

Matlab Code for the Second Case Study in Chapter 6

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clear;
h=1;
sum=0;
ya=zeros(4,3);
y=zeros(1,4);
yb=zeros(4,9);
sumc=0;
yac=zeros(4,3);
yc=zeros(1,4);
ybc=zeros(4,9);
r=zeros(1,300);
% Setting the first value of variables
da1=0;
da2=0;
da3=0;
da4=0;
da5=0;
da6=0;
db1=0;
db2=0;
db3=0;
db4=0;
db5=0;
db6=0;
dc1=0;
dc2=0;
dc3=0;
dc4=0;
dC5=0;
dC6=0;
% xre=def(1);
dw=[0 0 0 0 0 0 0 0];
w=[0 0 0 0 0 0 0 0];
% bell shape initial input
c1=2.35;
b1=2;
a1=1;
c2=5;
b2=2;
a2=1;
c3=7.65;
b3=2;
a3=1;
c4=2.35;
b4=2;
a4=1;
c5=5;
b5=2;
a5=1;
c6=7.65;
b6=2;
a6=1;
% training data
tdata=[2 3 0 0 0.1 0 0 0 0 0;5 7 0 0 0.1 0 0 0 0 0;7.5 4.5 0 0 0.1 0 0 0 0 0;2 2 0 0 0.1 0 0 0 0 0];
cdata=[7 2 0 0 0.1 0 0 0 0 0;5 3 0 0 0.1 0 0 0 0 0;2 8 0 0 0.1 0 0 0 0 0;5 6 0 0 0.1 0 0 0 0 0];
% checking data
% Loop for starting training
for k=1:4
% x1 , x2 input
x1=tdata(k,1);
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x2=tdata(k,2);

xc1=cdata(k,1);
xc2=cdata(k,2);
%yd = desire output
yd=[0.8 0.6 0.4 0.7];
ydc=[0.65 0.70 0.60 0.25];
e=0;
% finding the membership function of x1 , x2 based on the triangular
% function (ai , bi are changing during learning algorithm)
if (x1>=0) && (x1<2.1)
    ya(k,1)=1;
    yac(k,1)=1;
end
if (x1>=2.1) && (x1<4.7)
    ya(k,1)=max(1/(1+(((x1-c1)/a1).^(2*b1))),1/(1+(((x1-c2)/a2).^(2*b2))));
    yac(k,1)=max(1/(1+(((x1-c1)/a1).^(2*b1))),1/(1+(((x1-c2)/a2).^(2*b2))));
end
if (x1>=4.7) && (x1<5.3)
    ya(k,2)=1;
    yac(k,2)=1;
end
if (x1>=5.3) && (x1<8.1)
    ya(k,3)=max(1/(1+(((x1-c2)/a2).^(2*b2))),1/(1+(((x1-c3)/a3).^(2*b3))));
    yac(k,3)=max(1/(1+(((x1-c2)/a2).^(2*b2))),1/(1+(((x1-c3)/a3).^(2*b3))));
end
if (x1>=8.1) && (x1<=10)
    ya(k,3)=1;
    yac(k,3)=1;
end

if (x2>=0) && (x2<2.1)
    yb(k,1)=1;
    ybc(k,1)=1;
end
if (x2>=2.1) && (x2<4.7)
    yb(k,1)=max(1/(1+(((x1-c1)/a1).^(2*b1))),1/(1+(((x1-c2)/a2).^(2*b2))));
    ybc(k,1)=max(1/(1+(((x1-c1)/a1).^(2*b1))),1/(1+(((x1-c2)/a2).^(2*b2))));
end
if (x2>=4.7) && (x2<5.3)
    yb(k,2)=1;
    ybc(k,2)=1;
end
if (x2>=5.3) && (x2<8.1)
    yb(k,3)=max(1/(1+(((x1-c2)/a2).^(2*b2))),1/(1+(((x1-c3)/a3).^(2*b3))));
    ybc(k,3)=max(1/(1+(((x1-c2)/a2).^(2*b2))),1/(1+(((x1-c3)/a3).^(2*b3))));
end
if (x2>=8.1) && (x2<=10)
    yb(k,3)=1;
    ybc(k,3)=1;
end

