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

A rescue robot designed for ease of use
—Development of exploration system using behavior of bombycid —

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Abstract: Rescue operation is one of most effective applications of robots. However, previous rescue systems that use robots have a serious problem that is a shortage of professional operators. In this paper, we develop an exploration system of survivors using carbon dioxide, and to solve the problem we apply searching mechanism of bombycid to our system. To demonstrate the effectiveness of the proposed system, experiments have been conducted.

Keywords: ease of use, rescue robot, bombycid.

I. INTRODUCTION

In recent years, disasters occur in all parts of the world, and a lot of people are sacrificed. In the disaster scene, a most immediate priority is to rescue survivors. Then, a rescue robot that searches a narrow place and a dangerous place to save a life safety has attracted much attention [1]-[3]. However, conventional rescue robots are designed for professional operators, and user interfaces of the rescue robots are very complex. Thus, special training is required for operating them. So, it is difficult for non-professional operators to operate them.

On the other hand, in a large-scale disaster, the lack of rescue staffs is a serious problem. This means that, even if there are many rescue robots, it is difficult to utilize them. To solve this problem, rescue robots for non- professional operators are required.

In our previous works, we have developed a robot that can be operated by a steering wheel [4][5]. As the user interface of the robot is similar to usual automobile, it is possible for non- professional operators to operate it. However, there is another problem. This is an incomprehensibility of displayed sensor information. Even if the output of the sensors is displayed directly on the screen, it is difficult for non-professional operators to understand them, because non-professional operators do not have prior knowledge. So, the system that converts sensor information into comprehensible information is necessary for non-professional operators.

In this paper, we propose a system that searches carbon dioxide of human-breath by utilizing "Pheromone search algorithm of a bombycid". This algorithm is very simple [6][7] and it can be installed in a micro computer. In the proposed system, "pheromone" is replaced with "carbon dioxide", the computer indicates moving directions based on the bombycid's algorithm to the operator, and the operator controls the robot to the indicated directions. As a result, robot can reach survivors. The only thing that the operator has to do is to control the robot to the indicated direction. Thus, the operator can search for survivors without understanding sensor information.

To demonstrate the effectiveness of the proposed system, we realize a prototype system and experiments of searching for survivors are conducted.

II. Carbon dioxide

Human-breath includes carbon dioxide. So, we can explore survivors by utilizing the density of carbon dioxide. As sensors are approaching survivors, a density of carbon dioxide is increasing in the atmosphere. However, it is not strictly increase. It increases with oscillating. Therefore, going to a direction of high density is not effective for searching survivors. Fig. 1 shows density distribution of carbon dioxide. As a result, if information of density is given for non-professional operators, they can not understand and utilize the information. So, discovery of survivors are difficult.

III. Pheromone search algorithm of the bombycid

"Pheromone" exists as a discontinuous filament in the atmosphere [8]. And "Pheromone search algorithm of the bombycid" has attracted much attention, and various hypotheses have been proposed.

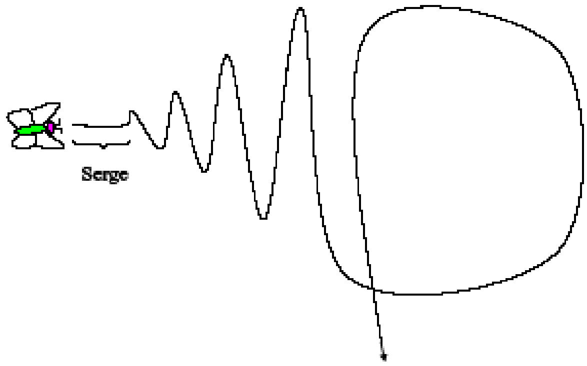

Fig. 1 Pheromone search algorithm of the bombycid

Fig. 1 shows memorized flying pattern [6][7]. First the bombycid flies straightly, and then begins zigzag motion. The zigzag motion widens gradually and finally the bombycid turns [6][7].

