Fuzzy Logic Toolbox

MATLAB FUZZY LOGIC TOOLBOX

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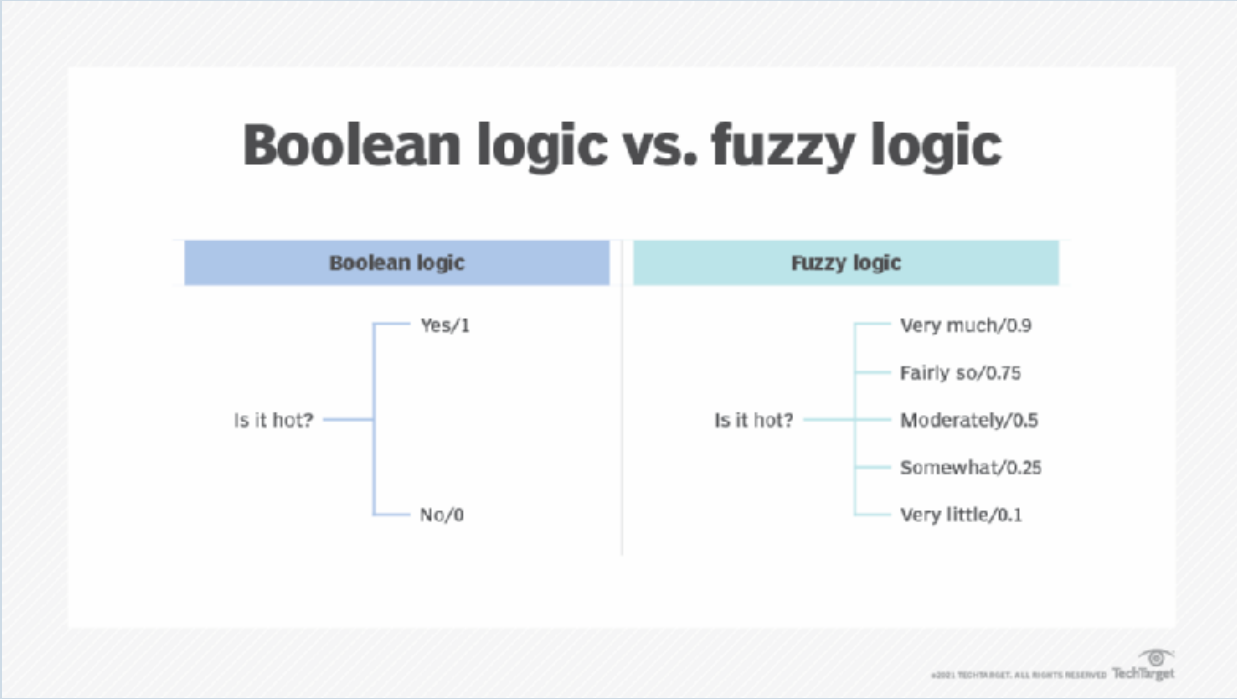
Introduction

Fuzzy Logic:

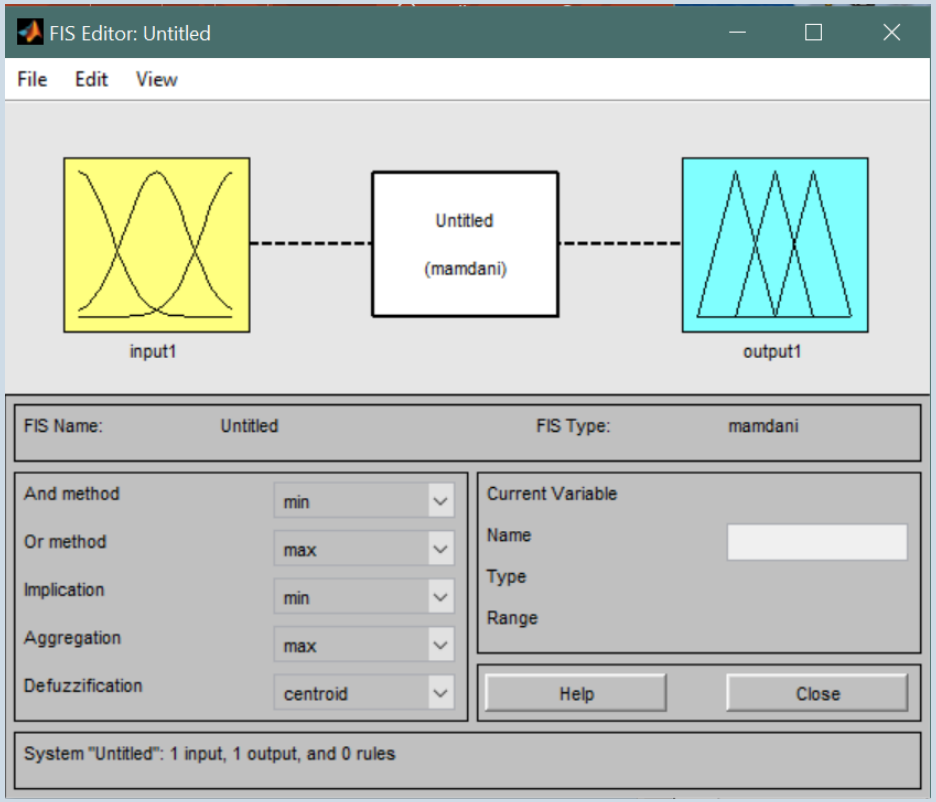
- Fuzzy logic is an approach to computing based on "degrees of truth"
- Since most activities in life are not easily translated into the absolute terms of 0 and 1, It may help to work with problems using fuzzy logic.



