THE UNIVERSITY OF TEXAS AT ARLINGTON, TEXAS
DEPARTMENT OF ELECTRICAL ENGINEERING

EE 5327 - 001

SYSTEM IDENTIFICATION & ESTIMATION

HW # 6
ASSIGNMENT

by

SOUTRIK MAITI

1001569883

Presented to

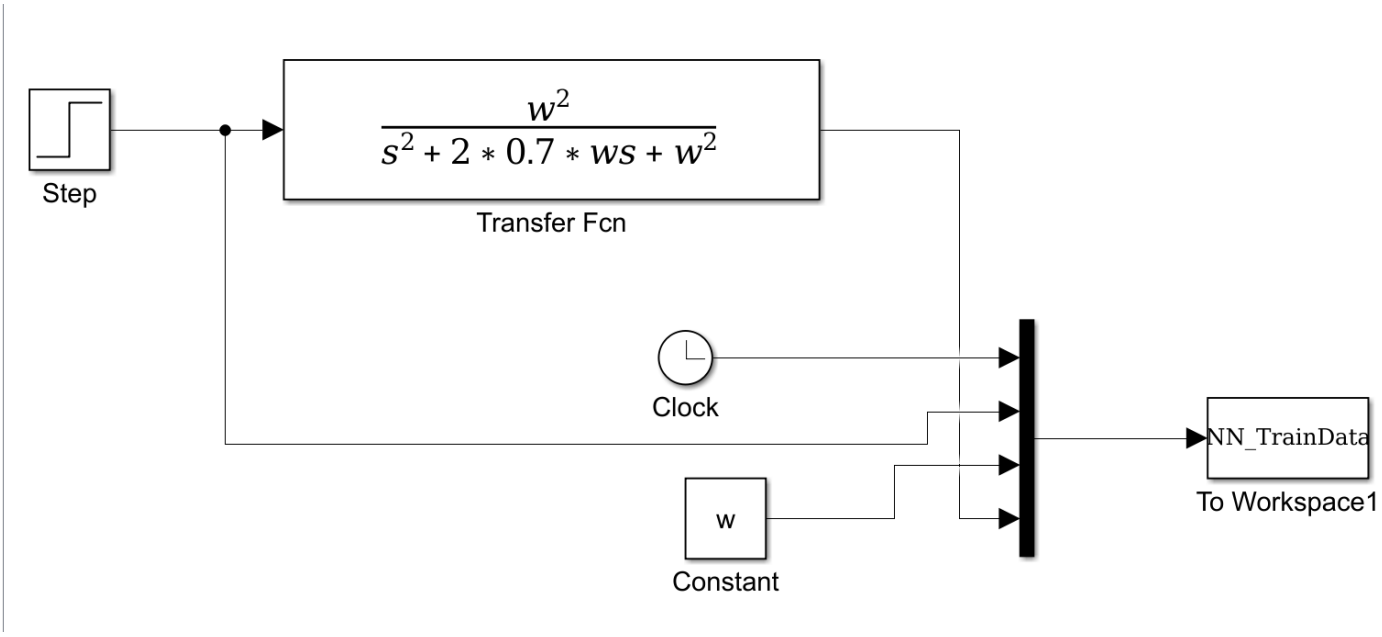
Prof. Michael Niestroy

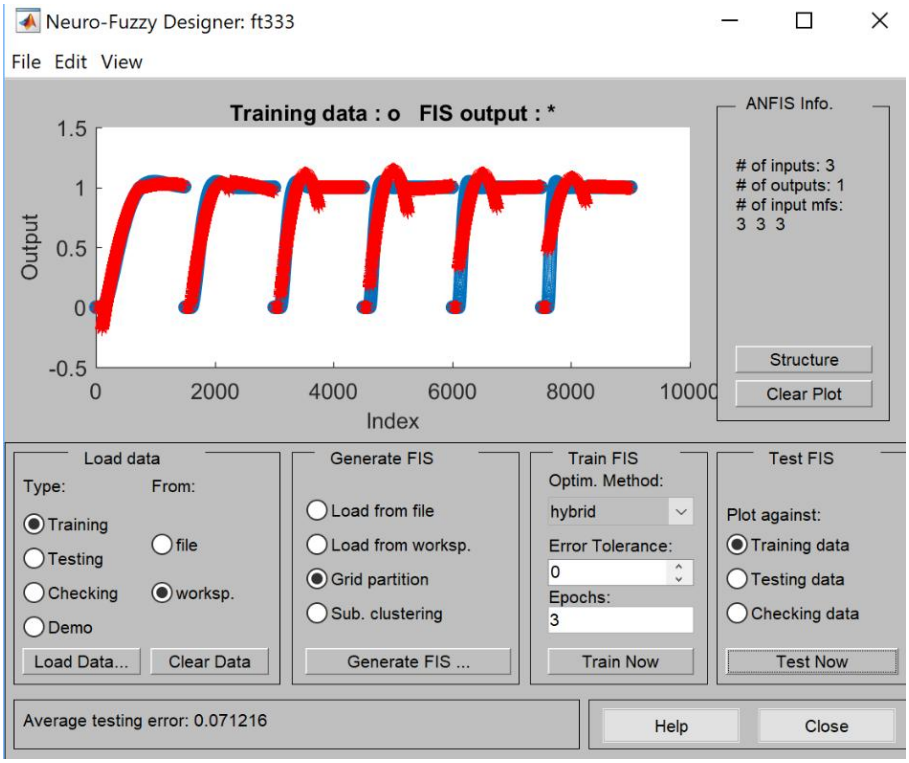
Nov 30, 2017

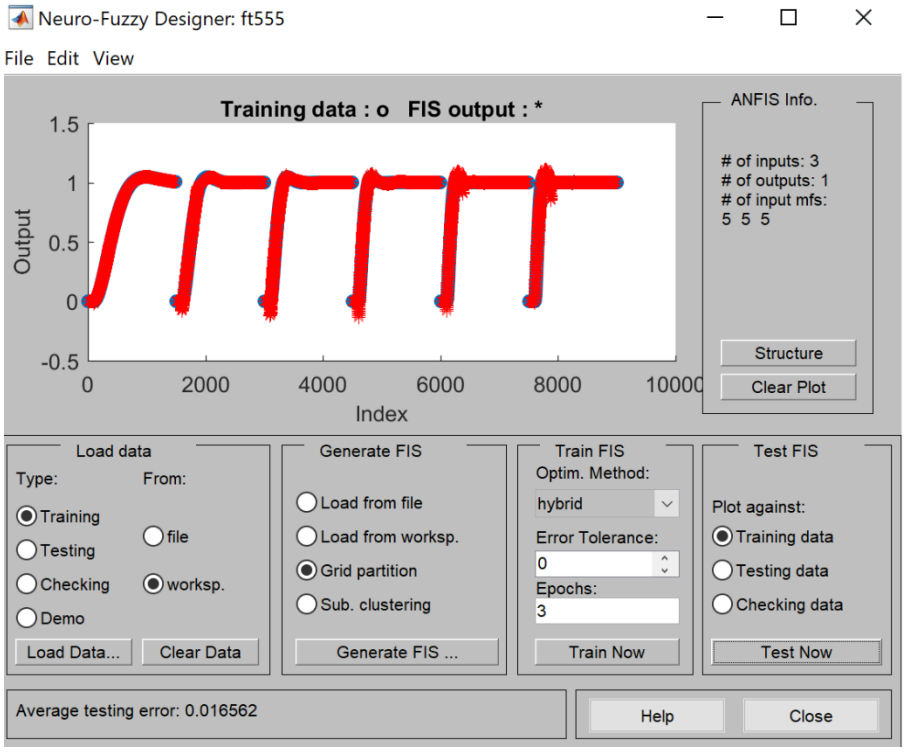
Problem 1:

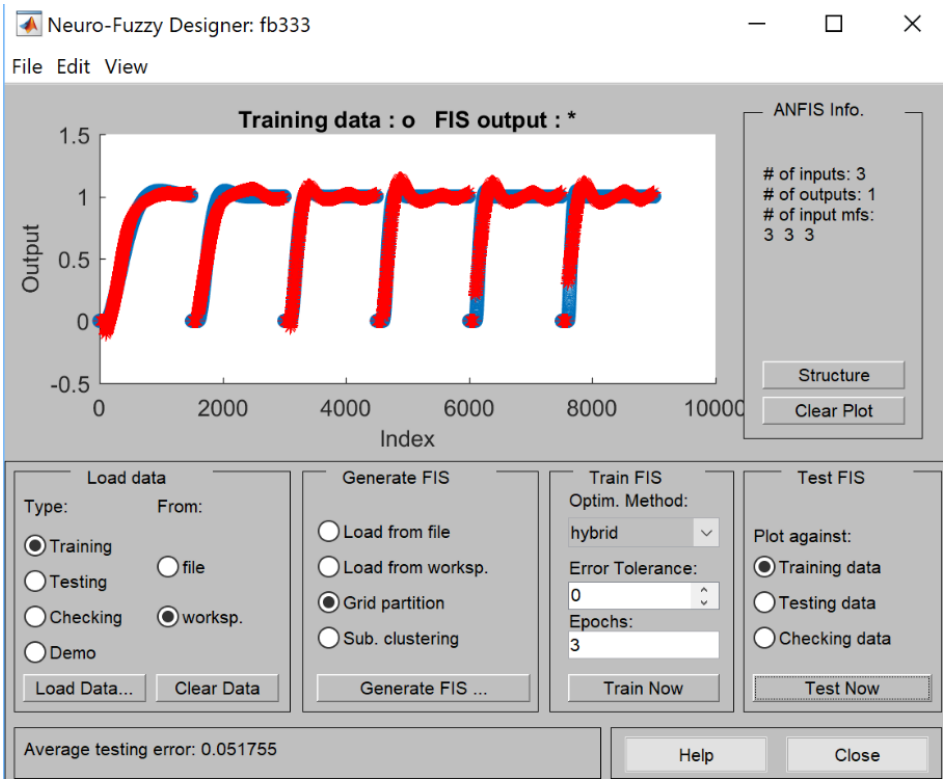
MATLAB code for generating the training set for Fuzzy controller

