Peiyuan (Alexander) Liao

Csef 2018

research notebook 9.3-11.9

***Manipulator evaluation***: Motion of an anthropomorphic arm through a straight line in Cartesian space by interpolation & trajectory planning

Date: 9/3/17

Alexander Liao

Brainstorming

**I/O:**

Warning: floor tiles too small, making them 30.000000 x bigger - change the size or disable them

> In RTBPlot.create\_tiled\_floor (line 619)

In RTBPlot.create\_floor (line 575)

In SerialLink/plot (line 250)

In RobotTest (line 38)

linreg =

Linear regression model:

y ~ 1 + x1

Estimated Coefficients:

Estimate SE tStat pValue

\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_

(Intercept) 10.039 0.0066362 1512.7 0

x1 -0.0019077 0.00053394 -3.5729 0.00045138

Number of observations: 185, Error degrees of freedom: 183

Root Mean Squared Error: 0.0508

R-squared: 0.0652, Adjusted R-Squared 0.0601

F-statistic vs. constant model: 12.8, p-value = 0.000451

**Code:**

clear Arm

t=[0 0 0 0 0 0 0];

l=[17.25 15.85 5.75];

xdata=[];

ydata=[];

L(1)= Link([t(1) 0 0 pi/2 0],'modified');

L(2)= Link([t(2)+pi/2 0 0 pi/2 0],'modified');

L(3)= Link([t(3)+pi/2 l(1) 0 pi/2 0],'modified');

L(4)= Link([t(4)+pi 0 0 pi/2 0],'modified');

L(5)= Link([t(5)+pi l(2) 0 pi/2 0],'modified');

L(6)= Link([t(6)+pi/2 0 0 pi/2 0],'modified');

L(7)= Link([t(7)+pi 0 l(3) pi/2 0],'modified');

Arm=SerialLink([L(1) L(2) L(3) L(4) L(5) L(6) L(7)]);

t=20;

%ti=0:t^-1:1;

er=ctraj(transl(0,10,10),transl(20,10,10),t);

solv=[];

solve1=Arm.jtraj(er(:,:,1),er(:,:,2),5);

finale=solve1;

for i=2:t-1

solv=Arm.jtraj(er(:,:,i),er(:,:,i+1),10);

finale =[finale;solv];

end

clear i

for i=1:size(finale)

for k=1:7

t(k)=finale(i,k);

end

intm=Arm.fkine(t);

intm2=intm.t;

xdata=horzcat(xdata,intm2(1));

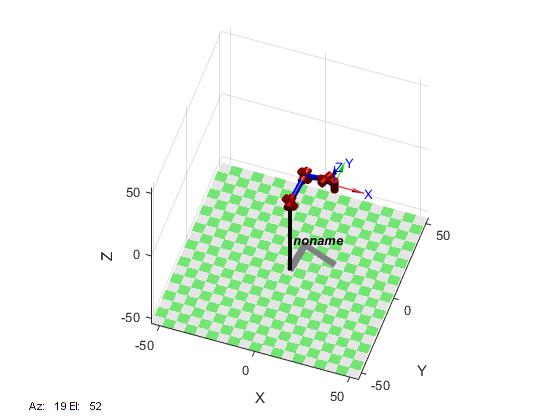
ydata=horzcat(ydata,intm2(2));

Arm.plot(t);

end

linreg=fitlm(xdata,ydata)

**Visualization:**



Improvement to allow

end

counter3 =counter3+1;

voxel1(:,:,counter3)=pixel1;

voxel2(:,:,counter3)=pixel2;

end

clear counter1 counter2

[sizeRow,sizeColumn,size3D]=size(voxel1);

%JointAngles=zeros(2,7);

for counter1=1:size3D

for counter2=1:sizeRow

LinPlan=trinterp(transl(voxel1(counter2,:,counter1)),transl(voxel2(counter2,:,counter1)),vxlPerRow);

TrajPlan=M.ikine(LinPlan);

JointAngles=[JointAngles;TrajPlan];

%SurfPlan=cat(4,SurfPlan,LinPlan);

end

for counter3=1:size(JointAngles)

hmTrans=M.fkine(JointAngles(counter3,:));

vector=hmTrans.t;

endX=horzcat(endX,vector(1));

endY=horzcat(endY,vector(2));

M.plot(JointAngles(counter3,:))

end

plot(endX,endY)

hold on

%clear counter2

%TrajPlan=Manipulator.ikinem(SurfPlan(:,:,1,counter1),SurfPlan(:,:,2,counter1),subVxlDensity)

%JointAngles=TrajPlan

%for counter2=2:vxlPerRow-1

% TrajPlan=Manipulator.jtraj(SurfPlan(:,:,counter2,counter1),SurfPlan(:,:,counter2+1,counter1),subVxlDensity);

% JointAngles=[JointAngles;TrajPlan];

%end

end

clear counter2

clear counter1 counter2 counter3

Date: 9/28/17

Alexander Liao

Brainstorming

planning in Cartesian

3D space:

**Code:**

%Initialization

clear all

theta=[0 0 0 0 0 0 0];

l=[17.25 15.85 5.75];

endX=[];

endY=[];

TrajPlan=[];

LinPlan=[];

SurfPlan=[];

JointSpaceTraj=[];

JointAngles=[];

hmTrans=[];

vector=[];

%subVxlDensity=19;

vxlPerRow=9;

counter3=0;

L(1)= Link([theta(1) 0 0 pi/2 0],'modified');

L(2)= Link([theta(2)+pi/2 0 0 pi/2 0],'modified');

L(3)= Link([theta(3)+pi/2 l(1) 0 pi/2 0],'modified');

L(4)= Link([theta(4)+pi 0 0 pi/2 0],'modified');

L(5)= Link([theta(5)+pi l(2) 0 pi/2 0],'modified');

L(6)= Link([theta(6)+pi/2 0 0 pi/2 0],'modified');

L(7)= Link([theta(7)+pi 0 l(3) pi/2 0],'modified');

M=SerialLink([L(1) L(2) L(3) L(4) L(5) L(6) L(7)]);

pixel=[];

%voxel=zeros(2\*(voxelPerRow),3,voxelPerRow);

for counter1=-20:20/(vxlPerRow-1):0

pixel1=[];

pixel2=[];

for counter2=10:20/(vxlPerRow-1):30

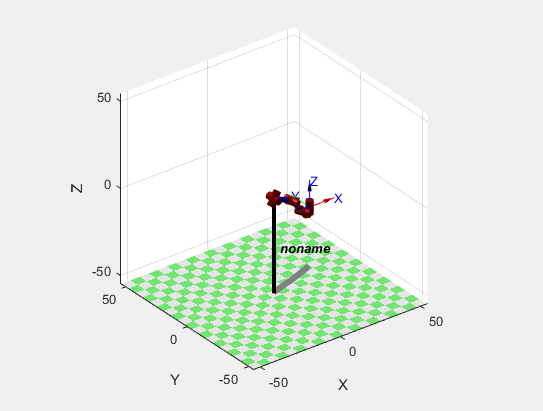
pixel1=vertcat(pixel1,[10,counter2,counter1]);

pixel2=vertcat(pixel2,[30,counter2,counter1]);

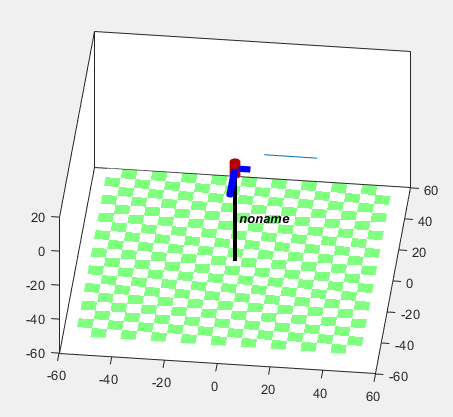
%pixel=vertcat(pixel,[counter2,10,counter1]);

%pixel=vertcat(pixel,[counter2,30,counter1]);

**Visualization 1:**



**Visualization 2 (failed when plotting the line of motion):**



**I/O:**

Warning: floor tiles too small, making them 30.000000 x bigger - change the size or disable them

> In RTBPlot.create\_tiled\_floor (line 619)

In RTBPlot.create\_floor (line 575)

In SerialLink/plot (line 250)

In Test (line 63)

Error using matlab.graphics.primitive.Group/set

Invalid or deleted object.

