Definition and Simulation of Fuzzy Controllers for the motion of a mobile robot and the force exerted at the robot´s hand

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Abstract: In this paper we show the simulation of two aplications of fuzzy logic: Design a fuzzy logic system for the motion control of a mobile robot on a rough terrain. The inputs to the system are the slope of the terrain and the terrain type, while the output is the robot's speed, and an aplication of fuzzy logic for a robot's hand controller. The force exerted at the hand and the velocity of the hand are input variables, the porcent power of actuators is the output. We have simulated the control process in Matlab.

Key-Words: Fuzzy logic, linguistic variable, membership function, fuzzy rules.

1 Introduction

Fuzzy Logic has been applied in fields such as control process , image recognition, robotics and expert systems. Fuzzy Control is the first successful industrial application of fuzzy logic [1].

Fuzzy Control primarily refers to the processes control through the fuzzy linguistic descriptions [2]. The aim of controller is to incorporate the expert human knowledge in the control algorithm.

A fuzzy controller is that controls processes by means of a fuzzy algorithm; to design it consists on generate and to simulate this algorithm starting from the following sequence of steps:

- To determine the variables and linguistic values.
- To define the membership functions.
- To establish the fuzzy rules.
- For each input value, determine the degree of membership of the linguistic value (Fuzification).
- For each rule determine the degree of the consequent and the linguistic output value (Inference).
- Calculate the output value (Defuzzification).

The application of the diffuse logic in the control area has proposed from the begining several models for the definition of a fuzzy algorithm, due to this is important to conserve the following points:

- The definition of membership functions with triangular and trapezoidal form.
- Input and output Linguistic Variables-.
- For the inference of output values the use of the composition max - min, the implication operator Mandani - Min and the centroid defuzification method.

2 Problem Formulation.

The development of a control system based on fuzzy logic requires, before putting it into practice, to simulate the best possible way its operation, this is because the results are not completely predictable and many times it is required of adjustments in the fuzzy rules

before finding the appropriate parameters [2]. The most important applications have been developed by the experimentation of the system to be controled using software that simulates its behavior. When we have the desired behavior, the system is materialized so that it operates in the wanted atmosphere. For the above-mentioned, a previos simulation is necessary.

3 Problem Solution.

We present two simulation examples:

3.1 First Example: Design a fuzzy system for a Mobile Robot

The Fuzzy system will have two input values, and a output value, and they intended twenty fuzzy rules.

3.2 Input and output values, for the first example.

The inputs of the system are the slope and the percent of ruggedness of terrain, and the output value, is the speed of the mobile robot.

3.3 Linguistic values.

The slope can range between –45 and 45 degrees, divided into: Large-Negative, Negative, Level, Positive, and the Large-Positive , Figure 1.

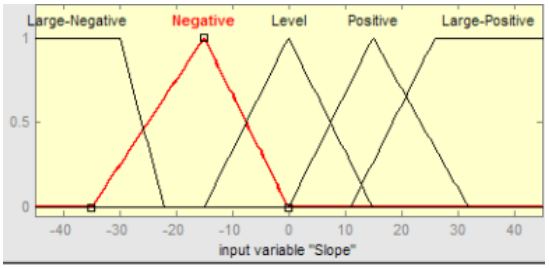

Figure 1 Terrain´s Slope

The terrain can be: Very-Rough, Rough, Moderate and Smooth, Figure 2.

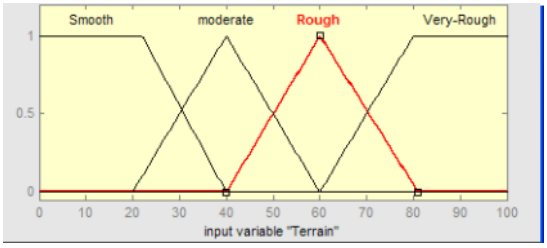

Figure 2 Ruggedness of Terrain.