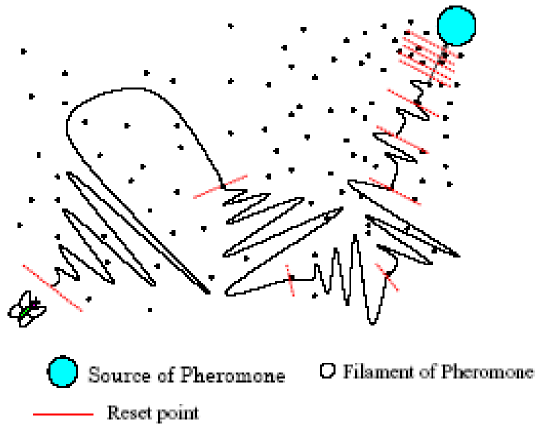

Fig. 2 An action of the bombycid

Fig. 2 shows a behavior realized by using the memorized pattern. The bombycid flies using the memorized pattern, and every time the bombycid perceives a filament of pheromone, the pattern is reset and is restarted from the beginning. When the bombycid is far from the source of the pheromone, as the frequency that the bombycid perceives a filament of the pheromone is small, the zigzag patterns are realized frequently and as a result, the bombycid can search wide area. As the bombycid approaches the source of the pheromone, the frequency to reset the memorized pattern is increased gradually and as a result, the zigzag pattern is reduced gradually.

Finally, the bombycid flies straightly and reaches at the source of the pheromone.

IV. Proposed system

1. Outline

We propose new rescue robot for non-professional operators. In this robot we use density of carbon dioxide as information for searching for survivors, and we employ pheromone search algorithm of bombycid for generating the direction to which the rescue robot should go. The user interface of the robot is similar to that of usual automobile, and the direction to which the robot should go is indicated by an arrow at a monitor. So, operator can understand which way the robot should go to and operate it without prior knowledge. Thus, even if the operator is non-professional and has no prior knowledge, the operator can search for survivors by utilizing information of carbon dioxide. And they can discover survivors. Fig.3 shows the realized user interface, and Fig. 4 shows the indication of an arrow.

Fig. 3 Realized user interface

Fig. 4 Indication of an arrow

2. The system for searching carbon dioxide

In this system, the operator and the computer share their roles. A role of the non-professional operator is to operate the rescue robot in unknown environment to the indicated direction while avoiding obstacles. And a role of the computer is to generate the direction to which the robot should go.

By indicating the moving direction, the operator can operate the robot to suitable direction without using sensor information. So, even if the operator has no prior knowledge, it is possible to search for survivors.

On the other hand, by operating the robot by human operator, the computer does not have to control the robot. So, load of the computer is extremely reduced.

Thus, in the proposed system, advantage of the human operator compensates disadvantage of the computer and advantage of the computer compensates disadvantage of the human operator.

3. Interface

Fig.5 shows the "Fish-eye-camera" that is installed on the robot. Its view angle is about 180 degree, so wide area can be seen by one camera. The image from the camera is displayed by the six screens of LCD and we employ steering wheel and pedals so that non-professional operator can operate it as if he drives an automobile. Fig.6 shows the Steering wheel and pedals.

