Neural Networks & Fuzzy Logic

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Abstract - Automobiles have become an integrated part of our daily life. The development of technology has improved the automobile industry in both cost & efficiency. Still, accidents prove as challenge to technology. Highway accident news are frequently found in the newspapers. The automobile speed has increased with development in technology through years and the complexity of the accidents has also increased. Higher speeds the accidents prove to be more fatal. Man is intelligent with reasoning power and can respond to any critical situation. But under stress and tension he falls as a prey to accidents. The manual control of speed & braking of a car fails during anxiety. Thus automated speed control & braking system is required to prevent accidents. This automation is possible only with the help of Artificial Intelligence (Fuzzy Logic).

In this paper, Fuzzy Logic control system is used to control the speed of the car based on the obstacle sensed. The obstacle sensor unit senses the presence of the obstacle. The sensing distance depends upon the speed of the car. Within this distance, the angle of the obstacle is sensed and the speed is controlled according to the angle subtended by the obstacle. If the obstacle cannot be crossed by the car, then the brakes are applied and the car comes to rest before colliding with the obstacle. Thus, this automated fuzzy control unit can provide an accident free journey.

Keywords: *Automobiles, Artificial Intelligence, Fuzzy Logic.*

I. INTRODUCTION

Fuzzy logic is best suited for control applications, such as temperature control, traffic control or process control. Fuzzy logic seems to be most successful in two kinds of situations:
i) Very complex models where understanding is strictly limited, in fact, quite judgmental.
ii) Processes where human reasoning, human perception, or human decision making are inextricably involved.

Our understanding of physical processes is based largely on imprecise human reasoning. This imprecision (when compared to the precise quantities required by computers) is nonetheless a form of information that can be quite useful to humans. The ability to embed such reasoning and complex problem is the criterion by which the efficacy of fuzzy logic is judged.

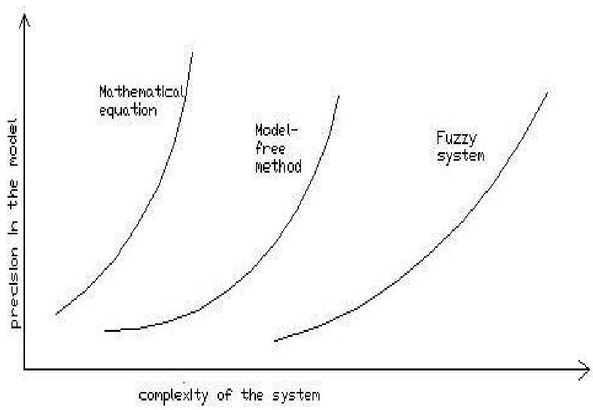
Undoubtedly this ability cannot solve problems that require precision - problems such as shooting precision laser beam over tens of kilometres in space; milling machine components to accuracies of parts per billion; or focusing a microscopic electron beam on a specimen of size of a nanometre. The impact of fuzzy logic in these areas might be years away if ever. But not many human problems require such precision - problems such as parking a car, navigating a car among others on a freeway, washing clothes, controlling traffic at intersections & so on. Fuzzy logic is best suited for these problems which do not require high degree of precision.

Fuzzy Vs. Probability

Fuzziness describes the ambiguity of an event, whereas randomness (probability) describes the uncertainty in the occurrence of the event. An example involves a personal choice. Suppose you are seated at a table on which rest two glasses of liquid. The liquid in the first glass is described to you as having a 95 percent change of being healthful and good. The liquid in the second glass is described as having a 0.95 membership in the class of "healthful & good" liquids. Which glass would you select; keeping in mind first glass has a 5 percent change of being filled with non-healthful liquids including poisons. What philosophical distinction can be made regarding these two forms of information? Suppose we are allowed to test the liquids in the glasses. The prior probability of 0.95 in each case becomes a posterior probability of 1.0 or 0; i.e., the liquid is either benign or not. However, the membership value of 0.95, which measures the drinkability of the liquid is "healthful & good", remains 0.95 after measuring & testing. These examples illustrate very clearly the difference in the information content between change & ambiguous events.

