# University Of Aberdeen

## Knowledge Representation and Reasoning

Assessment 1

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# 1 Part One:

## 1.1 INTRODUCTION

In the field of Artificial Intelligence where the prime focus is to build the machine intelligence inspired with how the human brain works, Fuzzy logic helps to develop human like capabilities for Artificial Intelligent systems. Fuzzy logic seems more close to how a human brain computes and handle the simple logics (if, and, or, then, etc.). Extreme cases of truth in fuzzy logic are 0 and 1 which can be understood as facts but it also includes the state of truth between two statements i.e., partial truth (example: 'good' or 'bad' but '0.75 of good').

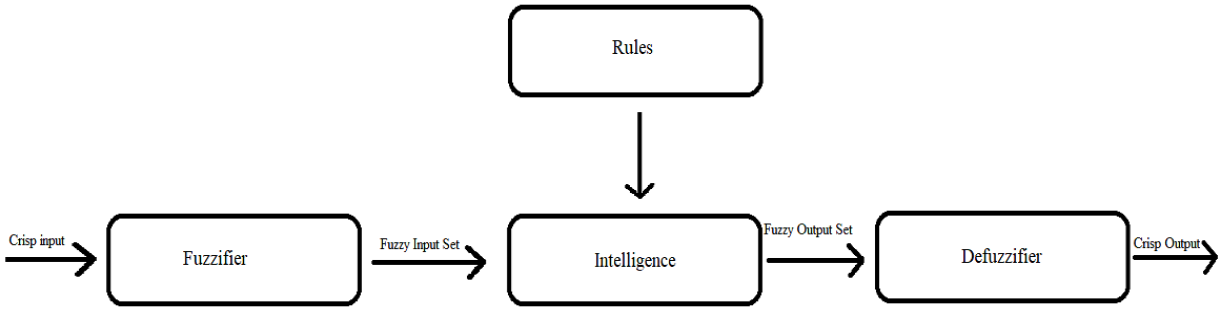
Uncertainty in engineering applications can be solved using fuzzy logic. It can be implemented in various controlling systems of variable sizes. Fuzzy logic can be integrated in software, hardware and it can also be implemented in both hardware and software.

## 1.2 HISTORY OF FUZZY LOGIC

Lotfi Zadeh, professor of UC Berkeley in California introduced fuzzy sets as a mathematical way to express the ambiguity in everyday life in 1965 (Zadeh, 1965). He observed that Fuzzy sets are a generalization of conventional set theory and conventional computer logic failed to manipulate and represent the unclear human ideas. The concept of the fuzzy logic is being studied since 1920's and it proves to be of a great significance in understanding unclear human data.

Fuzzy logic has been applied to various fields like control systems and Artificial intelligence. It was designed to allow computer to understand the difference between data which is not just zero and 1.

## 1.3 ARCHITECTURE OF FUZZY LOGIC




fig(1.3)

Fuzzy Logic has four main components as shown in the fig(3.1) Rules-base, Fuzzifier, Inference Engine and Defuzzifier.

### 1.3.1 Rule-Base:

Rule base contains the rules and the if-then statements which are used to control the decision making systems and are given by the experts. Tuning of fuzzy controllers can be achieved based on the recently updated fuzzy theory. Rule base has the linguistic information in form of rules (if-then) which can be reduced based on the recent developments in the field.

### 1.3.2 Fuzzification:

This is the process where the input conversion takes place i.e. crisp values are remolded into fuzzy sets. Crisp inputs are given by the sensors, online API or externally provided for the further processing into the control system. (Surya Priy, n.d.)

To understand how the crisp inputs are obtained, let's take an example of weather forecast. In this application where the forecast is determined, is based on the current available inputs to the decision making system which are provided by the sensor units i.e. wind direction sensor, humidity sensor, pressure sensor, temperature sensor, etc.

### 1.3.3 Inference Engine:

The degree of match between the fuzzy inputs and the rules in the rule base is determined by the inference engine. Inference engine provides the percentage of match which then determines, which rules should be implemented based on the given inputs. Then, control actions are developed after combining the applied rules. (Guru99, n.d.)

### 1.3.4 Defuzzification:

This is the last step in the architecture which plays role in converting the fuzzy sets into the crisp values. Many working techniques are known to be available for defuzzification, but to reduce the error correct and best suited method should be used.