Error in SerialLink/animate (line 148)

set(handle, 'UserData', h);

Error in SerialLink/plot (line 297)

robot.animate(qq);

Error in Test (line 63)

M.plot(JointAngles(counter3,:))

**Workspace:**

**Pose planning**

LinPlan(:,:,1) =

1.0000 0 0 10.0000

0 1.0000 0 30.0000

0 0 1.0000 -17.5000

0 0 0 1.0000

LinPlan(:,:,2) =

1.0000 0 0 12.5000

0 1.0000 0 30.0000

0 0 1.0000 -17.5000

0 0 0 1.0000

LinPlan(:,:,3) =

1.0000 0 0 15.0000

0 1.0000 0 30.0000

0 0 1.0000 -17.5000

0 0 0 1.0000

LinPlan(:,:,4) =

1.0000 0 0 17.5000

0 1.0000 0 30.0000

0 0 1.0000 -17.5000

0 0 0 1.0000

LinPlan(:,:,5) =

1.0000 0 0 20.0000

0 1.0000 0 30.0000

0 0 1.0000 -17.5000

0 0 0 1.0000

**Workspace:**

JointAngles =

-0.4940 0.8524 1.2426 1.4271 0.0239 -0.5089 -0.7566

-0.3986 0.9342 1.3036 1.4916 -0.0537 -0.3972 -0.7325

-0.3292 1.0172 1.3613 1.5766 -0.1128 -0.2746 -0.6959

-0.2849 1.0957 1.4151 1.6820 -0.1534 -0.1431 -0.6494

-0.2650 1.1649 1.4633 1.8096 -0.1765 -0.0042 -0.5957

-0.2692 1.2217 1.5037 1.9638 -0.1852 0.1427 -0.5377

-0.3002 1.2653 1.5344 2.1539 -0.1833 0.3015 -0.4782

-0.3682 1.2968 1.5537 2.4043 -0.1755 0.4849 -0.4180

-0.5296 1.3179 1.5574 2.8316 -0.1687 0.7531 -0.3497

-0.3465 0.7728 1.1908 1.2621 -0.2330 -0.5622 -1.0570

-0.2384 0.8893 1.2739 1.3388 -0.3396 -0.4406 -1.0316

-0.1628 1.0120 1.3609 1.4319 -0.4200 -0.3027 -0.9847

-0.1182 1.1292 1.4499 1.5399 -0.4699 -0.1545 -0.9169

-0.1017 1.2289 1.5351 1.6637 -0.4895 -0.0033 -0.8332

-0.1097 1.3042 1.6107 1.8076 -0.4849 0.1475 -0.7413

-0.1403 1.3539 1.6743 1.9785 -0.4646 0.2996 -0.6472

-0.1962 1.3792 1.7250 2.1897 -0.4351 0.4606 -0.5526

-0.2920 1.3795 1.7624 2.4758 -0.4011 0.6492 -0.4537

-0.2864 0.6998 1.3830 1.3181 0.0787 -0.4369 -0.8139

-0.2048 0.7956 1.4300 1.3864 0.0110 -0.3302 -0.7748

-0.1509 0.8864 1.4667 1.4744 -0.0389 -0.2133 -0.7289

-0.1207 0.9689 1.4957 1.5820 -0.0733 -0.0884 -0.6791

-0.1121 1.0406 1.5180 1.7106 -0.0946 0.0433 -0.6271

-0.1247 1.1009 1.5334 1.8634 -0.1057 0.1824 -0.5749

-0.1605 1.1505 1.5410 2.0475 -0.1099 0.3321 -0.5238

-0.2266 1.1912 1.5400 2.2798 -0.1109 0.5011 -0.4746

-0.3504 1.2265 1.5276 2.6167 -0.1144 0.7191 -0.4252

-0.2511 0.5913 1.4258 1.4100 0.2142 -0.3067 -0.7806

-0.1851 0.6831 1.4607 1.4783 0.1618 -0.2117 -0.7339

-0.1457 0.7671 1.4785 1.5667 0.1225 -0.1058 -0.6859

-0.1286 0.8425 1.4841 1.6759 0.0934 0.0093 -0.6392

-0.1319 0.9095 1.4799 1.8077 0.0718 0.1333 -0.5953

-0.1563 0.9697 1.4673 1.9669 0.0549 0.2677 -0.5557

-0.2055 1.0260 1.4469 2.1632 0.0395 0.4173 -0.5210

-0.2915 1.0827 1.4186 2.4228 0.0214 0.5955 -0.4916

-0.4865 1.1564 1.3724 2.8915 -0.0133 0.8784 -0.4653

First attempt in formulating an evaluation method: absolute error between planned trajectory and straight line between nodes of cuboid partitions

Date: 9/29/17

Alexander Liao

Brainstorming

**Code:**

%Initialization

clear all

%SerialLink Parameters

theta=[0 0 0 0 0 0 0];

l=[17.25 15.85 5.75];

%Target Space

x1=10;

x2=20;

y1=10;

y2=20;

z1=-8;

z2=2;

%Specifications for Voxels

interpVal=3;

numVxl=5;

zLayerHeight=5;

%Final Result

dataGraySclImage=[];

%Creating the SerialLink object

L(1)= Link([theta(1) 0 0 pi/2 0],'modified');

L(2)= Link([theta(2)+pi/2 0 0 pi/2 0],'modified');

L(3)= Link([theta(3)+pi/2 l(1) 0 pi/2 0],'modified');

L(4)= Link([theta(4)+pi 0 0 pi/2 0],'modified');

L(5)= Link([theta(5)+pi l(2) 0 pi/2 0],'modified');

L(6)= Link([theta(6)+pi/2 0 0 pi/2 0],'modified');

L(7)= Link([theta(7)+pi 0 l(3) pi/2 0],'modified');

M=SerialLink([L(1) L(2) L(3) L(4) L(5) L(6) L(7)]);

%Generating grayscale image

for z=z1:zLayerHeight:z2;

if z==z2

disp('Test')

else

%Invoking the surface function for at the height "z"

[surfPlan,SizeZ] = surfaceRobotTest(L,M,interpVal,numVxl,x1,x2,y1,y2,z);

[SizeX,SizeY]=size(surfPlan);

endX=zeros(1,SizeX);

endY=zeros(1,SizeY);

%Calculating the trajectories from joint angle to Cartesian Coordinates

for i=1:size(surfPlan);

hmTrans=M.fkine(surfPlan(i,:));

vector=hmTrans.t;

endX(i)=vector(1);

endY(i)=vector(2);

%Optional Visualization: M.plot(surfPlan(i,:))

end

%Prelocating space for intermidiate matrices to save time

[~,y]=size(endY);

preFitx=zeros(1,(SizeZ-1)\*interpVal);

preFity=zeros(1,(SizeZ-1)\*interpVal);

standardD=zeros(1,y/((SizeZ-1)\*interpVal));

a=1;

b=(SizeZ-1)\*interpVal;

%Finding the standard deviation of actual trajectories to ideal

%ones

for i=1:(y/((SizeZ-1)\*interpVal))

for k=a:b

preFitx(k)=endX(1,k);

preFity(k)=endY(1,k);

end

[~,y3]=size(preFitx);

[~,y4]=size(endX);

normalx=preFitx(1):(preFitx(k)-preFitx(1))/(y3-1):preFitx(k);

normaly=preFity(1):(preFity(k)-preFity(1))/(y3-1):preFity(k);

for k1=1:1:((y4)/2)

preFity(k)=normaly(k)

end

for k2=(((y4)/2)+1):1:y4

preFitx(k)=normalx(k)

end

standardD=std([preFity;preFitx],0,1);

a=a+(SizeZ-1)\*interpVal;

b=b+(SizeZ-1)\*interpVal;

end

rowGrayScale=mat2gray(standardD);

dataGraySclImage=vertcat(dataGraySclImage,rowGrayScale);

end

end

%Trajectory Planning for a surface

function [surfPlan,SizeZ]= surfaceRobotTest(L,M,interpVal,numVxl,x1,x2,y1,y2,z)

surfPlan=[];

%Linear test along the y-direction

for i=x1:x2

terminal1=transl(i,y1,z);

terminal2=transl(i,y2,z);

[linPlan,SizeZ]=linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2);

surfPlan=vertcat(surfPlan,linPlan);

end

SizeZ=SizeZ;

%Linear test along the x-direction

for i=y1:y2

terminal1=transl(x1,i,z);

terminal2=transl(x2,i,z);

linPlan=linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2);

surfPlan=vertcat(surfPlan,linPlan);

end

end

%Trajectory Planning for a line

function [linPlan,SizeZ] = linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2)

linVoxel=trinterp(terminal1,terminal2,numVxl-1);

[~,~,SizeZ]=size(linVoxel);

linPlan=zeros((SizeZ-1)\*interpVal,numel(L));

for i=1:SizeZ-1

ptPlan=M.jtraj(linVoxel(:,:,i),linVoxel(:,:,i+1),interpVal);

index1=1+(i-1)\*interpVal;

index2=i\*interpVal;

linPlan(index1:index2,:)=ptPlan(:,:);

end

end

for i=1:size(surfPlan);

hmTrans=M.fkine(surfPlan(i,:));

vector=hmTrans.t;

endX(i)=vector(1);

endY(i)=vector(2);

%Optional Visualization: M.plot(surfPlan(i,:))

end

%Prelocating space for intermidiate matrices to save time

[~,y]=size(endY);

preFitx=zeros(1,(SizeZ-1)\*interpVal);

preFity=zeros(1,(SizeZ-1)\*interpVal);

standardD=zeros(1,y/((SizeZ-1)\*interpVal));

a=1;

b=(SizeZ-1)\*interpVal;

%Finding the standard deviation of actual trajectories to ideal

%ones

for i=1:(y/((SizeZ-1)\*interpVal))

for k=a:b

preFitx(k)=endX(1,k);

preFity(k)=endY(1,k);

end

[~,y3]=size(preFitx);

[~,y4]=size(endX);

normalx=preFitx(1):(preFitx(k)-preFitx(1))/(y3-1):preFitx(k);

normaly=preFity(1):(preFity(k)-preFity(1))/(y3-1):preFity(k);

for k1=1:1:((y4)/2)

preFity(k)=normaly(k)

end

for k2=(((y4)/2)+1):1:y4

preFitx(k)=normalx(k)

end

standardD=std([preFity;preFitx],0,1);

a=a+(SizeZ-1)\*interpVal;

b=b+(SizeZ-1)\*interpVal;

end

rowGrayScale=mat2gray(standardD);

dataGraySclImage=vertcat(dataGraySclImage,rowGrayScale);

end

end

%Trajectory Planning for a surface

function [surfPlan,SizeZ]= surfaceRobotTest(L,M,interpVal,numVxl,x1,x2,y1,y2,z)

surfPlan=[];

%Linear test along the y-direction

for i=x1:x2

terminal1=transl(i,y1,z);

terminal2=transl(i,y2,z);

[linPlan,SizeZ]=linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2);

surfPlan=vertcat(surfPlan,linPlan);

end

SizeZ=SizeZ;

