Assignment 5

All assignment submissions are to be made on LEARN Quiz by 11:59 PM on the assigned due date. No extensions will be given, and assignments will not be accepted after the due date.

Problem Statement: We have three barometers that measure atmospheric pressure and through that we can measure the elevation of the sensor. Each barometric sensor has a different noise profile. These noise profiles are presented in the data included. The data indicates the measurement of those sensors for a monotonic change of elevation motion and the outputs are normalized between -1 and 1. The goal of this assignment is to fuse those measurement using a simple Mamdani Type-I Fuzzy Inference System (MATLAB> Fuzzy Logic Designer toolbox).

To simplify the problem you need to follow these steps.

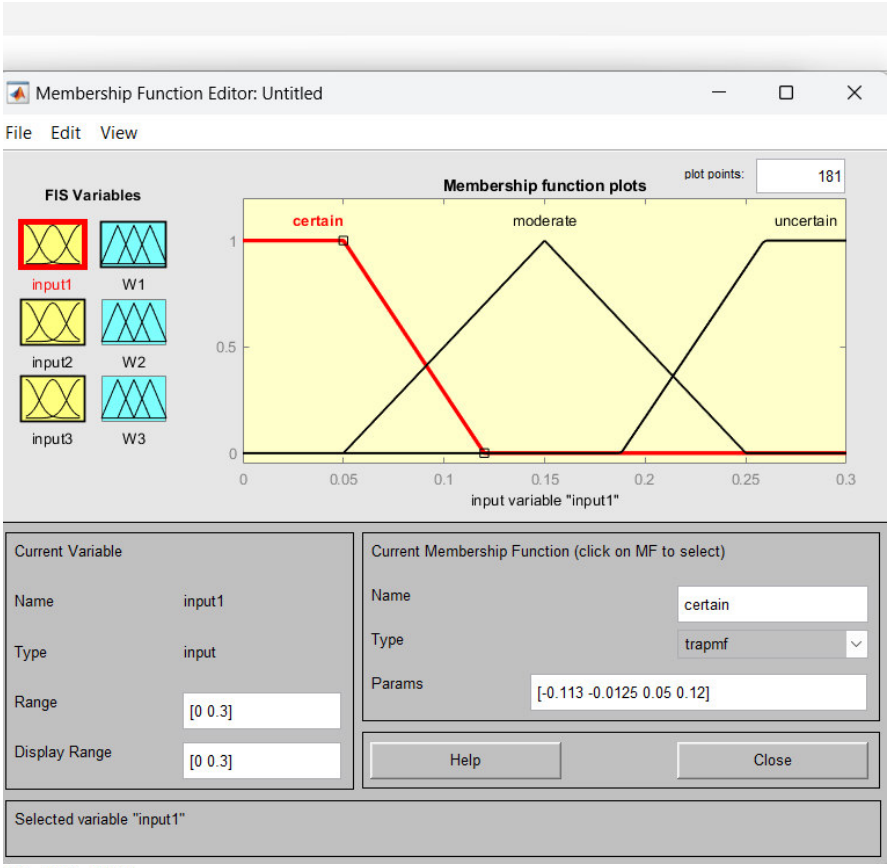
1) Use a low pass filter or smooth function of Mathlab with a window size of 11: smooth(X1,11). This allows you to compute the low passed signals of each sensor with less effect of noise. E.g., X1smooth=smooth(X1,11)

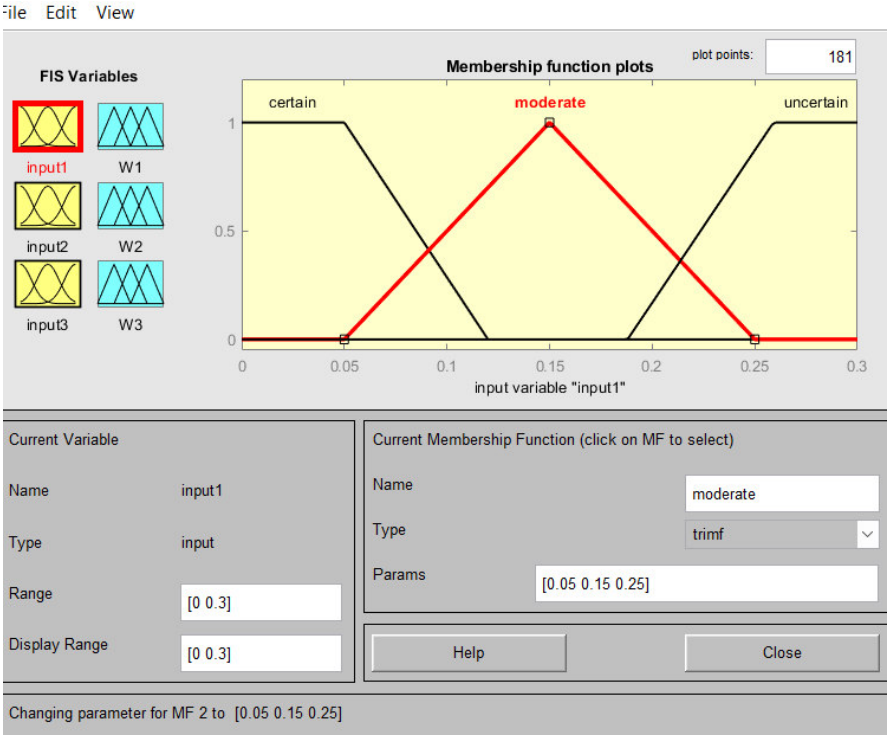
2) Subtract this low pass profile from the actual signal to only get the noise profile of each of the sensors. NoiseX1=X1-X1smooth