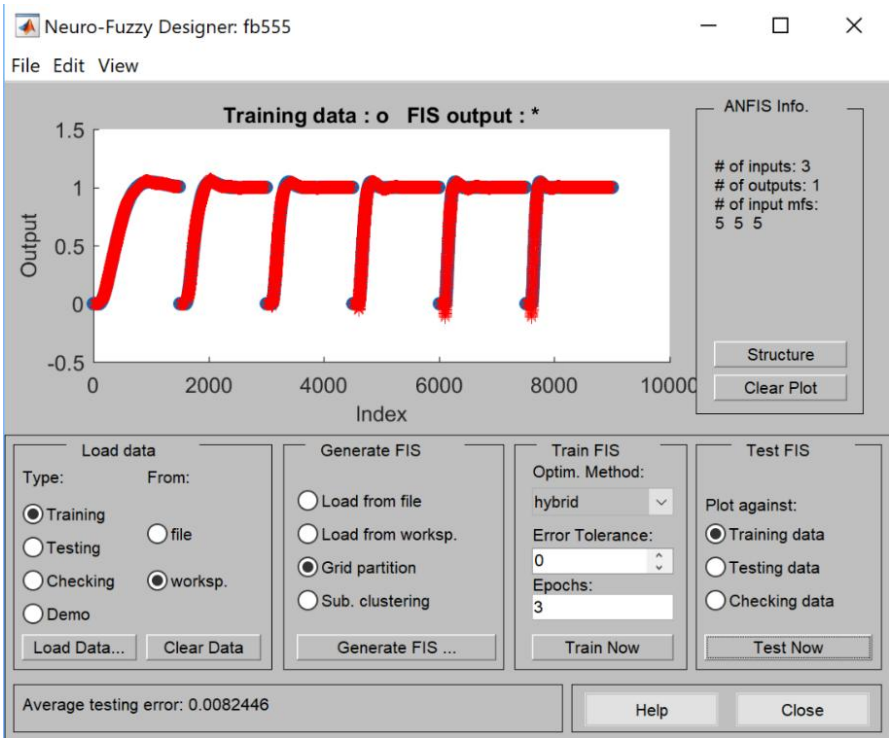
```
clc
close all
w=0;
wk=[0.5 1.0 1.5 2.0 2.5 3.0];
t=0;
i=0;
nnin=zeros(1001,4);

for i=1:6
    w=wk(i);
    [t,y]=sim('Hw6P1a',[0 15]);
    if i==1
        nnin=NN_TrainData;

    else
       nnin=[nnin;NN_TrainData];

    end

   end
```




Neuro-Fuzzy Designer: ft333
File Edit View
Training data : o FIS output : *
Output
Index
ANFIS Info.
# of inputs: 3
# of outputs: 1
# of input mfs:
3 3 3
Structure
Clear Plot
Load data
Type:
From:
Training
Testing
Checking
Demo
file
worksp.
Load Data...
Clear Data
Generate FIS
Load from file
Load from worksp.
Grid partition
Sub. clustering
Generate FIS ...
Train FIS
Optim. Method:
hybrid
Error Tolerance:
0
Epochs:
3
Train Now
Test FIS
Plot against:
Training data
Testing data
Checking data
Test Now
Average testing error: 0.071216
Help
Close


Neuro-Fuzzy Designer: ft555
File Edit View
Training data : o FIS output : *
Output
Index
ANFIS Info.
# of inputs: 3
# of outputs: 1
# of input mfs:
5 5 5
Structure
Clear Plot
Load data
Type:
From:
Training
Testing
Checking
Demo
file
worksp.
Load Data...
Clear Data
Generate FIS
Load from file
Load from worksp.
Grid partition
Sub. clustering
Generate FIS ...
Train FIS
Optim. Method:
hybrid
Error Tolerance:
0
Epochs:
3
Train Now
Test FIS
Plot against:
Training data
Testing data
Checking data
Test Now
Average testing error: 0.016562
Help
Close


Neuro-Fuzzy Designer: fb333
File Edit View
Training data : o FIS output : *
Output
Index
ANFIS Info.
# of inputs: 3
# of outputs: 1
# of input mfs:
3 3 3
Structure
Clear Plot
Load data
Type:
From:
Training
Testing
Checking
Demo
file
worksp.
Load Data...
Clear Data
Generate FIS
Load from file
Load from worksp.
Grid partition
Sub. clustering
Generate FIS ...
Train FIS
Optim. Method:
hybrid
Error Tolerance:
0
Epochs:
3
Train Now
Test FIS
Plot against:
Training data
Testing data
Checking data
Test Now
Average testing error: 0.051755
Help
Close


Neuro-Fuzzy Designer: fb555
File Edit View
Training data : o FIS output : *
Output
Index
ANFIS Info.
# of inputs: 3
# of outputs: 1
# of input mfs:
5 5 5
Structure
Clear Plot
Load data
Type:
From:
Training
Testing
Checking
Demo
file
worksp.
Load Data...
Clear Data
Generate FIS
Load from file
Load from worksp.
Grid partition
Sub. clustering
Generate FIS ...
Train FIS
Optim. Method:
hybrid
Error Tolerance:
0
Epochs:
3
Train Now
Test FIS
Plot against:
Training data
Testing data
Checking data
Test Now
Average testing error: 0.0082446
Help
Close

1. 3-3-3 with triangular membership functions and linear output

Final Error = 0.071216

2. 5-5-5 with triangular membership functions and linear output

Final Error = 0.016562

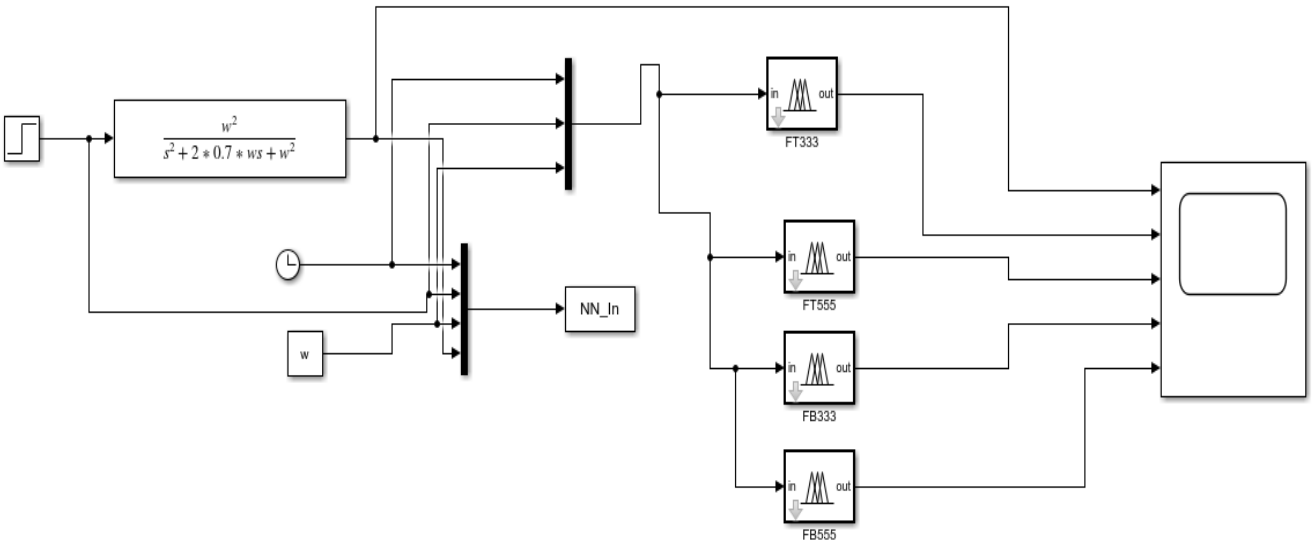
3. 3-3-3 with generalized bell membership functions and linear output

Final Error = 0.051755

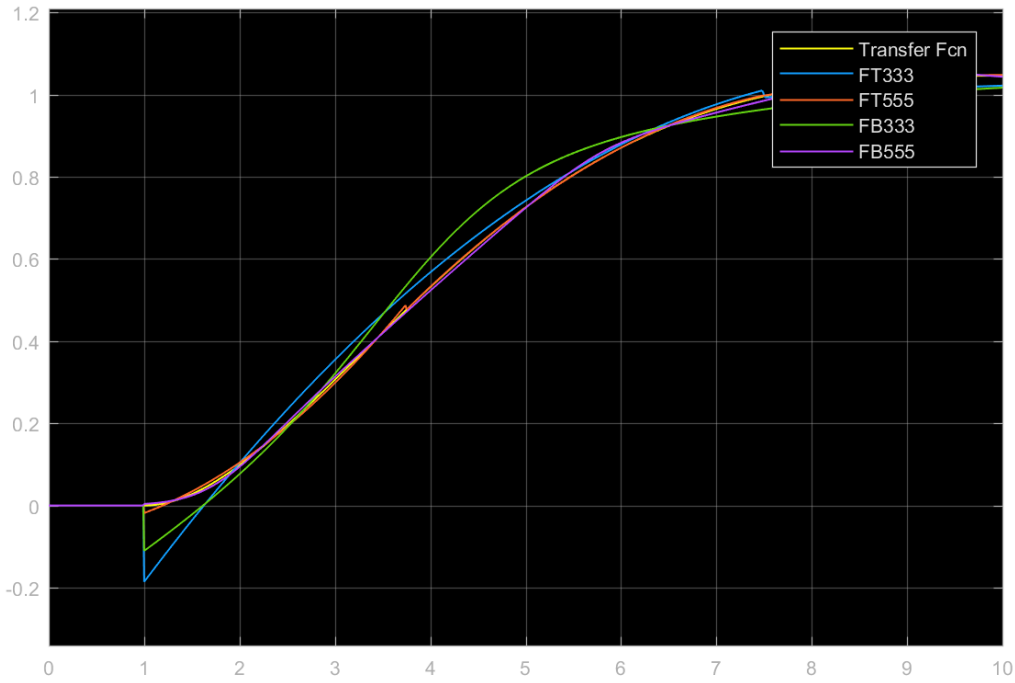
4. 5-5-5 with generalized bell membership functions and linear output

