1. INTRODUCTION

It has been fast increasing for the application of robots and their technology. The intelligent behavior of the wheeled intelligent mobile robot (robot) comes from its recognition and analysis of the surrounding environmental information and the order it received, based on which, a human-like judgment is generated to guide the direction for the robot. Therefore, the robot can avoid the obstacles intelligently and reach the destination.

Robots can detect the surrounding using traditional methods, such as ultrasound or infrared detectors to check whether there is an obstacle in front, and then decide whether to move forward or not. After that the detection is applied again to decide for the next movement. Based on a study, “Artificial life” means artificial systems that have behavior similar to that of the “natural life” [1]. It requires imitating human thinking from all aspects, not only from logical thinking, but also imaginary thinking. With both logical and imaginary thinking, information fusion can be achieved based on the artificial intelligence and intelligent algorithm to yield a better obstacle avoidance result. “Information fusion” means to analyze multiple feelings or information together as a human being and make reasonable judgments. In another word, the principle of information fusion is the same as that for human to process information, which means to organize the information according to certain optimization rules and obtain a consistent and accurate description for the objects that has been dealt with.

According to a research, the information fusion can be classified into three levels: data level fusion, character level fusion and judgment level fusion [2]. The data level fusion is the lowest level, which has only minimal process of the original information. The character level fusion is also called the middle level fusion, which extracts some characteristics from the original information and processes afterwards. The judgment level fusion is also called the highest level fusion, which directly combines the judgments from the original data and provides conclusions for the final decision.

Logical thinking while the higher level one can be used to imitate human imaginary thinking. Different fusion and thinking will generate different behavior when robots avoid obstacles.

2. THE OBSTACLE AVOIDANCE LOGIC UNDER THE SIMULATION OF HUMAN LOGICAL THINKING

2.1 The information gathering from ultrasound and infrared detectors

The robots we use in our experiments have two driving wheels and two supporting wheels [3]. Identification of sensor technology has many applications and research. For example, Control accessibility to biosensor probes, Radio frequency identification semi-active tag with sensing capabilities for the food logistic chain, etc. [4, 5]. The robots are driven under differential signals which agile movement and easy control. Study showed the robots can incorporate visual software to apply the intelligent control algorithm [6].

The real environment in which the robot is operated is complicated. The robot is equipped with 11 detectors in the front and right sides. The detectors in front are labeled with 4, 5 and 6, front-left with 2, 3 and 4, front-right with 6, 7 and 8, left with 11, 1 and 2, and right with 9, 9 and 10. The ultrasound and infrared detectors have different working ranges. The ultrasound detectors can detect object from a long distance but have blind spots in short ranges, in which infrared detectors are able to find obstacles.

Therefore, information gathering with the ultrasound and infrared detectors works as the following:

If the infrared detectors find an obstacle in the close range, the robot considers that there is an obstacle no matter what the ultrasound detectors have detected.

If the infrared detectors do not find any obstacles in the close range but the ultrasound detectors find an obstacle within 20 - 300 cm distance away, the ultrasound results are considered to be true.

If neither the infrared nor ultrasound detectors find any obstacles, it means the obstacles are at least 300 cm away. The information gathered from all detectors needs to be considered together (fused). The movement of the robot should be decided after judging whether or not...
there are obstacles in all directions, i.e. the front, front-left, front-right, left and right. To gather information accurately, the readout from the 11 detectors should all be considered. Since the shape of the obstacles is uncertain, three detectors are used to analyze each direction, i.e. 4, 5 and 6 for the front, 2, 3 and 4 for the front-left, 6, 7 and 8 for the front-right, 11, 1 and 2 for the left and 8, 9 and 10 for the right. It is reasonable to consider the distance of an obstacle to be the minimum of the three readouts from the three detectors in the group of the same direction.

2.2 The obstacle avoidance logic under the simulation of human logical thinking

To avoid obstacles while moving, different methods should be applied according to the characteristic of the detectors one robot may carry. To perform logical judgment based on the information gathered by the detectors comes to mind first. The information from multiple infrared and ultrasound detectors is fused and logical reasoning is performed based on the simulation of human logical thinking, which is shown in Fig. 1.

The robots make decisions of changing directions in a repeated loop to avoid the obstacles by logical reasoning.

3. THE OBSTACLE AVOIDANCE BEHAVIOR UNDER THE SIMULATION OF HUMAN IMAGINARY THINKING

3.1 BP neural network and the simulation of human imaginary thinking

BP neural network is one of the artificial neural networks (ANNs). It is to imitate the neural network in life to realize parallel performance, fault allowance, self-adjustment, self-learning and group calculation in the computer. The common BP neural network consists of the input layer, hide layer and output layer. It propagates the calculation forwards, i.e. the neurons in one level receive the signal from the neurons in the previous level and generate the result according to the weights assigned to the different neurons. The calculated result is then propagated backwards in order to adjust the weight such that the expected output is obtained.