Introduction (2)

Fuzzy Logic Toolbox:

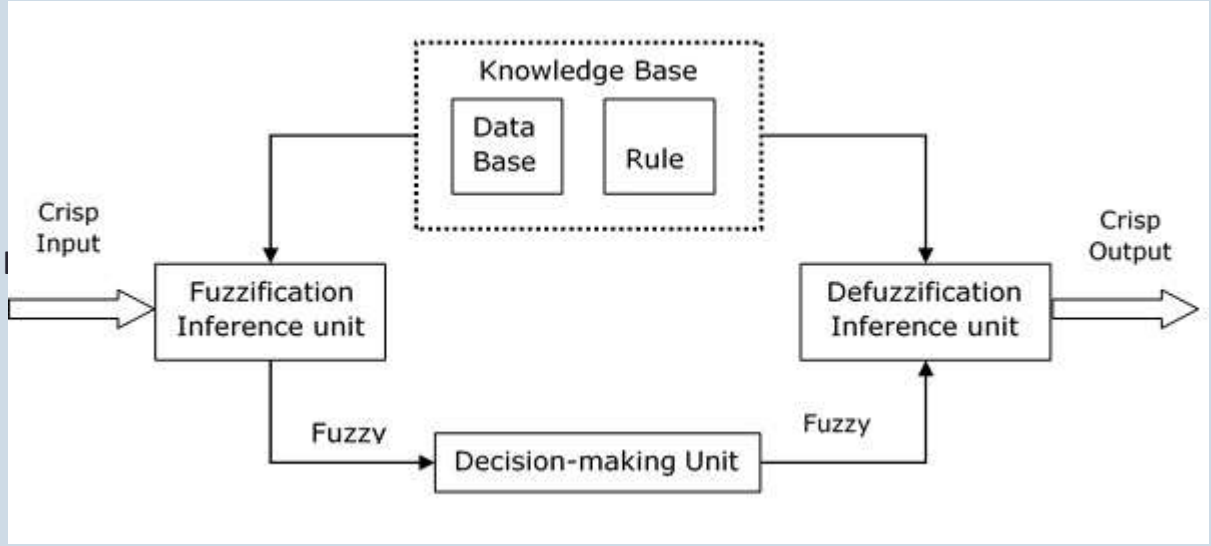
- Provides MATLAB functions, apps, and a Simulink block for analyzing, designing, and simulating systems based on fuzzy logic.
- lets you model complex system behaviors using simple logic rules, and then implement these rules in a fuzzy inference system.
- Can be used as a stand-alone fuzzy inference engine.



Fuzzy Inference System modeling

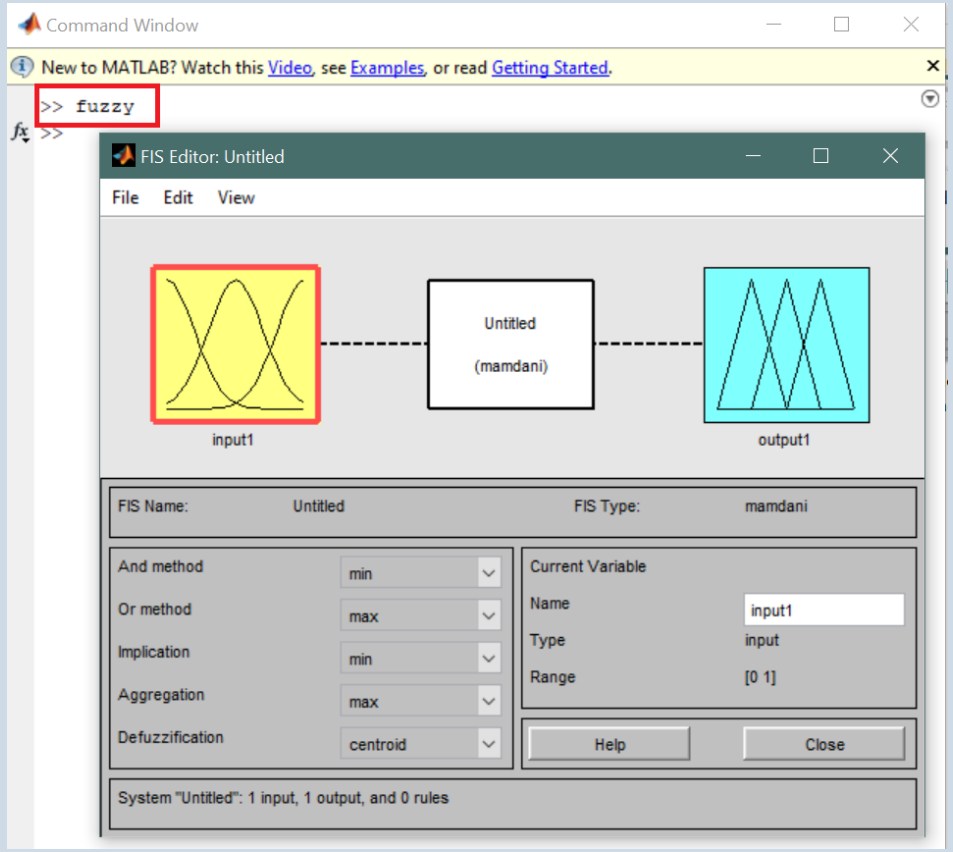
- Fuzzy Inference System is the key unit of a fuzzy logic system having decision making as its primary work.

