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Abstract

It is a project that aims to get new outputs after blurring some inputs that are about temperature and pressure, by inserting them into certain fuzzy inferences. And to provide these inputs we will be using a knowledge database and rule base. This knowledge base contains temperature and pressure inputs and the rule base contains some if-then conditions.With the help of these inputs, rules and some inferences we will calculate the percentage of Carbon Dioxide as output. In this project, we will take crispy inputs and blur them using Mamdani inference and center of area defuzzification methods. And we will try to show these fuzzy outputs we receive in a graphic with the help of matlab language.

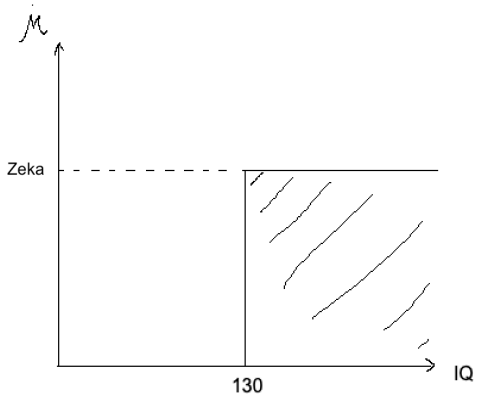
Introduction

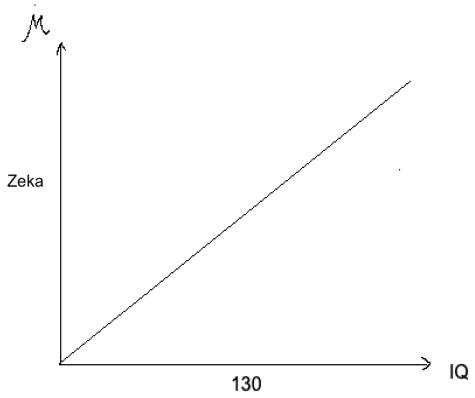
In the logic lesson, we say "true" (1) to the propositions that coincide with the facts, in other words, that are not contrary to logic; We used to call those who said the opposite of the truth 'false' (0).
Logic, in the simplest sense; It is the key to how we can transfer it to the world of numbers with certain methods of thinking in order to be able to solve any real-life problem. Fuzzy Logic works for exactly the same purpose. But with a few differences.

Within the limits drawn by classical logic, we predict that a proposition can only satisfy one of two conditions (true or false). Because the relationship of existence with absolute reality is in a kind of 'singularity' state. For example, your IQ cannot be both less than 130 and above. But people have realized that sometimes it's not possible to explain some truths with only right or wrong possibilities. For instance it is totally

right to say that a person is longer than 1.80 cm. In contrast, we can not say this person is long or small. Because the definition of height is a changeable variable. Here, at this point fuzzy logic comes into play. Fuzzy logic tries to approach and imitate human logic.

Let's talk about an example that explains the difference of fuzzy logic better. For example , we have a test that determines whether we are clever or not. If we calculate it with a crisp logic system, although in reality there is almost no intellectual difference between a person's IQ of 129 and 130, classical logic does not consider any person under the age of 130 to be intelligent. But for fuzzy logic ; while a 130 IQ individual is intelligent (membership grade 1), another 129-year-old individual is less intelligent (not 0).