% rules: definging the rules for each variables for example w1= ya1(good)*yb1(good)
w(1)=ya(k,1)*yb(k,1);
w(2)=ya(k,1)*yb(k,2);
w(3)=ya(k,1)*yb(k,3);
w(4)=ya(k,2)*yb(k,1);
w(5)=ya(k,2)*yb(k,2);
w(6)=ya(k,2)*yb(k,3);
w(7)=ya(k,3)*yb(k,1);
w(8)=ya(k,3)*yb(k,2);
w(9)=ya(k,3)*yb(k,3);

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wc(1)=yac(k,1)*ybc(k,1);
wc(2)=yac(k,1)*ybc(k,2);
wc(3)=yac(k,1)*ybc(k,3);
wc(4)=yac(k,2)*ybc(k,1);
wc(5)=yac(k,2)*ybc(k,2);
wc(6)=yac(k,2)*ybc(k,3);
wc(7)=yac(k,3)*ybc(k,1);
wc(8)=yac(k,3)*ybc(k,2);
wc(9)=yac(k,3)*ybc(k,3);

for i= 1:9
tw(k,i)=w(i);
twc(k,i)=wc(i);
end;
end;
% the function for each rule(zero-order sugeno)
f(1)= 0.7;
f(2)= 0.6;
f(3)= 0.9;
f(4)= 0.9;
f(5)= 0.8;
f(6)= 0.75;
f(7)= 0.8;
f(8)= 0.6;
f(9)= 0.8;
% first of epoch for learning algorithm
w1=w;
% the number of epoch
maxcycle=3000;
% the learning rate
alpha=.02;
%the acceptance errorr
ssegoal=.005;
for m=1:maxcycle
    for i= 1:4
        sum(i)=tw(i,1)+tw(i,2)+tw(i,3)+tw(i,4)+tw(i,5)+tw(i,6)+tw(i,7)+tw(i,8)+tw(i,9)+1;
        sumc(i)=twc(i,1)+twc(i,2)+twc(i,3)+twc(i,4)+twc(i,5)+twc(i,6)+twc(i,7)+twc(i,8)+twc(i,9)+1;
    end;

for j=1:4
    y(j)=0;
    yc(j)=0;
for i=1:9
    wn(j,i)= (tw(j,i))/sum(j);
    wy(j,i)=f(j)*wn(j,i);
    y(j)=y(j)+wy(j,i);
    wnc(j,i)= (twc(j,i))/sumc(j);
    wyc(j,i)=f(j)*wnc(j,i);
    yc(j)=yc(j)+wyc(j,i);
end
end
for j=1:4
    e(j)=yd(j)-y(j);
    ec(j)=ydc(j)-yc(j);
end
rmse=sqrt(abs(e(1)+e(2)+e(3)+e(4))/4);
rmsec=sqrt(abs(ec(1)+ec(2)+ec(3)+ec(4))/4);
re(m)=rmse;
rec(m)=rmsec;
if rmse<ssegoal;break;end;
for j=1:4;
for t=1:9;