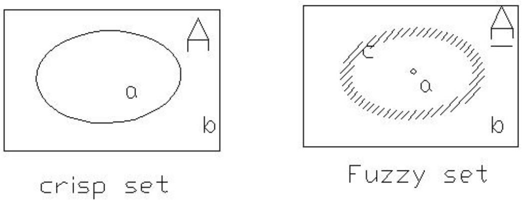
Complexity of a System vs. Precision in the model of the System

For systems with little complexity, hence little uncertainty, closed-form mathematical expressions provide precise descriptions of the systems. For systems that are a little more complex, but for which significant data exist, model-free methods, such as artificial neural networks, provide a powerful and robust means to reduce some uncertainty through learning, based on patterns in the available data. Finally, for the most complex systems where few numerical data exist and where only ambiguous or imprecise information may be available. Fuzzy reasoning provides a way to understand system behaviour by allowing us to interpolate approximately between observed input and output situations.



Fuzzy Set vs. Crisp Set

A classical set is defined by crisp boundaries; i.e., there is no uncertainty in the prescription or location of the boundaries of the set. A fuzzy set, on the other hand, is prescribed by vague or ambiguous properties; hence its boundaries are ambiguous.



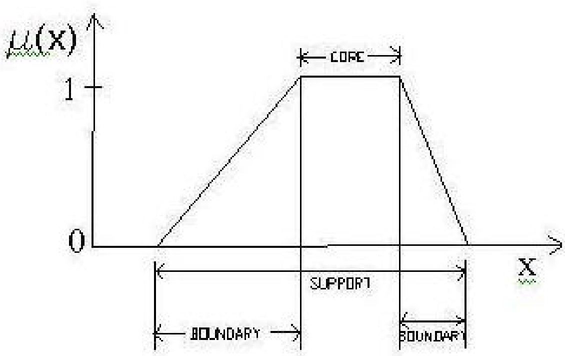
If complete membership in a set is represented by the number 1, and no membership is represented by 0, then point C must have some intermediate value of membership (partial membership in fuzzy set **A**) on the interval [0, 1]. Presumably the membership of point C in **A** approaches a value of 1as it moves closer to the control (unshaded) region of **A**, and membership of point C in **A** approaches a value of 0 as it moves closer to leaving the boundary region of **A**.

Membership Function

Membership function characterizes the fuzziness in a fuzzy set, whether the elements in the set are discrete or continuous - in a graphical form for eventual use in the mathematical formalisms of fuzzy set theory. Just as there is infinite number of ways to characterize fuzziness, there are an infinite number of ways to graphically depict the membership functions that describe fuzziness.

Features of Membership Function

The core of a membership function for some fuzzy set **A** is defined as that region of the universe that is characterized by complete and full membership in the set **A**, i.e., the core comprises those elements x of the universe such that μ **A** (x) = 1.



The support of a membership function for some fuzzy set **A** is defined as the region of the universe that is characterized by non-zero membership in the set A. That is, the support comprises those elements x of the universe such that $\mu_A(x) > 0$.

The boundaries of a membership function for some fuzzy set **A** are defined as the region of the universe containing elements that have non zero membership, but not complete membership. That is, the boundaries comprise these elements x of the universe such that $0 < \mu_A(x) < 1$.

Fuzzification

Fuzzification is the process of making a crisp quantity fuzzy. We do this by simply recognizing that many of the quantities that we consider to be crisp & deterministic are actually not deterministic at all. They carry considerable uncertainty. If the form of uncertainty happens to arise because of imprecision, ambiguity, or fuzzy and can be represented by a membership function. In this paper institution method is used for fozzification of the input variables, as it is very simple

Defuzzification

Defuzzification is the conversion of a fuzzy quantity to a precise quantity, just as fuzzification is the conversion of precise quantity to a fuzzy quantity.