## 1.4 REACTION TO FUZZY LOGIC

### 1.4.1 Positive Reaction:

- Fuzzy logic is extremely useful for people involved in research and development, software developers, mathematicians, scientists in medical, social and natural researches, business analysts, etc. (Harpreet Singh, 2013)
- There are large number of publications and 26 research journals on theory or applications of fuzzy logic around the world. The number of publications are significant in number to understand that many people from various fields are reacting positive and doing deep research on the topic. (Harpreet Singh, 2013)
- In "Comparison of detection and classification algorithms using Boolean and fuzzy techniques" by R. Dixit and H. Singh. For a hypothetical target classification scenario, Authors compared various logic analysis methods. The results were compared between Boolean, multi-quantization Boolean and fuzzy techniques. (Rahul Dixit, 2012)
- First consumer product was Matsushita's shower head, 1986. Followed by implementation in home appliances, photographic equipment and automobile transmissions.

### 1.4.2 Negative Reaction:

- Use of linguistic variables was criticized by the members of the scientific community because it is considered as numbers are more important and significant than words. (Harpreet Singh, 2013)
- Concept of linguistic variable is not widely recognized and appreciated.

### 1.4.3 Personal views:

Positive Views:

- According to my understanding fuzzy logic systems are playing important role in various emerging fields like Artificial Intelligence.
- Many advancements are seen in the theory of fuzzy logic and applications of fuzzy logic which are efficient in handling impure data.
- Neurofuzzy logic has been successfully implemented in many real-life applications. Like In "A neurofuzzy logic approach for modeling plant processes: A practical case of invitro direct rooting and acclimatization of Vitis vinifera L." Author Jorge Gago, Mariana Landin and Pedro P. Gallego explains the application in understanding of the cause-effect relationships between culture conditions and growth parameters.
- The mathematical concepts behind the fuzzy logic are simple and easy to understand and implement. It can handle non precision data and it works on natural language so it has so many positive applications which contribute in making the technology and consumer products better.

Negative views:

- Fuzzy logic is not always accurate and sometimes it leads to ambiguity because there is no systematic approach to solve a problem using fuzzy logic.
- When it comes to rule-base defining exact fuzzy rules and membership function is a difficult task, even a small mistake can lead to ambiguous behavior.
- Hence it deals with the linguistic variables we do not have mathematical explanation of implemented approach.

## 1.5 APPLICATIONS OF FUZZY LOGIC

Fuzzy logic has been successfully applied in various fields of engineering and even non-engineering fields. Listed are some of the known applications of fuzzy logic systems.

- Automobile industry has some applications like automatic gear box, four wheel steering, vehicle environment control and Traction control system. It has made the driving easy, safe and comfortable. Example: companies like Nissan and Mitsubishi use fuzzy logic system in vehicles for cruise control in adjusting the throttle and acceleration. (Guru99, n.d.)
- Domestic appliances like Microwave ovens, washing machine, vacuum machine, toasters and refrigerators.
- Canon photocopy machine uses fuzzy logic for adjusting drum voltage based on picture density, humidity and temperature. (Guru99, n.d.)
- It is used for altitude control in aviation and aerospace field.
- Fuzzy logic has large application in Natural Language processing, in the field of Artificial Intelligence.

- I have personally used fuzzy logic in my engineering major project to understand the natural language, and perform the set of action based on the given command. It works for almost 80% to 90% of commands but there are no fixed rules which sometimes gives you ambiguity.

# 2 Part two:

## 2.1 Design and Architecture

### 2.1.1 Overview

This program should be developed for understanding and analysis of a simple purpose Fuzzy Rule based System. Rule base is provided in the form of text file. Provided is a generalized syntax for rules, which makes this task easy as input files will be identical.

### 2.1.2 Context

Goal is to design and develop a fuzzy rule base system which can calculate the centroid.

### 2.1.3 Goals

Goal is to design and develop a fuzzy rule base system which can calculate the centroid. But to obtain the final output the system is divided in small modules which can then work together to compute the crisp output values.

- System should be able to read fuzzy rule base.
- System should be able to extract set of variables and fuzzy values.
- System should do fuzzifiction and deffuzzification to get the output.
- System should at least be able to handle one operation (AND/OR).