When the BP neural network propagates calculation forward, the input signals are gathered by the input layer, after analyzed by the hide layer, the result is broadcast by the output layer. When compare to the expected output, if the output is not acceptable from the expectation, the error is then propagated backwards through the hide layer to the input layer and assigned to each neuron. Each neuron then uses the error signal to adjust the weight. The adjustment of the weight matrix of each layer by signal forward propagation and error back propagation is done repeatedly. The adjusting process of the weight is also the learning (training) process of the network. This process is terminated till the output error is acceptable or a certain learning time is reached. The training process of the neural network can be considered as information fusion. The BP algorithm adjusts the threshold and weight of each neuron and when the network is stable, the network structure and the input-output model are determined. The training process of the BP network is shown in Fig. 2.

As shown in Fig. 2, after building the model, the input-output relation, i.e. usually as an uncertain function, is stored in the form of a network. Therefore when a new input is chosen, the output of the network is considered as a simulation of that of human imaginary thinking.

3.2 The obstacle avoidance under the simulation of human imaginary thinking

The information gathered by the infrared and ultrasound detectors is decomposed to build a BP neural network, which is trained afterwards. During the imitation of human imaginary thinking, the detected distance is abstracted in order to suit the input form of the neural network. The distance information is classified into three levels and the judgment is also assigned numerically into six levels. The abstraction of the sensors’ distance is shown in Table 1. And the abstraction of decision judgment is shown in Table 2.

<table>
<thead>
<tr>
<th>distance</th>
<th>integer</th>
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<tbody>
<tr>
<td>close</td>
<td>1</td>
</tr>
<tr>
<td>far</td>
<td>2</td>
</tr>
<tr>
<td>very far</td>
<td>3</td>
</tr>
</tbody>
</table>

will generate different behavior when robots avoid obstacles. The imitation of human thinking can be conducted within the two aspects of the logical and imaginary thinking. The intelligent algorithm is needed in order to imitate human imaginary thinking and the BP neural network can be used to promote the quality of obstacle avoidance of the robots. Robot obstacle avoidance would be better.

ACKNOWLEDGMENT

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[1] Y. Yin and X. Tu, Artificial Life-based Intelligent Control System [A], Proceeding of “Artificial Life and Application” Seminar, China Artificial Intelligence Society, Beijing, Beijing University of Science and Technology (2002). 10, pp. 80


3.3 Comparison of the experimental results

The difference in the result of robot moving is apparent for using normal logical adjustment and neural network to simulation human imaginary thinking as the system decision making methods. In the case of using logical judgment, the robots can avoid the obstacles aglely. However, when a dead angle presents, the robots may circle around. On the other hand, when adopt with neural network as the decision making system, the robots can also avoid the obstacles in time. Since the robots have been trained with environmental parameters, which is set according to human adjustment they will not circle around the dead angle. In this situation, the robots with imaginary thinking avoid the obstacles better than those with simple logic judgments.

In summary, human thinking represents the human intelligence and leads to intelligent behavior. The imitation of human thinking can be conducted within the two aspects of the logical and imaginary thinking. The intelligent algorithm is needed in order to imitate human imaginary thinking and the BP neural network can be used to promote the quality of obstacle avoidance of the robots. From the experiments, a neural network that imitates human imaginary thinking is used as the decision making system to control the robot movement. The decisions they made are better than those from imitation of the human logical thinking, able to both avoid the obstacles while moving and eliminate the situation of circling around dead angles. From the route of the movement, the human imaginary thinking suits human thinking habit better, and makes better choice for the direction in which no detector is applied. Further, the network can be trained with the examples made according to the different environments and needs. Therefore, the adaptability of the robots will be improved and better results of obstacle avoidance can be achieved.

4. CONCLUSIONS

In the present work we have presented that the lower level fusion can be used to imitate human logical thinking while the higher level one can be used to imitate human imaginary thinking. Different fusion and thinking

<table>
<thead>
<tr>
<th>decision</th>
<th>integer</th>
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<tbody>
<tr>
<td>straight</td>
<td>1</td>
</tr>
<tr>
<td>forward</td>
<td>2</td>
</tr>
<tr>
<td>right 45 degree</td>
<td>3</td>
</tr>
<tr>
<td>left 45 degree</td>
<td>4</td>
</tr>
<tr>
<td>right 90 degree</td>
<td>5</td>
</tr>
<tr>
<td>right 135 degree</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2: The abstraction of decision judgment

After the training of the network, it is reasonable to consider it has some level of imitating human imaginary thinking. During the movement of the robots, the gathered information is sent to the network and a reasonable output then is generated and the robot moves under the control of the intelligent algorithm.