%Linear test along the x-direction

for i=y1:y2

terminal1=transl(x1,i,z);

terminal2=transl(x2,i,z);

linPlan=linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2);

surfPlan=vertcat(surfPlan,linPlan);

end

end

%Trajectory Planning for a line

function [linPlan,SizeZ] = linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2)

linVoxel=trinterp(terminal1,terminal2,numVxl-1);

[~,~,SizeZ]=size(linVoxel);

linPlan=zeros((SizeZ-1)\*interpVal,numel(L));

for i=1:SizeZ-1

ptPlan=M.jtraj(linVoxel(:,:,i),linVoxel(:,:,i+1),interpVal);

index1=1+(i-1)\*interpVal;

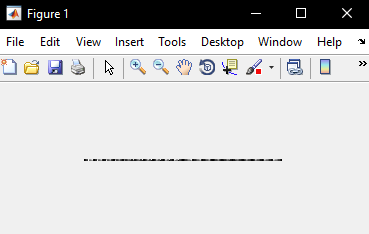
index2=i\*interpVal;

linPlan(index1:index2,:)=ptPlan(:,:);

end

end

**Visualization 1 (in grayscale image: darker means less error**



[linPlan,SizeZ]=linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2);

surfPlan=vertcat(surfPlan,linPlan);

end

SizeZ=SizeZ;

%Linear test along the x-direction

for i=y1:y2

terminal1=transl(x1,i,z);

terminal2=transl(x2,i,z);

linPlan=linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2);

surfPlan=vertcat(surfPlan,linPlan);

end

end

%Trajectory Planning for a line

function [linPlan,SizeZ] = linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2)

linVoxel=trinterp(terminal1,terminal2,numVxl-1);

[~,~,SizeZ]=size(linVoxel);

linPlan=zeros((SizeZ-1)\*interpVal,numel(L));

for i=1:SizeZ-1

ptPlan=M.jtraj(linVoxel(:,:,i),linVoxel(:,:,i+1),interpVal);

index1=1+(i-1)\*interpVal;

index2=i\*interpVal;

linPlan(index1:index2,:)=ptPlan(:,:);