### 2.1.4 Proposed Architecture

I plan to divide program into small but significant parts which can handle different computations individually and then and be integrated together for the final defuzzified output.

System will be divided into following modules:

- Read Rule-base (Text File):

This module will read the text file from the directory.

- Parser:

Functionality for this module is to extract the rule-base, membership functions, variables and their fuzzy values and put them into dictionary.

- Fuzzification:

In this module, rules are applied based on the four tuple representation.

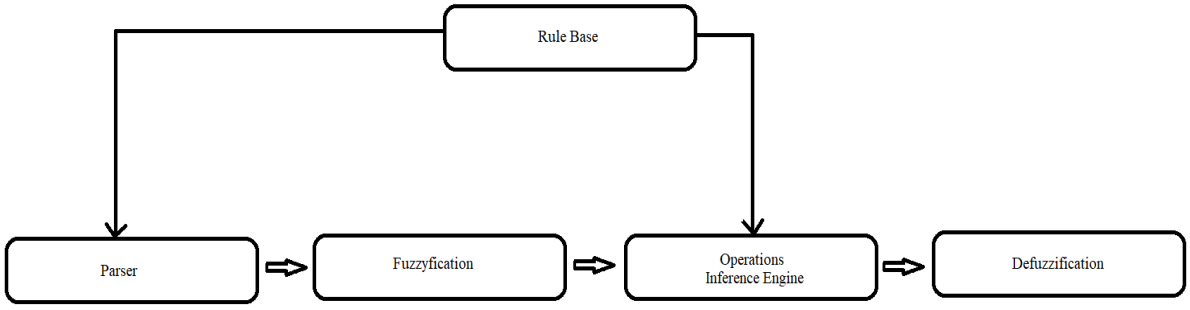
- Operation:

The information in processed in this module, I separate the variables and values from the rule base and do the necessary calculation to get the values in form of dictionary.

- Defuzzification:

This module gives the centroid for the shape. This module also performs small calculations like finding the area of triangle, center value of base.

- Architecture Diagram:




### 2.1.5 Timeline

Time frame for development of this project is estimated to be around 2 to 3 days. Time frame is large for such a small system, but it is justified since development is done by an individual person.

## 2.2 Implementation and results

Below are the features and facts about the developed fuzzy logic system:

- Development is done using python 3.
- Jupyter Notebook was used as IDE for fuzzy system development then converted to .py
- Modular programming approach is used for easy understanding and reusability.
- System is capable of handling any file with the following rule syntax.

```
Rule 1:  if <variable1> is <value1> [and|or] [<variablen> is <valuen>]
then <variablei> is <valuej>
Rule 2:  if <variable2> is <value2> [and|or] [<variablen> is <valuen>]
then <variablei> is <valuej>
```

Listed below are some of the implementation issues and limitations of the system:

- System can handle large number of rules but cannot handle more number of logics in the same rule.
- It is not designed to handle ‘AND’ and ‘OR’ in the same rule.
- In defuzzification calculation of centroid is just for equilateral triangle or area with same distribution on left and right (symmetric).

As the program was divided into different modules, each module was tested with at least 4 to 5 different input files and changing the crisp values. So, unit testing was carried out for each module and I received a satisfactory result which match the answers from examples solved by hands.

### 2.2.1 Result

```
###### calculating centroid :

divide = 0
tot_sum = 0
for i in tot_area:
    divide = divide + i

for k in centroid_add:
    tot_sum = tot_sum + k

centroid = tot_sum / divide
print(tot_area)
print(divide)
print(centroid_add)
print(tot_sum)
print("centroid is :", centroid)
```

```
small   :
base :  100  height :  1 area :  50.0

base1 :  80.0  height1 :  0.8 area :  32.0

total area of  0.2   small  is  18.0

center is  50.0

 ********************************************************************
moderate   :
base :  100  height :  1 area :  50.0

base1 :  40.0  height1 :  0.4 area :  8.0

total area of  0.6   moderate  is  42.0

center is  100.0

 ********************************************************************
[18.0, 42.0]
60.0
[900.0, 4200.0]
5100.0
centroid is : 85.0
```

## 2.3 Testing and Analysis

### 2.3.1 Unit and Integration testing

Unit testing was carried out during the development process. After that integration testing was performed and fuzzy system was found to be satisfying all the primary requirements set in part 2 of the assessment 1. System was tested against the example given in the practical and the crisp outputs were exactly same as in the answer sheet provided.

