智能系统控制 实验四

模糊控制

实验报告

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一、实验目的

设被控对象为

$$G(s)=\frac{400}{s^2+500s}$$

进行模糊控制的仿真。

二、实验环境

实验环境：MATLAB R2018b

三、实验步骤

对模糊控制进行仿真：

```
%Fuzzy Controller Design
clear all;
close all;

a=newfis('fuzzf');

a = addvar(a, 'input', 'e', [-0.3, 0.3]);          %Parameter e
a = addmf(a, 'input', 1, 'NB', 'zmf' , [-0.3, -0.1]);
a = addmf(a, 'input', 1, 'NM', 'trimf' , [-0.3, -0.2, 0]);
a = addmf(a, 'input', 1, 'NS', 'trimf' , [-0.3, -0.1, 0.1]);
a = addmf(a, 'input', 1, 'Z', 'trimf' , [-0.2, 0, 0.2]);
a = addmf(a, 'input', 1, 'PS', 'trimf' , [-0.1, 0.1, 0.3]);
a = addmf(a, 'input', 1, 'PM', 'trimf' , [0, 0.2, 0.3]);
a = addmf(a, 'input', 1, 'PB', 'smf' , [0.1, 0.3]);

a = addvar(a, 'input', 'ec', [-0.3, 0.3]);          %Parameter ec
a = addmf(a, 'input', 2, 'NB', 'zmf' , [-0.3, -0.1]);
a = addmf(a, 'input', 2, 'NM', 'trimf' , [-0.3, -0.2, 0]);
a = addmf(a, 'input', 2, 'NS', 'trimf' , [-0.3, -0.1, 0.1]);
a = addmf(a, 'input', 2, 'Z', 'trimf' , [-0.2, 0, 0.2]);
a = addmf(a, 'input', 2, 'PS', 'trimf' , [-0.1, 0.1, 0.3]);
a = addmf(a, 'input', 2, 'PM', 'trimf' , [0, 0.2, 0.3]);
a = addmf(a, 'input', 2, 'PB', 'smf' , [0.1, 0.3]);

a = addvar(a, 'output', 'u', [-30, 30]);          %Parameter u
a = addmf(a, 'output', 1, 'NB', 'zmf' , [-30, -30]);
a = addmf(a, 'output', 1, 'NM', 'trimf' , [-30, -20, 0]);
a = addmf(a, 'output', 1, 'NS', 'trimf' , [-30, -10, 10]);
a = addmf(a, 'output', 1, 'Z', 'trimf' , [-20, 0, 20]);
a = addmf(a, 'output', 1, 'PS', 'trimf' , [-10, 10, 30]);
a = addmf(a, 'output', 1, 'PM', 'trimf' , [0, 20, 30]);
a = addmf(a, 'output', 1, 'PB', 'smf' , [10, 30]);
```

```
rulelist=[1 1 1 1 1;                                    %Edit rule base
    1 2 1 1 1;
    1 3 2 1 1;
    1 4 2 1 1;
    1 5 3 1 1;
    1 6 3 1 1;
    1 7 4 1 1;

    2 1 1 1 1;
    2 2 2 1 1;
    2 3 2 1 1;
    2 4 3 1 1;
    2 5 3 1 1;
    2 6 4 1 1;
    2 7 5 1 1;

    3 1 2 1 1;
    3 2 2 1 1;
    3 3 3 1 1;
    3 4 3 1 1;
    3 5 4 1 1;
    3 6 5 1 1;
    3 7 5 1 1;

    4 1 2 1 1;
    4 2 3 1 1;
    4 3 3 1 1;
    4 4 4 1 1;
    4 5 5 1 1;
    4 6 5 1 1;
    4 7 6 1 1;

    5 1 3 1 1;
    5 2 3 1 1;
    5 3 4 1 1;
    5 4 5 1 1;
    5 5 5 1 1;
    5 6 6 1 1;
    5 7 6 1 1;

    6 1 3 1 1;
    6 2 4 1 1;
    6 3 5 1 1;
```

```
    6 4 5 1 1;
    6 5 6 1 1;
    6 6 6 1 1;
    6 7 7 1 1;

    7 1 4 1 1;
    7 2 5 1 1;
    7 3 5 1 1;
    7 4 6 1 1;
    7 5 6 1 1;
    7 6 7 1 1;
    7 7 7 1 1];

a = addrule(a,rulelist);
showrule(a)                    %Show fuzzy rule base

a1=setfis(a, 'DefuzzMethod', 'mom');          %Defuzzy
writefis(a1, 'fuzzf');                              %save to fuzzy file
"fuzz.fis" which can be
%simulated with fuzzy tool
a2 = readfis('fuzzf');
disp('----------------------------------------------------------------');
disp(' fuzzy controller table: e = [-3, +3], ec = [-3, +3]        ');
disp('----------------------------------------------------------------');

Ulist = zeros(7,7);

for i = 1:7
    for j = 1:7
        e(i) = -4+i;
        ec(j) = -4+j;
        Ulist(i, j) = evalfis([e(i),ec(j)], a2);
    end
end

Ulist = ceil(Ulist)

figure(1);
plotfis(a2);
figure(2);
plotmf(a,'input',1);
figure(3);
plotmf(a,'input',2);
figure(4);
```

```
plotmf(a,'output',1);

%close all;
%figure(1);
%plot(t,y(:,1),'r',t,y(:,2),'k:','linewidth',2);
%xlabel('time(s)');ylabel('yd,y');
%legend('Ideal position signal','position tracking');
```