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if (tw(j,t)~=0)
%defining the changes of w
    dw(j,t)=(alpha*e(j)*f(t)*wn(j,t)*(1-wn(j,t))*(1/tw(j,t)));
    tw(j,t)=tw(j,t)+dw(j,t);
    dwc(j,t)=(alpha*ec(j)*f(t)*wnc(j,t)*(1-wnc(j,t))*(1/twc(j,t)));
    twc(j,t)=twc(j,t)+dwc(j,t);
end;
end;
end;
end;
%changing the da & db
for j=1:4;
da1=((tw(j,1)+tw(j,2)+tw(j,3))*(2*b1*ya(j,1)*ya(j,1))*((x1-c1)^(2*b1))/(a1^(2*b1+1)))*yb(j,1);
db1=(tw(j,1)+tw(j,2)+tw(j,3))*(exp(x1-c1)*2*a1^(2*b1)/(a1^(2*b1)+(x1-c1)^(2*b1)))*yb(j,1);
dc1=(tw(j,1)+tw(j,2)+tw(j,3))*(ya(j,1)*ya(j,1)*2*b1*((x1-c1)/a1)^(2*b1-1))*yb(j,1);
da2=(tw(j,4)+tw(j,5)+tw(j,6))*((2*b2*ya(j,2)*ya(j,2))*(x1-c2)^(2*b2))/a1^(2*b2+1))*yb(j,2);
db2=(tw(j,4)+tw(j,5)+tw(j,6))*(exp(x1-c2)*2*a2^(2*b2)/(a2^(2*b2)+(x1-c2)^(2*b2)))*yb(j,2);
dc2=(tw(j,4)+tw(j,5)+tw(j,6))*(ya(j,2)*ya(j,2)*2*b2*((x1-c2)/a2)^(2*b2-1))*yb(j,2);
da3=(tw(j,7)+tw(j,8)+tw(j,9))*((2*b3*ya(j,3)*ya(j,3))*(x1-c3)^(2*b3))/a3^(2*b3+1))*yb(j,3);
db3=(tw(j,7)+tw(j,8)+tw(j,9))*(exp(x1-c3)*2*a3^(2*b3)/(a3^(2*b3)+(x1-c3)^(2*b3)))*yb(j,3);
dc3=(tw(j,7)+tw(j,8)+tw(j,9))*(ya(j,3)*ya(j,3)*2*b3*((x1-c3)/a3)^(2*b3-1))*yb(j,3);
da4=(tw(j,1)+tw(j,2)+tw(j,3))*((2*b4*yb(j,1)*yb(j,1))*(x2-c4)^(2*b4))/a4^(2*b4+1))*ya(j,1);
db4=(tw(j,1)+tw(j,2)+tw(j,3))*(exp(x2-c4)*2*a4^(2*b4)/(a4^(2*b4)+(x2-c4)^(2*b4)))*ya(j,1);
dc4=(tw(j,1)+tw(j,2)+tw(j,3))*(yb(j,1)*yb(j,1)*2*b4*((x2-c4)/a4)^(2*b4-1))*ya(j,1);
da5=(tw(j,4)+tw(j,5)+tw(j,6))*((2*b5*yb(j,2)*yb(j,2))*(x2-c5)^(2*b5))/a5^(2*b5+1))*ya(j,2);
db5=(tw(j,4)+tw(j,5)+tw(j,6))*(exp(x2-c5)*2*a5^(2*b5)/(a5^(2*b5)+(x2-c5)^(2*b5)))*ya(j,2);
dc5=(tw(j,4)+tw(j,5)+tw(j,6))*(yb(j,2)*yb(j,2)*2*b5*((x2-c5)/a5)^(2*b5-1))*ya(j,2);
da6=(tw(j,7)+tw(j,8)+tw(j,9))*((2*b6*yb(j,3)*yb(j,3))*(x2-c6)^(2*b6))/a6^(2*b6+1))*ya(j,3);
db6=(tw(j,7)+tw(j,8)+tw(j,9))*(exp(x2-c6)*2*a6^(2*b6)/(a6^(2*b6)+(x2-c6)^(2*b6)))*ya(j,3);
dc6=(tw(j,7)+tw(j,8)+tw(j,9))*(yb(j,3)*yb(j,3)*2*b6*((x2-c6)/a6)^(2*b6-1))*ya(j,3);

a1=a1+da1;
a2=a2+da2;
a3=a3+da3;
a4=a4+da4;
a5=a5+da5;
a6=a6+da6;
b1=b1+db1;
b2=b2+db2;
b3=b3+db3;
b4=b4+db4;
b5=b5+db5;
b6=b6+db6;
c1=c1+dc1;
c2=c2+dc2;
c3=c3+dc3;
c4=c4+dc4;
c5=c5+dc5;
c6=c6+dc6;

end;
%drawing the new figure based on the learning data and change ai and bi
x1=[0:0.1:10];
x2=[0:0.1:10];
yaa1=zeros(length(x1));
yaa2=zeros(length(x1));
yaa3=zeros(length(x1));

ya1=zeros(length(x1));
ya2=zeros(length(x1));
ya3=zeros(length(x1));

