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Investigation in Two Wheels Mobile Robot Movement: Stability and Motion Paths

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ABSTRACT

This paper deals with the problem of dynamic modelling of inspection robot two wheels. Fuzzy controller based on robotics techniques for optimize of an inspection stability. The target is to enhancement of robot direction and avoids the obstacles. To find collision free area, distance-sensors such as ultra-sonic sensors and laser scanners or vision systems are usually employed. The distance-sensors offer only distance information between mobile robots and obstacles. Also the target are shown can be reached by different directions. The fuzzy logic controller is effect to avoid the abstacles and get ideal direction to “the target box”.

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1. INTRODUCTION

Mobile robots should be able to operate autonomously in a working environment by avoiding obstacles and performing a mission. The obstacle detection and collision avoidance are research areas for a safe navigation. Wheeled mobile robots are mechanical devices capable ofoperating in an environment with a certain degree of autonomy [1-3]. The environment can be classified as structured whenit is perfectly known and motion can be planned in advance, or as partially structured when there are uncertainties thatimply some on line planning of motions. Autonomous navigation refers to the capability of capturing environmentinformation through external sensors, such as vision, distance or proximity sensors. Although distance sensors (e.g., ultrasound and laser types), are the most usual sensors todetect obstacles or to measure robot-to-obstacle distances, vision-based sensors are widely used. Vision-based sensors allow supplying a large amount of information from images [4-7].

2. MATHEMATICAL MODELING OF TWO WHEELS MOBILE ROBOT

This paper uses the two wheeled mobile robot. Hence, the position of the wheel is characterized by two constants: 2b – distance between wheels, R wheel radius. This means that the velocity of the contact point between each wheel and the horizontal plane is equal to zero. The rotation angle of the wheel about its horizontal axle is denoted by φ (t) and the radius of the wheel by R [1-2].

Kinematic model of the vehicle velocity V and the angular velocity $\dot{\theta}$& of the mobile robot are shown in Figure 1. Model of the differentially driven mobile robot in the two-dimensional work space and given by the Equation (1):

$$\begin{bmatrix} V \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} R/2 & R/2 \\ R/2b & -R/2b \end{bmatrix} \begin{bmatrix} \omega_r \\ \omega_l \end{bmatrix} \quad (1)$$

The model of the robot has two driving wheels which are attached to both sides of the vehicle and the angular velocities are ω_r : the right wheel velocity, and ω_l : the left wheel velocity.

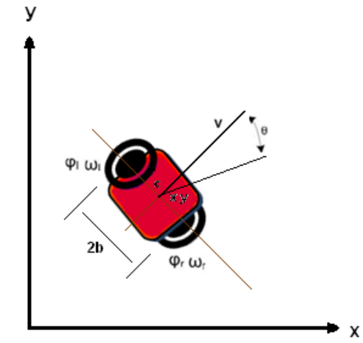

Figure 1. Model of the differentially driven mobile robot in the two-dimensional work space

3. ULTRASONIC SENSORS

Ultrasonic distance sensor determines thedistance to an object by measuring the time taken by the sound to reflect back from that object. The frequency of the sound is somewhere in the range of ultrasound, this ensures more concentrated direction of the sound wave because sound at higher frequency dissipates less in the environment. A typical Ultrasonic distance sensor consists of two membranes. One membrane produces sound, another catches reflected echo. This mobile robot uses ultrasonic sensors to infer environmentalinformation. These sensors determine distance by measuring the time of the ultrasound pulses that reflect off an object and return to the sensor. Although these sensors provide accurate distancemeasurements, their readings are not precise in the azimuth.The sensors measure distance to nearby obstacles, along axed direction termed the sensor measurement axis. The sensor measurement axis is a functionof the robot's position and orientation.