采用的模糊规则一共有 49 条：

```
    '1. If (e is NB) and (ec is NB) then (u is NB) (1) '
    '2. If (e is NB) and (ec is NM) then (u is NB) (1) '
    '3. If (e is NB) and (ec is NS) then (u is NM) (1) '
    '4. If (e is NB) and (ec is Z) then (u is NM) (1)  '
    '5. If (e is NB) and (ec is PS) then (u is NS) (1) '
    '6. If (e is NB) and (ec is PM) then (u is NS) (1) '
    '7. If (e is NB) and (ec is PB) then (u is Z) (1)  '
    '8. If (e is NM) and (ec is NB) then (u is NB) (1) '
    '9. If (e is NM) and (ec is NM) then (u is NM) (1) '
    '10. If (e is NM) and (ec is NS) then (u is NM) (1)'
    '11. If (e is NM) and (ec is Z) then (u is NS) (1) '
    '12. If (e is NM) and (ec is PS) then (u is NS) (1)'
    '13. If (e is NM) and (ec is PM) then (u is Z) (1) '
    '14. If (e is NM) and (ec is PB) then (u is PS) (1)'
    '15. If (e is NS) and (ec is NB) then (u is NM) (1)'
    '16. If (e is NS) and (ec is NM) then (u is NM) (1)'
    '17. If (e is NS) and (ec is NS) then (u is NS) (1)'
    '18. If (e is NS) and (ec is Z) then (u is NS) (1) '
    '19. If (e is NS) and (ec is PS) then (u is Z) (1) '
    '20. If (e is NS) and (ec is PM) then (u is PS) (1)'
    '21. If (e is NS) and (ec is PB) then (u is PS) (1)'
    '22. If (e is Z) and (ec is NB) then (u is NM) (1) '
    '23. If (e is Z) and (ec is NM) then (u is NS) (1) '
    '24. If (e is Z) and (ec is NS) then (u is NS) (1) '
    '25. If (e is Z) and (ec is Z) then (u is Z) (1)   '
    '26. If (e is Z) and (ec is PS) then (u is PS) (1) '
    '27. If (e is Z) and (ec is PM) then (u is PS) (1) '
    '28. If (e is Z) and (ec is PB) then (u is PM) (1) '
    '29. If (e is PS) and (ec is NB) then (u is NS) (1)'
    '30. If (e is PS) and (ec is NM) then (u is NS) (1)'
    '31. If (e is PS) and (ec is NS) then (u is Z) (1) '
    '32. If (e is PS) and (ec is Z) then (u is PS) (1) '
    '33. If (e is PS) and (ec is PS) then (u is PS) (1)'
    '34. If (e is PS) and (ec is PM) then (u is PM) (1)'
```