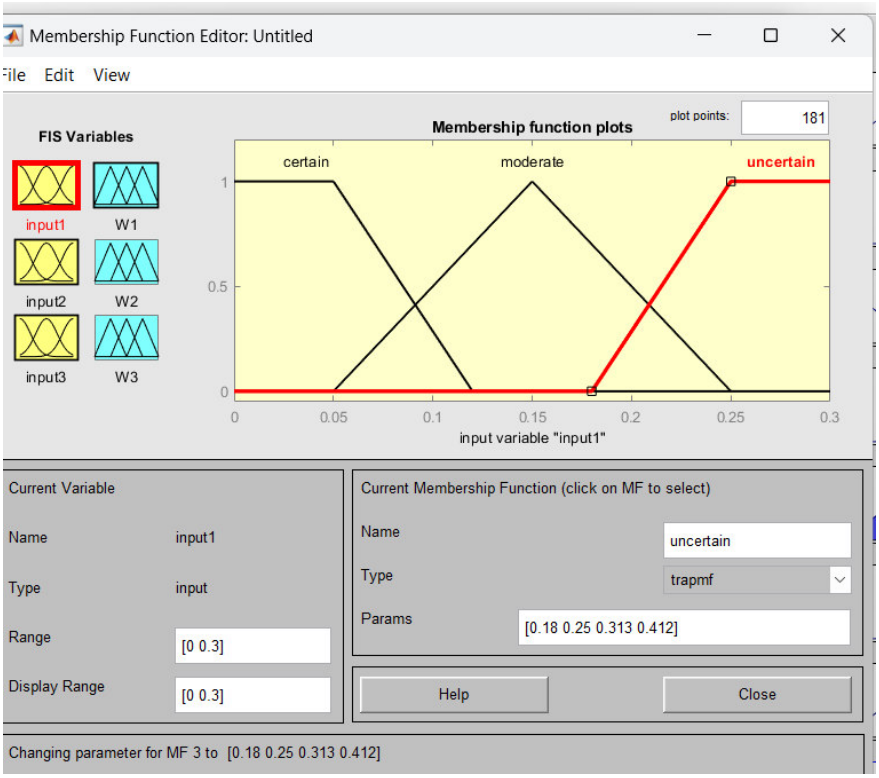
3) For every window of 100 sample, compute the standard deviation of noise. Use disjoint shifted windows for simplicity. STD_Noise_X1(1)=std(NoiseX1(1,1:100)), STD_Noise_X1(2)=std(NoiseX1(1,101:200)), …

4) Now design a fuzzy inference system with 3 inputs, each indicating the certainty of each sensor for a window of samples, and 3 outputs to indicate the raw weight of each sensor in the fusion.
   Use these operators:
   And method: MIN
   Or method: MAX
   Implication: MIN
   Aggregation: MAX
   Defuzzification: centroid

5) Use the three membership function for each input as shown in the figure below. Make sure to use the correct range for membership functions. Find the membership function types and parameters from the figure below.