- Blocks of FIS:
  - Rule Base: contains fuzzy rules
  - Data Base: contains membership functio
  - Decision-making unit (Inference unit)
  - Fuzzifier
  - Defuzzifier



Building FIS

- Fuzzy Logic Designer app or command-line functions can be used to design and test fuzzy inference systems.
- To start fuzzy toolbox type “fuzzy” in MATLAB command line.
- Steps of building and simulating FIS using fuzzy toolbox:
  1. Defining inputs and outputs
  2. Initiating Inference unit
  3. Creating membership functions
  4. Defining rules
  5. Simulating FIS



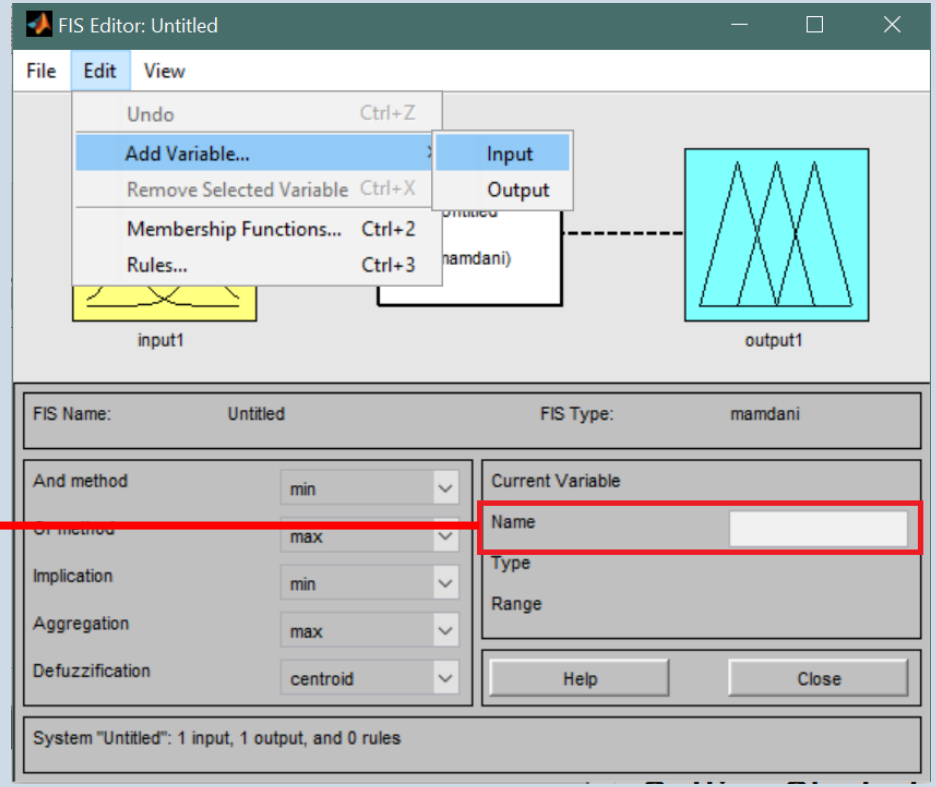
Building FIS (2)

1. Defining inputs and outputs

Number of inputs and outputs vary depending on definition of the problem.

Based on this number, in the Edit tab, select “Add Variables” and insert inputs and outputs.

Select the Input/output you want to name then type the name



Building FIS (3)

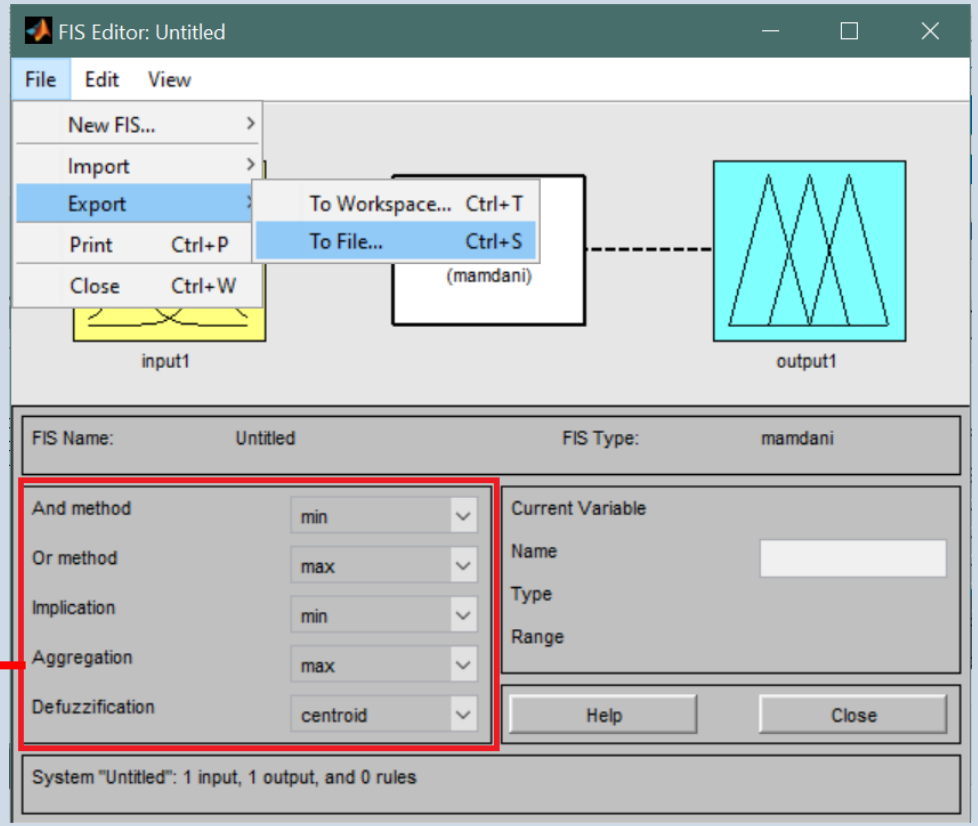
2. Initiating Inference unit

In the middle of diagram, you can see the name of the FIS and the type of Inference It uses.