### 2.3.2 Advance Testing

After the basic testing, system was tested for the performance against the following factors:

### 2.3.3 Testing against different examples

System was tested against different input files with different slightly different syntax, different values for 4 tuples and different fuzzy values for variables. System was able to process 4 out of five input files without giving any error.

Input files, in which syntax is not similar to the given syntax for rules, system throws errors in extracting the key elements from the text file. To avoid it new rules can be implemented in the system, but for every unique file it is not possible to make changes which as result make the system inefficient. But if more changes are made to the system, it becomes better such that it can process more input files.

### 2.3.4 Testing for different Crisp values

Tested system against the different input crisp values in the range and program executed successfully, but results are messed up sometimes for input values out of range.

Based on rules various input crisp values were paired randomly to test against the system to see if the system can handle this values. System performed well with the various crisp inputs without throwing errors.

### 2.3.5 Testing with more than one and different logical operator in rules

When the system was tested for more than one logical operators in the rule, it was able to handle multiple but same logical operators, but it failed to work for two different logical operators. Necessary changes can be made to ensure system can handle both type of operators in a single file but there might be complications.

# 3 Part Three:

## 3.1 Introduction

Qualitative Reasoning automates reasoning and problem solving about the real life situations around us. Qualitative reasoning has helped to develop systems and techniques which are efficient in various application domains. Some applications are Spacecraft support, failure analysis and onboard diagnosis of vehicle systems, etc.

Qualitative reasoning helps to overcome and address new problems and achieve goals. Rather than just a mathematical expression, qualitative reasoning provides explicit representation of the conceptual modelling layer.

## 3.2 Integration of Fuzzy system with Qualitative Reasoning System

Fuzzy System: The proposed and developed fuzzy logic system in the second part of the assignment can be integrated with the Qualitative Reasoning system to increase the efficiency by using QR for better understanding of the new problem environment.

As Qualitative reasoning focus on analyzing and explaining the behavior of system in terms of cause-effect relations which is close to human reasoning will help us understanding and representing the environment. It mainly focus on the quality which means it will include only those distinctions in the behavior model which are important for solving the problem in input file for our fuzzy logic system.

In fuzzy model we have if-then rules, there are two parts of this rule: the premise part and the consequent part so we will have two structures i.e. premise structure and consequent structure. For our system where premise structure in input file has two dimensional space of the inputs and is partitioned in three parts. Here Qualitative reasoning can help in determining how the input space should be partitioned.

So basically we divide problem in two steps where in first step we deal with the fuzzy model in terms of fuzzy numbers and in second step we deal with the fuzzy model with linguistic terms which will be our qualitative model. In order to derive qualitative model from fuzzy model we will use fuzzy numbers in the consequents.

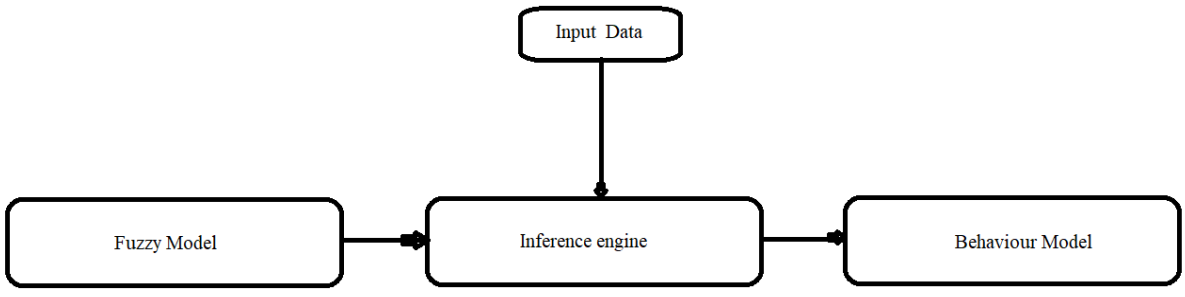



Fig (1): Qualitative Reasoning

### 3.3 Conclusion

Based on the discussed idea, I think if this concept is implemented in our system, it will improve the overall efficiency of the system in terms of handling ambiguous input file and files with different input format.

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