Final Error = 0.008245

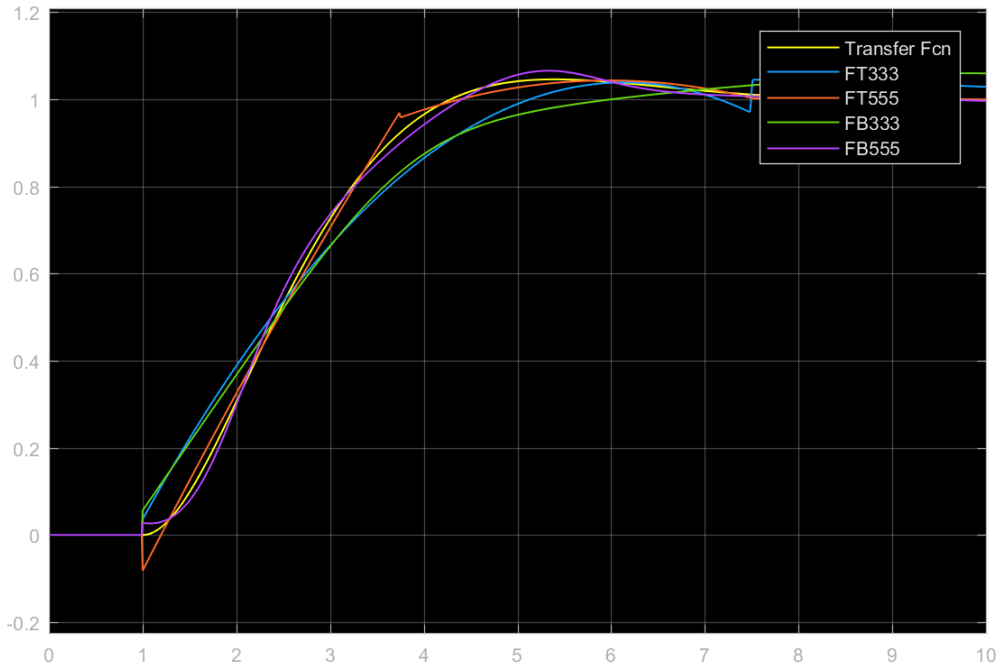
b) Comparison of training data & FIS output (zeta=0.7)