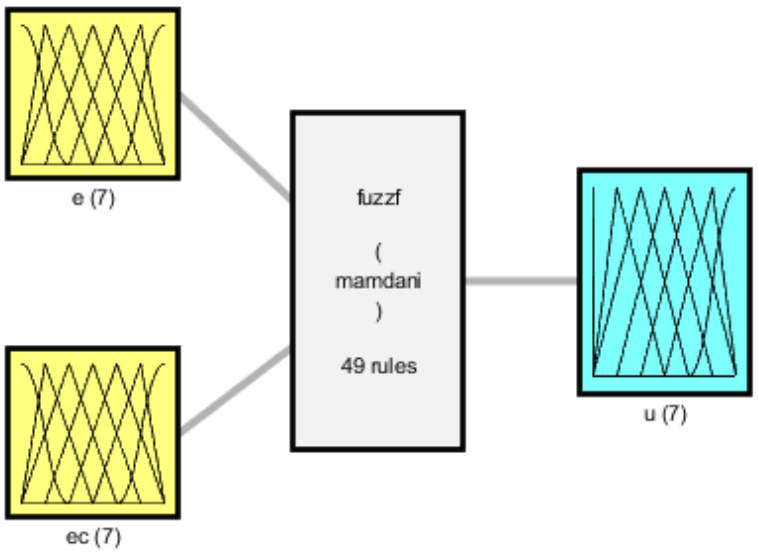
```
'35. If (e is PS) and (ec is PB) then (u is PM) (1)'
'36. If (e is PM) and (ec is NB) then (u is NS) (1)'
'37. If (e is PM) and (ec is NM) then (u is Z) (1) '
'38. If (e is PM) and (ec is NS) then (u is PS) (1)'
'39. If (e is PM) and (ec is Z) then (u is PS) (1) '
'40. If (e is PM) and (ec is PS) then (u is PM) (1)'
'41. If (e is PM) and (ec is PM) then (u is PM) (1)'
'42. If (e is PM) and (ec is PB) then (u is PB) (1)'
'43. If (e is PB) and (ec is NB) then (u is Z) (1) '
'44. If (e is PB) and (ec is NM) then (u is PS) (1)'
'45. If (e is PB) and (ec is NS) then (u is PS) (1)'
'46. If (e is PB) and (ec is Z) then (u is PM) (1) '
'47. If (e is PB) and (ec is PS) then (u is PM) (1)'
'48. If (e is PB) and (ec is PM) then (u is PB) (1)'
'49. If (e is PB) and (ec is PB) then (u is PB) (1)'
```