To set the name, select File->Export->To File (or Ctrl+s) and then choose or create a file.

To use Sugeno FIS Instead of Mamdani go to File->New FIS ->Sugeno

fuzzy Inference functions can be adjusted



Building FIS (4)

3. Creating membership functions

Click on any of the variables to open Membership Function Editor.

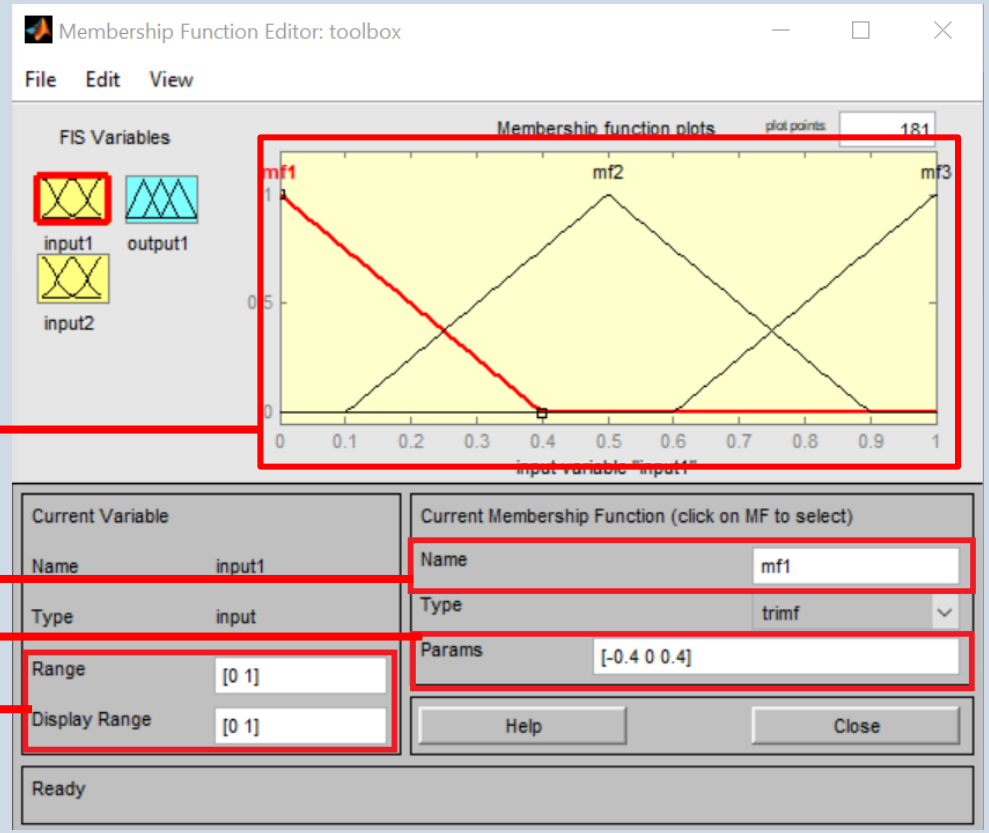
In this window, select any variable to edit Its membership function.

Change parameters of function by diagram

Change the name of the function

Change parameters of function by number

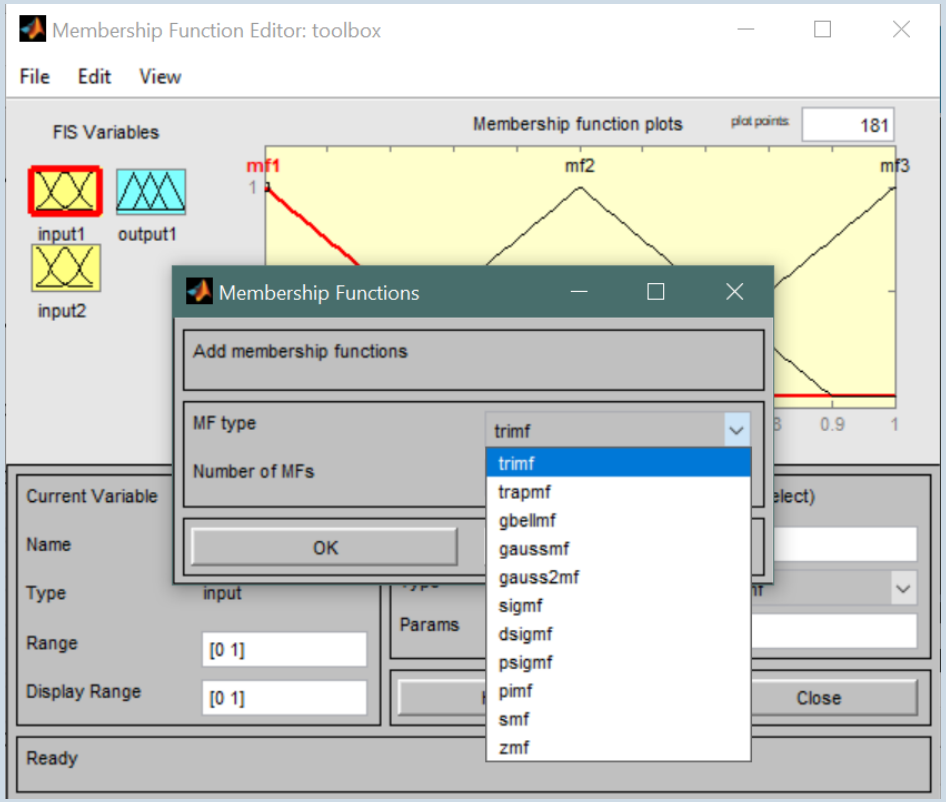
Change range of display and definition of function



