Computational Intelligence

Fuzzy Logic Air Conditioning System

February 2024

Paul Price – B00106786

Declaration

I/We declare that this material, which I/We now submit for assessment, is entirely my/our own work and has not been taken from the work of others, except where otherwise stated. I/We have identified and included the source of all facts, ideas, opinions, and viewpoints of others in the assignment references. Direct quotations from books, journal articles, internet sources, module text, or any other source whatsoever are acknowledged and the source cited are identified in the assignment references.

I/We understand that plagiarism, collusion, and copying are grave and serious offences and accept the penalties that would be imposed should I/we engage in plagiarism, collusion or copying. I acknowledge that copying someone else's assignment, or part of it, is wrong, and that submitting identical work to others constitutes a form of plagiarism. I/We have read and understood the colleges plagiarism policy 3AS08 (available here).

This material, or any part of it, has not been previously submitted for assessment for an academic purpose at this or any other academic institution.

I have not allowed anyone to copy my work with the intention of passing it off as their own work.

Name: Paul Price Dated: 22/02/2024

(Printing your name here will be taken as a digital signature)

Introduction

Fuzzy logic is a form of logic that typically deal with an outcome being neither completely true nor completely false. Where traditional logic is either true or false, fuzzy logic is when there is a level of uncertainty involved and the outcome will range somewhere between true and false but very rarely be absolutely false or absolutely true. Fuzzy logic is represented on a scale from 0 to 1, 0 being absolutely false and 1 being absolutely true. Fuzzy logic is particularly useful in the creation of home appliances such as air conditioners and rice cooker, artificial intelligence, decision making and pattern recognition. This is because it allows the machine or system to take it upon themselves to make decisions based on a level of confidence when uncertainty is involved.

For this assignment the we have been given code for an air conditioner system and it is up them to create the controller for this system using fuzzy logic. Three units of temperature will be tracked, this includes the target temperature, the room temperature and the outside temperature. The target temperature is the temperature we wish the room to be at, the only way to obtain this is through the use of a working air conditioner, if the air conditioner is coded correctly, it will bring the room temperature to the target temperature through heating or cooling methods and then maintain that temperature. If the air conditioner is switched off then the temperature will fluctuate largely depending on the outside temperature. The room temperature should always be within a range of 0 and 40 degrees Celsius.

Linguistic Variables and Membership Functions

Linguistic variables are input and output variables that use words and/or sentences as opposed to numerical values. These linguistic variables typically cover a general range of values, for example, if the temperature was 7 degrees, then an appropriate linguistic variable would be ‘cold’, the temperature may fluctuate but the linguistic variable is unlikely to change unless there is a drastic change in temperature. Linguistic variables typically consist of a terms set, membership functions and fuzzy logic rules.

Terms

A term set is a set of terms used to describe the linguistic variables. For this assignment the terms chosen are as follows:

- FREEZING – This term is used when referring to the room temperature or target temperature being below 5 degrees Celsius.
- COLD – This term is used when referring to the room temperature or target temperature being between 0 and 15 degrees Celsius.
- NORMAL – This term is used when referring to the room temperature or target temperature being between 10 and 25 degrees Celsius.
- WARM – This term is used when referring to the room temperature or target temperature being between 20 and 35 degrees Celsius.
- HOT – This term is used when referring to the room temperature or target temperature being above 30 degrees Celsius.