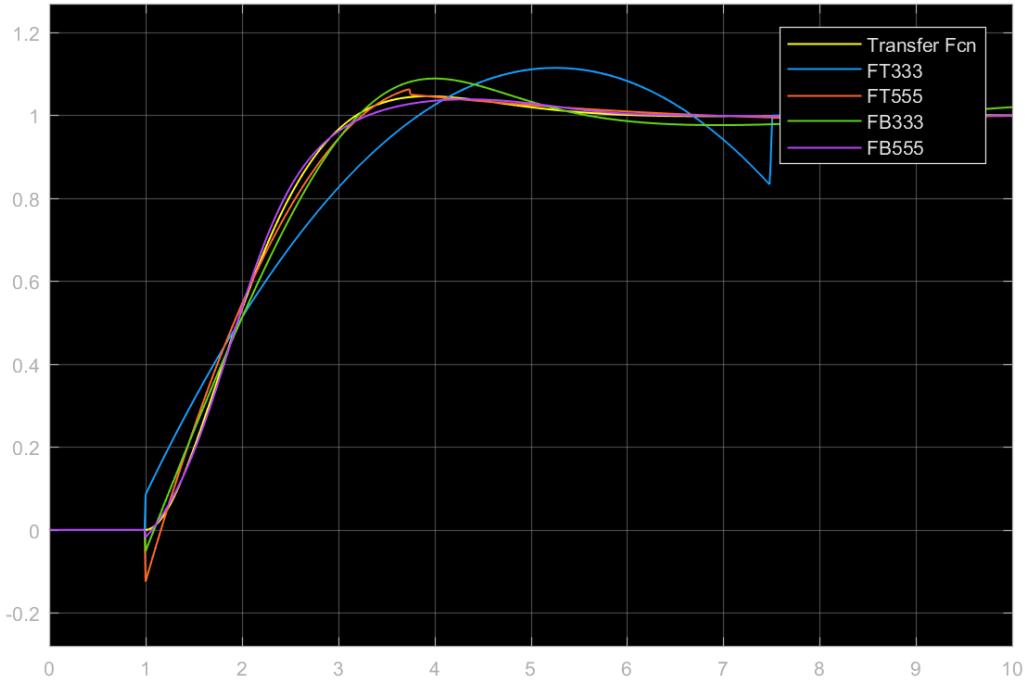
Comparison when w=0.5



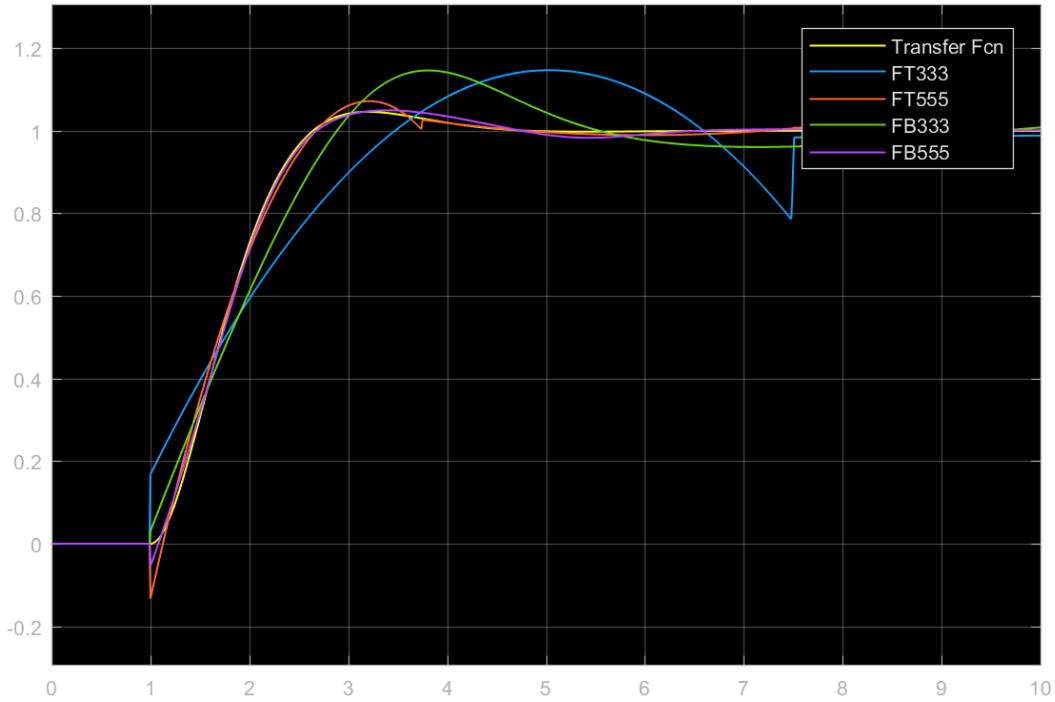
Comparison when w=1



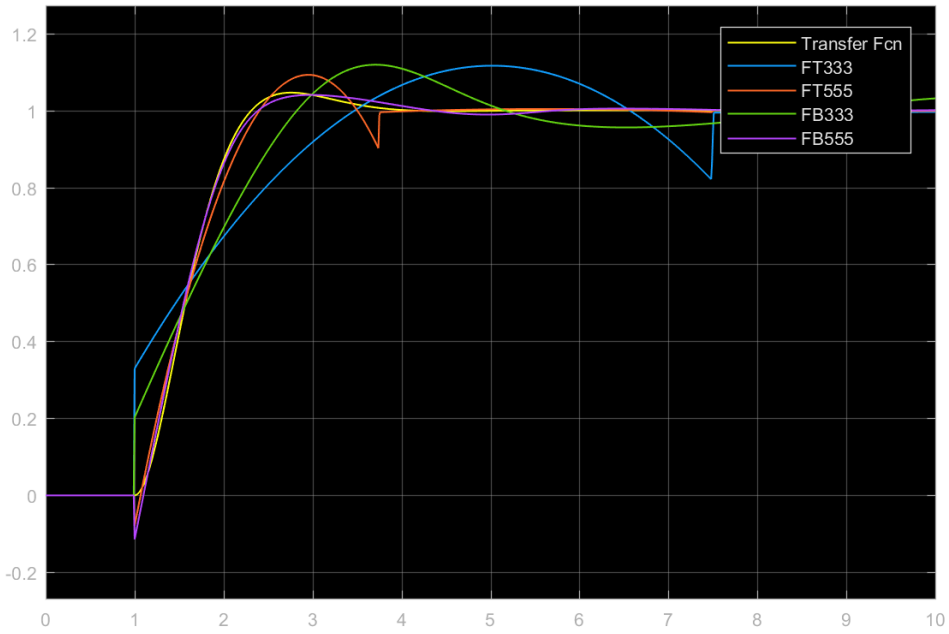
Comparison when w=1.5



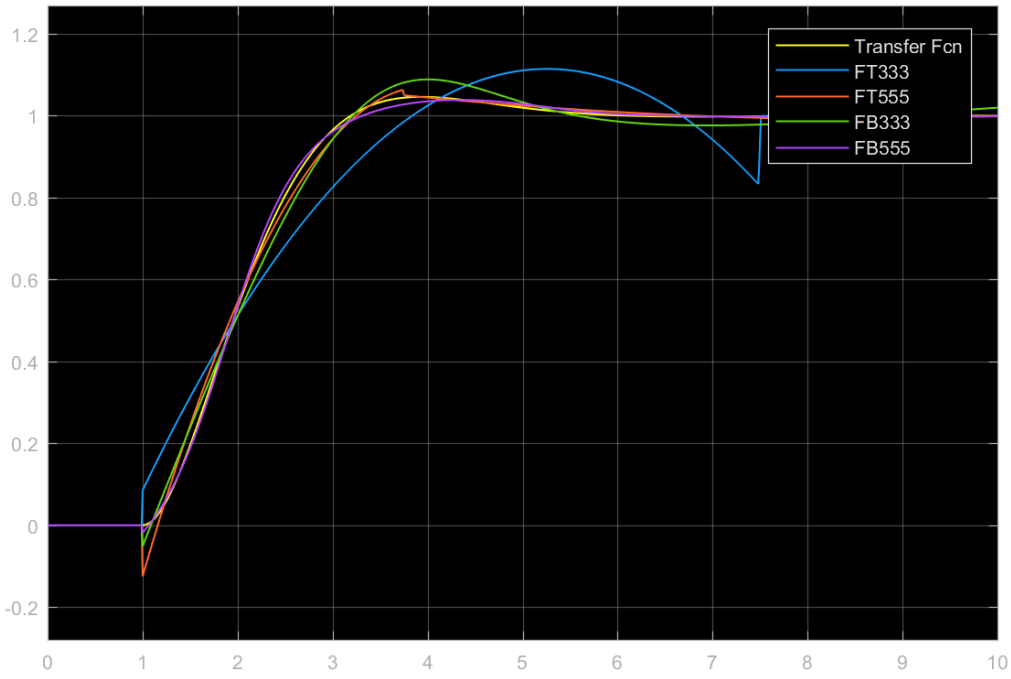
Comparison when w=2



Comparison when w=2.5

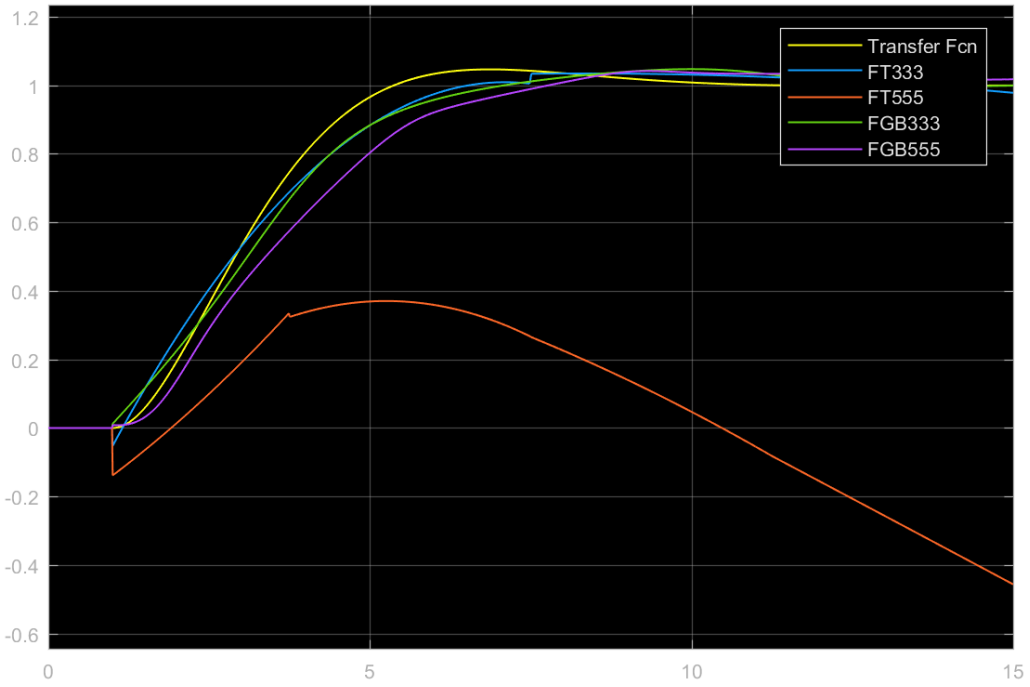


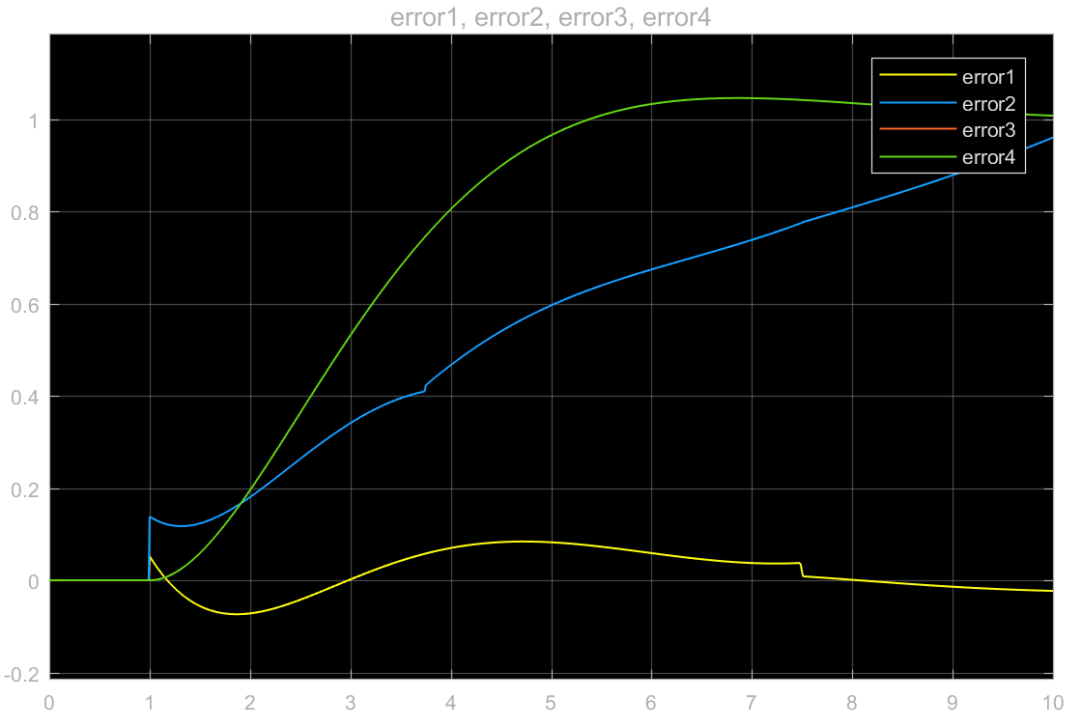
Comparison when w=3



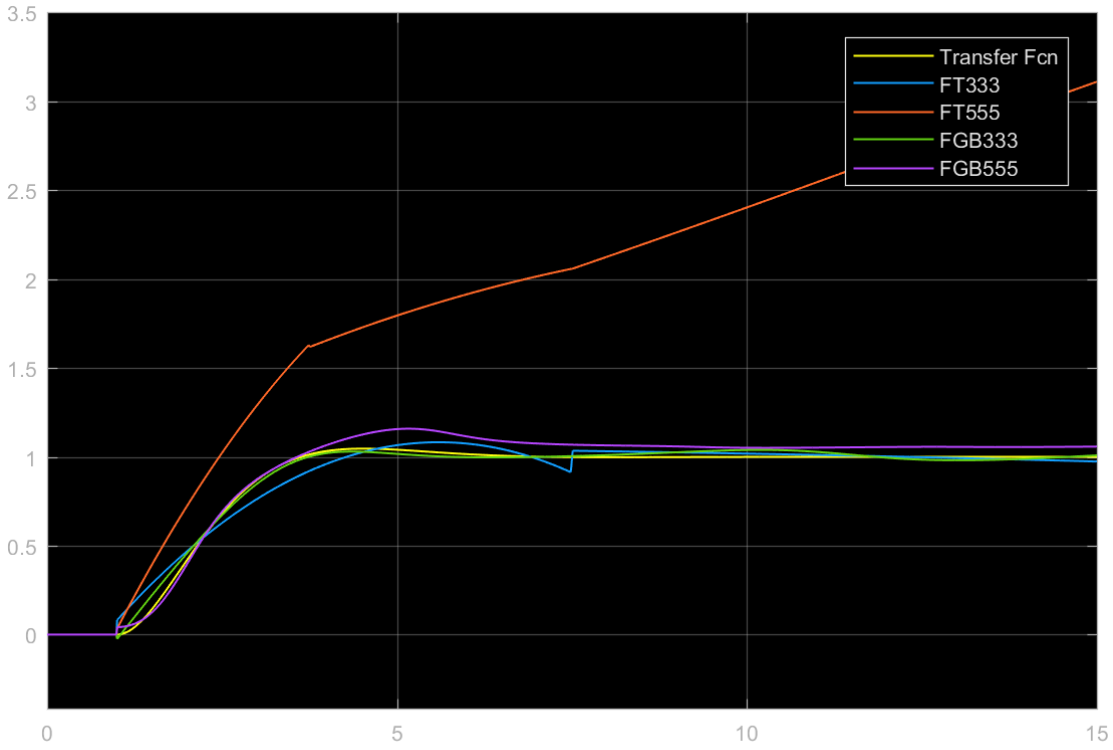
As per the comparison, the FIS with 5-5-5 generalized bell membership function is the closest to the training data at various values of w. Now, if we observe the error between the training data at ‘w’ value & the FIS output, we can see a clear difference in the accuracy of various types of FIS.