end

end

**Workspace:**

**Trajectory planning of motion in 2D plane:**

Joint angles=

0.0162 0.1810 0.2488 0.9734 -1.4406 -1.3771 -2.3510

0.0151 0.1193 0.2329 1.1004 -1.4715 -1.3783 -2.5425

0.0140 0.0576 0.2170 1.2274 -1.5024 -1.3795 -2.7341

0.0140 0.0576 0.2170 1.2274 -1.5024 -1.3795 -2.7341

-0.8730 -0.3857 -0.1243 1.0747 -0.4216 -0.5829 -1.6583

-1.7600 -0.8289 -0.4655 0.9220 0.6592 0.2136 -0.5824

-1.7600 -0.8289 -0.4655 0.9220 0.6592 0.2136 -0.5824

-1.5690 -0.7554 -0.3825 1.0414 0.7982 0.3721 -0.5414

-1.3780 -0.6819 -0.2995 1.1608 0.9373 0.5306 -0.5004

0.4527 0.2919 0.7479 1.0388 -1.5221 -1.2385 -2.3574

0.2586 0.2036 0.5083 1.1650 -1.5215 -1.3053 -2.5500

0.0644 0.1153 0.2686 1.2911 -1.5208 -1.3722 -2.7427

0.0644 0.1153 0.2686 1.2911 -1.5208 -1.3722 -2.7427

-0.7971 -0.3293 -0.0995 1.1401 -0.3322 -0.5225 -1.5766

-1.6586 -0.7738 -0.4676 0.9891 0.8565 0.3272 -0.4106

-1.6586 -0.7738 -0.4676 0.9891 0.8565 0.3272 -0.4106

-1.4532 -0.6990 -0.3862 1.1008 0.9612 0.4916 -0.4053

-1.2477 -0.6242 -0.3049 1.2124 1.0660 0.6560 -0.3999

0.4542 0.3534 0.7597 1.1161 -1.5662 -1.2084 -2.3914

0.3225 0.2663 0.5868 1.2378 -1.5614 -1.2756 -2.5739

0.1908 0.1793 0.4138 1.3595 -1.5565 -1.3427 -2.7565

0.1908 0.1793 0.4138 1.3595 -1.5565 -1.3427 -2.7565

-0.6575 -0.2573 -0.0272 1.2092 -0.2566 -0.4280 -1.5091

-1.5059 -0.6939 -0.4683 1.0589 1.0432 0.4868 -0.2617

-1.5059 -0.6939 -0.4683 1.0589 1.0432 0.4868 -0.2617

-1.3186 -0.6289 -0.3911 1.1592 1.1025 0.6300 -0.2949

-1.1313 -0.5639 -0.3138 1.2595 1.1617 0.7732 -0.3281

0.4861 0.4276 0.8172 1.1990 -1.6275 -1.1592 -2.4351

0.4907 0.3612 0.8139 1.3181 -1.6490 -1.1918 -2.6115

0.4954 0.2948 0.8105 1.4372 -1.6706 -1.2243 -2.7878

0.4954 0.2948 0.8105 1.4372 -1.6706 -1.2243 -2.7878

-0.4012 -0.1489 0.1795 1.2805 -0.2318 -0.2698 -1.4689

-1.2979 -0.5926 -0.4515 1.1237 1.2070 0.6847 -0.1500

-1.2979 -0.5926 -0.4515 1.1237 1.2070 0.6847 -0.1500

-1.1444 -0.5443 -0.3783 1.2149 1.2304 0.7917 -0.2097

-0.9910 -0.4961 -0.3051 1.3062 1.2539 0.8987 -0.2693

0.5513 0.5310 0.9398 1.2927 -1.7302 -1.0725 -2.5025

0.5398 0.4582 0.9203 1.4084 -1.7442 -1.1184 -2.6691

0.5282 0.3854 0.9008 1.5240 -1.7582 -1.1643 -2.8358

0.5282 0.3854 0.9008 1.5240 -1.7582 -1.1643 -2.8358

-0.2288 -0.0442 0.2680 1.3530 -0.1972 -0.1204 -1.4537

-0.9857 -0.4737 -0.3648 1.1821 1.3638 0.9234 -0.0716

-0.9857 -0.4737 -0.3648 1.1821 1.3638 0.9234 -0.0716

-0.8620 -0.4447 -0.2939 1.2682 1.3685 0.9939 -0.1442

-0.7383 -0.4156 -0.2231 1.3544 1.3733 1.0644 -0.2168

0.6224 0.6798 1.1242 1.4124 -1.9206 -0.9421 -2.6373

0.5706 0.5720 1.0332 1.5152 -1.8818 -1.0337 -2.7659

0.5188 0.4641 0.9423 1.6180 -1.8429 -1.1254 -2.8945

0.5188 0.4641 0.9423 1.6180 -1.8429 -1.1254 -2.8945

-0.1203 0.0389 0.3288 1.4238 -0.1974 -0.0229 -1.4647

-0.7594 -0.3864 -0.2847 1.2295 1.4482 1.0797 -0.0349

-0.7594 -0.3864 -0.2847 1.2295 1.4482 1.0797 -0.0349

-0.6771 -0.3690 -0.2311 1.3135 1.4406 1.1198 -0.1118

-0.5949 -0.3516 -0.1775 1.3975 1.4329 1.1600 -0.1888

0.6406 0.8293 1.3004 1.5613 -2.1950 -0.8380 -2.8644

0.5574 0.6755 1.1140 1.6380 -2.0490 -0.9783 -2.9071

0.4742 0.5218 0.9276 1.7148 -1.9029 -1.1186 -2.9498

0.4742 0.5218 0.9276 1.7148 -1.9029 -1.1186 -2.9498

-0.0287 0.1055 0.3773 1.4951 -0.1945 0.0430 -1.4808

-0.5317 -0.3108 -0.1730 1.2754 1.5139 1.2046 -0.0118

-0.5317 -0.3108 -0.1730 1.2754 1.5139 1.2046 -0.0118

-0.4886 -0.3006 -0.1421 1.3583 1.4988 1.2230 -0.0900

-0.4455 -0.2903 -0.1112 1.4413 1.4838 1.2414 -0.1681

0.6000 0.8783 1.3207 1.6735 -2.3105 -0.8471 -2.9753

0.5155 0.7286 1.1196 1.7459 -2.1384 -0.9822 -2.9932

0.4311 0.5789 0.9184 1.8182 -1.9664 -1.1173 -3.0111

0.4311 0.5789 0.9184 1.8182 -1.9664 -1.1173 -3.0111

0.0546 0.1661 0.4360 1.5699 -0.2031 0.0883 -1.5041

-0.3218 -0.2467 -0.0464 1.3216 1.5603 1.2939 0.0029

-0.3218 -0.2467 -0.0464 1.3216 1.5603 1.2939 0.0029

-0.3103 -0.2395 -0.0379 1.4040 1.5418 1.2993 -0.0752

-0.2989 -0.2323 -0.0295 1.4865 1.5233 1.3046 -0.1533

0.4651 0.7652 0.9997 1.7126 -2.0465 -1.0153 -2.8197

0.4429 0.7148 0.9998 1.8263 -2.0745 -1.0522 -2.9657

0.4207 0.6643 0.9998 1.9401 -2.1025 -1.0891 -3.1116

0.4207 0.6643 0.9998 1.9401 -2.1025 -1.0891 -3.1116

0.1489 0.2373 0.5475 1.6547 -0.2555 0.1328 -1.5494

-0.1230 -0.1898 0.0951 1.3693 1.5915 1.3547 0.0129

-0.1230 -0.1898 0.0951 1.3693 1.5915 1.3547 0.0129

-0.1390 -0.1834 0.0812 1.4514 1.5714 1.3524 -0.0650

-0.1550 -0.1769 0.0672 1.5336 1.5513 1.3502 -0.1428

0.7200 1.6227 1.9723 1.0912 -0.8762 0.4372 -1.0640

0.5638 1.1937 1.5537 1.5851 -1.5915 -0.3119 0.9839

0.4077 0.7648 1.1350 2.0789 -2.3069 -1.0610 3.0317

0.4077 0.7648 1.1350 2.0789 -2.3069 -1.0610 3.0317

0.2363 0.3143 0.6918 1.7490 -0.3496 0.1646 1.5258

0.0650 -0.1362 0.2486 1.4192 1.6078 1.3901 0.0198

0.0650 -0.1362 0.2486 1.4192 1.6078 1.3901 0.0198

0.0239 -0.1295 0.2122 1.5011 1.5870 1.3841 -0.0579

-0.0172 -0.1227 0.1758 1.5830 1.5663 1.3780 -0.1356

0.7838 1.4140 1.9059 1.0881 -0.4173 0.3233 -0.7443

0.5748 1.1314 1.5749 1.6544 -1.4593 -0.3727 1.0788

0.3657 0.8488 1.2440 2.2207 -2.5013 -1.0686 2.9019

0.3657 0.8488 1.2440 2.2207 -2.5013 -1.0686 2.9019

0.3045 0.3835 0.8290 1.8461 -0.4468 0.1668 1.4633

0.2433 -0.0818 0.4140 1.4716 1.6078 1.4022 0.0246

0.2433 -0.0818 0.4140 1.4716 1.6078 1.4022 0.0246

0.1747 -0.0746 0.3512 1.5534 1.5870 1.3952 -0.0533

0.1061 -0.0673 0.2883 1.6352 1.5662 1.3883 -0.1311

0.0162 0.1810 0.2488 0.9734 -1.4406 -1.3771 -2.3510

0.2603 0.3193 0.5494 1.1010 -1.5479 -1.2563 -2.4023

0.5044 0.4577 0.8500 1.2286 -1.6552 -1.1355 -2.4536

0.5044 0.4577 0.8500 1.2286 -1.6552 -1.1355 -2.4536

0.5620 0.6688 1.0984 1.4370 -1.9854 -0.9818 -2.7135

0.6195 0.8799 1.3467 1.6454 -2.3155 -0.8281 -2.9735

0.6195 0.8799 1.3467 1.6454 -2.3155 -0.8281 -2.9735

0.7017 1.1470 1.6263 1.3668 -1.3664 -0.2524 -1.8589

0.7838 1.4140 1.9059 1.0881 -0.4173 0.3233 -0.7443

0.4210 0.1652 0.6845 1.0414 -1.4923 -1.3052 -2.4598

0.5390 0.3350 0.8839 1.1740 -1.6298 -1.1700 -2.5271

0.6570 0.5048 1.0833 1.3066 -1.7673 -1.0347 -2.5944

0.6570 0.5048 1.0833 1.3066 -1.7673 -1.0347 -2.5944

0.5433 0.5529 0.9658 1.4577 -1.8121 -1.0718 -2.6718

0.4296 0.6010 0.8483 1.6088 -1.8569 -1.1090 -2.7492

0.4296 0.6010 0.8483 1.6088 -1.8569 -1.1090 -2.7492

0.4339 0.7791 1.1019 1.8379 -2.2231 -1.0385 0.1228

0.4382 0.9573 1.3555 2.0669 -2.5894 -0.9681 2.9949

0.0813 0.0984 0.2986 1.1207 -1.4821 -1.3715 -2.5854

0.3703 0.2765 0.6896 1.2484 -1.6294 -1.2197 -2.6413

0.6593 0.4546 1.0806 1.3760 -1.7766 -1.0679 -2.6972

0.6593 0.4546 1.0806 1.3760 -1.7766 -1.0679 -2.6972

0.6128 0.5813 1.1338 1.5502 -1.9568 -1.0167 -2.8433

0.5663 0.7081 1.1869 1.7243 -2.1370 -0.9655 -2.9895

0.5663 0.7081 1.1869 1.7243 -2.1370 -0.9655 -2.9895

0.4169 0.7208 0.9743 1.8888 -2.0775 -1.0723 -3.0197

0.2674 0.7335 0.7617 2.0532 -2.0179 -1.1791 -3.0500

0.0548 0.0668 0.2621 1.2001 -1.4982 -1.3763 -2.6974

0.2985 0.2070 0.5762 1.3203 -1.6035 -1.2785 -2.7346

0.5422 0.3472 0.8904 1.4405 -1.7088 -1.1806 -2.7717

0.5422 0.3472 0.8904 1.4405 -1.7088 -1.1806 -2.7717

0.5184 0.4757 0.9559 1.6047 -1.8592 -1.1238 -2.8828

