detected by a potentiometer. Fig.16 shows the expanded figure of Fig.15. The robot system was stopped by decreasing the actuating voltage of the motors automatically when the sensor detected a distance of 50[cm]. The validity of the swing type obstacle sensing system has been confirmed by the experimental results.

7. Conclusions

A swing type obstacle sensing for a remote Internet controlled substitute robot is proposed in this paper. The two personal computers of the robot and an operator are connected using the Internet. Using a CCD camera, a speaker, a microphone, and a PC display, both persons can communicate with each other. A swing type obstacle sensing and an easy graphical human interface are proposed in order to ease the difficulty of remote operation. The designs of the swing type obstacle sensing have the advantage of cutting down the sensor numbers and the system cost. The validity of the swing type sensing system was confirmed by the experimental results. The evaluation experiments were conducted with the assistance of elementary school children and a bedridden person (see Appendix). The questionnaire survey results showed that the test subjects could enjoy the operation of the robot system.

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Appendix: Application experiments with the assistances of elementary school children and a bedridden person

The application experiments were conducted with the assistance of elementary school children and a bedridden person. A questionnaire survey was conducted after the operation of the robot system.

Six elementary children were invited to our laboratory. Fig.17 shows the scene of the operation experiments. They were divided into two groups in order to operate the robot system, and to communicate through the robot system. The following items are examples of information obtained by the questionnaire survey.

(a) Shape of the robot system was good or not bad.
(b) Speed of the robot system was perfect or rather slow.
(c) Operation of the robot system by the Internet was very interesting.

A quadriplegic person became the test subject. Fig.18 shows the scene of the operation experiments. The house of the test subject was located at Ayase city, Kanagawa prefecture, Japan. The distance between Ayase city and Atsugi city, our university, is about 20[Km]. The test subject operated the robot by using his personal computer at his house. Our robot was placed in our laboratory. In order to use his personal computer, he used a shin wooden stick. He could operate our robot from his house, and see the inside of our laboratory. The questionnaire survey results showed that the test subject could enjoy the robot operations.

