Navigation Control of Autonomous Robot using Fuzzy Logic

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ABSTRACT
In the field of electronic engineering the work of automation is growing at speed of light. The fundamental concept of autonomous operation depends on technique and logic that we are using. The simple fundamental concept of operating autonomous robot or simply we can say that a mobile robot is a navigation of that robot. The navigation consists of providing the specific path to follow optimal distance. In case if any obstacles are hitting to that robot, the robot should understand how to find a path by avoiding that obstacles. Simple thing is that we can direct that robot with some logic. That simple logic is explained in this paper. The way of navigation is decided by that robot itself by using fuzzy logic. It will direct that robot how to avoid any obstacles which is having various characteristics depends on nature i.e. obstacles is moving or static, height of that obstacles etc. The fuzzy logic criterion gives brief explanation about this concept.

Keywords
Autonomous robot, mobile robot, fuzzy logic, navigation

1. INTRODUCTION
The autonomous robot simply we can call it as a mobile robot is used in many engineering fields such as industrial, medical, institutional, agriculture etc. The work of that robot simply depends on the control or programming done inside that robot. The fundamental functioning is to be done very carefully. Hence the autonomous robot works very efficiently.

In autonomous robot, various parameters are to be considering for the smooth working of that robot without any error. The working parameters are driving the wheels of that robot, navigation of that robot, reaching to its destination etc. Here the main parameters we are considering as a point of view is navigation of that robot. The navigation consists of driving that autonomous robot in a specified direction without any disturbance. Disturbance considering is like few obstacles are running in between the robot while it is moving from any specific point to its destination point. That robot may be static or dynamic in nature depending on the current condition of those obstacles. We have to drive that robot simply avoiding those obstacles.

For the perfect navigation point of view we can use various methods like driving that wheel using electric motors, by using various sensors, by providing remote sensing etc. Here we are using fuzzy controller for controlling the direction of autonomous robot. The concept of fuzzy logic controller is very useful for perfect navigation. Fuzzy means not exact condition while comparing with real sets. The number of condition given in the sets is non-exact type in nature. Non exact means which cannot compare with real world condition. So for the navigation purpose it is required to control the exact condition of movement of that robot. This will show how we can turn that robot with some constant range through fuzzy controller. The condition which we are putting in controller depends on the movement of that robot.

In the real world control of autonomous robot we are considering a camera sensor attach with this robot. That sensor will sense the edges of that moving or static obstacle. After sensing, sensor will decide the position of movement whether it needs to move right, left or straight. The fuzzy controller will give the control to the sensor. That controlling will provide the navigation of robot perfect. This process decides how to navigate the robot in required direction. The direction will be decided according the movement and nature of obstacles.

2. RELATED WORK
In this paper the robot consist of camera sensors. That sensor will sense the moving or static object. By using fuzzy logic criteria we have designed set of fuzzy logic. That sets will decide the direction of movement of that robot. Depending on the range of that obstacle from sensor, it will decide the distance of obstacles whether it is very close, close or far from the sensor. This concept of how fuzzy logic will decide the direction of movement of that robot is explained in this paper.

3. PROPOSED WORK
Proposed work consists of navigation of robot through moving or static obstacles. The obstacles consist of various movements in terms of speed, weight, material of that obstacles etc. We have the autonomous robot which is self-operating in nature. The autonomous robot is standing on its initial position. We have to move that robot through random obstacles

Input:.

Sensor mounting on the robot will sense the nature of that obstacles i.e. speed, nature of material, edges, direction of movement etc. We have decided the minimum range of those obstacles from the sensor. Simply we can consider three basic conditions that the obstacles are very close to robot, close to the robot and far from the robot. This range decides the further procedure. Following ranges are considered for sensor.

Max. Range = [0, 40] pixel

Very close = [8, 0] pixel

Close = [5, 15] pixel

Far = [5, 25] pixel

The given ranges are defined in pixels for sensor data simulation purpose. For acquiring simulation base result we are considering this range in pixel. The ranges further decide the position of robot from any obstacles and decide where it will be moving. After sensing the proper range input is given to the sensor. That input parameter will decide the movement of the robot according to the obstacles movement. Hence the sensor is very important parameter as per the navigation of robot is concerned. Sensor input shows the three important parameters according to the movement direction of robot. If sensor is moving in right direction then it will consider the condition "SENSOR RIGHT", If sensor is moving in straight direction then it will consider the condition "SENSOR STRAIGHT" AND If sensor is moving in left direction then it will consider the condition "SENSOR LEFT". These three conditions will consider the position of that robot against the position of moving obstacles.

- Sensor right:

If the sensor is moving in right direction from its initial position the sensor sense the position of object according to the three parameters i.e. very close, close and far. Following cases are considered to identify the range of object in fuzzy variables.

Very Close = Low
Close = Medium
Far = High

- Sensor Right:

If the sensor is moving in right direction from its initial position the sensor sense the position of object according to the three parameters i.e. very close, close and far. Following cases are considered to identify the range of object in fuzzy variables.

Very Close = Low
Close = Medium
Far = High

- Sensor Straight:

If the sensor is moving in straight direction from its initial position the sensor sense the position of object according to the three parameters i.e. very close, close and far. Following cases are considered to identify the range of object in fuzzy variables.

Very Close = Low
Close = Medium
Far = High

- Sensor Left:

If the sensor is moving in left direction from its initial position the sensor sense the position of object according to the three parameters i.e. very close, close and far. Following cases are considered to identify the range of object in fuzzy variables.