The output speed can range between 0 and 20 miles per hour and is divided into Very Slow, Slow, Medium, Fast, and Very Fast , Figure 3

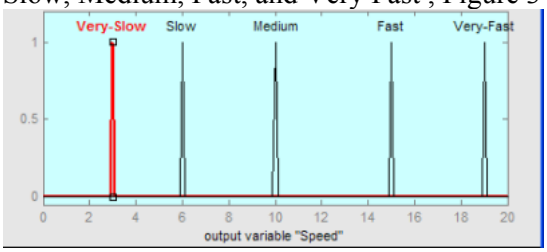

Figure 3 Speed.

Are twenty rules proposals:

1. If slope is large-positive and terrain is very Rough then speed is very slow.
2. If slope is large positive and terrain is rough then speed is slow.
3. If slope is large positive and terrain is moderate then speed is medium.
4. If slope is large positive and terrain is smooth then speed is medium.
5. If slope is positive and terrain is very rough then speed is very slow.
6. If slope is positive and terrain is rough then speed is slow.
7. If slope is positive and terrain is moderate then speed is medium.
8. If slope is positve and terrain is smooth then speed is fast.
9. If slope is level and terrain is very rough then speed is slow.
10. If slope is level and terrain is rough then speed is medium.
11. If slope is level and terrain is moderate then speed is fast.
12. If slope is level and terrain is smooth then speed is very fast.
13. If slope is negative and terrain is very rough then speed is very slow
14. If slope is negative and terrain is rough then speed is slow.

15. If slope is negative and terrain is moderate then speed is medium.
16. If slope is negative and terrain is smooth then speed is fast.
17. If slope is large negative and terrain is very rough then speed is very slow.
18. If slope is large negative and terrain is rough then speed is very slow.
19. If slope is large negative and terrain is moderate then speed is slow.
20. If slope is large negative and terrain is smooth then speed is medium.

3.4 Simulation of fuzzy controller

The figure 4 and figure 5 show the result of the simulation of the rules base by fuzzy inference development with the Matlab environment.

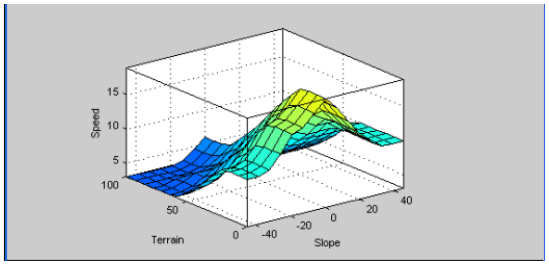

Figure 4 Simulation of the example 1.

For a slope of 19.8 degrees and terrain 29.5 percent of ruggedness, result the velocity 12.5, as show in the figure 5.

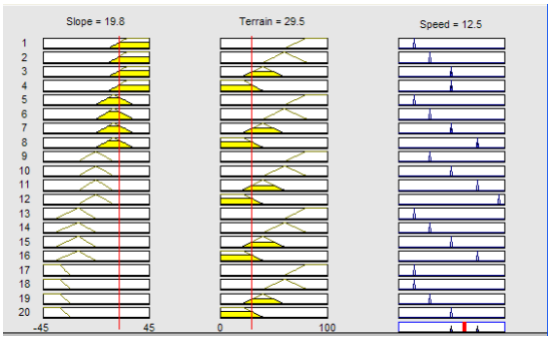

Figure 5 Specific values of the simulation

4. Second Example: Fuzzy inference system for a robot´s hand.

4.1 Input and output values, for the second example.

The inputs of the system are the force exerted at the hand and the velocity of the hand, and the power percent to the actuators is the output.

4.2 Linguistic Values.

The force can range between 0 and 2 Newtons, divided into very low, low, medium, strong, and very strong, Figure 6, and the velocity of the hand range

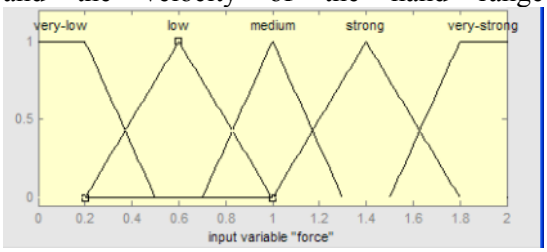

Figure 6 Force exerted at the hand

Between 0 to 4 meters per second, divided into very slow, slow, medium, fast and very fast. Figure 7