Building FIS (5)

3. Creating membership functions(continued)

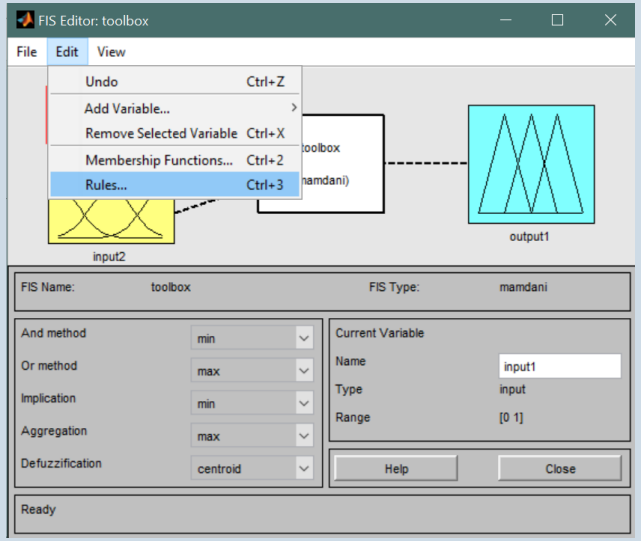
To add a new function go to Edit->Add MFS. In the opening window you can set type and number of functions used. You can also add custom functions in Edit -> Add Custom MF.

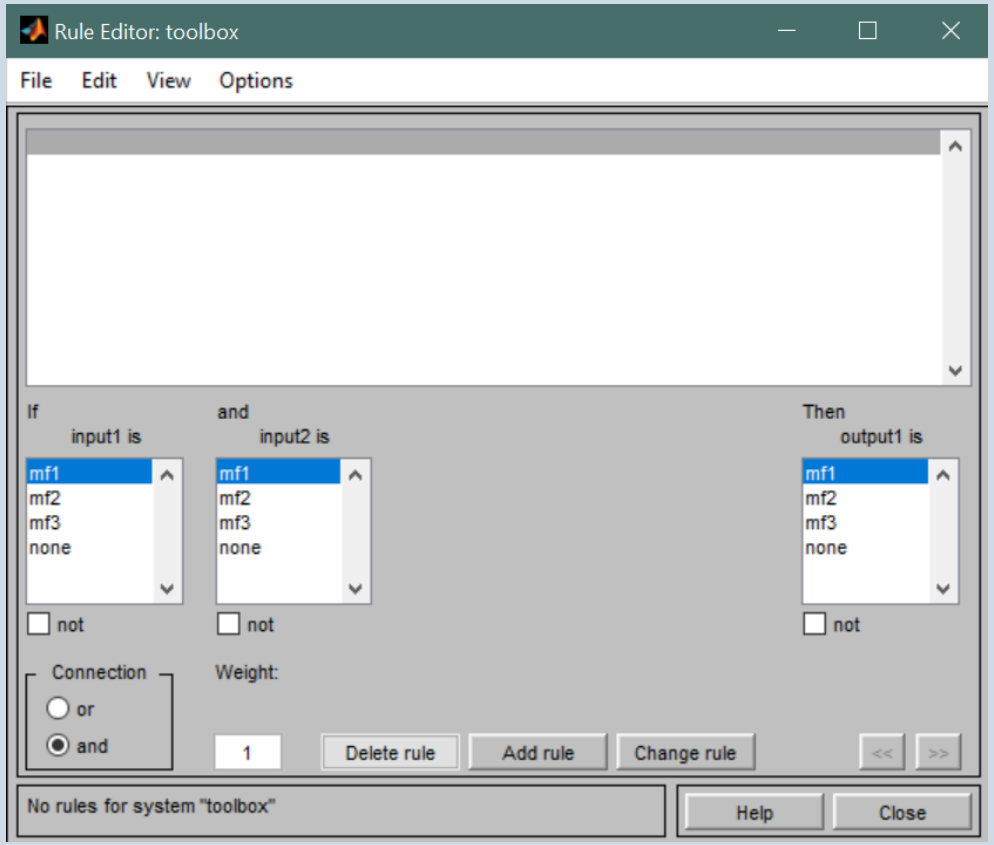


Building FIS (6)

4. Defining rules

To start defining rules, either go to Edit->Rules (or Ctrl+3) or double click on the FIS in diagram to open Rule Editor.