Very Close = Low
Close = Medium
Far = High

Output:

Now we have given input to the sensor. As per the input given to the sensor it will check the position of those obstacles. Now after deciding the position of that object sensor will manage its fuzzy variable. Those fuzzy based sets of output further decide the movement of robot. The robot is now producing the various condition for output so that robot will react according to that output.

As we know, the robot is navigated so that it should follow proper path and reach to the destination. Now at the output side we are considering the degree of navigation. The degree of navigation completely shows us the exact position of movement of that robot. We are considering five different parameters given below.

Range = [-120 120]

m1 = [-80 -120]

m2 = [-90 -20]

m3 = [-40 40]

m4 = [20 90]

m5 = [60 120]

Above value decide the degree of navigation. These values further decide the movement of that robot according to the position of obstacles.

After deciding the degree of navigation we will calculate the membership function for fuzzy controller. Fuzzy controller will control the direction of robot. Membership function is very important parameter for deciding the sets of fuzzy values. These values will further accept the condition for movement. The membership function can be calculated by using the following formula.

T = max(range-min(range));

range1 = (range-min (range))/max (range-min (range));

m1 = (m1val-min (range))/T;

We will further calculate membership function for all the given values. After calculation of membership function we are getting output in terms of fuzzy parameter. That will be decided by the robot sensor. These parameters are directly depends on the degree of navigation and membership function. The output parameters can be classified within five classes that show the proper direction of that robot. For each input it will give output in five parameters. That parameters are only depends on the smooth, hard or straight turning capacity of robot.

- Hard Right
- Soft Right
- Straight
- Hard Left
- Soft Left.

Now the robot is ready to create its own path. The path finding robot can be used to check the above method. The output properties of the robot should be obtained according to the input.

4. SIMULATION RESULT

Navigation of robot using fuzzy logic shows that we can draw any mobile robot through the programming logic. In this paper we are getting the result of fuzzy variables in terms of fuzzy membership function which lies in between 0 and 1. It shows that the exact movement of robot is in between 0 and 1. Which is non-exact condition as compare to the real world condition?

We have obtained the different result for different condition given as input for their output.

- The fuzzy membership function for the condition given to the robot if the sensor will move to right direction is,

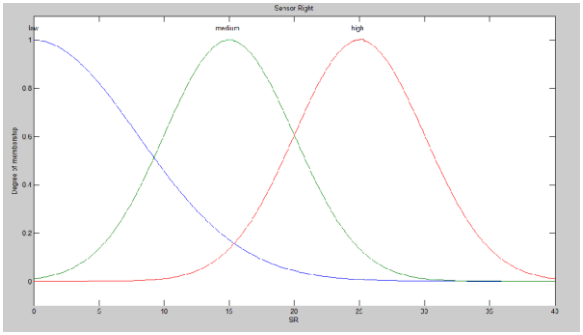

Figure 1. Sensor Right

- The fuzzy membership function for the condition given to the robot if the sensor will move to straight direction is,

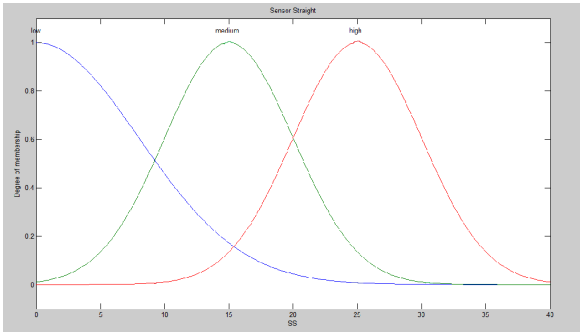

Figure 2. Sensor Straight

- The fuzzy membership function for the condition given to the robot if the sensor will move to left direction is,

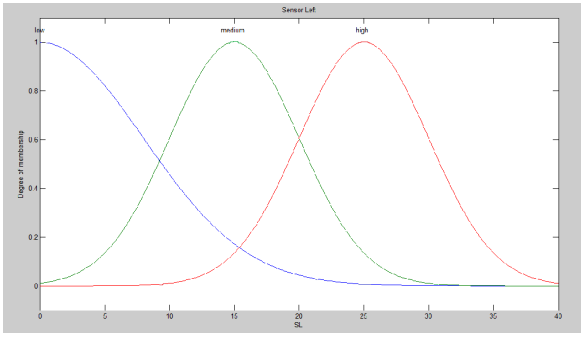

Figure 3. Sensor Left

- The fuzzy membership function for the overall condition given to the robot if the sensor will move to given any direction is,

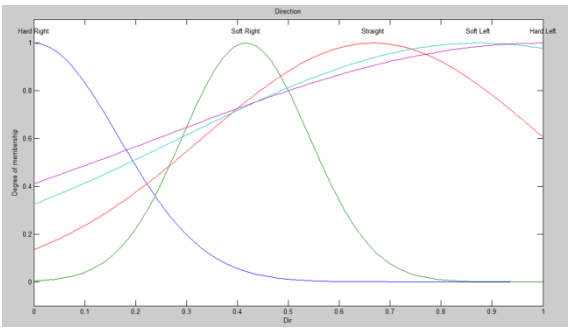

Figure 4. Sensor Direction

This simulation is based on the condition of ranges provided inside the program for given membership function. If we change the values in the program then the output parameters will also get change.

5. CONCLUSION

The fuzzy based application we are using in this paper can also be applied in any research field related to engineering. From this experiment we got the simulation result. And from this paper we can conclude that the fuzzy sets can be obtained for the movement of autonomous robot. So that it will find the exact path without any error. Also for finding the average time required to cover total distance also we can able to know.

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