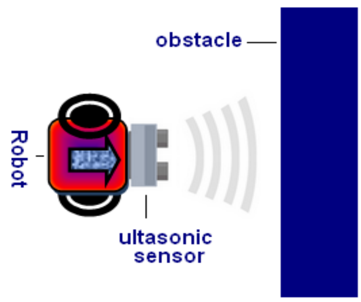

Figure 2. Ultrasonic sensor to distance measurement and obstacle detect

4. FUZZY LOGIC CONTROLLER

MATLAB is used for implementing fuzzy relations and sets. The Matlab toolbox and simulink helps the user to view the real time simulations and how the fuzzy logic works and can be applied for different fields.To account for the real-world gradient that exists between true and false, fuzzy logic was created. Instead of an element being 100% true or false, fuzzy logic deals with degrees of membership and degrees of truth, instead of yes and no. Something can be partially true and partially false at the same time. Fuzzy logic has the ability to add an extra layer of intelligence to the computer and swifter, more practical means of problem solving. Figure 1 shows how fuzzy Logic implements a gradient of possible states as opposed to a binary one or zero.

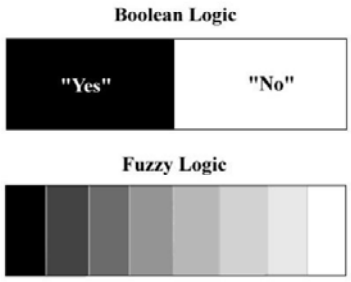

Figure 3. Boolean Logic vs. Fuzzy Logic

Fuzzy logic controller is method based on the systems. Fuzzy logic is not really "fuzzy". Just as fuzzy logic can be described simply as "computing with words rather than numbers", fuzzy control can be described simply as "control with sentences rather than equations''. For many real world applications a great deal of information is provided by human experts, who do not reason in terms of mathematics but instead describe the system verbally through vague or imprecise statements like,

IF *The Temperature* is ***Big*****THEN***ThePressure* is ***High***.

Because so much human knowledge and expertise come in terms of such verbal rules, one of the sound engineering approaches is to try to integrate such linguistic information into the modeling process. A convenient and common approach of doing this is to use fuzzy logic concepts to cast the verbal knowledge into a conventional mathematical representation. Fuzzy logic facilitates the representation in digital computers of this kind of knowledge, which subsequently can be fine-tuned using process experiments (e.g. based on input-output process data). From this basis, fuzzy system is a computation framework based on the concepts of fuzzy sets, fuzzy if-then rules, and fuzzy reasoning. This section will introduce the reader to the structure of fuzzy models. The Fuzzy Logic Toolbox is a collection of functions built on the MATLAB numeric computing environment. It provides tools for you to create and edit fuzzy inference systems within the framework of MATLAB.the fuzzy controller used in this paper two inputs, one output which the GUI graph shown below, where the input 1 is the error and the input 2 is the change in the error, and the output is the velocity angle. Fuzzy-logic-based control is applied to the navigation of the autonomous mobile robot in unknown environments with obstacles.

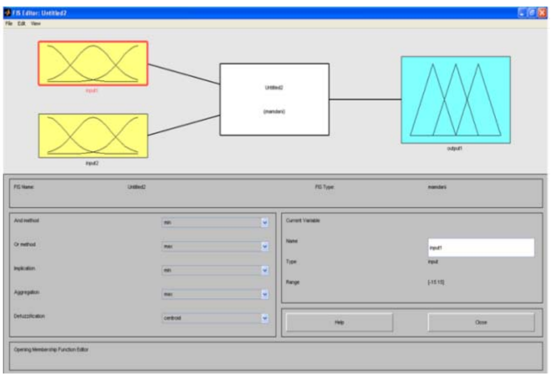

Figure 5. Fuzzy interface system (2 inputs, one output)

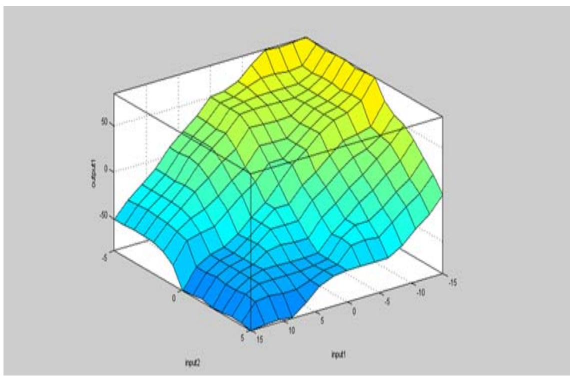

Figure 6. Surface viewer

Figure 6 shows mesh graph (surface viewer) of the fuzzy controller rules that applied to the robot, where 25 conditions in this fuzzy system has been done to get the stability for the system and detect the object in the correct direction.