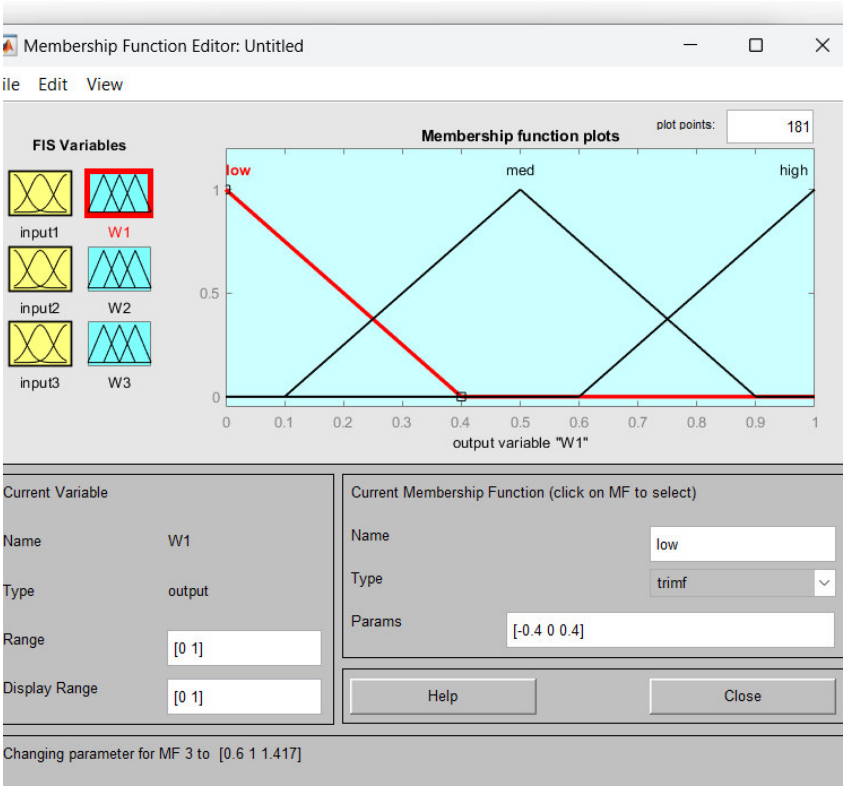

Membership Function Editor: Untitled
File Edit View
FIS Variables
input1
W1
input2
W2
input3
W3
Membership function plots
plot points:
181
certain
moderate
uncertain
input variable "input1"
Current Variable
Name
input1
Type
input
Range
[0 0.3]
Display Range
[0 0.3]
Current Membership Function (click on MF to select)
Name
certain
Type
trapmf
Params
[-0.113 -0.0125 0.05 0.12]
Help
Close
Selected variable "input1"


File Edit View
FIS Variables
input1
W1
input2
W2
input3
W3
Membership function plots
plot points:
181
certain
moderate
uncertain
input variable "input1"
Current Variable
Name
input1
Type
input
Range
[0 0.3]
Display Range
[0 0.3]
Current Membership Function (click on MF to select)
Name
moderate
Type
trimf
Params
[0.05 0.15 0.25]
Help
Close
Changing parameter for MF 2 to [0.05 0.15 0.25]



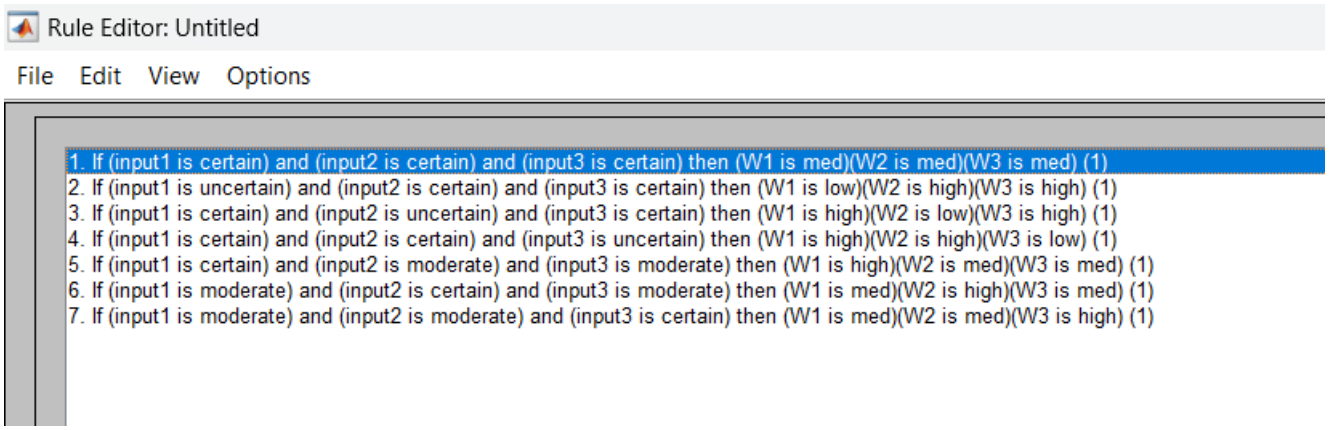
Note that "trapmf" may have changed to "Trapezoidal" for more recent versions of Matlab, "trimf" may have changed to "Triangular" as well.

6) Use also 3 membership functions for each output (see figure below)



Output membership functions: all triangular memberships
Low parameters: [-0.4 0 0.4]
Med parameters: [0.1 0.5 0.9]
High parameters: [0.6 1 1.4]

7) Write these rules:



Q1) Obtain the raw weights for combining the sensors using this FIS for the inputs in the window of 201-300 samples: answer should be three weight values **(note that you can simply use the rule viewer and put the input noise std as the input to the FIS to obtain those weights)**
Q2) Obtain the raw weights for the window of samples from 801-900.

Q3) to fuse the sensors we need to normalize those weight by sum of the weights;
Perform the normalization

$$Xfused = \frac{w1 * X1 + w2 * X2 + w3 * X3}{w1 + w2 + w3}$$

obtain the mean of fused measurements for the window of 201-300 samples and window of 801-900 samples.