Building FIS (7)

4. Defining rules(continued)

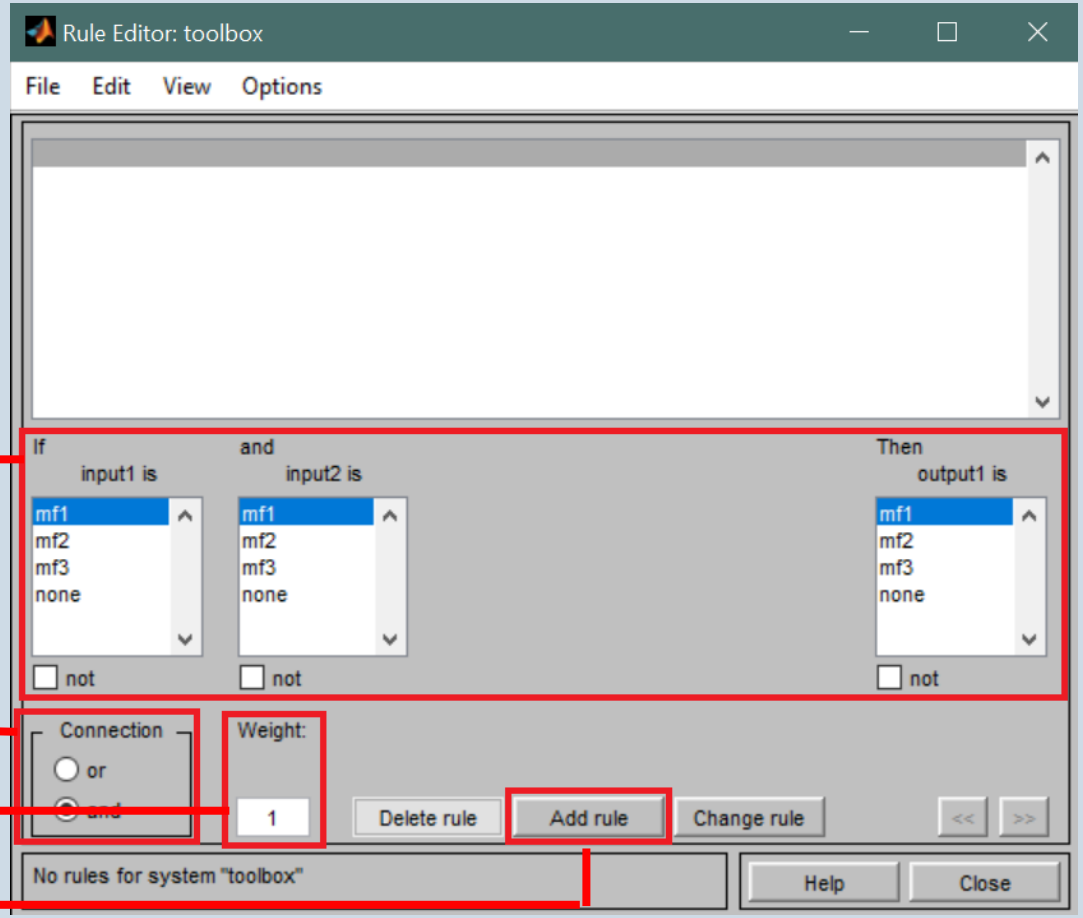
To define each rule:

select on item from each of the inputs and outputs

Select one item from connection to indicate how inputs are related.

Indicate the importance of rule by assigning a weight

Click to add the rule



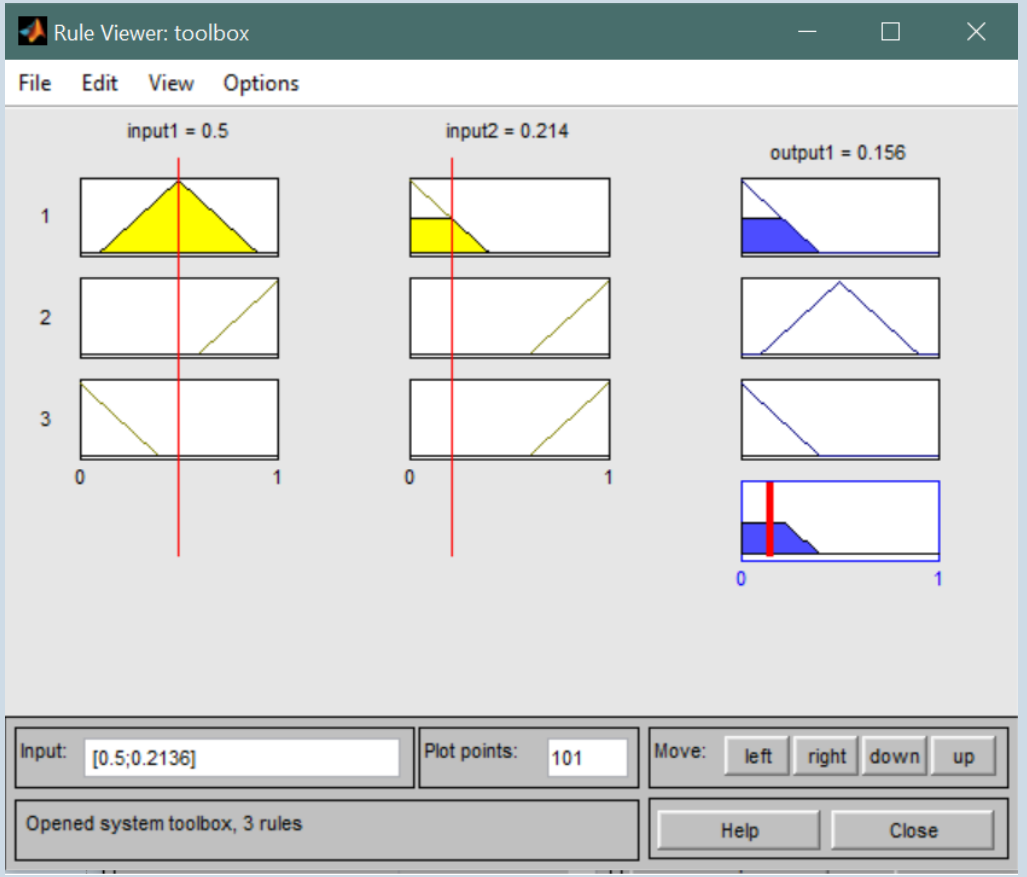
Building FIS (8)

5. Simulating FIS

Go to View->Rules(or Ctrl+5) to open rule viewer. Each column in this diagram shows a set of membership functions for one of the Inputs/outputs and each row is correspondent to one of the rules.