0.4947 0.6042 1.0215 1.7689 -2.0096 -1.0669 -2.9940

0.4947 0.6042 1.0215 1.7689 -2.0096 -1.0669 -2.9940

0.4389 0.7394 1.1599 1.9844 -2.2812 -1.0562 -0.0490

0.3831 0.8746 1.2984 2.1998 -2.5529 -1.0456 2.8959

0.1024 0.0437 0.3048 1.2828 -1.5169 -1.3754 -2.8053

0.3458 0.1922 0.6336 1.4032 -1.6353 -1.2721 -2.8442

0.5892 0.3406 0.9625 1.5235 -1.7536 -1.1688 -2.8831

0.5892 0.3406 0.9625 1.5235 -1.7536 -1.1688 -2.8831

0.5091 0.4411 0.9345 1.6798 -1.8527 -1.1516 -2.9670

0.4290 0.5417 0.9065 1.8360 -1.9519 -1.1344 -3.0508

0.4290 0.5417 0.9065 1.8360 -1.9519 -1.1344 -3.0508

0.3331 0.6285 0.8521 2.0335 -2.0264 -1.1700 -0.0088

0.2373 0.7154 0.7976 2.2310 -2.1010 -1.2057 3.0332

0.0015 0.0259 0.1959 1.3697 -1.5315 -1.3803 -2.9109

0.0615 0.1245 0.2678 1.4833 -1.5678 -1.3654 -2.9319

0.1215 0.2231 0.3396 1.5970 -1.6042 -1.3506 -2.9529

0.1215 0.2231 0.3396 1.5970 -1.6042 -1.3506 -2.9529

0.2514 0.3659 0.5913 1.7579 -1.7722 -1.2622 -3.0436

0.3813 0.5087 0.8431 1.9187 -1.9402 -1.1739 -3.1342

0.3813 0.5087 0.8431 1.9187 -1.9402 -1.1739 -3.1342

0.3012 0.6152 0.8468 2.1304 -2.0619 -1.1952 -0.1097

0.2211 0.7216 0.8506 2.3421 -2.1835 -1.2165 2.9148

-1.6988 -0.8134 -0.4272 0.9107 0.8152 0.2303 -0.4587

-1.2928 -0.6547 -0.3546 1.0193 1.1133 0.5846 -0.2517

-0.8868 -0.4960 -0.2821 1.1279 1.4114 0.9389 -0.0447

-0.8868 -0.4960 -0.2821 1.1279 1.4114 0.9389 -0.0447

-0.5746 -0.3805 -0.1389 1.2020 1.4957 1.1217 -0.0070

-0.2624 -0.2651 0.0043 1.2760 1.5800 1.3044 0.0308

-0.2624 -0.2651 0.0043 1.2760 1.5800 1.3044 0.0308

0.1889 -0.1851 0.3863 1.3588 1.6152 1.3770 0.0423

0.6401 -0.1052 0.7683 1.4415 1.6504 1.4495 0.0538

-1.5965 -0.7730 -0.3816 0.9769 0.8778 0.3209 -0.4475

-1.3656 -0.6541 -0.3901 1.0702 1.0804 0.5634 -0.2868

-1.1348 -0.5352 -0.3986 1.1634 1.2831 0.8060 -0.1262

-1.1348 -0.5352 -0.3986 1.1634 1.2831 0.8060 -0.1262

-0.7670 -0.4012 -0.2475 1.2424 1.4116 1.0355 -0.0717

-0.3992 -0.2671 -0.0965 1.3214 1.5401 1.2651 -0.0173

-0.3992 -0.2671 -0.0965 1.3214 1.5401 1.2651 -0.0173

-0.0813 -0.1745 0.1554 1.4040 1.5724 1.3334 -0.0042

0.2366 -0.0820 0.4073 1.4867 1.6047 1.4016 0.0090

-1.3704 -0.7086 -0.2911 1.0618 1.0398 0.4879 -0.3811

-1.1702 -0.6032 -0.3034 1.1401 1.1817 0.6963 -0.2689

-0.9700 -0.4977 -0.3156 1.2184 1.3235 0.9047 -0.1568

-0.9700 -0.4977 -0.3156 1.2184 1.3235 0.9047 -0.1568

-0.6769 -0.3811 -0.2000 1.2937 1.4266 1.0876 -0.1107

-0.3837 -0.2644 -0.0844 1.3690 1.5296 1.2706 -0.0646

-0.3837 -0.2644 -0.0844 1.3690 1.5296 1.2706 -0.0646

-0.1161 -0.1714 0.1223 1.4513 1.5595 1.3320 -0.0511

0.1515 -0.0784 0.3290 1.5336 1.5895 1.3935 -0.0376

-1.3528 -0.6921 -0.2865 1.1129 1.0042 0.5209 -0.4327

-1.1579 -0.5898 -0.2981 1.1907 1.1516 0.7192 -0.3196

-0.9630 -0.4875 -0.3098 1.2685 1.2989 0.9176 -0.2065

-0.9630 -0.4875 -0.3098 1.2685 1.2989 0.9176 -0.2065

-0.6728 -0.3735 -0.1966 1.3437 1.4077 1.0952 -0.1590

-0.3826 -0.2594 -0.0835 1.4189 1.5164 1.2729 -0.1116

-0.3826 -0.2594 -0.0835 1.4189 1.5164 1.2729 -0.1116

-0.1371 -0.1666 0.1031 1.5010 1.5465 1.3310 -0.0979

0.1084 -0.0738 0.2896 1.5830 1.5767 1.3892 -0.0843

-1.3780 -0.6819 -0.2995 1.1608 0.9373 0.5306 -0.5004

-1.1588 -0.5772 -0.2984 1.2411 1.1102 0.7357 -0.3766

-0.9397 -0.4726 -0.2973 1.3215 1.2832 0.9407 -0.2528

-0.9397 -0.4726 -0.2973 1.3215 1.2832 0.9407 -0.2528

-0.6424 -0.3619 -0.1770 1.3964 1.3975 1.1134 -0.2052

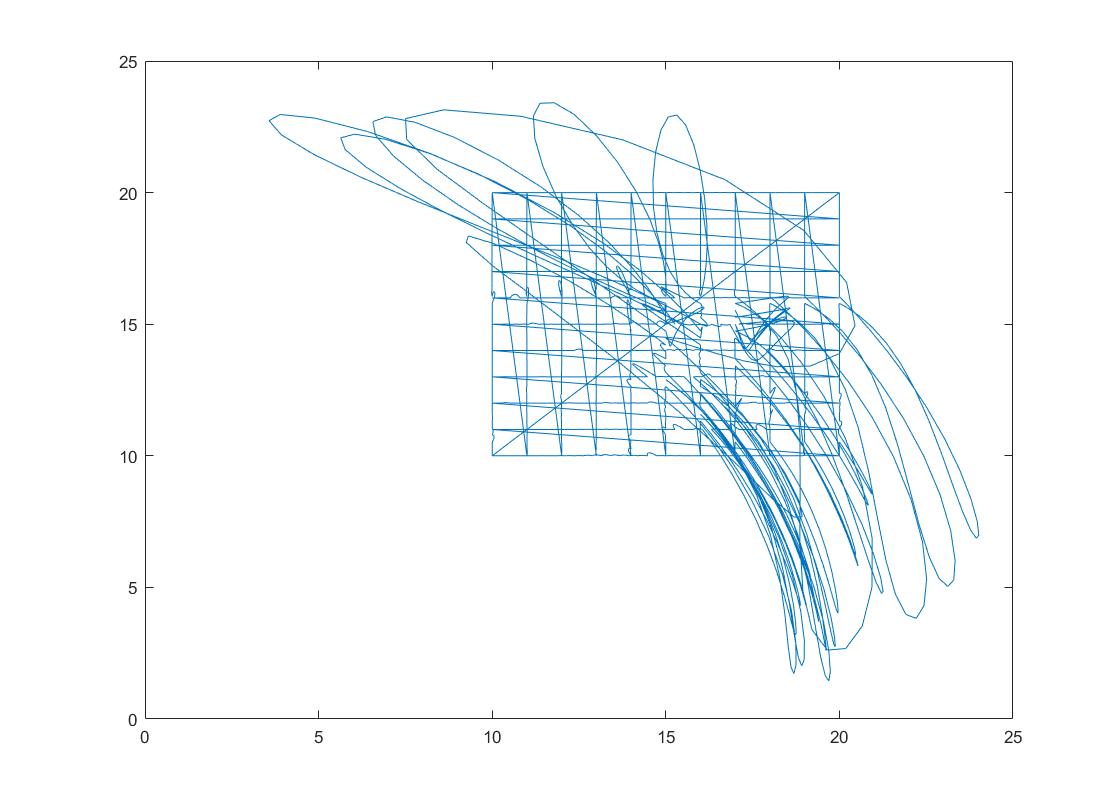
-0.3452 -0.2512 -0.0568 1.4712 1.5119 1.2861 -0.1577

-0.3452 -0.2512 -0.0568 1.4712 1.5119 1.2861 -0.1577

-0.1195 -0.1593 0.1158 1.5532 1.5390 1.3372 -0.1444

0.1061 -0.0673 0.2883 1.6352 1.5662 1.3883 -0.1311

**Visualization 2: Trajectory of the manipulator**



Tentative data generation: Gray scale images corresponding to the accuracy map of a manipulator in motion between nodes of cuboid partitions in Cartesian 3D space

Date: 9/30/17

Alexander Liao

Brainstorming

**Function 1:**

%Trajectory Planning for a line

function [linPlan,SizeZ] = linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2)

linVoxel=trinterp(terminal1,terminal2,numVxl);

[~,~,SizeZ]=size(linVoxel);

linPlan=zeros((SizeZ-1)\*interpVal,numel(L));

for i=1:SizeZ-1

intm=ctraj(linVoxel(:,:,i),linVoxel(:,:,i+1),interpVal);

ptPlan=M.ikine6s(intm);

index1=1+(i-1)\*interpVal;

index2=i\*interpVal;

linPlan(index1:index2,:)=ptPlan(:,:);

end

end

**Function 2:**

%Trajectory Planning for a surface

function [surfPlan,SizeZ]= surfaceRobotTest(L,M,interpVal,numVxl,x1,x2,y1,y2,z)

surfPlan=[];

for i=x1:abs((x2-x1)/(numVxl)):x2

terminal1=transl(i,y1,z);

terminal2=transl(i,y2,z);

[linPlan,SizeZ]=linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2);

surfPlan=vertcat(surfPlan,linPlan);

end

end

**Main file:**

%Initialization

clear all

numData=1;

%Target Space

spc\_x1=0.2;

xmin=spc\_x1;

spc\_x2=0.6;

xmax=spc\_x2;

spc\_y1=-0.2;

ymin=spc\_y1;

spc\_y2=0.2;

ymax=spc\_y2;

spc\_z1=-0.4;

zmin=spc\_z1;

spc\_z2=0;

zmax=spc\_z2;

%Specifications for Voxels

vxl\_interpVal=10;

vxl\_num=5;

vxl\_zLayerHeight=0.025;

%Final Result

performanceVector=[];

performanceMatrix=[];

inputMatrix=[];

x1=[xmin xmin xmax xmax];

y1=[ymin ymax ymax ymin];

z1=[zmin zmin zmin zmin];

x2=[xmin xmin xmax xmax];

y2=[ymin ymax ymax ymin];

z2=[zmax zmax zmax zmax];

x3=[xmin xmin xmin xmin];

y3=[ymin ymax ymax ymin];

z3=[zmax zmax zmin zmin];

x4=[xmax xmax xmax xmax];

y4=[ymin ymax ymax ymin];

z4=[zmax zmax zmin zmin];

x5=[xmin xmax xmax xmin];

y5=[ymin ymin ymin ymin];

z5=[zmax zmax zmin zmin];

x6=[xmin xmax xmax xmin];

y6=[ymax ymax ymax ymax];

z6=[zmax zmax zmin zmin];

for num=1:numData

rawdata=[];

performanceVector=[];

%{

%SerialLink Parameters

link\_theta=[0 0 0 0 0 0];

link\_D=[ 0 0 rand() rand() 0 0];

link\_A=[0 rand() 0 0 0 0];

link\_Alpha=[pi/2 0 -pi/2 pi/2 -pi/2 0];

linkType=[0 0 0 0 0 0];

%Creating the SerialLink object

linkL(1)= Link([link\_theta(1) link\_D(1) link\_A(1) link\_Alpha(1) linkType(1)]);

linkL(2)= Link([link\_theta(2) link\_D(2) link\_A(2) link\_Alpha(2) linkType(2)]);

linkL(3)= Link([link\_theta(3) link\_D(3) link\_A(3) link\_Alpha(3) linkType(3)]);

linkL(4)= Link([link\_theta(4) link\_D(4) link\_A(4) link\_Alpha(4) linkType(4)]);

linkL(5)= Link([link\_theta(5) link\_D(5) link\_A(5) link\_Alpha(5) linkType(5)]);

linkL(6)= Link([link\_theta(6) link\_D(6) link\_A(6) link\_Alpha(6) linkType(6)]);

link\_M=SerialLink([linkL(1) linkL(2) linkL(3) linkL(4) linkL(5) linkL(6)]);

link\_M.plot(link\_theta);

%Generating grayscale image

%}

link\_D=[ 0 0 rand() rand() 0 0];

link\_A=[ 0 rand() 0 0 0 0];

link\_alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 link\_D(1) link\_A(1) link\_alpha(1)]);

l2=Link([0 link\_D(2) link\_A(2) link\_alpha(2)]);

l3=Link([0 link\_D(3) link\_A(3) link\_alpha(3)]);

l4=Link([0 link\_D(4) link\_A(4) link\_alpha(4)]);

l5=Link([0 link\_D(5) link\_A(5) link\_alpha(5)]);

l6=Link([0 link\_D(6) link\_A(6) link\_alpha(6)]);

linkL=[l1,l2,l3,l4,l5,l6];

mdl\_puma560;

link\_M=SerialLink(p560);