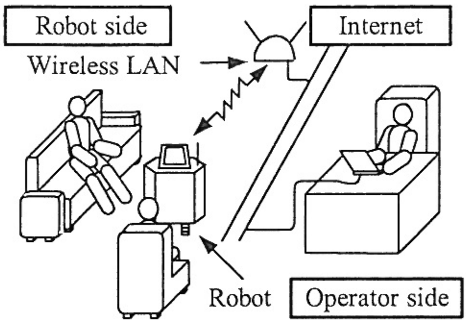


Fig.1 Concept of how to use remote controlled robot

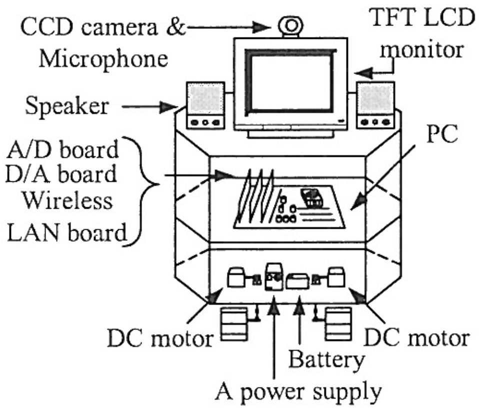


Fig.2 Robot mechanical system

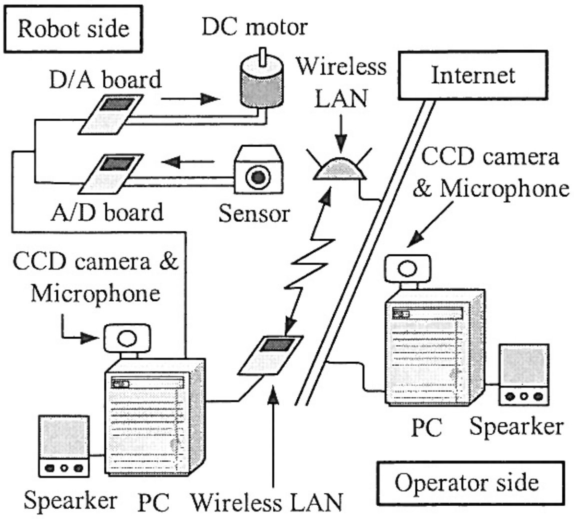


Fig.3 Command flow

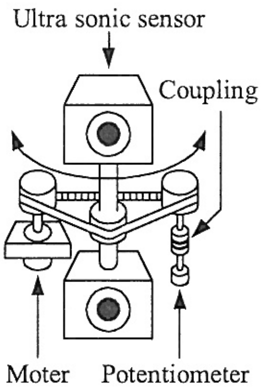


Fig.4 Sensor structure

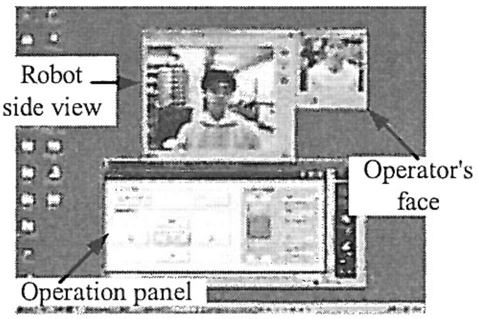


Fig.5 PC display during remote operation

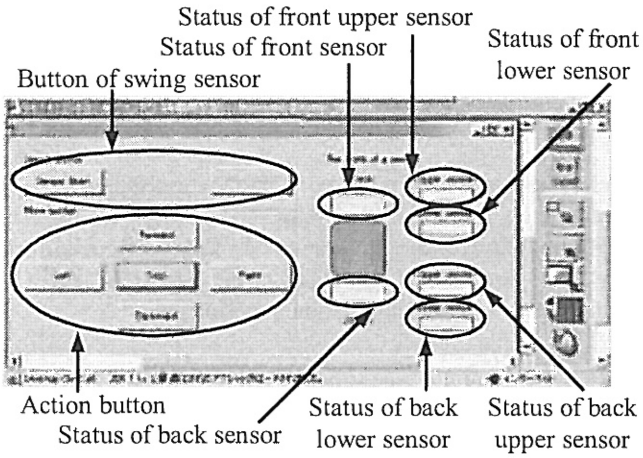
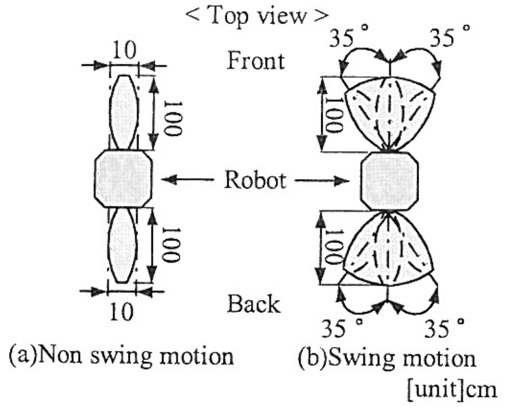