The bottom right plot shows how the output of rules are combined.

The red lines show the crisp Inputs/outputs which can be slide to get different values.

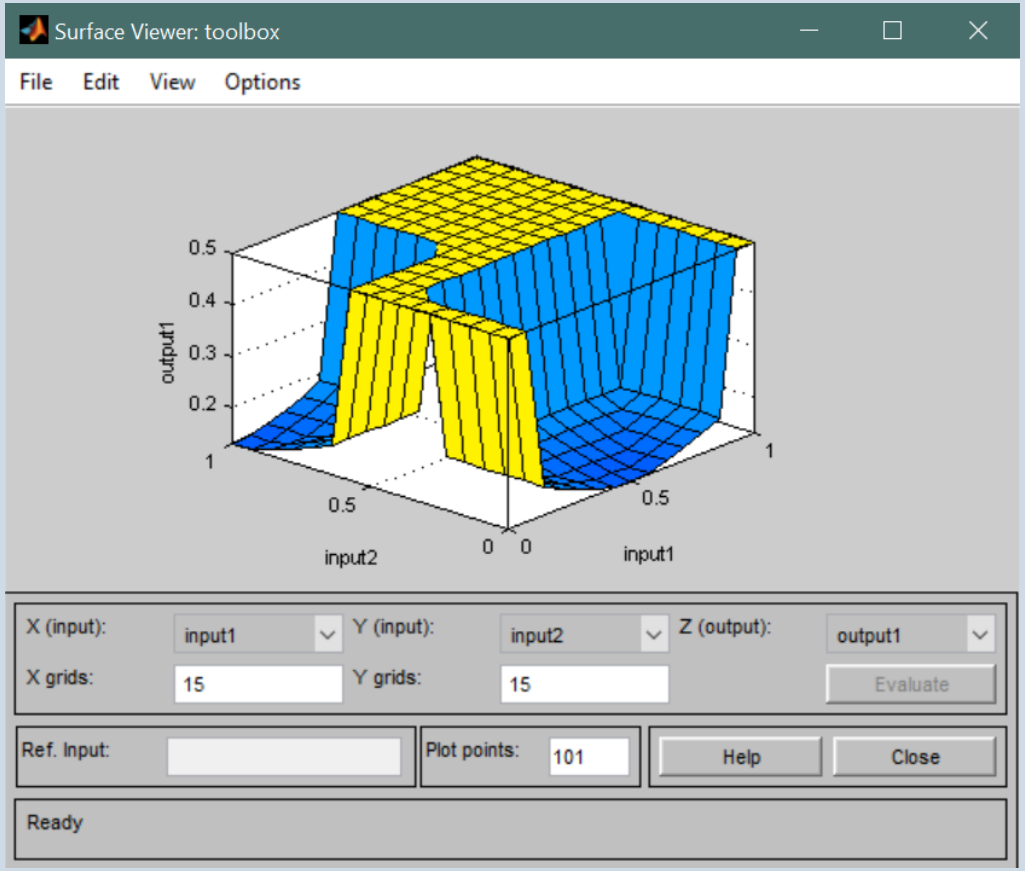


Building FIS (9)

5. Simulating FIS(continued)

To see Inputs and outputs on a surface go to View->Surface(or Ctrl+6).

For systems with more than two inputs you can select any two inputs and any one output for plotting.



Data Clustering

- Data clustering aims to partition a collection of data into a number of subsets (or clusters) that are optimal in terms of some function.

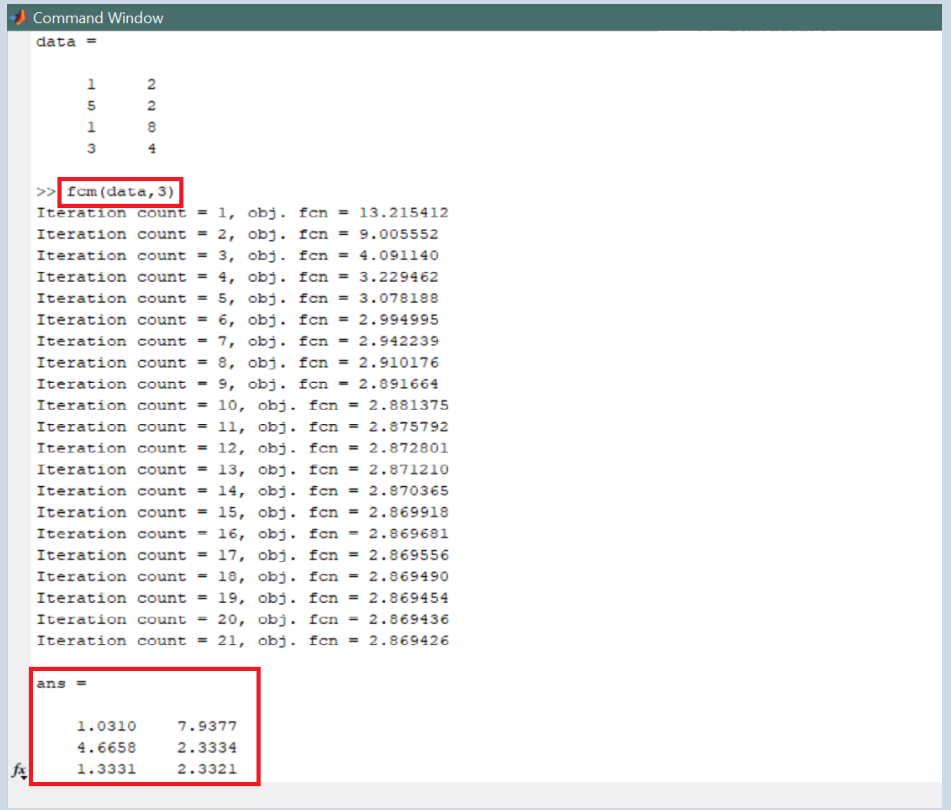
- Clustering problems can be solved by various algorithms including Fuzzy C-Means or Subtractive Clustering.