Some of the defuzzification techniques are:

1. Max - Membership Principle

Also known as the height method, this scheme is limited to peaked output junctions. This method is given by the algebraic expression $\mu_c(Z^*) \geq \mu_{\underset{\sim}{C}}(Z)$ for all $z \in Z$

2. Centroid Method

This procedure (also called center of area, center of gravity) is the most prevalent & physically appealing of all the defuzzification methods; it is given by the algebraic expression:

$$Z^* = \frac{\int \mu_{\underset{\sim}{C}}(Z).z\,dz}{\int \mu_{\underset{\sim}{C}}(Z)\,dz}$$

3. Weighted Average Method

This method is only valid for symmetrical output membership function. It is given by the algebraic expression:

$$Z^* = \frac{\sum \mu_{\underset{\sim}{c}}(\bar{z}).\bar{z}}{\sum \mu_{\underset{\sim}{c}}(\bar{z})}$$, where Σ denotes an algebraic sum.

4. Means-Max Membership

This method (also called middle-of-maxima) is closely related to the first method, except that the locations of the maximum membership can be non-unique (i.e., the maximum membership can be a plateau rather than a single point.

This method is given by the expression:

$$Z^* = \frac{a+b}{2}$$, where a & b are shown in the figure.

In this paper, centroid method is used for defuzzification if the output variables.

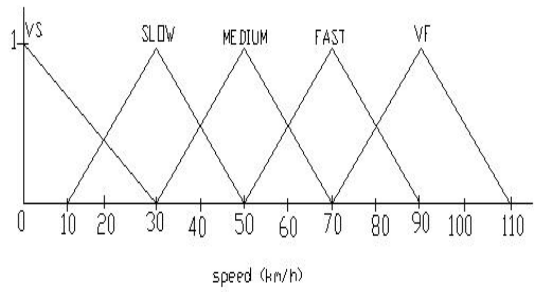
II. Fuzzy Logic Control System

Obstacle Sensor Unit: The car consists of a sensor in the front panel to sense the presence of the obstacle.

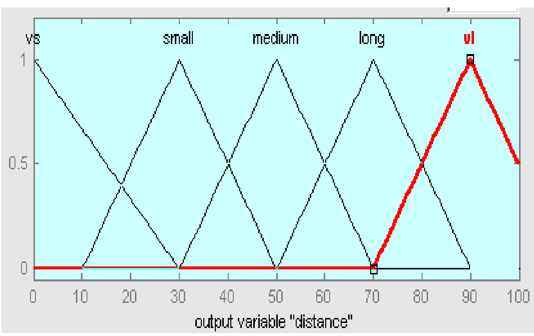
Sensing Distance

The sensing distance depends upon the speed of the car. As the speed increases the sensing distance also gets increased, the obstracle can be sensed at a large distance for higher speed and the speed can be controlled by gradual anti skid braking system.
The speed of the car is taken as the input and the distance sensed by the sensor is controlled.

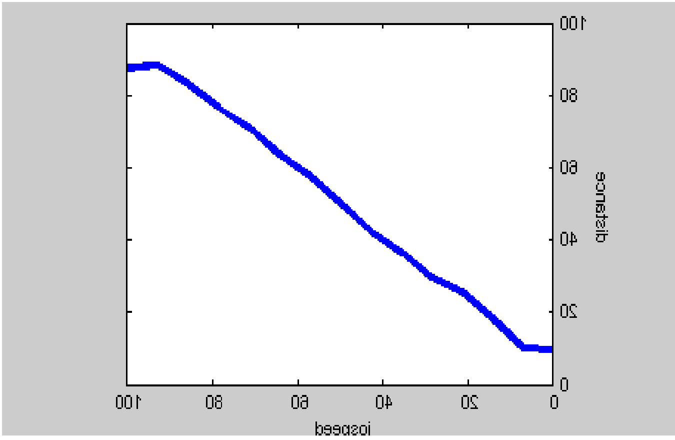
Input Membership Function

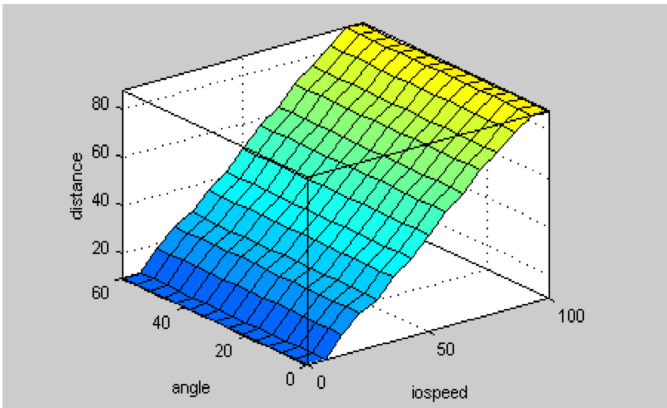


Output Membership Function



The input & output are properly related by the If i/p then o/p rules. The defuzzified values are obtained and the variation of speed with sensing distance is plotted as a surface graph using matlab.