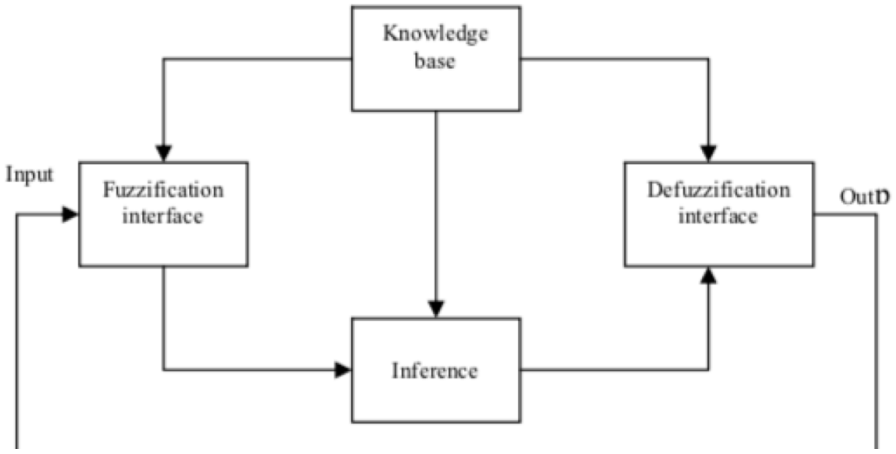
Normal Logic Fuzzy Logic

The general logic is making smooth our decidition when we don't want to decide with only true or false.
Since fuzzy logic includes classical logic, every system created with classical logic can also be created with fuzzy logic.
Since it can work close to the human mind, it is understandable according to many control methods.

It's not hard to create the theories and math that works in the background. And without being aware, we already do these logic systems in daily life many times when we code some logics and operations.

So Fuzzy logic, going further than classical logic, covers the logic model that people actually have and use. And the most significant field of this system is implementation in computers and machines. With fuzzy logic we convert human logic to math rules. And we decide something with using a knowledge base and a rule base (like human experience and ethical rules) . It is really similar to the human thinking system. So it is predictable to understand that we can use this system to teach something to computers and machines.

In the other words , we can develop many Artificial Intelligence Systems this way. Now we will investigate the stages of fuzzy logic systems.



Fuzzification Interface :

It is the unit that converts the plain values to the fuzzy values (between 0 and 1) by using the membership function. In other words, we can say that it calculates the membership degree of each input value to the fuzzy set.

Inference:
This part tries to draw conclusions from the fuzzy values that come to it by collaborating with the knowledge base. The knowledge of how and according to which these results will be drawn is kept in the knowledge base.

Knowledge Base:
Relationships between fuzzy sets are kept here. Here are the rules about what inferences will be made based on future data.

Defuzzification Interface:
The inferred data come up to this point in the fuzzy value range. However, the output data we need may need to be in a different range. Clarifier; It allows scaling the incoming fuzzy values according to a desired range.

General Information About Inference

Sometimes we have to make an inference with more than one variable. In this situation, we need to use fuzzy logic operations. Also to explain rules which are inside the knowledge base, with the if-then method. We will explain in more detail after the presentation. In addition to the basic methods mentioned above, there are many inference methods we can use when working with fuzzy logic. The most commonly used inference methods in fuzzy systems are as follows:

1. Mamdani Inference

2. Sugeno Inference

Construction

Now , we represent all of these steps in a machine (computer.). Let's see the codes and their logics.

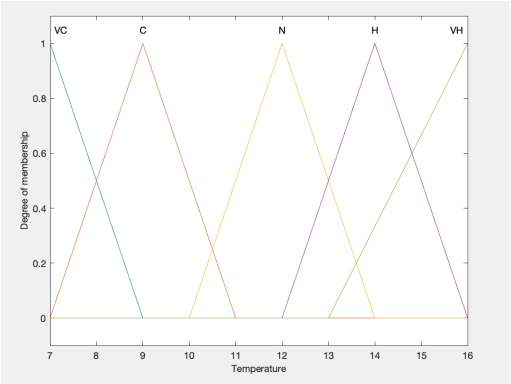
First of all, as you see below , we have created mamdani inference in matlab.

```
% Ismail Gokbas
fis = mamfis;
```

Then we need to create a fuzzification interface for the system. For that
We created inputs and gave names for them. And plotted it.

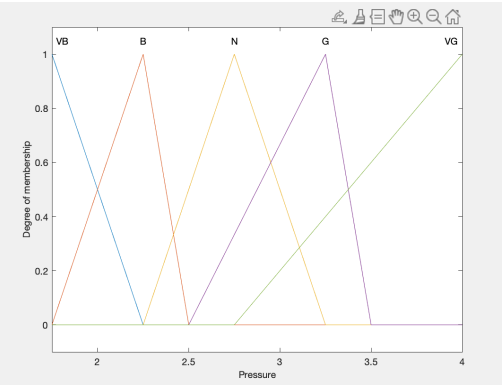
First Input (Temperature):

```
% Ismail Gokbas
fis = addInput(fis,[1.75 4],"Name","Pressure");
fis = addMF(fis,"Pressure","trimf",[1.75 1.75 2.25],'Name',"VB");
fis = addMF(fis,"Pressure","trimf",[1.75 2.25 2.50],'Name',"B");
fis = addMF(fis,"Pressure","trimf",[2.25 2.75 3.25],'Name',"N");
fis = addMF(fis,"Pressure","trimf",[2.50 3.25 3.50],'Name',"G");
fis = addMF(fis,"Pressure","trimf",[2.75 4 4],'Name',"VG");
plotmf(fis,"input",2)
```