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ybb1=zeros(length(x2));
ybb2=zeros(length(x2));
ybb3=zeros(length(x2));
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yb1=zeros(length(x1));
yb2=zeros(length(x1));
yb3=zeros(length(x1));
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cc1=2.35;
bb1=2;
aa1=2;
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cc2=5;
bb2=2;
aa2=2;
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cc3=7.65;
bb3=2;
aa3=2;
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cc4=2.35;
bb4=2;
aa4=1.5;
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cc5=5;
bb5=2;
aa5=1;
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cc6=7.65;
bb6=2;
aa6=1.5;
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for i=1:100
% drawing the changed figure
if (x1(i)>=c1-2*a1) && (x1(i)<=c1+2*a1)
    ya1(i)=max(min(abs(1/(1+(((x1(i)-c1)/a1)^(2*b1))))),1),0);
end
% drawing initial figure
if (x1(i)>=0) && (x1(i)<4.7)
    ya1(i)=1/(1+(((x1(i)-cc1)/aa1)^(2*bb1)));
end
if (x1(i)>=0) && (x1(i)<=2.1)
    ya1(i)=1;
    yaa1(i)=1;
end
if (x1(i)>=2.1) && (x1(i)<=8.1)
    ya2(i)=max(min(abs(1/(1+(((x1(i)-cc2)/aa2)^(2*bb2))))),1),0);
end
if (x1(i)>=c2-2*a2) && (x1(i)<=c2+2*a2)
    ya2(i)=max(min(abs(1/(1+(((x1(i)-c2)/a2)^(2*b2))))),1),0);
end
if (x1(i)>=c3-2*a3) && (x1(i)<=c3+2*a3)
    ya3(i)=max(1/(1+(((x1(i)-cc3)/aa3)^(2*bb3))),1/(1+(((x1(i)-cc2)/aa2)^(2*bb2))));
end
if (x1(i)>=5.3) && (x1(i)<8.1)
    ya3(i)=max(min(abs(1/(1+(((x1(i)-cc3)/aa3)^(2*bb3))))),1),0);
end
if (x1(i)>=8.1) && (x1(i)<=10)
    ya3(i)=1;
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    yaa3(i)=1;
end
%-----
if (x2(i)>=c4-2*a4) && (x2(i)<=c4+2*a4)
    ybb1(i)=max(min(abs(1/(1+(((x2(i)-c4)/a4)^(2*b4)))),1),0);
end
% drawing initial figure
if (x2(i)>=0) && (x2(i)<4.7)
    yb1(i)=1/(1+(((x2(i)-cc4)/aa4)^(2*bb4)));
end
if (x2(i)>=0) && (x2(i)<=2.1)
    yb1(i)=1;
    ybb1(i)=1;
end
if (x2(i)>=2.1) && (x2(i)<=8.1)
    yb2(i)=max(min(abs(1/(1+(((x2(i)-cc5)/aa5)^(2*bb5)))),1),0);
end
if (x2(i)>=c5-2*a5) && (x2(i)<=c5+2*a5)
    ybb2(i)=max(min(abs(1/(1+(((x2(i)-c5)/a5)^(2*b5)))),1),0);
end
if (x2(i)>=c6-2*a6) && (x2(i)<=c6+2*a6)
    ybb3(i)=max(1/(1+(((x2(i)-cc6)/aa6)^(2*bb6))),1/(1+(((x2(i)-cc2)/aa2)^(2*bb2))));
end
if (x2(i)>=5.3) && (x2(i)<8.1)
    yb3(i)=max(min(abs(1/(1+(((x2(i)-cc6)/aa6)^(2*bb6)))),1),0);
end
if (x2(i)>=8.1) && (x2(i)<=10)
    yb3(i)=1;
    ybb3(i)=1;
end
end

end;

subplot(2,1,1);plot(x1,yaa1,x1,yaa2,x1,yaa3,x1,ya1,x1,ya2,x1,ya3);
subplot(2,1,2);plot(x2,ybb1,x2,ybb2,x2,ybb3,x2,yb1,x2,yb2,x2,yb3);

%these are input and output
x1=6;% answer{ 1,1 };%
x2=5;% answer{ 2,1 };%
yra1=0;
yaa1=0;
yra2=0;
yaa2=0;
yra3=0;
yaa3=0;
yrb1=0;
yrb1=0;
yrb2=0;
yrb2=0;
yrb3=0;
yrb3=0;

if (x1>=c1-2*a1) && (x1<=c1+2*a1)
    yaa1=max(min(abs(1/(1+(((x1-c1)/a1)^(2*b1)))),1),0);
end
% drawing initial figure
if (x1>=0) && (x1<4.7)
    yra1=1/(1+(((x1-cc1)/aa1)^(2*bb1)));
end
if (x1>=0) && (x1<=2.1)
    yra1=1;