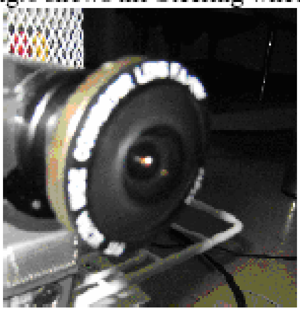

Fig. 5 Fish-eye-camera

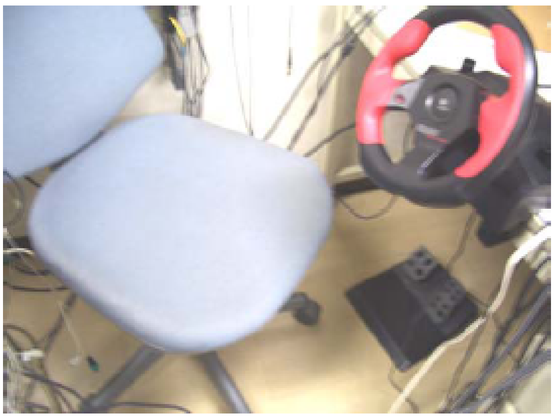

Fig. 6 Steering wheel and pedals

V. Experiment

1. Experiment methods

We prepare 6m*3m-room and employ chairs and cardboard boxes as obstacles. In the environment, non-professional operator looks at the screens and operates the rescue robot towards the indicated direction. In the experiment, we employ the tank type robot as the rescue robot. Fig.7 shows the experiment environment, and Fig.8 shows tank type robot that is used for the experiment. Fig. 8 shows a camera image installed a tank type robot.

Fig. 7 Experiment environment

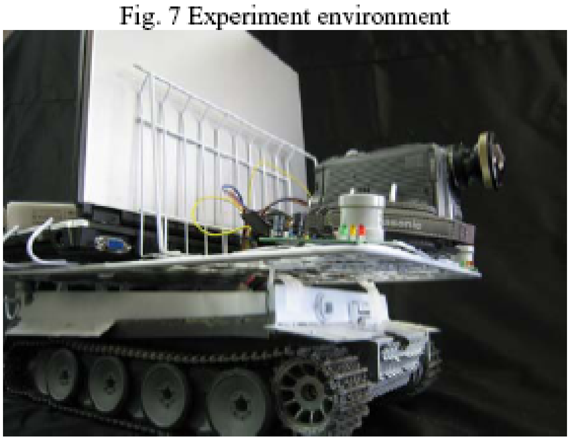

Fig. 8 Tank type robot

Fig. 9 A camera image installed a tank type robot

2. Experiment result

Operator has driven the robot to the indicated direction while avoiding obstacles, and as a result zigzag behavior has been realized and the robot has gradually approached hidden human examinee. Success rate was about 50%.

Fig. 10 shows the standardized values of sensors installed in the robot.

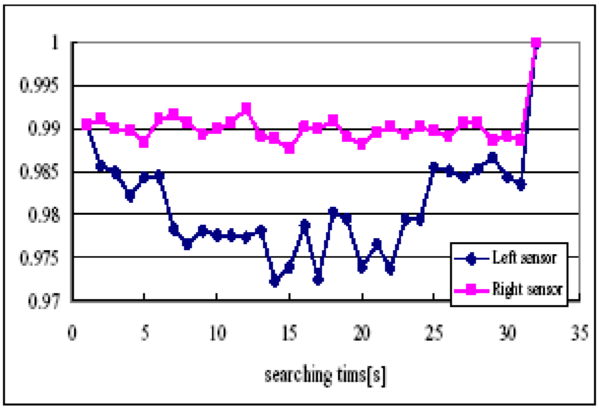

Fig. 10 Experiment result

VI. Discussion

From the results, we can confirm that by using the proposed system, operator can discover survivors without priori knowledge of the sensor information, and we can conclude that problem of incomprehensibility is solved by using pheromone search algorithm of bombycid

To increase success rate, we have to tune various parameters of the search algorithm of bombycid and it is our future work.

VII. Conclusion

In this paper, to solve the problem of lack of rescue staffs in large scale disasters, we have considered a rescue robot for non-professional operator. We have pointed out the problem of incomprehensibility that occurs in realizing the rescue robot for non-professional operator, and to solve the problem we have proposed new rescue robot which utilize search algorithm of bombycid. Prototype system has been realized and experiments have been conducted. As a result, operator has discovered human examinee without understanding sensor information. We can conclude that proposed rescue system is useful for non-professional operator. Our future work is to tune the proposed system and to evaluate it from various view-points.

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