From the graph it is clear that the sensing distance almost varies linearly with speed. And the curve is not very smooth because we deal with fuzzy values.

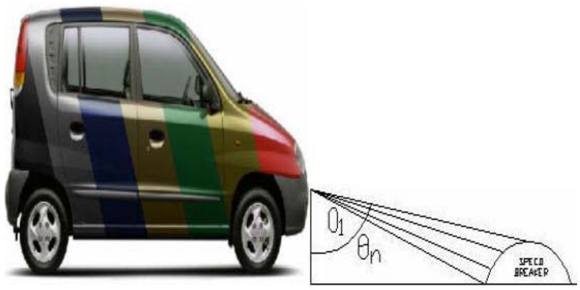
Speed Control

The speed of the car is controlled according to the angle subtended by the obstacle. The angle subtended by the obstacle is sensed at every instant.

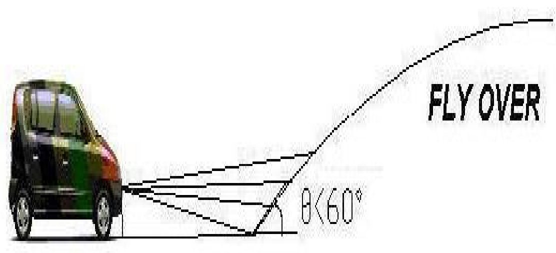
Obstacles which the car can overcome:

At any instant, if the obstacle subtends an angle less than 60°, then the car can overcome the obstacles and the speed of the car reduces according to the angle.

1. **Speed breaker**



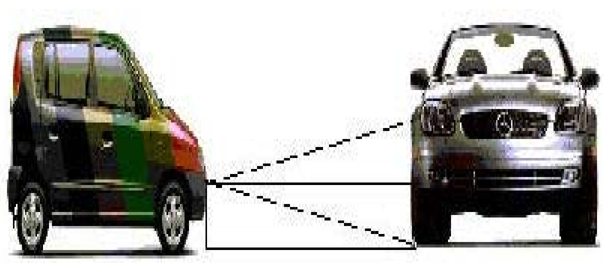
2. **Fly over**



Obstacles which the car cannot overcome:

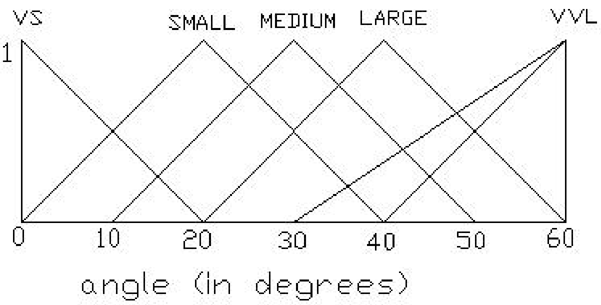
At any instant, if the angle subtended by the obstacle is greater than 60°, then the car comes to rest before colliding with the obstacle as the car cannot overcome the obstacle.

E.g. 1. Vehicles

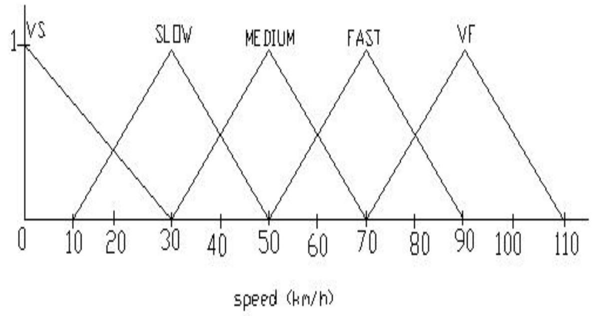


The angle is taken as the i/p & the o/p speed is controlled.

