OBSTACLE AVOIDANCE IN COMPARATION USING FUZZY LOGIC AND NEURAL NETWORK

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ABSTRACT
This paper proposes a Fuzzy Logic and Neural Network control system that is able to guide the Mobile robots (AmigoBot and P3DX) traverse through a maze with arbitrary obstacles and computed data and algorithm in Personal Computer (PC) in wireless system. For input data, controller (Fuzzy Logic and Neural Network) receives data from sensors (sonar and laser range finder). This paper checked the efficiency of controller (Fuzzy Logic or Neural Network) through various experiments. The empirical results show the effectiveness and the validity of the obstacle avoidance behavior of the proposed Neural Network control strategy by using laser range finder as the main sensor.

Keywords: Mobile Robot, Fuzzy Logic, Neural Network, Obstacle Avoidance

INTRODUCTION
Investigate mobile robot’s history, obstacle avoidance is one of most important research area and also the foundation of building robot’s successful behaviors. The uncertainties in the environment affect the obstacle avoidance algorithms during navigation process.

The mobile robot system obtains information from environment through two sensors (sonar and laser range finder). To avoid the obstacles successfully, sonar data can be used as input to fuzzy sets for the global mapping that is to model environment and indentify robot’s position and orientation. Make the good accuracy and performance of sonar data detection [2]. On other case, Ganapathy (2009) concluded that his proposed behaviors of the controllers with Path Remembering make the mobile robot to be capable in reaching the desired goal even when the environment consists of some odd shaped acute obstacles. The author also found that the best combination of the algorithms is obtained when the Obstacle Avoidance behavior is controlled by Artificial Neural Network [3].

Harb (2009) proposed Neural Network controllers for local navigation, Neural Networks for environmental recognition, and a Fuzzy system for speed control. The system is fed off-line by a simulated model of a laser range-finder. These major components of the control system perform a global Neural navigation and a Fuzzy-Neural speed control that guide a mobile robot to track its predefined path to arrive at its final goal through a set of sub-goals, or autonomously plan its path to arrive at the desired final goal while avoiding obstacles that are found along the way [4].

Motlagh (2009) prove that Fuzzy systems have the ability to treat uncertain and imprecise information using linguistic rules. They offer possible implementation of human knowledge and experience, and have an advantage in that they do not require a precise analytical model of the environment [5]. Keeping track of the position and orientation over time using sensor data, i.e., pose tracking, is a central component in many mobile robot systems. Yau-Zen (2007) used a scanning laser range finder to acquire distance information for motion planning with wall following strategy [6].

There are researches published on obstacle avoidance, dynamic environment recognition and mobile robot speed control using Fuzzy Logic and Neural Network [1]-[4]. We applied the methods in those papers [1]-[4] to AmigoBot and P3DX and also tried to extend to several conditions different from the previous researches. This paper presents the approach to eliminate the sensory data error to enhance the
sensory information equality. We propose to analyze behavior of the sensors data so that we find valid data based on real environment.

Furthermore in mobile robot control, it is usually found difficulties in modeling caused complexity of the system. The uncertainty in the model of the mobile robot is contributed by mobile robot system (slip, center of wheel alignment and usage time) and environment (uneven, unstructured and unknown terrain). Therefore the autonomous mobile robot system appeared to have nonlinear characters. So the method what apply for complex environment in algorithm which we choose two different algorithms (Fuzzy Logic & Neural Network) to compare and implement the effective behavior in reality.

To solve it, we demonstrate in Matlab to execute methodology (Fuzzy Logic and Neural Network) based intelligent behavior control system for the mobile robot (AmigoBot and P3DX). The obstacle avoidance behavior is realized through Neural Network to model the environmental situation that mobile robot encountering during the travel and followed by the motion control through the Fuzzy Logic to infer the avoidance action from a rule base associated with the recognized situation. The Neural Network method to indentify environment is based on the work of Beom, H.R. and H.S. Cho [1] with the laser range finder as sensor. The advantage of this system is the mobile robot can be controlled without implicit modeling of mobile robot and environment. We investigate several methods and strategies to design Fuzzy Logic and Neural Network to control mobile robot.

EQUIPMENT OF ROBOT AND SENSOR

The Comparison with Neural Network and Fuzzy Logic method implemented on a mobile robot P3dx and Amigo which has eight sonar sensor on the front as shown in Fig. 1.

Fig.1: (Left) P3DX (Right) Amigo

The 8 sonar are already based on the P3DX as Fig. 2. But in the maze environment, the data of sonar is not too stable because the angle reflection when its feedback in reality. Laser range finder is divided its 681 reading into 20 regions as shown in Fig. 2. In paper’s experiment, a2-a19 is used for sensor range. Through the calibration of laser range finder we noticed that region with zero reading randomly (data lost in feedback progress). The blank part in Fig. 2 presents the situation of data lost.

FUZZY LOGIC OBSTACLES AVOIDANCE

To implement this control, we have to design output of system, input membership function, use several Fuzzy Logic rules and check the respond. Rule defined and appropriate respond which in motion output are important consideration for Fuzzy Logic design. Fig. 4 is configuration of the laser range finder with three defined region (close, middle and far). Fig. 5 shows the output of Fuzzy control and Fig. 6 shows the input.