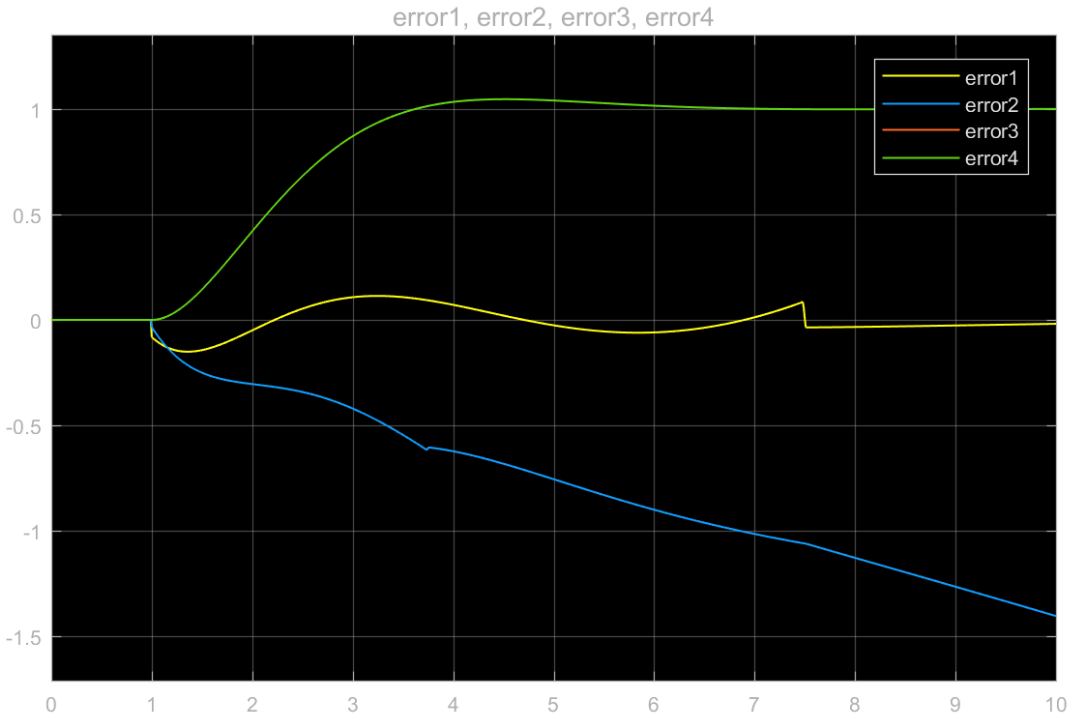
When w=0.75, the comparison and the error plots are as follows:



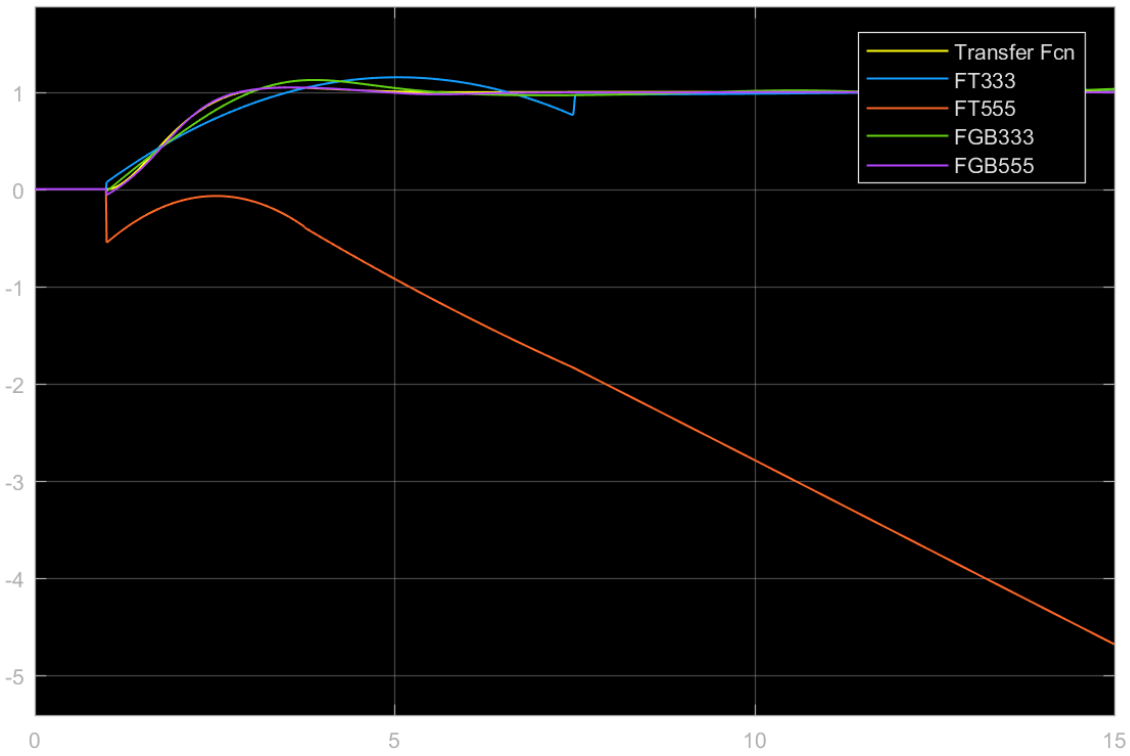


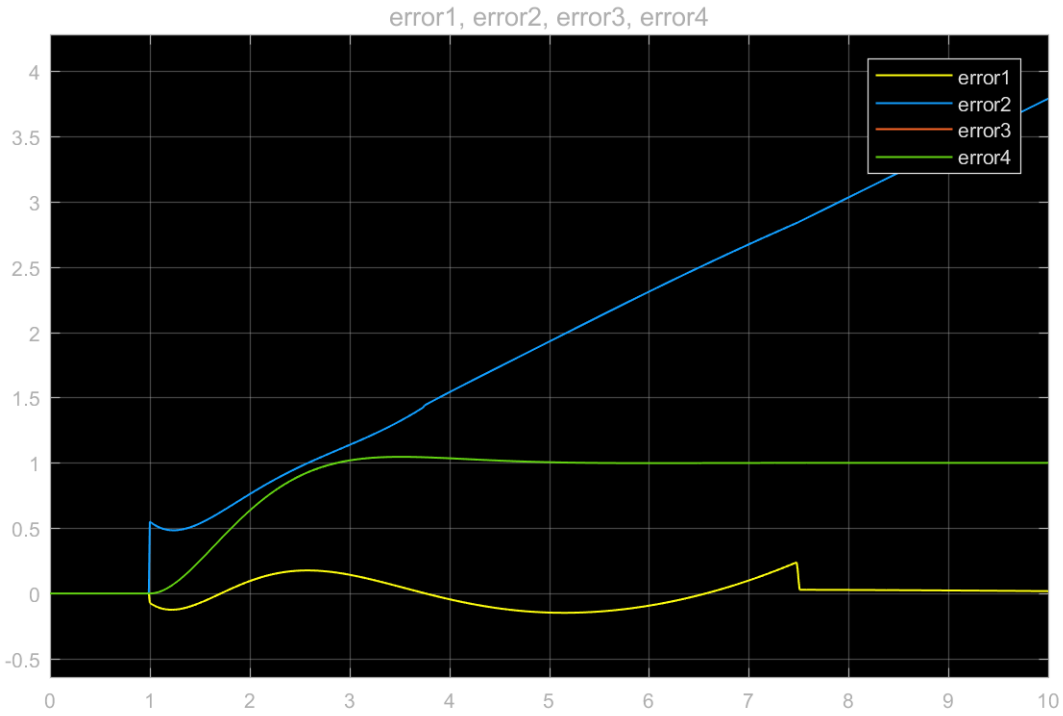
When w=1.25, the comparison and the error plots are as follows:



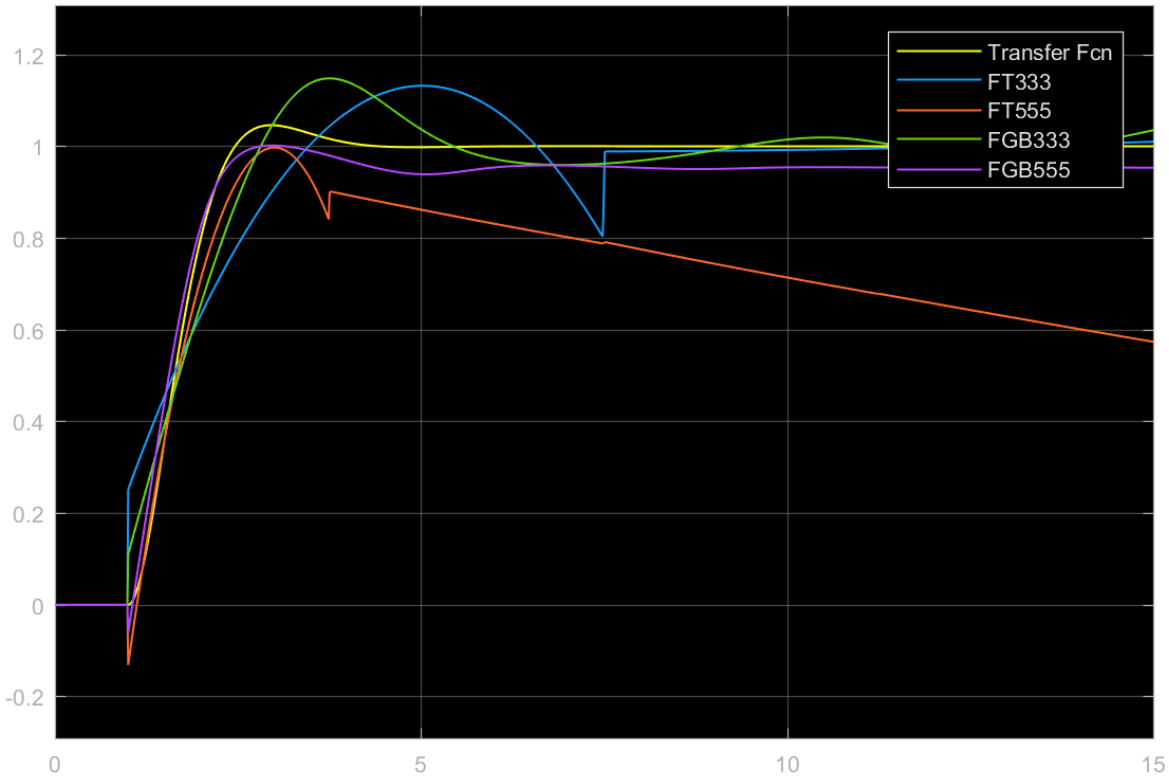


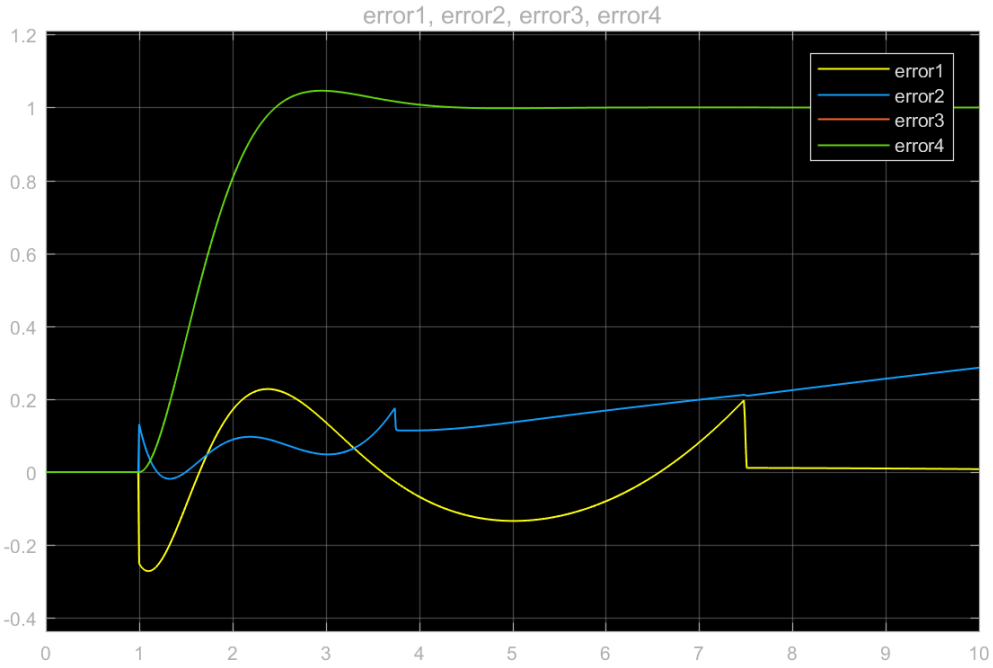
When w=1.75, the comparison and the error plots are as follows:



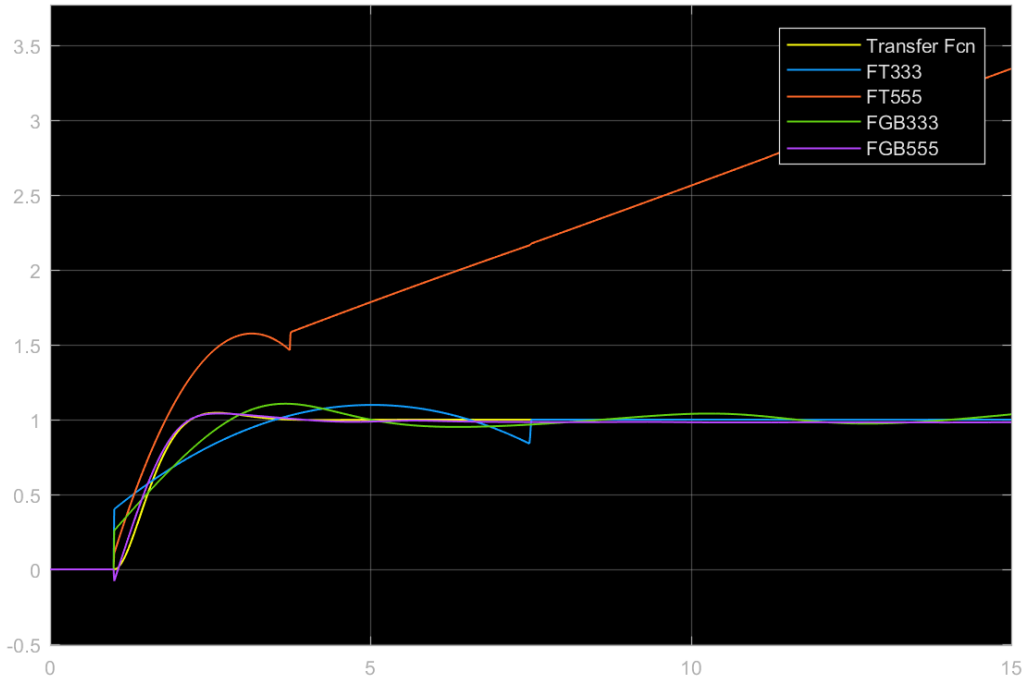


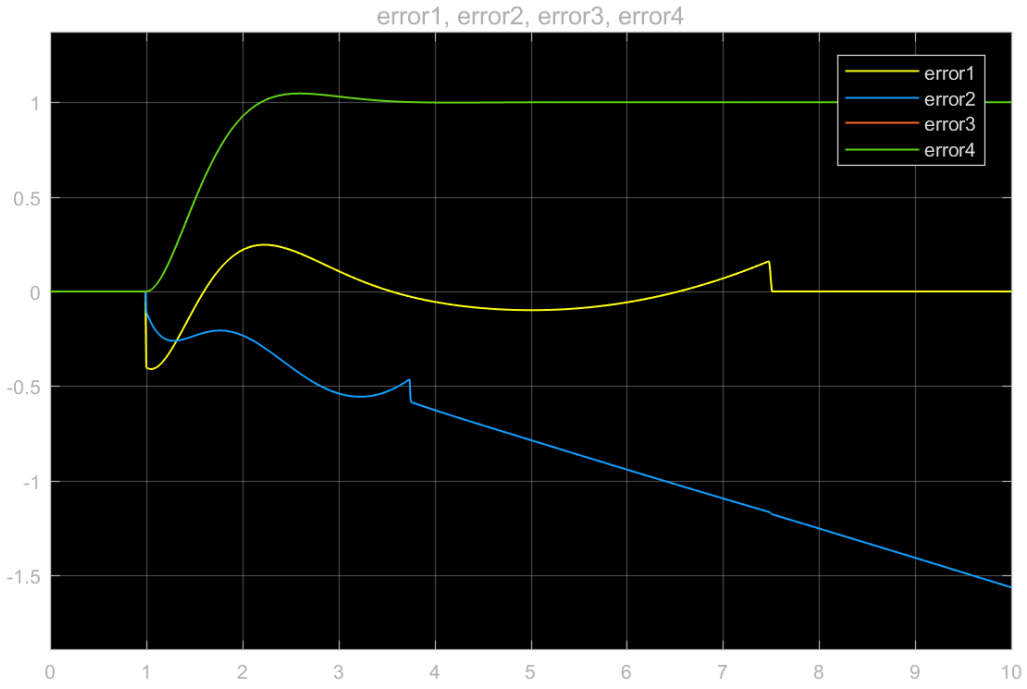
When w=2.25, the comparison and the error plots are as follows:





When w=2.75, the comparison and the error plots are as follows:





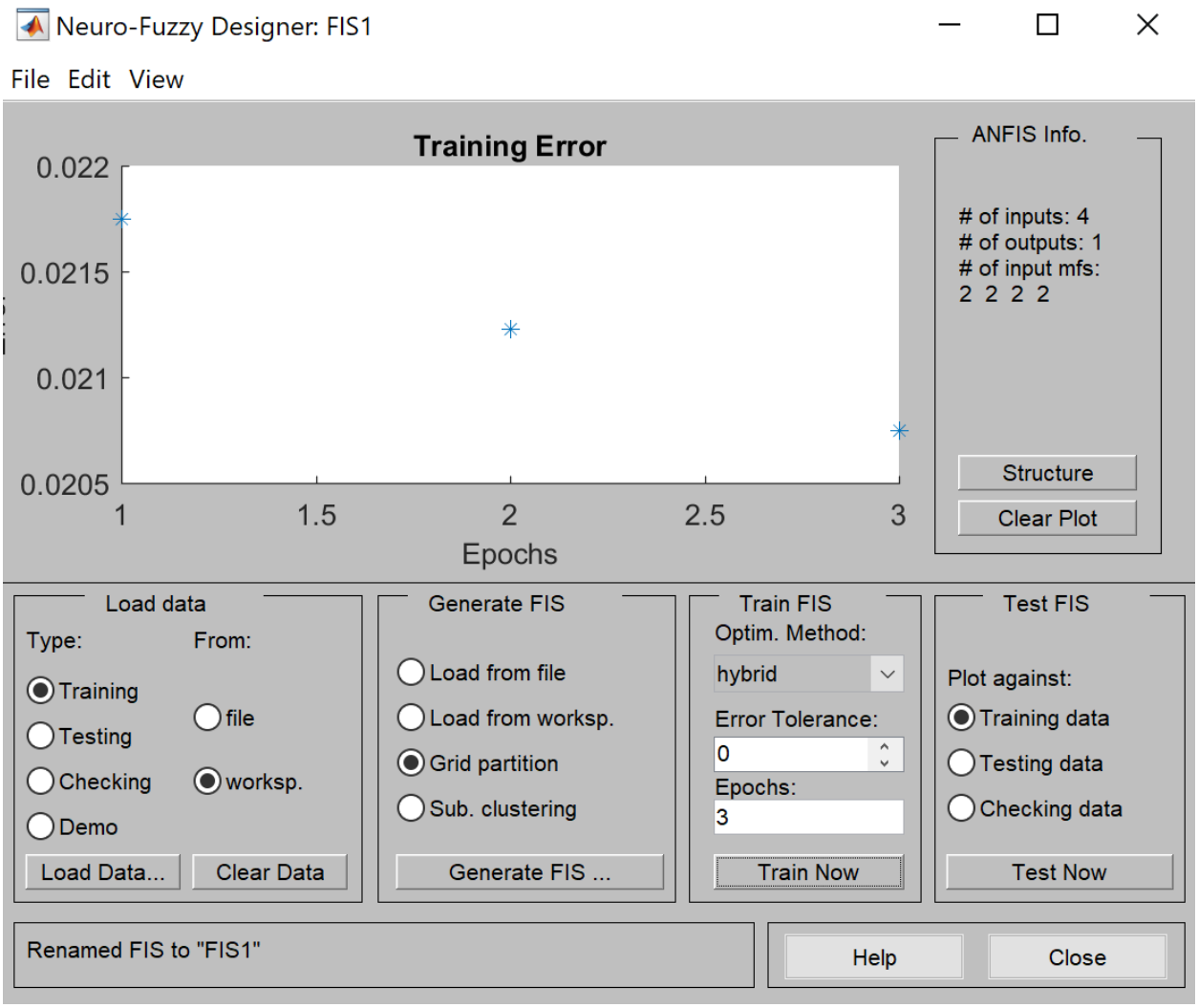
Generalized bell membership function (5-5-5) produces a pretty accurate estimate of the training data in all the different values of ‘w’.

d) For the application using a FIS to fit the training data works when using a Generalized bell membership function with linear output, the generalized bell membership function with 5-5-5 configuration is accurate with *0.008245* overall error.

Problem 2

MATLAB Code for Generating the data for the Fuzzy Controller

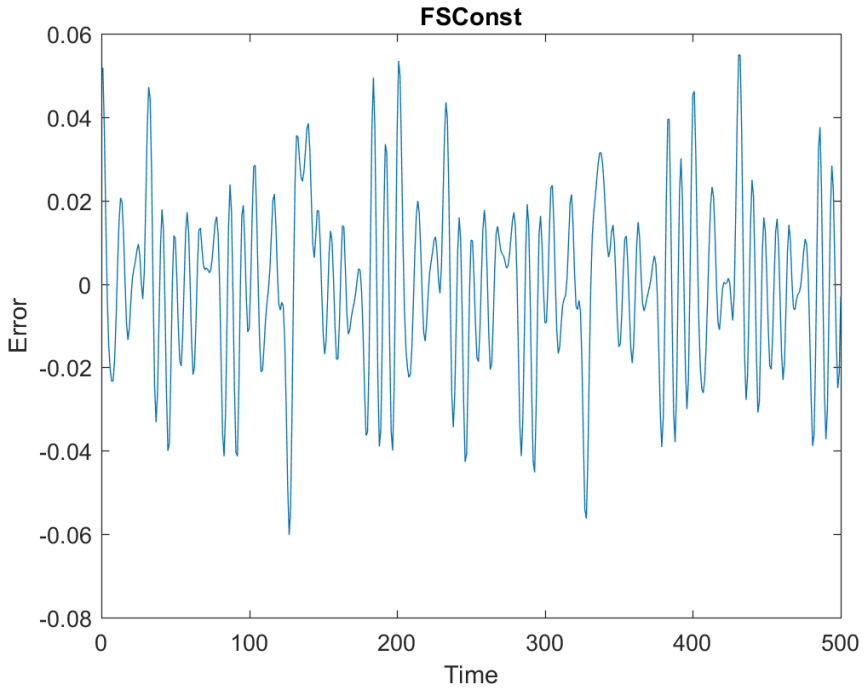
```
load mgdata.dat
a = mgdata;
time = a(:, 1);
x_t = a(:, 2);

trn_data = zeros(500, 5);
chk_data = zeros(500, 5);

% prepare training data
trn_data(:, 1) = x_t(101:600);
trn_data(:, 2) = x_t(107:606);
trn_data(:, 3) = x_t(113:612);
trn_data(:, 4) = x_t(119:618);
trn_data(:, 5) = x_t(125:624);


% prepare checking data
chk_data(:, 1) = x_t(601:1100);
chk_data(:, 2) = x_t(607:1106);
chk_data(:, 3) = x_t(613:1112);
chk_data(:, 4) = x_t(619:1118);
chk_data(:, 5) = x_t(625:1124);
```



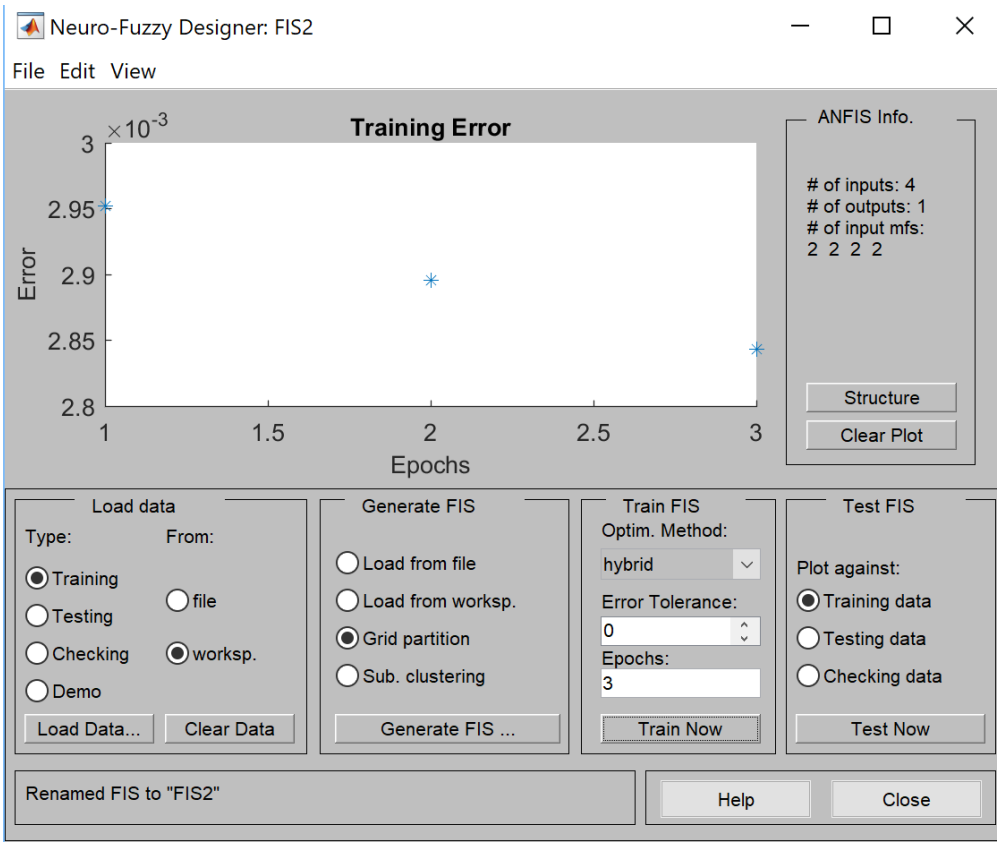
For sum squared error calculation:

```
%For sum squared error calculation

fis_data=evalfis(chk_data(:,1:4),FIS1);
error= chk_data(:,5)-fis_data;

plot(error);
xlabel('Time');
ylabel('Error');
title('FSTriangular');

%For sum squared error
sserror1=sum(error.^2)
```

```
sserror1 =

    0.2060
```