ruleList 是一个矩阵，每一行为一条规则，他们之间是 ALSO 的关系。

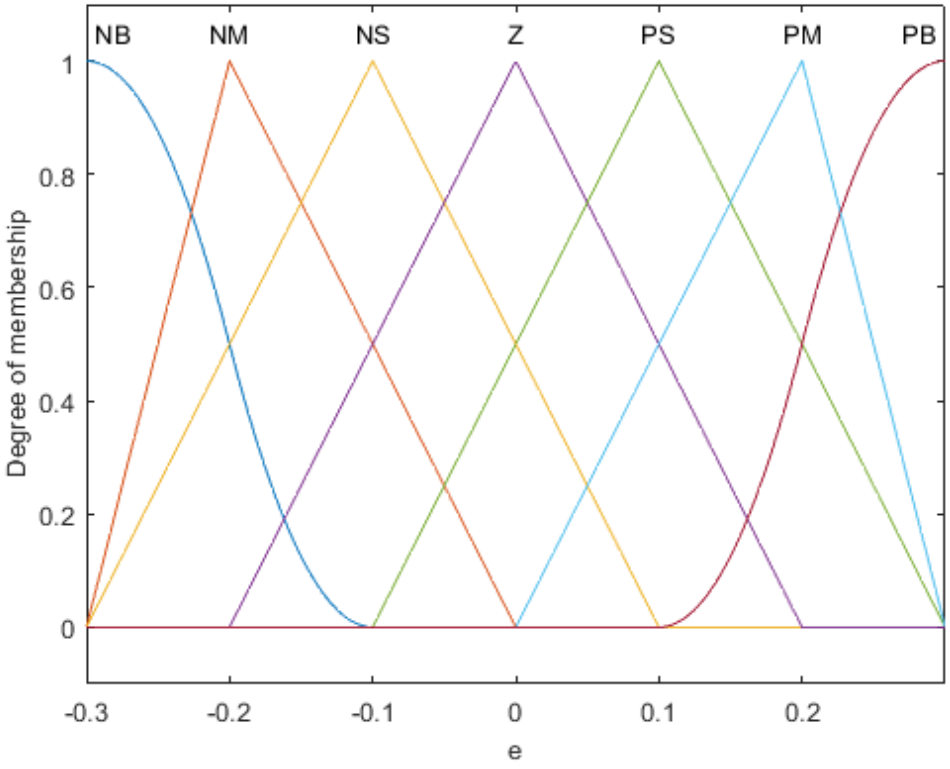
假定该 FIS 有 N 个输入和 M 个输出，则每行有 N+M+2 个元素，前 N 个数分别表示 N 个输入变量的某一个语言名称的 index，没有的话用 0 表示，后面的 M 个数也类似，最后两个分别表示该条规则的权重和各个条件的关系，1 表示 AND，2 表示 OR。

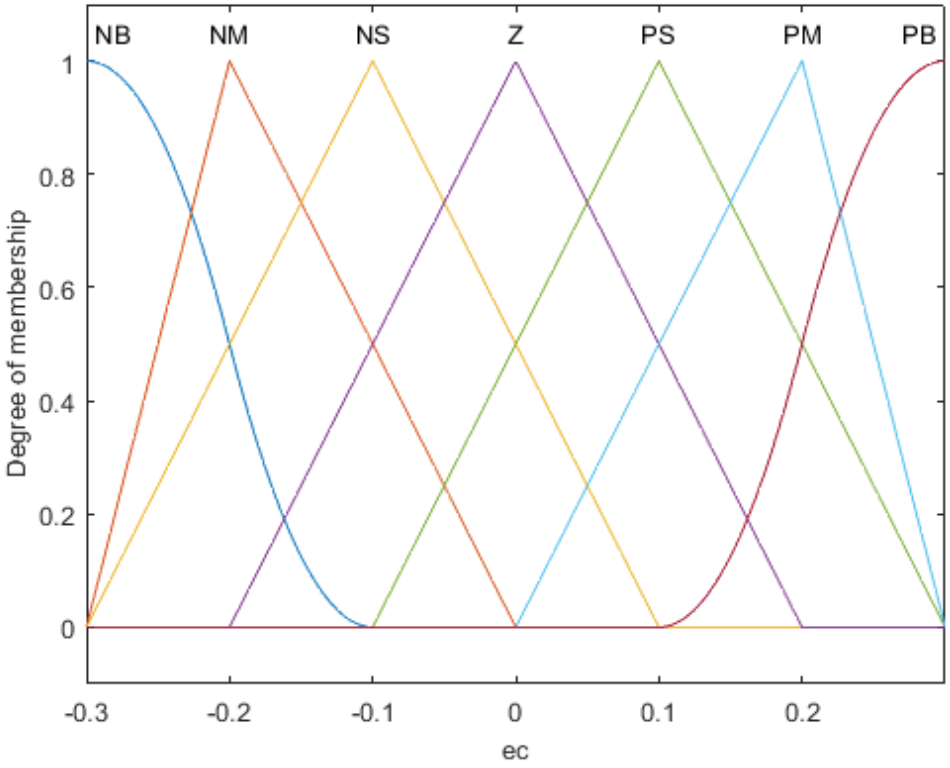
例如，当“输入 1” 为“名称 1” 和 “输入 2” 为“名称 3” 时，输出为 “ 输出 1” 的“状态 2”，则写为：[1 3 2 1 1].