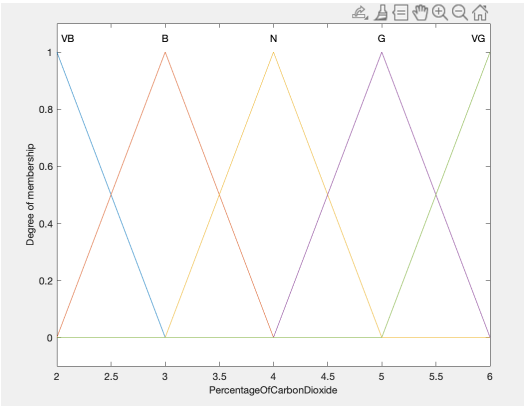
Second Input (Temperature):

```
% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

fis = addInput(fis,[1.75 4],"Name","Pressure");
fis = addMF(fis,"Pressure","trimf",[1.75 1.75 2.25],'Name',"VB");
fis = addMF(fis,"Pressure","trimf",[1.75 2.25 2.50],'Name',"B");
fis = addMF(fis,"Pressure","trimf",[2.25 2.75 3.25],'Name',"N");
fis = addMF(fis,"Pressure","trimf",[2.50 3.25 3.50],'Name',"G");
fis = addMF(fis,"Pressure","trimf",[2.75 4 4],'Name',"VG");
```



After that we need to teach what outputs will be to the computer. So we created output.

```
% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

fis = addOutput(fis,[2 6],"Name","PercentageOfCarbonDioxide");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[2 2 3],'Name',"VB");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[2 3 4],'Name',"B");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[3 4 5],'Name',"N");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[4 5 6],'Name',"G");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[5 6 6],'Name',"VG");
```



Now we have created a fuzzification interface and mamdani inference . Let's create Knowledge base with rules given in pdf by teacher.

Rules:

If temperature is very cold and pressure is very bad then percentage of carbon dioxide is normal
If temperature is very cold and pressure is bad then percentage of carbon dioxide is normal
If temperature is very cold and pressure is normal then percentage of carbon dioxide is good
If temperature is very cold and pressure is good then percentage of carbon dioxide is very good
If temperature is very cold and pressure is very good then percentage of carbon is dioxide very good

If temperature is cold and pressure is very bad then percentage of carbon dioxide is bad
If temperature is cold and pressure is bad then percentage of carbon dioxide is good
If temperature is cold and pressure is normal then percentage of carbon dioxide is good
If temperature is cold and pressure is good then percentage of carbon dioxide is good
If temperature is cold and pressure is very good then percentage of carbon dioxide is very good

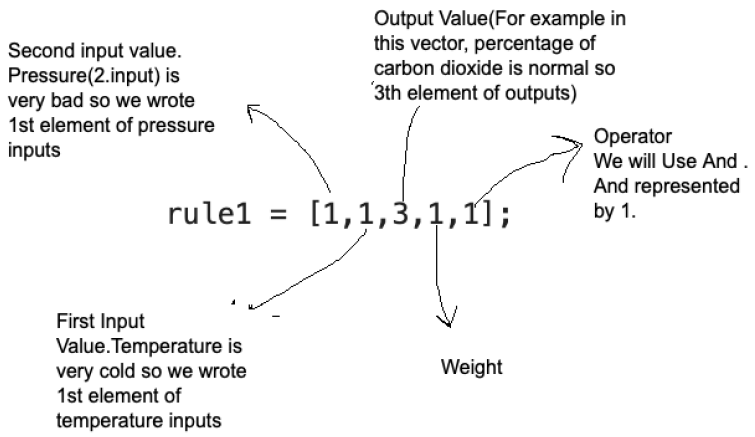
If temperature is normal and pressure is very bad then percentage of carbon dioxide is bad
If temperature is normal and pressure is bad then percentage of carbon dioxide is normal
If temperature is normal and pressure is normal then percentage of carbon dioxide is normal