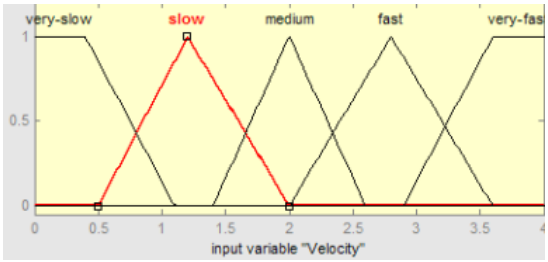

Figure 7 Velocity of the hand

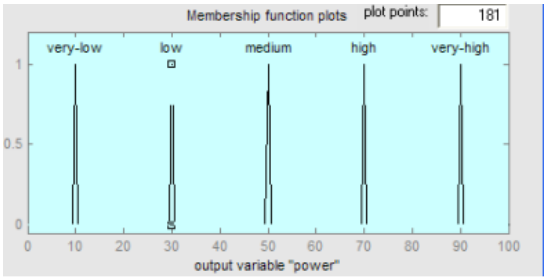

Figure 8 The percent power to the actuator.

Fourteen rules are proposals:

1. If the force exerted at the hand is very stronge and the speed is very fast then the percent power to the actuators is very high.
2. If the force exerted at the hand is very stronge and the speed is fast then the percent power to the actuators is high.
3. If the force is very stronge and the speed is moderate then the power is medium.
4. If the force is very stronge and the speed is slow then the power is low.
5. If the force is very stronge and the speed is very slow then the power is very low.
6. If the force is stronge and the speed is very fast then the power is high.
7. .If the force is stronge and the speed is fast then the power is medium.
8. If the force is stronge and the speed is medium then the power is low.
9. If the force is stronge and the speed is low then power is low.
10. If the force is stronge and the speed is very low then power is very low.
11. If the force is medium and the speed is very fast then the power is medium.
12. If the force is medium and the speed is very fast then the power is low.
13. If the force is medium and the speed is moderate then the power is low.
14. If the force is medium and the speed is slow then the power is very low.

4.3 Simulation of fuzzy controller

The figure 4 and figure 5 show the result of the simulation of the rules base by fuzzy inference development environment Matlab.

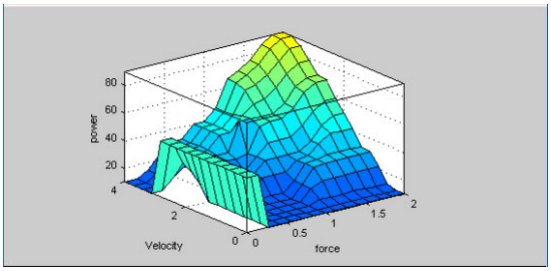

Figure 9 Result of the simulation of the second example.

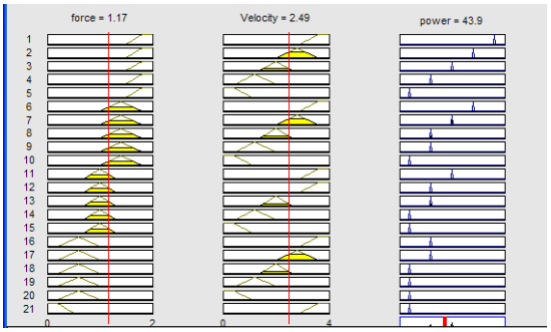

Figure 10 Specific values of the simulation.

5. Results

As we can see in the figure 4, the velocity decreases as the slope increases up, as well as when the terrain becomes more and more rough.

For the second example, we can see in the figure 9, the percent power of the actuator increases up, as well as when the velocity and the force exerted at the hand increase up.

6. Conclusion and future work.

In this paper we show only the design and simulation of two fuzzy controllers, using the Matlab tool, actually we are work in the first example implementation stage of the: Designing the Mobile Robot: we are choice the sensors to detecte the terrain ruggedness and the development of the fuzzy controller in a PIC microcontroller.

The number of the fuzzy applications continues being increased every year, generating a great incentive to the investigators dedicated to the development of the fuzzy control. The necessity of the simulation is very important for the development of the applications, and Matlab is a useful and friendly tool for do that work.

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