b) For Linear output membership function

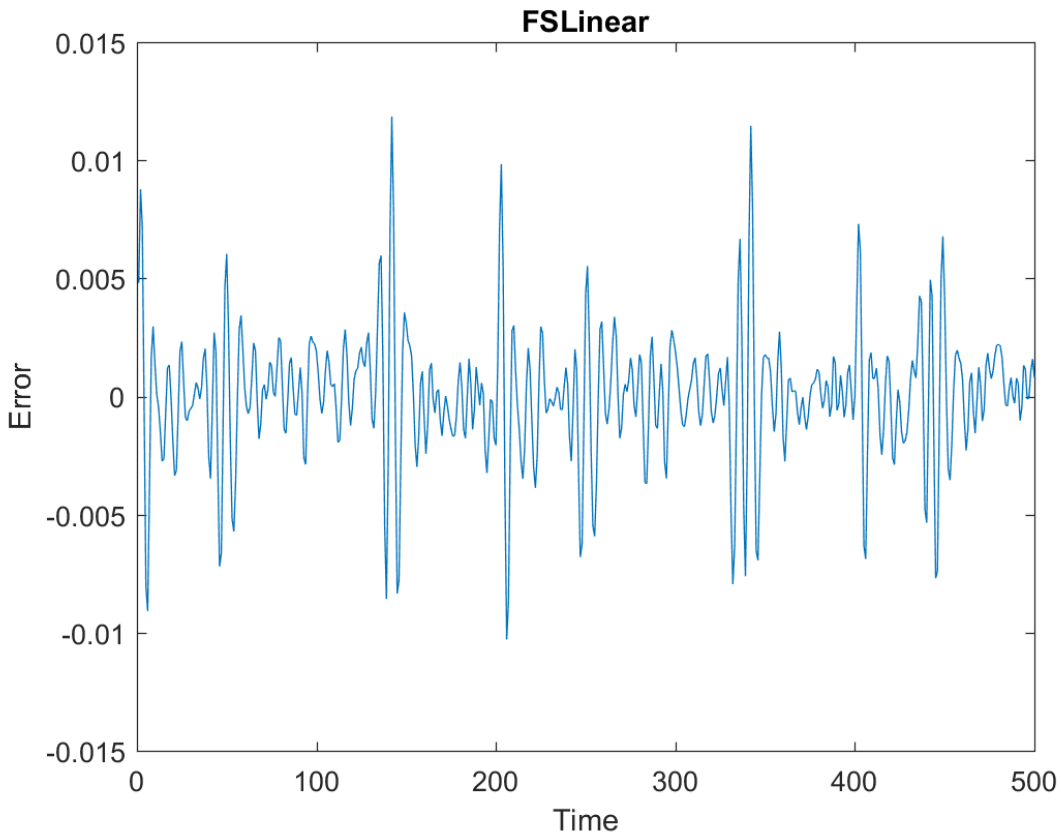


For sum squared error calculation:

```
%For sum squared error calculation

fis_data=evalfis(chk_data(:,1:4),FIS2);
error= chk_data(:,5)-fis_data;

plot(error);
xlabel('Time');
ylabel('Error');
title('FSLinear');

%For sum squared error
Sserror2=sum(error.^2)
```

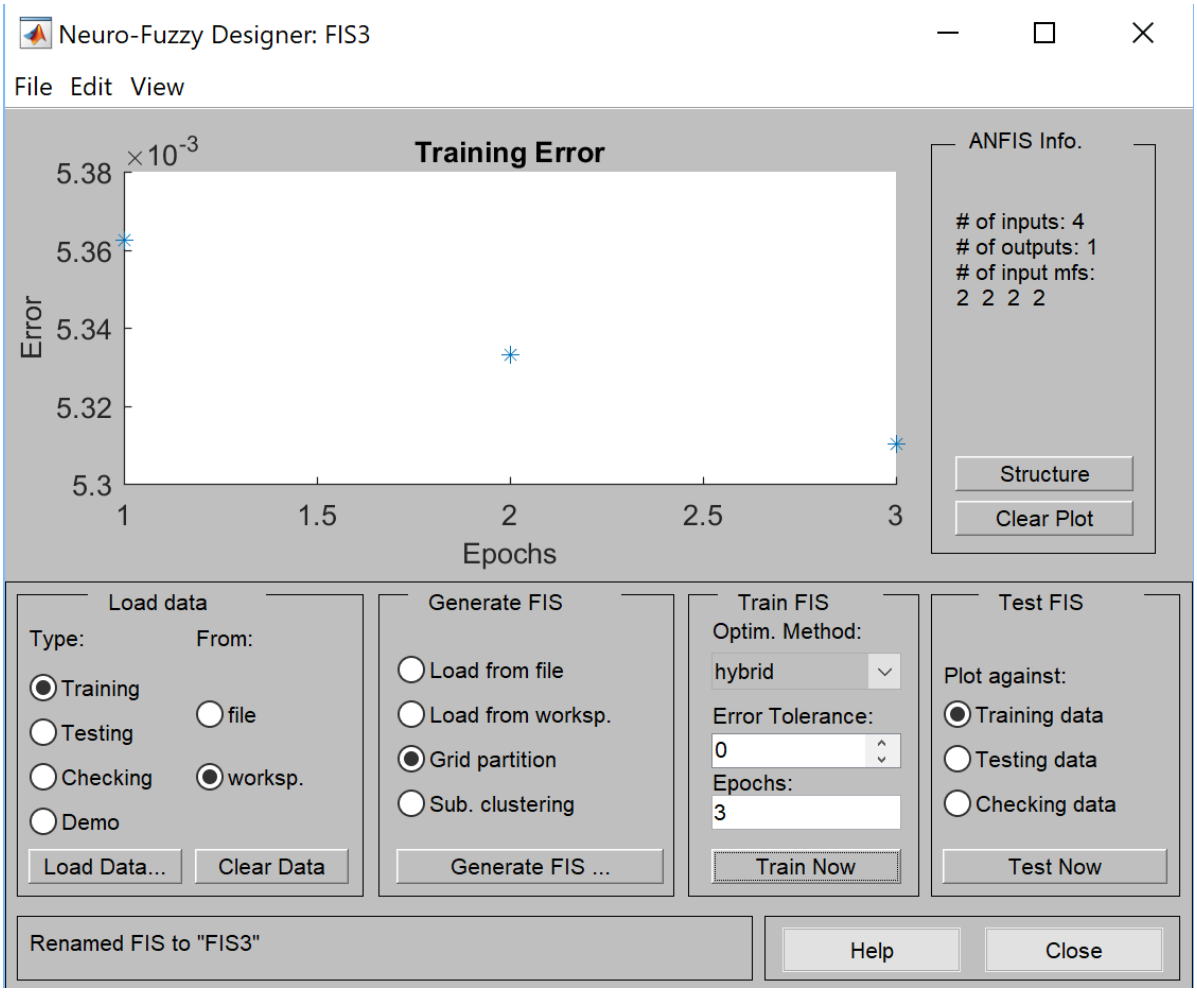
Result:

```
sserror2 =

    0.0038

>>
```



From the sum squared error value we observe that the FIS with linear output membership function has lower error as compared to the constant case. Hence, FIS with 2-2-2-2 Generalized bell membership function with linear membership function is better.

c) For Triangular Membership Function

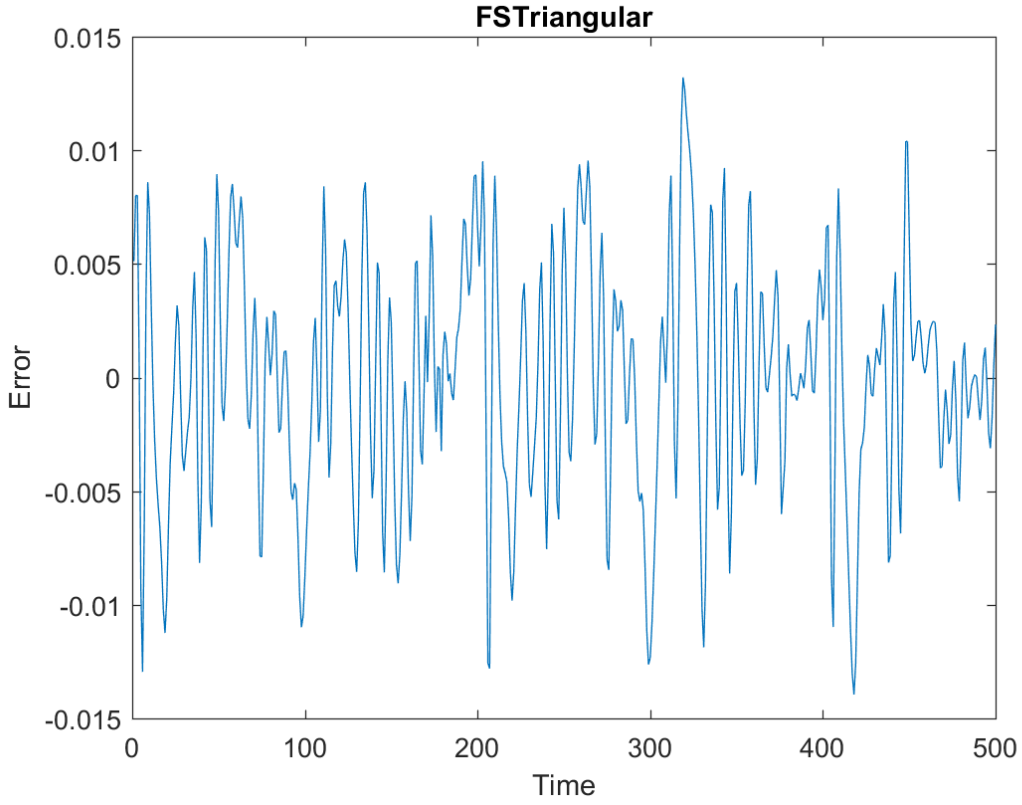


For Sum Squared Error calculation:

```
%For sum squared error calculation

fis_data=evalfis(chk_data(:,1:4),FIS3);
error= chk_data(:,5)-fis_data;

plot(error);
xlabel('Time');
ylabel('Error');
title('FSTrianguka');

%For sum squared error
sserror3=sum(error.^2)
```

Result:

```
sserror3 =

    0.0132
```



Thus, we can observe that the FIS with 2-2-2-2 Generalized bell membership function & linear output membership function has much lower error than the other two cases (sse = 0.0038) & is better as compared to the other two FIS.