If temperature is normal and pressure is good then percentage of carbon dioxide is good
If temperature is normal and pressure is very good then percentage of carbon dioxide is very good

If temperature is hot and pressure is very bad then percentage of carbon dioxide is bad
If temperature is hot and pressure is bad then percentage of carbon dioxide is bad
If temperature is hot and pressure is normal then percentage of carbon dioxide is normal
If temperature is hot and pressure is good then percentage of carbon dioxide is normal
If temperature is hot and pressure is very good then percentage of carbon dioxide is good

If temperature is very hot and pressure is very bad then percentage of carbon dioxide is very bad
If temperature is very hot and pressure is bad then percentage of carbon dioxide is bad
If temperature is very hot and pressure is normal then percentage of carbon dioxide is normal
If temperature is very hot and pressure is good then percentage of carbon dioxide is normal
If temperature is very hot and pressure is very good then percentage of carbon dioxide is good

These are our rules. And we will teach them how to compute the matrix and addRule method. But before giving code , let's have a look at how this function works.



With this way we added all rules (25). Its code:

```
% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

rule1 = [1,1,3,1,1]; rule2 = [1,2,3,1,1]; rule3 = [1,3,4,1,1]; rule4 = [1,4,5,1,1]; rule5 = [1,5,5,1,1];

rule6 = [2,1,2,1,1]; rule7 = [2,2,4,1,1]; rule8 = [2,3,4,1,1]; rule9 = [2,4,4,1,1]; rule10 =[2,5,5,1,1];

rule11 = [3,1,2,1,1]; rule12 = [3,2,3,1,1]; rule13 = [3,3,3,1,1]; rule14 = [3,4,4,1,1]; rule15 = [3,5,5,1,1];

rule16 = [4,1,2,1,1]; rule17 = [4,2,2,1,1]; rule18 = [4,3,3,1,1]; rule19 = [4,4,3,1,1]; rule20 = [4,5,4,1,1];

rule21 = [4,1,1,1,1]; rule22 = [4,2,2,1,1]; rule23 = [4,3,3,1,1]; rule24 = [4,4,3,1,1]; rule25 = [4,5,4,1,1];
```

Now We need to create a rule list to give computers.

```
% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

ruleList = [rule1;rule2;rule3;rule4;rule5;rule6;rule7;rule8;rule9;rule10;rule11;rule12;rule13;rule14;
    rule15;rule16;rule17;rule18;rule19;rule20;rule21;rule22;rule23;rule24;rule25];
```

Now We need to give our rules to the computer and try random inputs basicly.

```
%Ismail Gokbas
fis2 = addRule(fis,ruleList);

output = evalfis(fis2,[8 2 ; 10 4]);
```

```
output returns =    4.0000
                    5.6216
```

This is the result of that when we give [8 value for temperature and 2 value for pressure](result is 4.0000) AND [10 value for temperature and 4 value for pressure](result is 5.6216) . Let's give some other inputs.

1. temperature = 10 and pressure =3 => 5.0294
2. temperature = 12 and pressure = 3.5 => 5.6393
3. temperature = 13 and pressure = 2 => 3.3686

But when we give multiple inputs we may want to get the center value of the given area. To get defuzzification of this output we should use center of area defuzzification method.

```
% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

difuzzMemberfunc = trimf(output,[2 3 5]);
defuzz(output,mf,'centroid') %returns 4.5105
```

As you see, to make this fuzzy logic system we have used center of area defuzzification method and mamdani inference in matlab.