%{

link\_M.plot([0 0 0 0 0 0]);

hold on

patch(x1,y1,z1,'blue','facealpha',.25)

hold on

patch(x2,y2,z2,'blue','facealpha',.25)

hold on

patch(x3,y3,z3,'red','facealpha',.25)

hold on

patch(x4,y4,z4,'red','facealpha',.25)

hold on

patch(x5,y5,z5,'yellow','facealpha',.25)

hold on

patch(x6,y6,z6,'yellow','facealpha',.25)

hold on

%}

for z=spc\_z1:vxl\_zLayerHeight:spc\_z2

if z==spc\_z2

disp('\*');

else

%Invoking the surface function for at the height "z"

logic=0;

while logic==0

try

[surfPlan,SizeZ] = surfaceRobotTest(linkL,link\_M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

logic=1;

catch

warning('jtraj function error. Generating a new random arm.')

link\_D=[ 0 0 rand() rand() 0 0];

link\_A=[ 0 rand() 0 0 0 0];

link\_alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 link\_D(1) link\_A(1) link\_alpha(1)]);

l2=Link([0 link\_D(2) link\_A(2) link\_alpha(2)]);

l3=Link([0 link\_D(3) link\_A(3) link\_alpha(3)]);

l4=Link([0 link\_D(4) link\_A(4) link\_alpha(4)]);

l5=Link([0 link\_D(5) link\_A(5) link\_alpha(5)]);

l6=Link([0 link\_D(6) link\_A(6) link\_alpha(6)]);

linkL=[l1,l2,l3,l4,l5,l6];

link\_M=SerialLink([l1,l2,l3,l4,l5,l6]);

logic=0;

end

end

[SizeX,SizeY]=size(surfPlan);

columnImage=surfPlan;

performanceVector=vertcat(performanceVector,columnImage);

end

end

inputVector=vertcat(link\_D',link\_A');

inputMatrix=horzcat(inputMatrix,inputVector);

performanceMatrix=horzcat(performanceMatrix,performanceVector);

end

for num=1:numData

rawdata=[];

performanceVector=[];

%{

%SerialLink Parameters

link\_theta=[0 0 0 0 0 0];

link\_D=[ 0 0 rand() rand() 0 0];

link\_A=[0 rand() 0 0 0 0];

link\_Alpha=[pi/2 0 -pi/2 pi/2 -pi/2 0];

linkType=[0 0 0 0 0 0];

%Creating the SerialLink object

linkL(1)= Link([link\_theta(1) link\_D(1) link\_A(1) link\_Alpha(1) linkType(1)]);

linkL(2)= Link([link\_theta(2) link\_D(2) link\_A(2) link\_Alpha(2) linkType(2)]);

linkL(3)= Link([link\_theta(3) link\_D(3) link\_A(3) link\_Alpha(3) linkType(3)]);

linkL(4)= Link([link\_theta(4) link\_D(4) link\_A(4) link\_Alpha(4) linkType(4)]);

linkL(5)= Link([link\_theta(5) link\_D(5) link\_A(5) link\_Alpha(5) linkType(5)]);

linkL(6)= Link([link\_theta(6) link\_D(6) link\_A(6) link\_Alpha(6) linkType(6)]);

link\_M=SerialLink([linkL(1) linkL(2) linkL(3) linkL(4) linkL(5) linkL(6)]);

link\_M.plot(link\_theta);

%Generating grayscale image

%}

link\_D=[ 0 0 rand() rand() 0 0];

link\_A=[ 0 rand() 0 0 0 0];

link\_alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 link\_D(1) link\_A(1) link\_alpha(1)]);

l2=Link([0 link\_D(2) link\_A(2) link\_alpha(2)]);

l3=Link([0 link\_D(3) link\_A(3) link\_alpha(3)]);

l4=Link([0 link\_D(4) link\_A(4) link\_alpha(4)]);

l5=Link([0 link\_D(5) link\_A(5) link\_alpha(5)]);

l6=Link([0 link\_D(6) link\_A(6) link\_alpha(6)]);

linkL=[l1,l2,l3,l4,l5,l6];

mdl\_puma560;

link\_M=SerialLink(p560);

%{

link\_M.plot([0 0 0 0 0 0]);

hold on

patch(x1,y1,z1,'blue','facealpha',.25)

hold on

patch(x2,y2,z2,'blue','facealpha',.25)

hold on

patch(x3,y3,z3,'red','facealpha',.25)

hold on

patch(x4,y4,z4,'red','facealpha',.25)

hold on

patch(x5,y5,z5,'yellow','facealpha',.25)

hold on

patch(x6,y6,z6,'yellow','facealpha',.25)

hold on

%}

for z=spc\_z1:vxl\_zLayerHeight:spc\_z2

if z==spc\_z2

disp('\*');

else

%Invoking the surface function for at the height "z"

logic=0;

while logic==0

try

[surfPlan,SizeZ] = surfaceRobotTest(linkL,link\_M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

logic=1;

catch

warning('jtraj function error. Generating a new random arm.')

link\_D=[ 0 0 rand() rand() 0 0];

link\_A=[ 0 rand() 0 0 0 0];

link\_alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 link\_D(1) link\_A(1) link\_alpha(1)]);

l2=Link([0 link\_D(2) link\_A(2) link\_alpha(2)]);

l3=Link([0 link\_D(3) link\_A(3) link\_alpha(3)]);

l4=Link([0 link\_D(4) link\_A(4) link\_alpha(4)]);

l5=Link([0 link\_D(5) link\_A(5) link\_alpha(5)]);

l6=Link([0 link\_D(6) link\_A(6) link\_alpha(6)]);

linkL=[l1,l2,l3,l4,l5,l6];

link\_M=SerialLink([l1,l2,l3,l4,l5,l6]);

logic=0;

end

end

[SizeX,SizeY]=size(surfPlan);

columnImage=surfPlan;

performanceVector=vertcat(performanceVector,columnImage);

end

end

inputVector=vertcat(link\_D',link\_A');

inputMatrix=horzcat(inputMatrix,inputVector);

performanceMatrix=horzcat(performanceMatrix,performanceVector);

end

patch(x2,y2,z2,'blue','facealpha',.25)

hold on

patch(x3,y3,z3,'red','facealpha',.25)

hold on

patch(x4,y4,z4,'red','facealpha',.25)

hold on

patch(x5,y5,z5,'yellow','facealpha',.25)

hold on

patch(x6,y6,z6,'yellow','facealpha',.25)

hold on

%}

for z=spc\_z1:vxl\_zLayerHeight:spc\_z2

if z==spc\_z2

disp('\*');

else

%Invoking the surface function for at the height "z"

logic=0;

while logic==0

try

[surfPlan,SizeZ] = surfaceRobotTest(linkL,link\_M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

logic=1;

catch

warning('jtraj function error. Generating a new random arm.')

link\_D=[ 0 0 rand() rand() 0 0];

link\_A=[ 0 rand() 0 0 0 0];

link\_alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 link\_D(1) link\_A(1) link\_alpha(1)]);

l2=Link([0 link\_D(2) link\_A(2) link\_alpha(2)]);

l3=Link([0 link\_D(3) link\_A(3) link\_alpha(3)]);

l4=Link([0 link\_D(4) link\_A(4) link\_alpha(4)]);

l5=Link([0 link\_D(5) link\_A(5) link\_alpha(5)]);

l6=Link([0 link\_D(6) link\_A(6) link\_alpha(6)]);

linkL=[l1,l2,l3,l4,l5,l6];

link\_M=SerialLink([l1,l2,l3,l4,l5,l6]);

logic=0;

end

end

[SizeX,SizeY]=size(surfPlan);

columnImage=surfPlan;

performanceVector=vertcat(performanceVector,columnImage);

end

end

inputVector=vertcat(link\_D',link\_A');

inputMatrix=horzcat(inputMatrix,inputVector);

performanceMatrix=horzcat(performanceMatrix,performanceVector);

end

columnImage=surfPlan;

performanceVector=vertcat(performanceVector,columnImage);

end

end

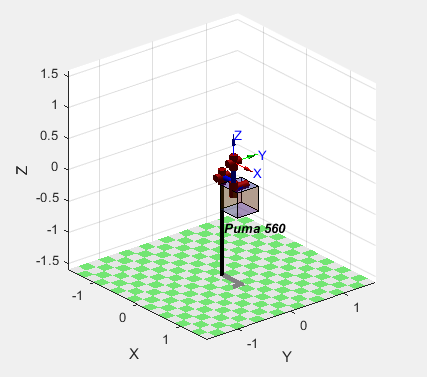
inputVector=vertcat(link\_D',link\_A');

inputMatrix=horzcat(inputMatrix,inputVector);