Fig.6 Details of operation panel



(a)Non swing motion (b)Swing motion

Fig.7 Deference in detection range of sensor

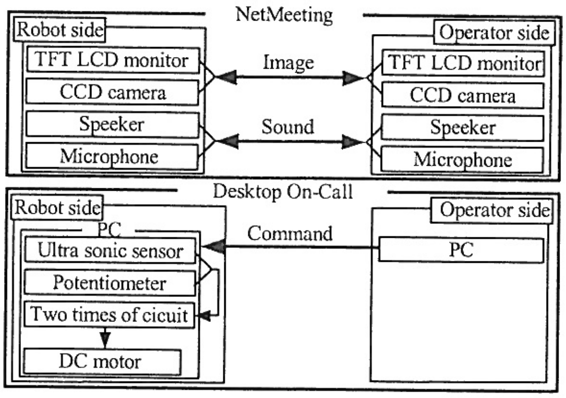


Fig.8 Software composition

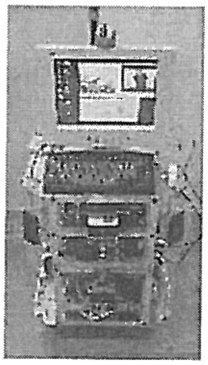


Fig.9 Photograph of experimental set up

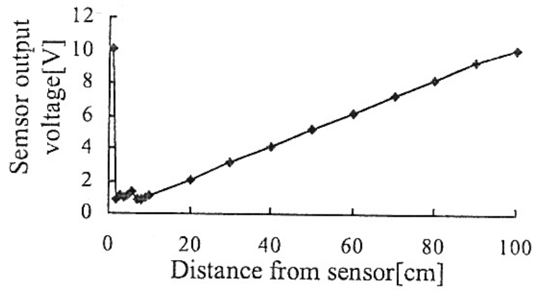


Fig.10 Experimental results on sensing linearity

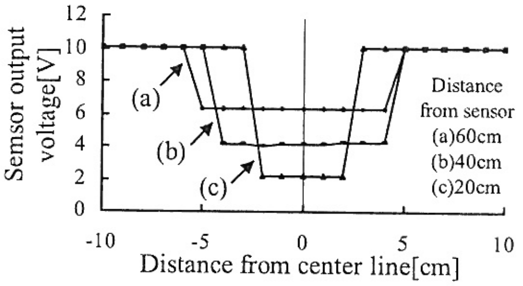


Fig.11 Experimental results on sensing width

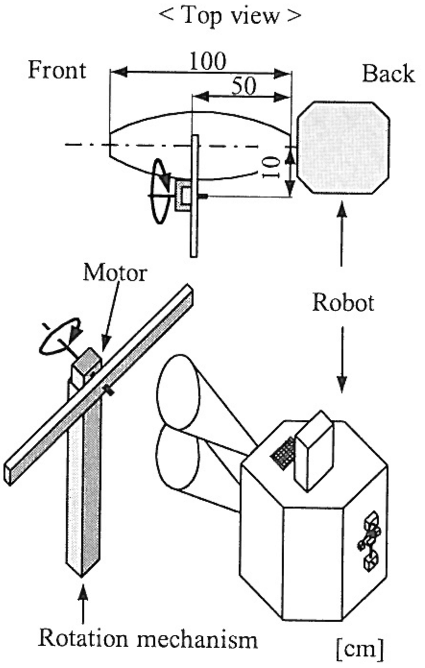


Fig.12 Experimental set up of sensing response and speed

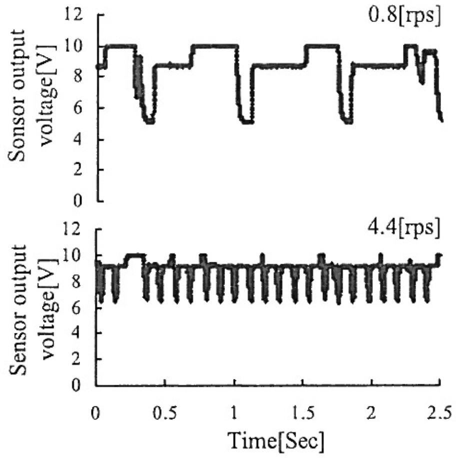


Fig.13 Experimental results on sensing time response

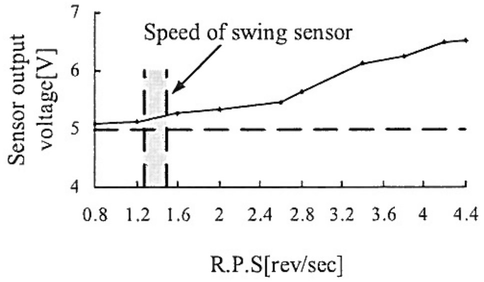


Fig.14 Experimental results on sensing speed

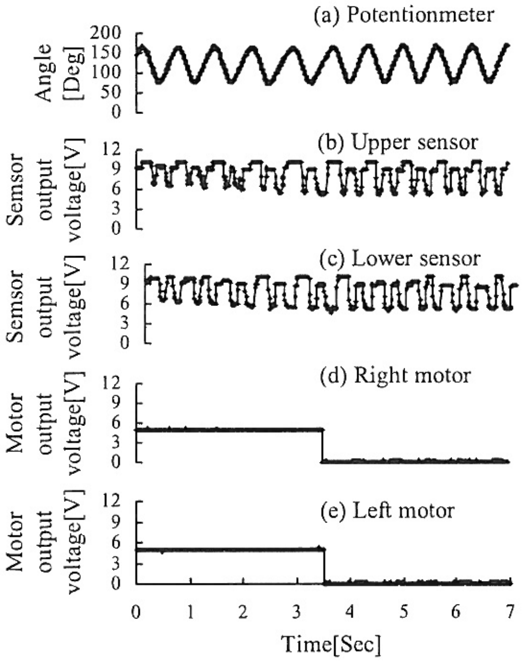


Fig.15 Experimental results on object detection

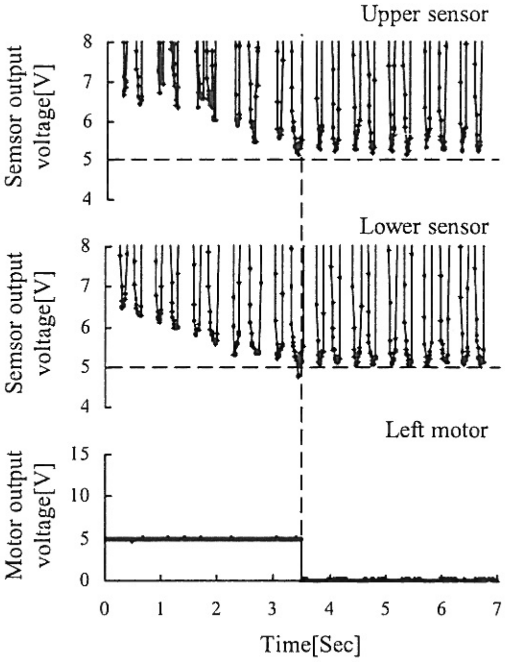


Fig.16 Enlarged experimental results on object detection

Fig.17 Operation by elementary school children

Fig.18 Operation by bedridden person