Fig. 3: (Left) 8 sonar direction and degree in P3DX (Right) 20 regions definition and blank demonstrate data lost case

Fig. 4: (Right) Laser Range Finder (Hokuyo URG-04LX) (Left) Configuration of laser range finder as input of Control

Fig. 5: Output of fuzzy logic control

Fig. 6: Input of fuzzy logic control
The rule of Fuzzy Logic definition is presented in Table 1. The methodology is depending on Laser Range Finder from a2-a19.

<table>
<thead>
<tr>
<th>Decision Result</th>
<th>Environment Condition</th>
</tr>
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<tbody>
<tr>
<td>Front</td>
<td>a9 is Far OR a10 is Far OR a11 is Far OR a12 is Far</td>
</tr>
<tr>
<td>Left-Front-Front</td>
<td>a8 is close OR a8 is middle</td>
</tr>
<tr>
<td>left-Front-Front</td>
<td>a9 is close OR a9 is middle</td>
</tr>
<tr>
<td>Right-Front-Front</td>
<td>a13 is close OR a13 is middle</td>
</tr>
<tr>
<td>Right-Right-Front</td>
<td>a12 is close OR a12 is middle</td>
</tr>
<tr>
<td>Right</td>
<td>{a6 - a15 is close OR a6 - a15 is middle} AND {a16 - a19 is close OR a16 - a19 is middle}</td>
</tr>
<tr>
<td>Left</td>
<td>{a6 - a15 is close OR a6 - a15 is middle} AND {a2 - a5 is close OR a2 - a5 is middle}</td>
</tr>
</tbody>
</table>

The robot make turn by controlling the velocity of right and left wheel as shown in Fig. 7 as

$$\omega_R = \frac{R+L}{2R-L} \omega_L$$  \hspace{1cm} (1)

$$R = \frac{L \omega_R + \omega_L}{2 \omega_R - \omega_L}$$  \hspace{1cm} (2)

![Fig 7: Instantaneous center of rotation (ICR)](image)

To make it simple in training data, we define one region (adjustable). If obstacle is inside the region, we set the threshold of this region to be one (1), otherwise, zero (0). One means when system will start to respond. If we want the mobile robot to respond to obstacle in long distance, we can set the region bigger.

To train data and build Neural Network, the interface of using is the toolbox of Matlab Neural Network function. The steps and equations what we use to train in Backpropagation is the basic method and also one of most important to develop the training result. After we try several methods and hidden layer amount combination, we decide that combination with 9 neurons in hidden layers 1, 8 neurons in hidden layer 2, and 6 neurons in hidden layer 3 are the Neural Network structure we use. This combination is chosen manually after trying possible combination of hidden layer or neurons.

**FLOW CHART OF THE MAIN STRUCTURE**

In progress of algorithm, the main structure build in the flow chart is shown as the Fig. 9 below. Sense the indoor environment first, when data valid, the region separated as the different areas and continue the main algorithm computing of Fuzzy logic or Neural Network intelligent system. Then the environment changed and having sensing data input to fix the heading angle and make sure robot not to hitting obstacle and pass through the maze.

![Fig 9: Flow chart of main algorithm structure](image)

**ALGORITHM OF NEURAL NETWORK**

In Neural Network control, we define eighteen areas (a1-a19) to be eight areas (s1-s8) which is showed in Fig.8.

![Fig 8: Configuration from a1-a19 to s1-s8](image)
RESULTS AND ANALYSIS

1. Fuzzy logic control
The ability to avoid the obstacle is unreliable in comparison with Neural network so that the mobile to hit the maze or obstacle sometimes. From Fig. 10 we can observe trajectories of mobile robot when use Fuzzy Logic as controller and find out the hitting place as marked.

![Fig. 10: Trajectories and maze plot of Fuzzy Logic (The unit of x-y label is mm)](image)

2. Neural Network control
This system can avoid obstacle better. From our observation, we get the appropriate distance for the region which is 700 mm as shown in Fig. 7. This distance is suitable for the maze system. Check the responds, we record the trajectories when it avoids the obstacle. Fig. 11 shows its trajectories when use neural network as controller.

![Fig. 11: Trajectories and maze plot of Neural Network (The unit of x-y label is mm)](image)

CONCLUSIONS

In this paper, to enable the system to avoid the obstacle successfully, we get conclusion that sonar sensor can’t read data well in maze structure. Alternatively, we use laser range finder to get the data. Although laser ranger finder also sometimes has error data, we can eliminate it by taking average for non-zero regions.

Regarding with the proposed method to optimally avoid the obstacle, system with Fuzzy Logic control does not work consistently. On the other hand, system with Neural Network control can successfully avoid the obstacle. To get good respond of Neural Network, it needs further experimental to get good data training. The more valid trained data, the better Neural Network system we have. In Fuzzy Logic control, it needs many investigations in building rule. These rules will decide the respond of the Fuzzy system.

For the application in real world, this research can be used in ruin building to find the victims. This system can find way in complex environment. With improvement in recognizing victim characteristic, this system can be used for that purpose.

REFERENCES


