**Project Report**

on

# Tip Prediction Using Fuzzy Logic

# Controller (Fuzzy Inference System)

**Submitted For**

**IT3140- Soft Computing**

**Internal Assessment Component**

**Submitted By Submitted To**

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OVERVIEW

Fuzzy Logic Control (FLC) is the most active research area in the application of fuzzy set theory, fuzzy reasoning, and fuzzy logic. The application of FLC extends from industrial process control to biomedical instrumentation and securities. Compared to conventional control techniques, FLC has been best utilized in complex ill-defined problems, which can be controlled by an efficient human operator without knowledge of their underlying dynamics.

APPLICATIONS

FLC systems find a wide range of applications in various industrial and commercial products and systems. In several applications- related to nonlinear, time-varying, ill-defined systems, and also complex systems – FLC systems have proved to be very efficient in comparison with other conventional control systems. The applications of FLC systems include:

1. Traffic Control
2. Steam Engine
3. Aircraft Flight Control
4. Missile Control
5. Adaptive Control
6. Liquid-Level Control
7. Helicopter Model
8. Automobile Speed Controller
9. Braking System Controller
10. Process Control (includes cement kiln control)
11. Robotic Control
12. Elevator (Automatic Lift) control
13. Automatic Running Control
14. Cooling Plant Control
15. Water Treatment
16. Boiler Control
17. Nuclear Reactor Control
18. Power Systems Control
19. Air Conditioner Control (Temperature Controller)
20. Biological Processes
21. Knowledge-Based System
22. Fault Detection Control Unit
23. Fuzzy Hardware implementation and Fuzzy Computers

ADVANTAGES

The benefits of using Fuzzy Logic systems are as follows:

* It is a robust system where no precise inputs are required.
* These systems are able to accommodate several types of inputs including vague, distorted, or imprecise data.
* In case the feedback sensor stops working, you can reprogram it according to the situation.
* The Fuzzy Logic algorithms can be coded using less data, so they do not occupy a huge memory space.
* As it resembles human reasoning, these systems are able to solve complex problems where ambiguous inputs are available and take decisions accordingly.
* These systems are flexible and the rules can be modified.
* The systems have a simple structure and can be constructed easily.
* You can save system costs as inexpensive sensors can be accommodated by these systems.

CONCEPTS AND TECHNOLOGIES USED

Fuzzy Logic: The term Fuzzy means something that is a bit vague. When a situation is vague, the computer may not be able to produce a result that is True or False. As per Boolean Logic, the value 1 refers to True and 0 means False. But a Fuzzy Logic algorithm considers all the uncertainties of a problem, where there may be possible values besides True or False.

The term Fuzzy Logic was first described by Lotfi Zadeh in 1965. He thought that traditional computer logic is not capable of handling unclear or vague data. Similar to humans, there are many possible values between True and False that a computer can incorporate. These can be:

* Certainly yes
* Possibly yes
* Can’t say
* Possibly no
* Certainly no

Fuzzy Logic Architecture:

Diagram

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Graphical user interface

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Rule Base: This is the set of rules along with the If-Then conditions that are used for making decisions. But, modern developments in Fuzzy Logic have reduced the number of rules in the rule base. These set of rules are also called a knowledge base.

Fuzzification: This is the step where crisp numbers are converted into fuzzy sets. A crisp set is a set of elements that have identical properties. Based on certain logic, an element can either belong to the set or not. Crisp sets are based on binary logic – Yes or No answers.

Here, the error signals and physical values are converted into a normalized fuzzy subset. In any Fuzzy Logic system, the fuzzifier separates the input signals into five states that are:

* Large positive
* Medium positive
* Small
* Medium negative
* Large negative

The fuzzification process converts crisp inputs, such as room temperature, fetched by sensors and passes them to the control system for further processing. A Fuzzy Logic control system is based on Fuzzy Logic. Common household appliances, such as air-conditioners and washing machines have Fuzzy Control systems within them.

Inference Engine: The inference engine determines how much the input values and the rules match. The rules are applied based on the input values received. Then, the rules are used to develop control actions. The inference engine and the knowledge base together are called a controller in a Fuzzy Logic system.

Defuzzification: This is the inverse process of fuzzification. Here, the fuzzy values are converted into crisp values by mapping. There will be several defuzzification methods for doing this, but the best one is selected as per the input. This is a complicated process where methods, such as the maximum membership principle, weighted average method and centroid method, are used.