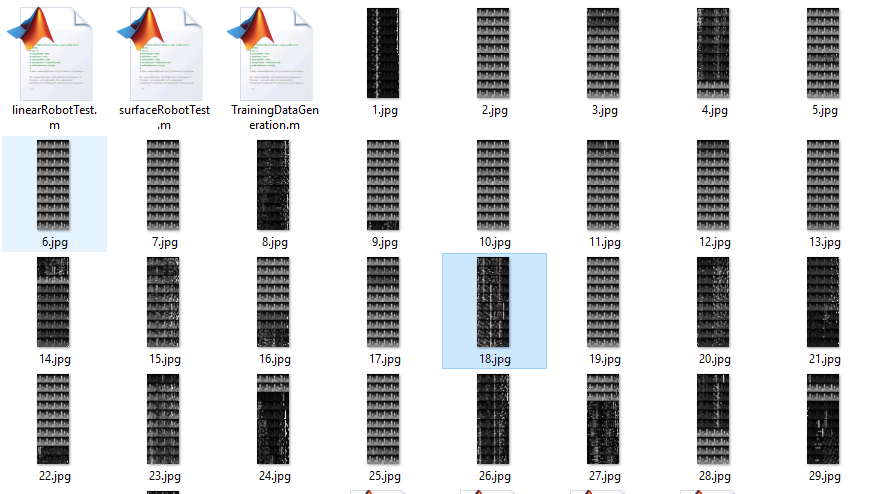
performanceMatrix=horzcat(performanceMatrix,performanceVector);

end

**Visualization 1: the transparent box denotes the boundary of the partitions**



**Sample data generation:**



***Goal: train a neural network that can predict the kinematic structure of a 7-DOF manipulator from the accuracy map***

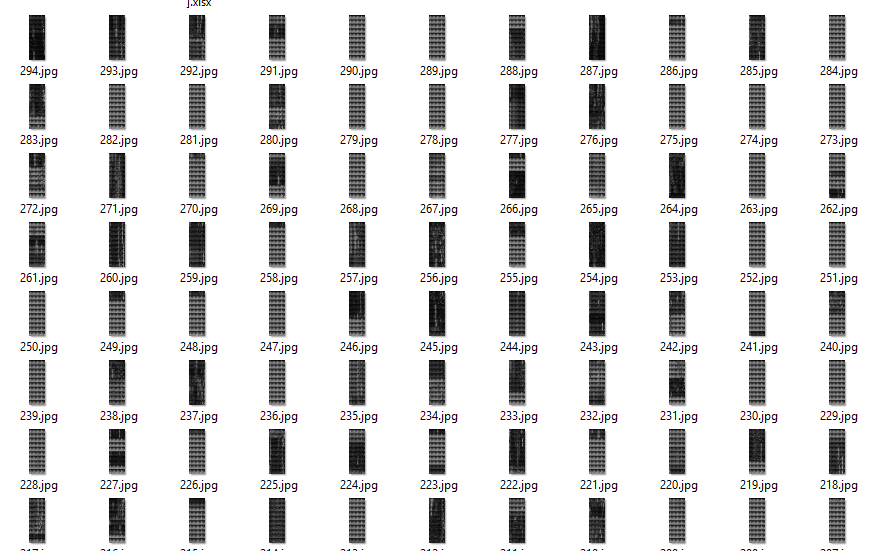
Date: 10/2/17

Alexander Liao

Idea 1

Intention: An input of artificially generated map of high accuracy will help the network to calculate the most suitable manipulator for the given task.

**Training batch of 1000 samples:**



**Rounded length of the first link (first 50 samples):**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| D3 | D27 | D13 | D16 | D23 |
| D15 | D1 | D5 | D17 | D2 |
| D19 | D10 | D28 | D0 | D14 |
| D10 | D3 | D28 | D13 | D9 |
| D7 | D13 | D30 | D28 | D6 |
| D15 | D29 | D16 | D28 | D11 |
| D9 | D11 | D24 | D6 | D23 |
| D7 | D27 | D8 | D10 | D18 |
| D3 | D12 | D27 | D1 | D2 |
| D7 | D16 | D2 | D22 | D13 |

**DH-parameters of a sample:**

2.533075365

11.99347947

7.796112086

24.00205441

12.94241482

27.31942783

5.455410849

7.914087496

4.366169412

4.082056761

26.07876623

17.39113762

16.49580606

4.348643947

1.570796327

1.570796327

1.570796327

1.570796327

1.570796327

1.570796327

1.570796327

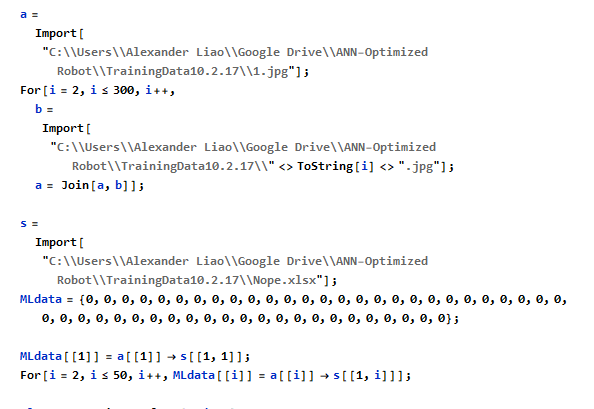
Implementation of a Convolutional Neural Network in Mathematica to predict the rounded length of the first link

Date: 10/4/17

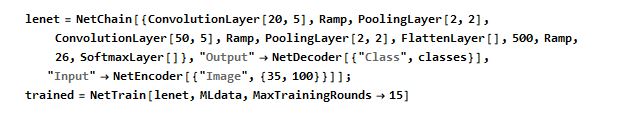
Alexander Liao

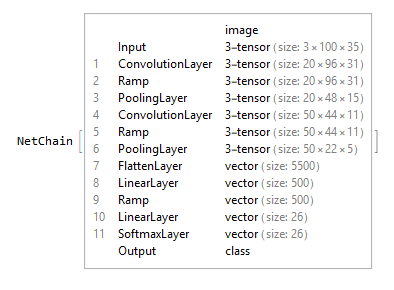
Idea 1

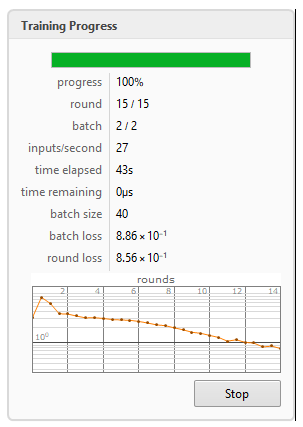
**Pre-processing of 50 samples:**



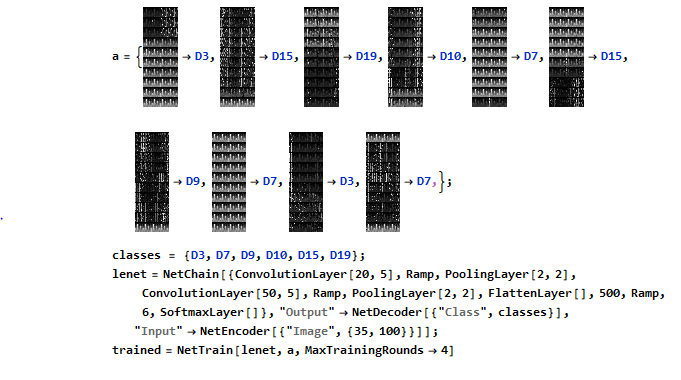
**ConvNet initialization:**



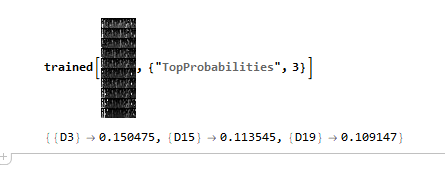


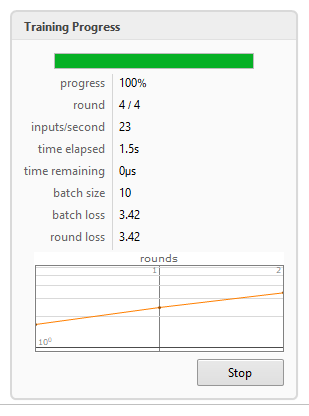


**2nd attempt:**

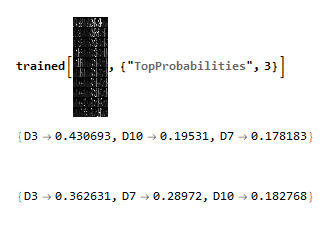


**Prediction failed:**





**Prediction failed even within the training batch (sample size too small):**



Minor modifications on the training data generation code

Date: 10/5/17

Alexander Liao

Idea 1

%Initialization

clear all

numData=1:50;

%Target Space

spc\_x1=10;

spc\_x2=20;

spc\_y1=10;

spc\_y2=20;

spc\_z1=-8;

spc\_z2=2;

%Specifications for Voxels

vxl\_interpVal=4;

vxl\_num=5;

vxl\_zLayerHeight=1;

%Final Result

Final\_dataImage=[];

Final=[];

parfor num= numData

rawdata=[];

Final\_dataImage=[];

%SerialLink Parameters

link\_theta=[0 0 0 0 0 0 0];

link\_D=30\*rand(1,7);

link\_A=30\*rand(1,7);

link\_Alpha=[pi/2,pi/2,pi/2,pi/2,pi/2,pi/2,pi/2];

linkType=[0 0 0 0 0 0 0];

linkNum=[1 2 3 4 5 6 7];

%Creating the SerialLink object

link1= Link([link\_theta(1) link\_D(1) link\_A(1) link\_Alpha(1) linkType(1)],'modified');

link2= Link([link\_theta(2) link\_D(2) link\_A(2) link\_Alpha(2) linkType(2)],'modified');

link3= Link([link\_theta(3) link\_D(3) link\_A(3) link\_Alpha(3) linkType(3)],'modified');

link4= Link([link\_theta(4) link\_D(4) link\_A(4) link\_Alpha(4) linkType(4)],'modified');

link5= Link([link\_theta(5) link\_D(5) link\_A(5) link\_Alpha(5) linkType(5)],'modified');

link6= Link([link\_theta(6) link\_D(6) link\_A(6) link\_Alpha(6) linkType(6)],'modified');

link7= Link([link\_theta(7) link\_D(7) link\_A(7) link\_Alpha(7) linkType(7)],'modified');

link\_M=SerialLink([link1 link2 link3 link4 link5 link6 link7]);

%Generating grayscale image

for z=spc\_z1:vxl\_zLayerHeight:spc\_z2

if z==spc\_z2

disp('\*');

else

%Invoking the surface function for at the height "z"

logic=0;

while logic==0

try

[surfPlan,SizeZ] = surfaceRobotTest(linkNum,link\_M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

logic=1;

catch

warning('jtraj function error. Generating a new random arm.')