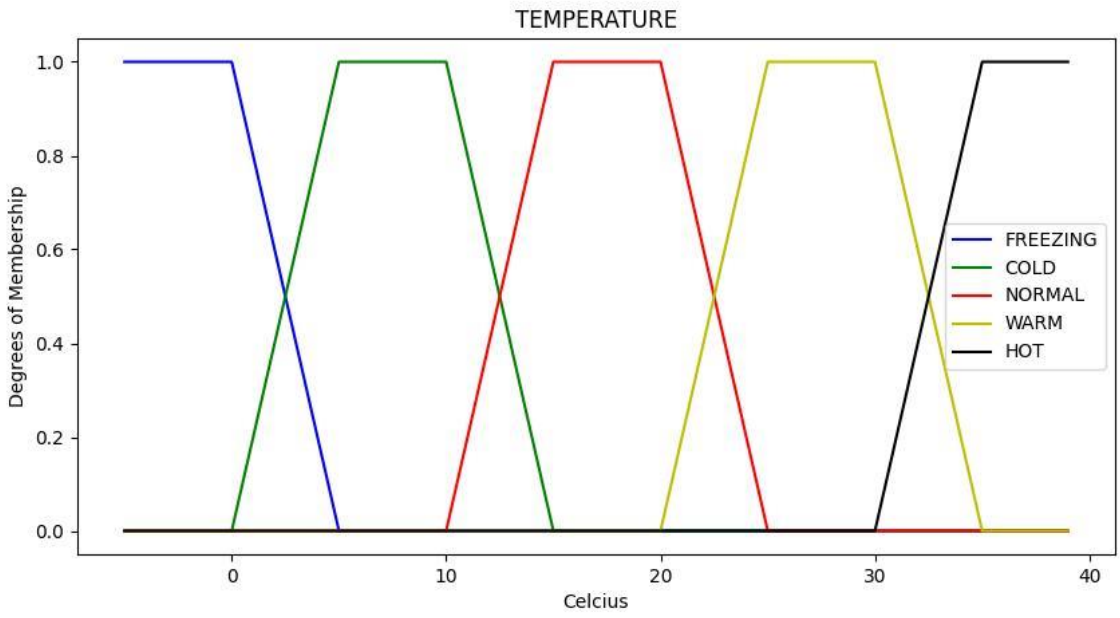
We must assign start and end values to FREEZING and HOT in our code, so technically FREEZING doesn’t necessarily cover every temperature below 5 degrees and HOT doesn’t cover

every temperature above 30 degrees, however, we have parameters in our code that restrict the room temperature and target temperature to stay withing the range of 0 to 40 degrees Celsius so for all intensive purposes they do as the target temperature and room temperature will never exceed 40 or drop below 0. There is a 5-degree overlap between each of the linguistic variables, this is because the change from one linguistic variable to another is gradual, if the change from one linguistic variable to another was instantaneous then the turning point where the linguistic variables meet could be considered neither and would cause errors within our code. This is why fuzzy logic is perfect for this kind of system as when the temperature falls within the overlap it can't be definitely referred to by either linguistic variable.

We also use linguistic variables for the ac commands. If the target temperature is below the room temperature we call the command "cool" which is assigned negative values and begins to cool the temperature down until it reaches the target temperature. If the target temperature is above the room temperature we call the command "heat" which is assigned positive values and begin to heat the temperature up until it reaches the target temperature. If the room temperature is within a range of between -3 and 3 degrees of the target temperature we call the command "maintain", this command stops any heating/cooling in an attempt to keep the room temperature within that range of the target temperature.

Membership Functions

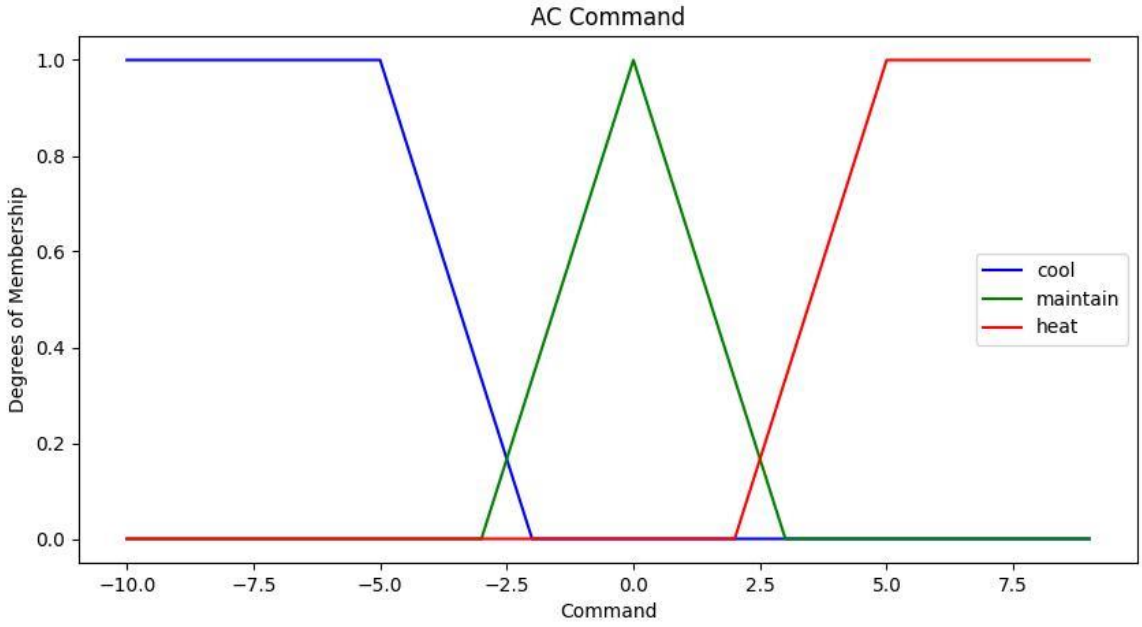
Membership functions are a method of plotting linguistic terms on a graph in order to visualize them. Below is a membership function plotting the terms used for room temperature and target temperature:



The x-axis in the above diagram represents the temperature whereas the y-axis represents how true it is. If a linguistic variable is at 0 at a given temperature it is absolutely false, if it is at 1 it is absolutely true, if it's somewhere in between then it is neither completely true nor completely false. For example, lets look at the linguistic variable for COLD, if the temperature is below 0 we can say with absolute certainty that the temperature is no longer considered cold and if the temperature is above 15 we can also say with absolute certainty that the temperature is no

longer considered cold, if the temperature is between 0 and 5 the temperature starts to become less COLD and more FREEZING, similarly if the temperature is between 10 and 15 the temperature starts to become less COLD and more NORMAL.

Below is a membership function of the ac commands:



From the above diagram can see that if the temperature falls within the -3 and 3 the ac command works to maintain the current temperature. If the target temperature is more than -3 degrees away from the room temperature then the ac command “cool” works to cool the room temperature down and get it to the target temperature, the further the target temperature is from the room temperature the harder the command works to cool the temperature down, once it gets to -5 degrees from the room temperature the commands starts to slow down and cool the room temperature less rapidly. If the target temperature is more than 3 degrees away from the room temperature then the ac command “heat” works to heat the room temperature up and get it to the target temperature, the further the target temperature is from the room temperature the harder the command works to heat the temperature up, once it gets to 5 degrees from the room temperature the commands starts to slow down and heat the room temperature less rapidly.

Fuzzy Logic Rules

The rules matrix for the temperatures is represented in the table below. The top row of temperatures represent the target temperature whereas the left column of temperatures represent the room temperature. If the room temperature and target temperature match then the maintain command is called, otherwise the cool/heat commands are called.

Temperature	Freezing	Cold	Normal	Warm	Hot
Freezing	maintain	heat	heat	heat	heat
Cold	cool	maintain	heat	heat	heat
Normal	cool	cool	maintain	heat	heat
Warm	cool	cool	cool	maintain	heat
Hot	cool	cool	cool	cool	maintain

Rules to maintain temperature:

1. if roomTemp is FREEZING and targetTemp is FREEZING then acCommand is maintain
2. if roomTemp is COLD and targetTemp is COLD then acCommand is maintain
3. if roomTemp is NORMAL and targetTemp is NORMAL then acCommand is maintain
4. if roomTemp is WARM and targetTemp is WARM then acCommand is maintain
5. if roomTemp is HOT and targetTemp is HOT then acCommand is maintain

Rules to cool temperature:

1. if (roomTemp is HOT or roomTemp is WARM or roomTemp is NORMAL or roomTemp is COLD) and (targetTemp is FREEZING) then acCommand is cool
2. if (roomTemp is HOT or roomTemp is WARM or roomTemp is NORMAL) and (targetTemp is COLD) then acCommand is cool
3. if (roomTemp is HOT or roomTemp is WARM) and targetTemp is NORMAL then acCommand is cool
4. if (roomTemp is HOT) and targetTemp is WARM then acCommand is cool

Rules to heat temperature:

1. if (roomTemp is FREEZING) and targetTemp is COLD then acCommand is heat
2. if (roomTemp is FREEZING or roomTemp is COLD) and targetTemp is NORMAL then acCommand is heat
3. if (roomTemp is FREEZING or roomTemp is COLD or roomTemp is NORMAL) and (targetTemp is WARM) then acCommand is heat
4. if (roomTemp is FREEZING or roomTemp is COLD or roomTemp is NORMAL or roomTemp is WARM) and (targetTemp is HOT) then acCommand is heat