Some Input Sets

```
inputs = [8 2; 12 3.05];
output = evalfis(fis2,inputs);
difuzzMemberfunc = trimf(output,[4 5 6]);
defuzz(output,difuzzMemberfunc,'centroid') %returns   4.6413
```

```
inputs = [11 3.25; 12 4; 10 4];
output = evalfis(fis2,inputs);
difuzzMemberfunc = trimf(output,[4 5 6]);
defuzz(output,difuzzMemberfunc,'centroid') %returns  5.3342
```

```
inputs = [7 3.9; 10.3 3.05 ;7.49 3];
output = evalfis(fis2,inputs);
difuzzMemberfunc = trimf(output,[4 5 6]);
defuzz(output,difuzzMemberfunc,'centroid') %returns   5.0968
```

```
inputs = [7.3 2.67; 10.31 3.13 ;9.49 2.23; 13 4];
output = evalfis(fis2,inputs);
difuzzMemberfunc = trimf(output,[4 5 6]);
defuzz(output,difuzzMemberfunc,'centroid') %returns 4.9530
```

```
inputs = [7.12 2.18; 11.4 3.1];
output = evalfis(fis2,inputs);
difuzzMemberfunc = trimf(output,[4 5 6]);
defuzz(output,difuzzMemberfunc,'centroid') %returns   4.7102
```

Source Codes In Matlab :

Source Code Github link : https://github.com/ismail119/fuzzyProject

Or Here :

Editor - /Users/macpro/Documents/MATLAB/assignment.m

assignment.m

```
% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

fis = mamfis('Name',"MyFis");
fis = addInput(fis,[7 16],"Name","Temperature");

fis = addMF(fis,"Temperature","trimf",[7 7 9],'Name',"VC");
fis = addMF(fis,"Temperature","trimf",[7 9 11],'Name',"C");
fis = addMF(fis,"Temperature","trimf",[10 12 14],'Name',"N");
fis = addMF(fis,"Temperature","trimf",[12 14 16],'Name',"H");
fis = addMF(fis,"Temperature","trimf",[13 16 16],'Name',"VH");


% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

fis = addInput(fis,[1.75 4],"Name","Pressure");
fis = addMF(fis,"Pressure","trimf",[1.75 1.75 2.25],'Name',"VB");
fis = addMF(fis,"Pressure","trimf",[1.75 2.25 2.50],'Name',"B");
fis = addMF(fis,"Pressure","trimf",[2.25 2.75 3.25],'Name',"N");
fis = addMF(fis,"Pressure","trimf",[2.50 3.25 3.50],'Name',"G");
fis = addMF(fis,"Pressure","trimf",[2.75 4 4],'Name',"VG");

% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

fis = addOutput(fis,[2 6],"Name","PercentageOfCarbonDioxide");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[2 2 3],'Name',"VB");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[2 3 4],'Name',"B");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[3 4 5],'Name',"N");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[4 5 6],'Name',"G");
fis = addMF(fis,"PercentageOfCarbonDioxide","trimf",[5 6 6],'Name',"VG");

% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.


rule1 = [1,1,3,1,1]; rule2 = [1,2,3,1,1]; rule3 = [1,3,4,1,1]; rule4 = [1,4,5,1,1]; rule5 = [1,5,5,1,1];

rule6 = [2,1,2,1,1]; rule7 = [2,2,4,1,1]; rule8 = [2,3,4,1,1]; rule9 = [2,4,4,1,1]; rule10 =[2,5,5,1,1];

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rule16 = [4,1,2,1,1]; rule17 = [4,2,2,1,1]; rule18 = [4,3,3,1,1]; rule19 = [4,4,3,1,1]; rule20 = [4,5,4,1,1];

rule21 = [4,1,1,1,1]; rule22 = [4,2,2,1,1]; rule23 = [4,3,3,1,1]; rule24 = [4,4,3,1,1]; rule25 = [4,5,4,1,1];

% Ismail Gokbas, Demircan Demir,Ismet Mert EskiBorekcioglu tarafindan hazirlanmistir.

ruleList = [rule1;rule2;rule3;rule4;rule5;rule6;rule7;rule8;rule9;rule10;rule11;rule12;rule13;rule14;
    rule15;rule16;rule17;rule18;rule19;rule20;rule21;rule22;rule23;rule24;rule25];

%Ismail Gokbas
fis2 = addRule(fis,ruleList);


inputs = [7.3 2.67; 10.31 3.13 ;9.49 2.23; 13 4];
output = evalfis(fis2,inputs);
difuzzMemberfunc = trimf(output,[4 5 6]);
defuzz(output,difuzzMemberfunc,'centroid') %returns 4.9530
```

References :

https://www.mathworks.com/help/fuzzy

Teacher PDFs

Some youtube videos.