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    yraa1=1;
end
if (x1>=2.1) && (x1<=8.1)
    yraa2=max(min(abs(1/(1+(((x1-cc2)/aa2)^(2*bb2))))),1),0);
end
if (x1>=c2-2*a2) && (x1<=c2+2*a2)
    yraa2=max(min(abs(1/(1+(((x1-c2)/a2)^(2*b2))))),1),0);
end
if (x1>=c3-2*a3) && (x1<=c3+2*a3)
    yraa3=max(1/(1+(((x1-cc3)/aa3)^(2*bb3))),1/(1+(((x1-cc2)/aa2)^(2*bb2))));
end
if (x1>=5.3) && (x1<8.1)
    yraa3=max(min(abs(1/(1+(((x1-cc3)/aa3)^(2*bb3))))),1),0);
end
if (x1>=8.1) && (x1<=10)
    yraa3=1;
end
%-----
if (x2>=c4-2*a4) && (x2<=c4+2*a4)
    yrbb1=max(min(abs(1/(1+(((x2-c4)/a4)^(2*b4))))),1),0);
end
% drawing initial figure
if (x2>=0) && (x2<4.7)
    yrb1=1/(1+(((x2-cc4)/aa4)^(2*bb4)));
end
if (x2>=0) && (x2<=2.1)
    yrb1=1;
    ybb1=1;
end
if (x2>=2.1) && (x2<=8.1)
    yrbb2=max(min(abs(1/(1+(((x2-cc5)/aa5)^(2*bb5))))),1),0);
end
if (x2>=c5-2*a5) && (x2<=c5+2*a5)
    yrbb2=max(min(abs(1/(1+(((x2-c5)/a5)^(2*b5))))),1),0);
end
if (x2>=c6-2*a6) && (x2<=c6+2*a6)
    yrbb3=max(1/(1+(((x2-cc6)/aa6)^(2*bb6))),1/(1+(((x2-cc2)/aa2)^(2*bb2))));
end
if (x2>=5.3) && (x2<8.1)
    yrbb3=max(min(abs(1/(1+(((x2-cc6)/aa6)^(2*bb6))))),1),0);
end
if (x2>=8.1) && (x2<=10)
    yrbb3=1;
end
% rules: definging the rules for each variables for example w1= ya1(good)*yb1(good)
w(1)=yraa1*yrbb1;
w(2)=yraa1*yrbb2;
w(3)=yraa1*yrbb3;
w(4)=yraa2*yrbb1;
w(5)=yraa2*yrbb2;
w(6)=yraa2*yrbb3;
w(7)=yraa3*yrbb1;
w(8)=yraa3*yrbb2;
w(9)=yraa3*yrbb3;

wa(1)=yra1*yrb1;
wa(2)=yra1*yrb2;
wa(3)=yra1*yrb3;
wa(4)=yra2*yrb1;
wa(5)=yra2*yrb2;

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wa(6)=yra2*yrb3;
wa(7)=yra3*yrb1;
wa(8)=yra3*yrb2;
wa(9)=yra3*yrb3;
% the function for each rule(zero-order sugeno)
f(1)= 0.7;
f(2)= 0.6;
f(3)= 0.9;
f(4)= 0.9;
f(5)= 0.8;
f(6)= 0.75;
f(7)= 0.8;
f(8)= 0.6;
f(9)= 0.8;
sum=w(1)+w(2)+w(3)+w(4)+w(5)+w(6)+w(7)+w(8)+w(9)+1;
suma=wa(1)+wa(2)+wa(3)+wa(4)+wa(5)+wa(6)+wa(7)+wa(8)+wa(9)+1;

for i=1:9
    wn1(i)= (w(i))/sum;
    wy1(i)=f(i)*wn1(i);

    wna1(i)= (wa(i))/suma;
    wya1(i)=f(i)*wna1(i);

end
sum2=wy1(1)+wy1(2)+wy1(3)+wy1(4)+wy1(5)+wy1(6)+wy1(7)+wy1(8)+wy1(9);
y=sum2;
% define the wich rule fired
resultd=0;
result=max(wy1);
for i=1:9
    if wy1(i)==result
        resultd=i;
    end;
end;
if resultd==1
    h = msgbox('Divest');
end
if resultd==2
    h = msgbox('Limited expansion or harvest');
end
if resultd==3
    h = msgbox('Build selectively');
end
if resultd==4
    h = msgbox('Manage for earnings');
end
if resultd==5
    h = msgbox('Selectivity/ Manage For Earning');
end
if resultd==6
    h = msgbox('Invest to build');
end
if resultd==7
    h = msgbox('Protect and refocus');
end
if resultd==8
    h = msgbox('Selectivity build');
end
if resultd==9
    h = msgbox('Protect position');
end
end

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