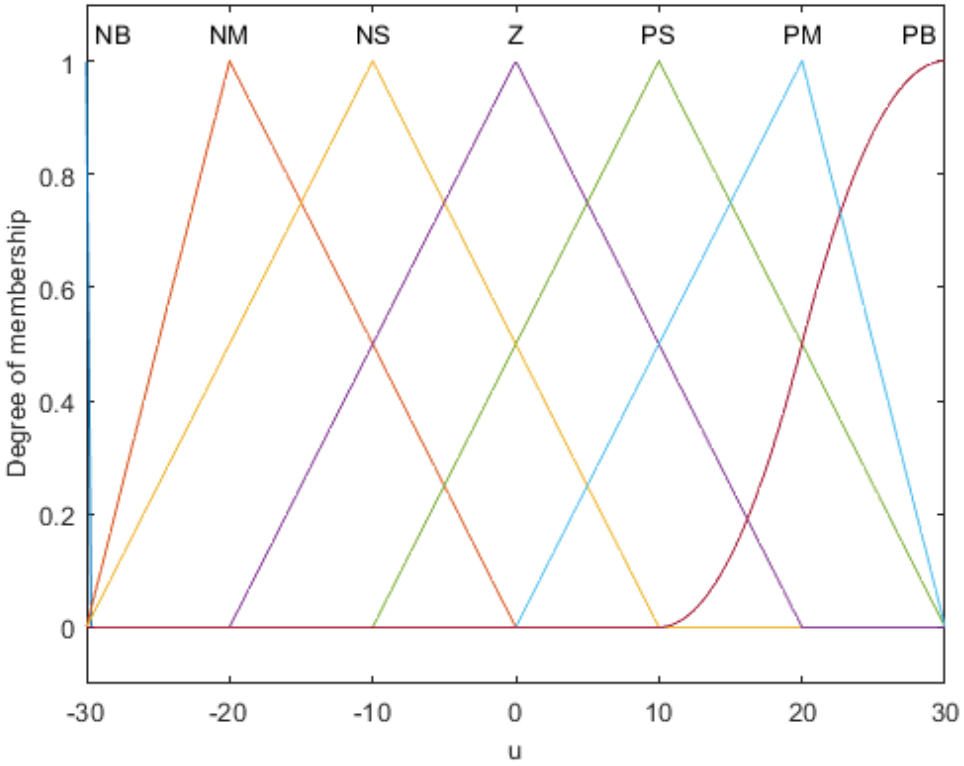
可以得到模糊系统：



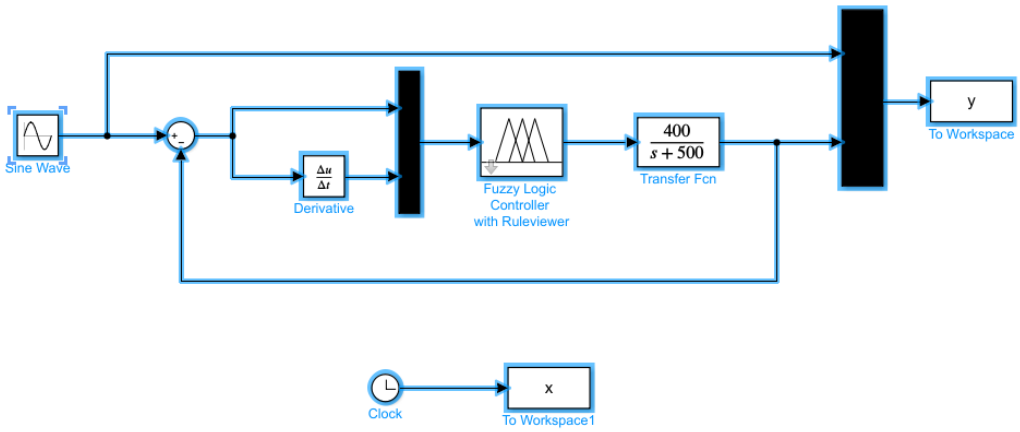
System fuzzf: 2 inputs, 1 outputs, 49 rules