5. RESULT AND DISCUSSION

This paper presented the fuzzy logic controller to enhancement the motion to the correct direction to the target and the result as Figure 7 below shows that the similarity of the behavior in the motion in the desired input and the measured output, and in figure 8 shows the error between them, where the error decreased. These results are perfect and achieve the target to reach to the object by avoid the obstacles.

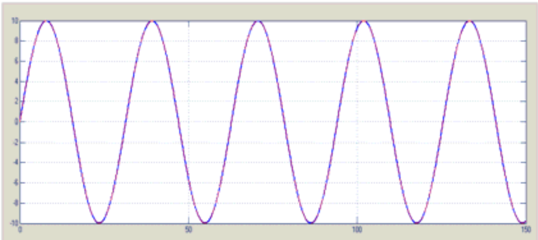

Figure 7. Stability of the robot motion
(--- desired input, ---output stability response of the robot motion)

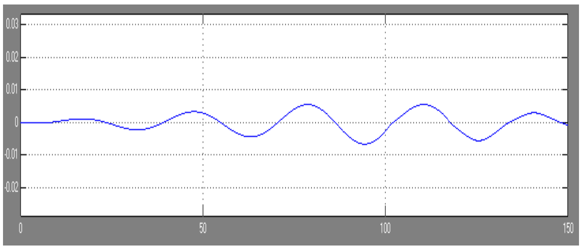

Figure 8. The error of the stability response of the robot motion
(--- desired input, --- output stability response of the robot motion)

The error between the desired input and the output stability response of the robot motion, where is the error first increased through the time after that the error decreased according to increasing the time as Table 1.

Table 1. The error between the desired input and the output stability response of the robot motion

Time(sec)	4	17	32	47	63	78	94	114	125	141
Error	2E-3	13E-3	23E-3	33E-3	36E-3	55E-3	57E-3	56E-3	37E-3	31E-3

The robot has many directions to the "target box" by avoid the obstacles, and that takes different time to reach to the "target". The directions calculated according the time and the distance and the number of the angles to reach to "the target box", the robot takes the nearest distance to reach to "the target box".

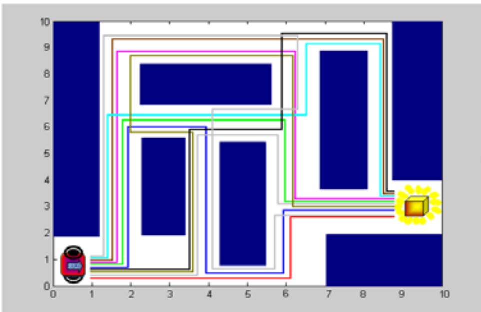

Figure 9. The robot motion to the target in many directions

Table 2. The robot baths, distances, number of angles, and directions to "the target box"

Number	1	2	3	4	5	6	7	8	9	10
color	—	—	—	—	—	—	—	—	—	—
Distance to the "target box"	9 m	16 m	20.5 m	16 m	21.3m	16 m	21.3 m	21.1 m	21 m	28.7 m
Number of corners	2	4	6	6	6	4	4	4	6	8
Directions	↑→	↑→↓→	↑←↑→↓→	↑→↑→↓→	↑→↓→↑→	↑→↓→	↑→↓→	↑→↓→	↑→↑→↓→	↑→↓←↓→↑→

6. CONCLUSION

The mathematical modeling of two wheels mobile robot presented in this paper to avoid the obstacle and gettig the right direction to “the target box”. Fuzzy controller controlled the wheels angle velocity and ultrasounic sensor used to detect the abstacles and distances so that shows the similarity of the behavior in the motion in the desired input and the measured output are achieved with limited error errors during the time. The fuzzy logic controller is effect to avoid the abstacles and get ideal direction and nearst path to “the target box”.

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