Fuzzy Inference System:

There are two main types of Fuzzy Inference Systems:

* Mamdani FIS- The Mamdani fuzzy inference system was proposed by Ebhasim Mamdani. Firstly it was designed to control a steam engine and boiler combination by a set of linguistic control rules obtained from the experienced human operators. In the Mamdani inference system, the output of each rule to be a fuzzy logic set.
* Sugeno FIS- This fuzzy inference system was proposed by Takagi, Sugeno, and Kang to develop a systematic approach for generating fuzzy rules from a given input-output dataset. A typical fuzzy rule in a first-order Sugeno fuzzy model has the form:

IF x is A and y is B THEN z = f(x, y)

where:

1. A and B are fuzzy sets in the antecedent
2. z = f(x, y) is a crisp function in the consequent.

Higher-order Sugeno fuzzy models are also possible, but while designing, those introduce significant complexity.

METHODOLOGY

Problem: The goal is to create a Fuzzy Control System which models how you might choose to tip at a restaurant. When tipping, you consider the Service and Food Quality, rated between 0 and 10. You use this to leave a tip of between 0 and 30%.

Setting Up Input and Output Variables:

Inputs:

* Service:

Universe (i.e., Crisp Value Range): How good was the service of the staff, on a scale of 0 to 10?

Fuzzy Set (i.e., Fuzzy Value Range): Poor, Good, Excellent.

Graphical user interface

Description automatically generated

* Food Quality:

Universe (i.e., Crisp Value Range): How good was the food, on a scale of 0 to 10?

Fuzzy Set (i.e., Fuzzy Value Range): Bad, Delicious.

Graphical user interface

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Output:

* Tip:

Universe (i.e., Crisp Value Range): How much we should tip on a scale of 0 to 30%.

Fuzzy Set (i.e., Fuzzy Value Range): Less, Average, High.

A picture containing graphical user interface

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Setting Up the Rule Base:

Rules:

1. If the service is poor or food quality is bad, then tip is less.
2. If the service is good, then tip is average.
3. If the service is excellent or food quality is delicious, then tip is high.
4. If the service is good and food quality is bad, then tip is less.
5. If the service is poor and the food quality is delicious then tip is average.

Graphical user interface, text, application, email

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RESULTS AND ANALYSIS

Testing the Model:

Test Cases:

1. If the Service is given a rating of 3 out of 10 and the Food Quality is given a rating of 8 out of 10.

Graphical user interface

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Tip comes out to be 16.7%.

1. If the Service is given a rating of 2 out of 10 and the Food Quality is given a rating of 1 out of 10.

Graphical user interface, diagram

Description automatically generated

Tip comes out to be 7.95%.

1. If the Service is given a rating of 9 out of 10 and the Food Quality is given a rating of 8 out of 10.

Graphical user interface, diagram, application

Description automatically generated

Tip comes out to be 23.7%.

1. If the Service is given rating of 5 out of 10 and the Food Quality is given a rating of 4 out of 10.

A picture containing graphical user interface

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Tip comes out to be 15%.

1. If the Service is given a rating of 3 out of 10 and the Food Quality is given a rating of 10 out of 10.

Graphical user interface

Description automatically generated

Tip comes out to be 17.6%.

CONCLUSION

Although Fuzzy Logic in artificial intelligence helps to mimic human reasoning, these systems need expert guidance to be built. This lets you rely on the experience of experts who have a better understanding of the system. Fuzzy Logic can also be used for enhancing the execution of algorithms. IBM Watson uses Fuzzy Logic and fuzzy semantics.

FUTURE SCOPE

Fuzzy logic allows for the inclusion of vague human assessments in computing problems. Also, it provides an effective means for conflict resolution of multiple criteria and better assessment of options. New computing methods based on fuzzy logic can be used in the development of intelligent systems for decision making, identification, pattern recognition, optimization, and control.

Fuzzy logic is extremely useful for many people involved in research and development including engineers (electrical, mechanical, civil, chemical, aerospace, agricultural, biomedical, computer, environmental, geological, industrial, and mechatronics), mathematicians, computer software developers and researchers, natural scientists (biology, chemistry, earth science, and physics), medical researchers, social scientists (economics, management, political science, and psychology), public policy analysts, business analysts, and jurists.

Indeed, the applications of fuzzy logic, once thought to be an obscure mathematical curiosity, can be found in many engineering and scientific works. Fuzzy logic has been used in numerous applications such as facial pattern recognition, air conditioners, washing machines, vacuum cleaners, antiskid braking systems, transmission systems, control of subway systems and unmanned helicopters, knowledge-based systems for multiobjective optimization of power systems, weather forecasting systems, models for new product pricing or project risk assessment, medical diagnosis and treatment plans, and stock trading.

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