NB
NM
NS
Z
PS
PM
PB
1
0.8
0.6
0.4
0.2
0
Degree of membership
-0.3
-0.2
-0.1
0
0.1
0.2
e


NB
NM
NS
Z
PS
PM
PB
1
0.8
0.6
0.4
0.2
0
Degree of membership
-0.3
-0.2
-0.1
0
0.1
0.2
ec

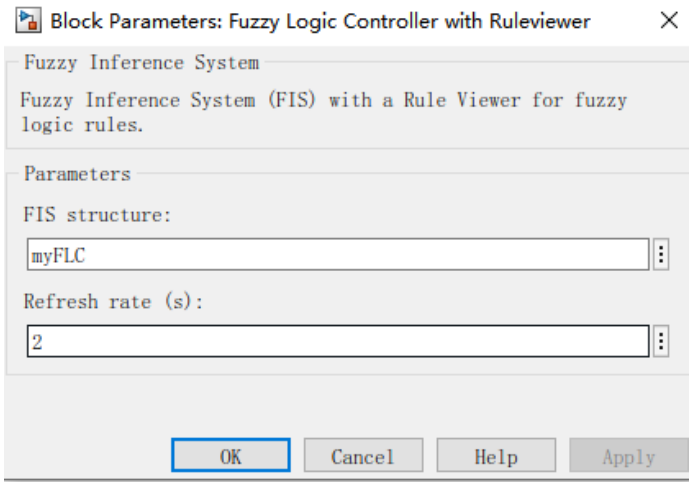


使用 Stimulink 进行建模：

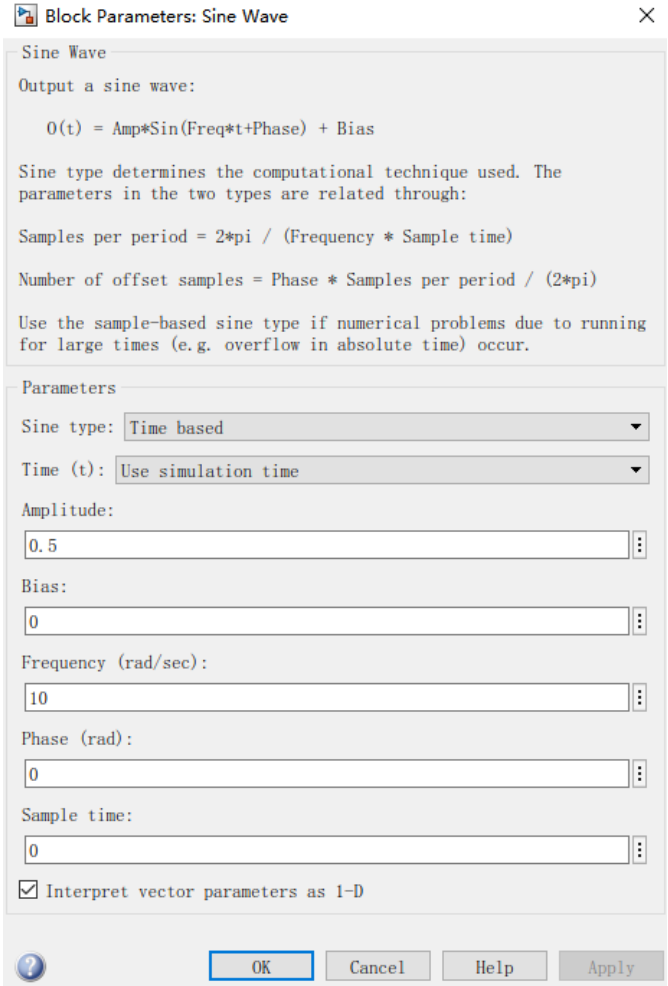


用命令加载刚刚生成的模糊控制模型。

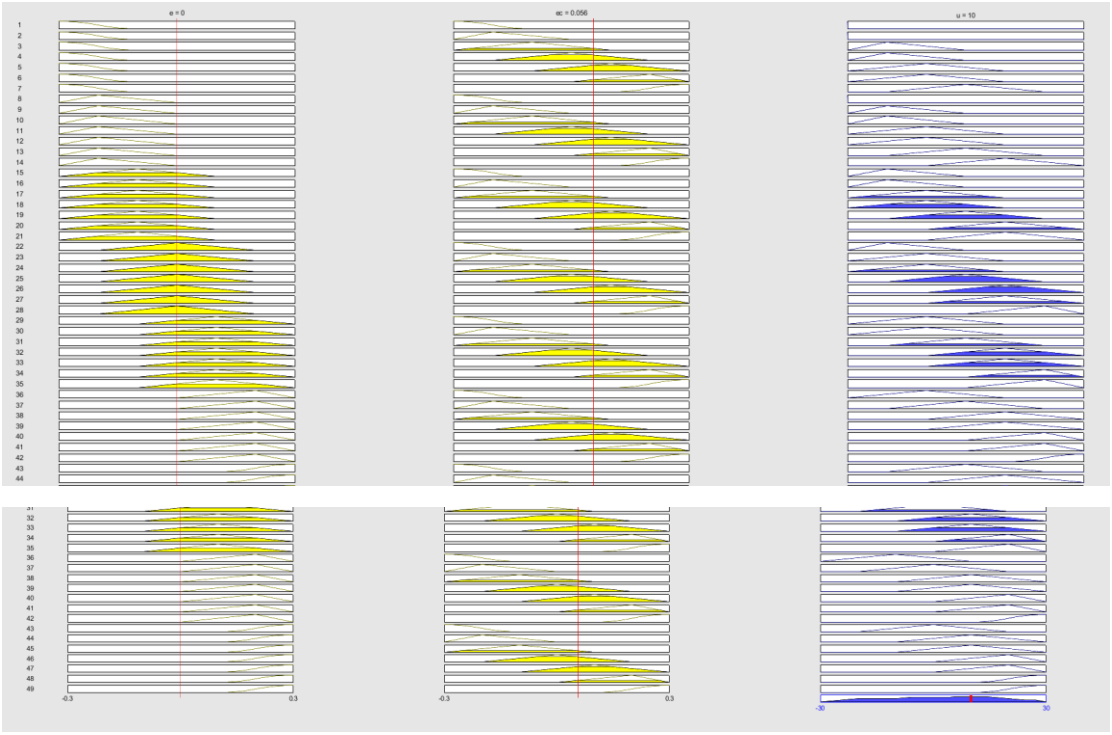
```
myFLC=readfis('fuzzf.fis');
```



调节输入信号：



运行仿真程序，可以得到如下结果：



3.4 模糊推理：

Matlab 代码：

```
clear all;
close all;

A = [1; 0.5];
B = [0.1 0.5 1];
C = [0.2 1];
for i = 1 : 2
    for j = 1 : 3
        AB(i, j) = min(A(i), B(j));
    end
end

T1 = [];
for i = 1 : 2
    T1 = [T1, AB(i, :)];
end

for i = 1 : 6
    for j = 1 : 2
        R(i, j) = min(T1(i), C(j));
    end
end
```

```
A1 = [0.8 0.1];
B1 = [0.5 0.2 0];

for i = 1 : 2
    for j = 1 : 3
        AB1(i, j) = min(A1(i), B1(j));
    end
end

T2 = [];
for i = 1 : 2
    T2 = [T2, AB1(i, :)];
end

for i = 1 : 6
    for j = 1 : 2
        D(i, j) = min(T2(i), R(i, j));
        C1(j) = max(D(:, j));
    end
end

C1
```

```
>> chap3_3_4

C1 =

    0.2000    0.2000
```