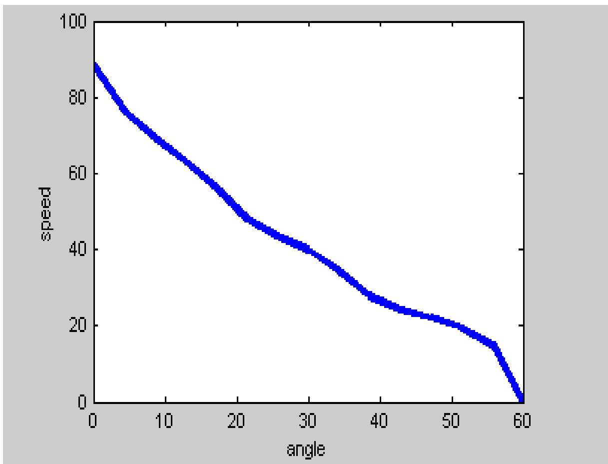
Input - Membership Function

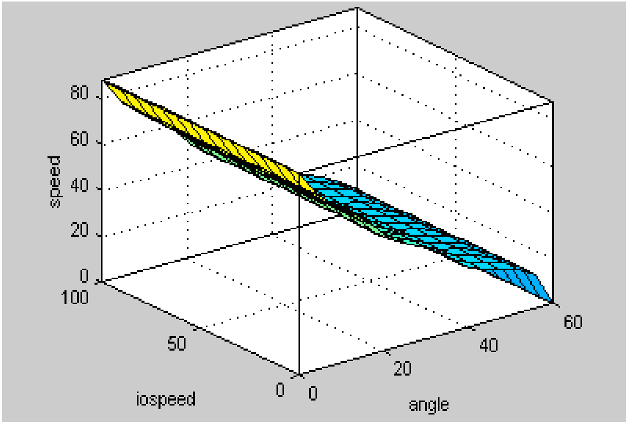


Output - Membership Function



The input & the output functions are related by the If i/p then o/p rules. Using matlab the surface graph relating the speed and angle is obtained.





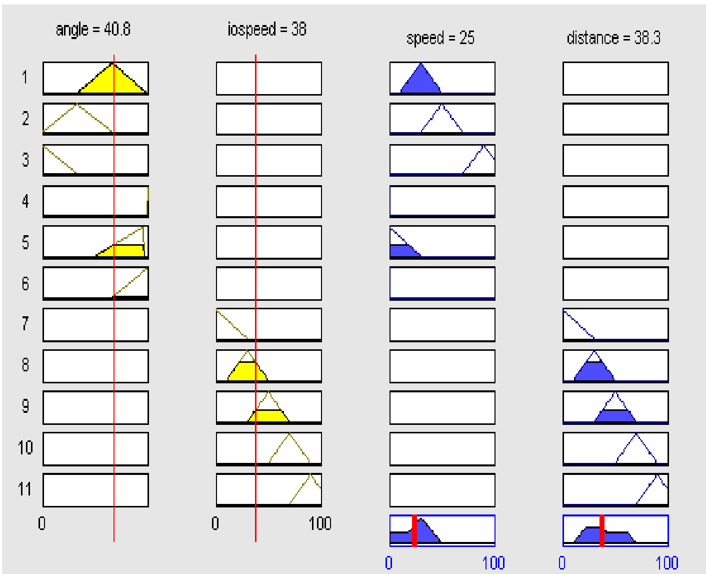
From the graph it is clear that the speed becomes zero when the angle of the obstacle is greater than 60°.The rules are applicable not only for obstacles that have elevation but also depression like a small pit, subway, etc.

Rear Sensing

This fuzzy control can be extended to rear sensing by placing a sensor at the back side of the car, and can be used to control the motion of the car when the wheals rotate in the opposite direction or when the car is in rear gear.

III. SIMULATION RESULTS

Some of the sample readings obtained from the matlab simulations are shown:



IV. CONCLUSION

In this world of stress and tension where the driver's concentration is distracted in many ways, an automated accident prevention system is necessary to prevent accidents. The fuzzy logic control system can relieve the driver from tension and can prevent accidents. This fuzzy control unit when fitted in all the cars can result in an accident free world.

REFERENCE

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