- Fuzzy Logic toolbox allow you to find clusters in input-output training data. You can use the cluster information to generate a Sugeno-type fuzzy inference system that best models the data behavior using minimum number of rules.

Fuzzy C-Means Clustering

- FCM is a data clustering technique wherein each data point belongs to a cluster to some degree that is specified by a membership grade.

- fcm(data,n)
  - Performs fuzzy c-means clustering on the given data and returns n cluster centers
  - Displays the value of objective function in each Iteration

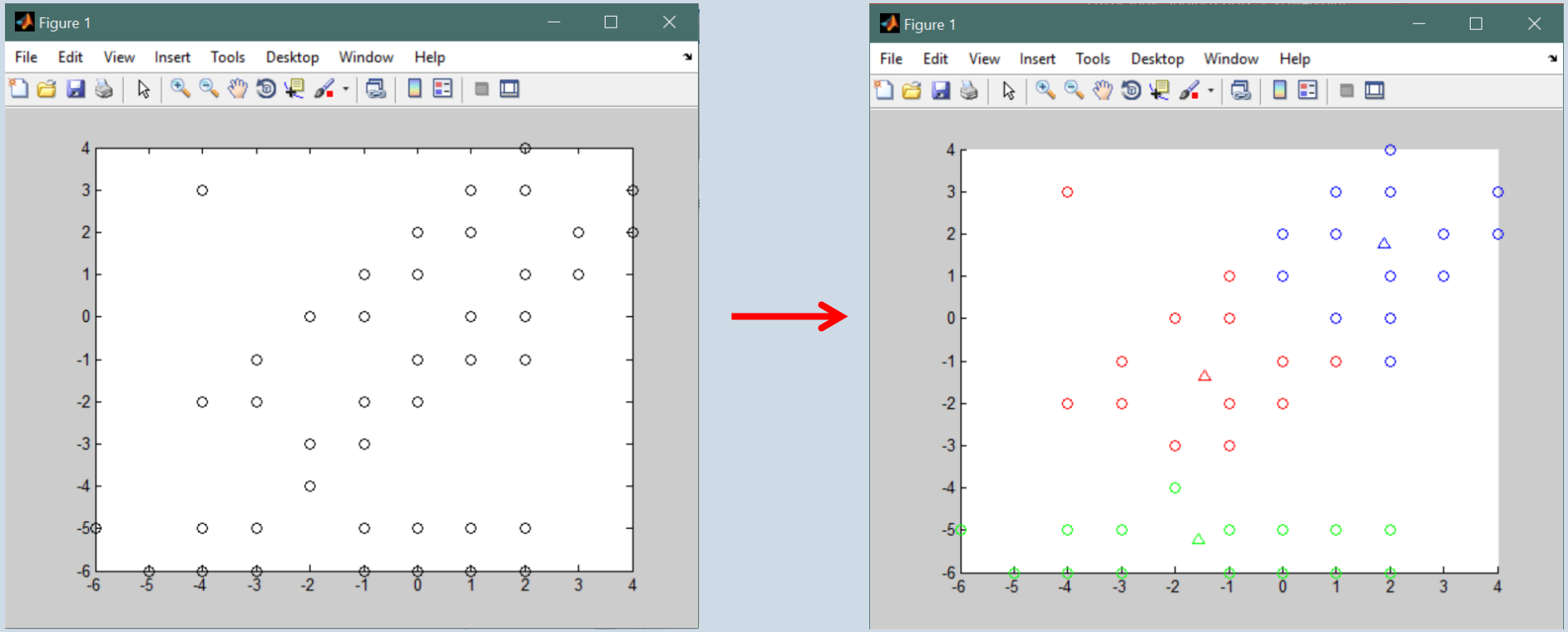


Fuzzy C-Means Clustering (2)

- fcm(data,n,options)
  - To specify additional clustering options
  - options = [a b c d]
    - a: fuzzy partition matrix exponent (2)
    - b: maximum number of iterations (100)
    - c: minimum improvement in objective function between back to back iterations (1e-5)
    - d: Information display flag (true)
- stepfcm(data,U,C,M)
  - Perform one iteration of fcm on data with U as partition matrix, C as number of clusters and M as exponent.

Fuzzy C-Means Clustering (3)

- Example: fuzzy-cmean.mp4



Other Features

- Type-2 Fuzzy Inference Systems
  - Creating and evaluating fuzzy inference systems with additional membership function uncertainty
- Fuzzy Inference Systems Tuning
  - Tuning fuzzy membership function parameters and learning new fuzzy rules using Global Optimization Toolbox tuning methods such as Genetic Algorithms and Particle Swarm Optimization
- Fuzzy Logic Deployment
  - Generate C code for evaluating and implementing fuzzy systems

References

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- https://link.springer.com/