%SerialLink Parameters

link\_theta=[0 0 0 0 0 0 0];

link\_D=30\*rand(1,7);

link\_A=30\*rand(1,7);

link\_Alpha=[pi/2,pi/2,pi/2,pi/2,pi/2,pi/2,pi/2];

linkType=[0 0 0 0 0 0 0];

%Creating the SerialLink object

link1= Link([link\_theta(1) link\_D(1) link\_A(1) link\_Alpha(1) linkType(1)],'modified');

link2= Link([link\_theta(2) link\_D(2) link\_A(2) link\_Alpha(2) linkType(2)],'modified');

link3= Link([link\_theta(3) link\_D(3) link\_A(3) link\_Alpha(3) linkType(3)],'modified');

link4= Link([link\_theta(4) link\_D(4) link\_A(4) link\_Alpha(4) linkType(4)],'modified');

link5= Link([link\_theta(5) link\_D(5) link\_A(5) link\_Alpha(5) linkType(5)],'modified');

link6= Link([link\_theta(6) link\_D(6) link\_A(6) link\_Alpha(6) linkType(6)],'modified');

link7= Link([link\_theta(7) link\_D(7) link\_A(7) link\_Alpha(7) linkType(7)],'modified');

link\_M=SerialLink([link1 link2 link3 link4 link5 link6 link7]);

logic=0;

end

end

[SizeX,SizeY]=size(surfPlan);

intm\_endX=zeros(1,SizeX);

intm\_endY=zeros(1,SizeY);

%Calculating the trajectories from joint angle to Cartesian Coordinates

for i=1:size(surfPlan)

hmTrans=link\_M.fkine(surfPlan(i,:));

intm\_vector=hmTrans.t;

intm\_endX(i)=intm\_vector(1);

intm\_endY(i)=intm\_vector(2);

%Optional Visualization: M.plot(surfPlan(i,:))

end

[~,surfaceDataPtsSize]=size(intm\_endY);

intm\_preFitx=[];

intm\_preFity=[];

counter=1;

intm\_residVector=[];

rawImageData=[];

numDataPt=1;

intm\_normal=[];

%Normalizing the trajectories of robot to lines

while numDataPt<=surfaceDataPtsSize

if numDataPt<= (surfaceDataPtsSize/2)

intm\_comparedData=intm\_endY(numDataPt);

intm\_normal=[];

intm\_preFity=[];

for k=1:(vxl\_interpVal-2)\*vxl\_num

if numDataPt<=surfaceDataPtsSize

b=numDataPt+vxl\_interpVal;

intm\_normal=vertcat(intm\_normal,intm\_comparedData);

intm\_preFity=vertcat(intm\_preFity,intm\_endY(numDataPt));

numDataPt=numDataPt+1;

end

end

try

intm\_residVector=abs(intm\_normal-intm\_preFity);

rawImageData=horzcat(rawImageData,intm\_residVector);

end

end

if numDataPt> (surfaceDataPtsSize/2)

intm\_comparedData=intm\_endX(numDataPt);

intm\_normal=[];

intm\_preFitx=[];

for k=1:(vxl\_interpVal-2)\*vxl\_num

if numDataPt<=surfaceDataPtsSize

b=numDataPt+vxl\_interpVal;

intm\_normal=vertcat(intm\_normal,intm\_comparedData);

intm\_preFitx=vertcat(intm\_preFitx,intm\_endX(numDataPt));

numDataPt=numDataPt+1;

end

end

try

intm\_residVector=abs(intm\_normal-intm\_preFitx);

rawImageData=horzcat(rawImageData,intm\_residVector);

end

end

end

rowImage=rawImageData;

Final\_dataImage=vertcat(Final\_dataImage,rowImage);

end

end

Final=vertcat(Final,mean(Final\_dataImage));

%imageInfo=strcat(int2str(num),'.jpg');

%imwrite(Final\_dataImage,imageInfo);

rawdata=vertcat(link\_D',link\_A');

[sizeRaw,~]=size(rawdata);

filename='Data.xlsx';

startData=sizeRaw\*(num-1)+1;

endData=sizeRaw\*num;

dataOption=strcat('A',int2str(startData),':A',int2str(endData));

xlswrite(filename,rawdata,dataOption);

end

Formulation of a research topic, proposal to the pre-engineering department

A Method to Evaluate the Manipulability of a 6-DOF Manipulator and its Application in Artificial Neural Network

Date: 10/15/17

Alexander Liao

Idea 1

Alexander Liao

I. Introduction

* The determination of the length of a manipulator is often based on the torque of the motor
* Yet the manipulability of the arm is less taken care of when engineers determine the length of each link
* Over-designing is a common practice
* The purpose of this method is to shift the attention from the torque to the effect of lengths of links themselves on the dexterity of the robot.

\*refer to code in 10/5/17\*

II. Method

* Central idea:
  + divide the predetermined space in to voxels with equal volume
  + find a data point to represent the voxel
  + obtain the joint configuration of the robot in order to reach the point
  + calculate the manipulability
  + store all results in a vector
* Prevalent methods of a manipulator’s manipulability at a given joint configuration include Yoshikawa’s manipulability measure
* Levenberg–Marquardt algorithm is implemented to solve the inverse kinematics equation
* Peter Corke’s Robotics Toolbox in MATLAB provides great help on the calculation
  + Generate 6-DOF manipulator with random d/a parameters (from 1 to 10) with modified D-H convention
  + Generate matrix for voxels
  + Generate matrix for trajectory planning (joint configurations)
  + Calculate the manipulability index for each configuration
  + Store results

IV. Applications

* Since both the input and the output are vectors, they can be fed into an artificial neural network to look for an optimized result
* However, this unconventional approach might require a modified network structure

V. Possible Defects

* There are errors in the solutions of inverse kinematics function
* *I’m not sure if the manipulability of arm at a configuration obtained by approximation is still significant*

Warning: ikine: rejected-step limit 100 exceeded (pose 1), final err 0.300062

> In SerialLink/ikine (line 244)

In SerialLink>@(varargin)r.ikine(varargin{:}) (line 846)

In SerialLink/jtraj (line 851)

In linearRobotTest (line 10)

In surfaceRobotTest (line 9)

In TrainingDataGeneration (line 59)

Finished annotation of *Robotics, Vision and Control* by Peter Corke

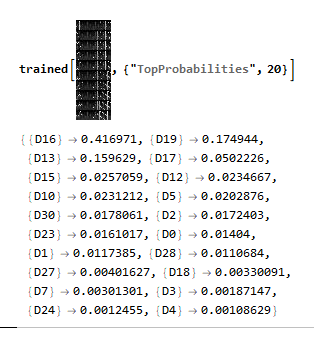
Date: 10/20/17

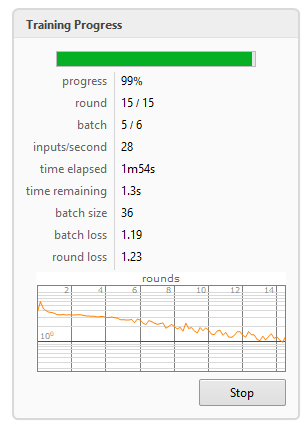
Alexander Liao

Idea 1

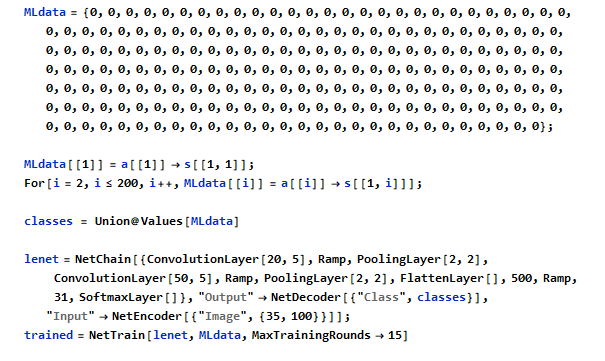
Improved version of ConvNet in Mathematica

**Successful prediction of member within the training batch**





**Initialization with 200 samples**

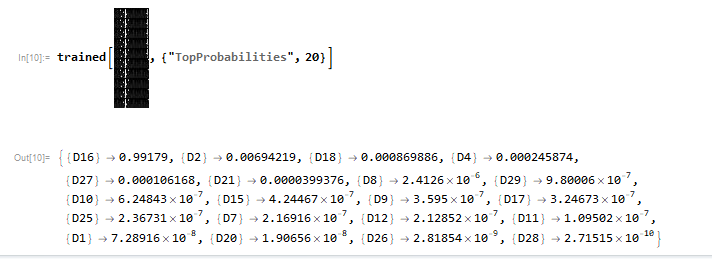


Date: 10/21/17

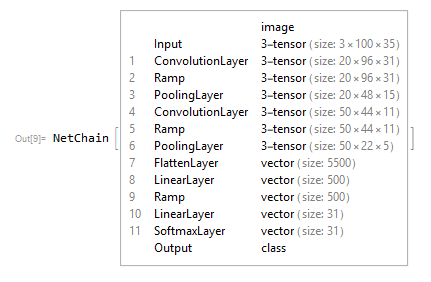
Alexander Liao

Idea 1

**Failed prediction of unseen sample:**



**ConvNet architecture**



Proposal 2nd draft:

Date: 10/22/17

Alexander Liao

Idea 1

A Method to Evaluate a Rigid-Link Manipulator and its Application in Artificial Neural Network

Alexander Liao

I. Introduction

* The determination of the length of a manipulator is often based on the torque of the motor
* Yet the manipulability of the arm is less taken care of when engineers determine the length of each link
* Over-designing is a common practice
* The purpose of this method is to shift the attention from the torque to the effect of lengths of links themselves on the performance of the robot.

II. Method

* Based on modified Denavit - Hartenberg convention, a specific vector can be created to define a specific rigid arm-type robot (assuming that all joints are revolute):

, where is the degree of freedom of the robot.

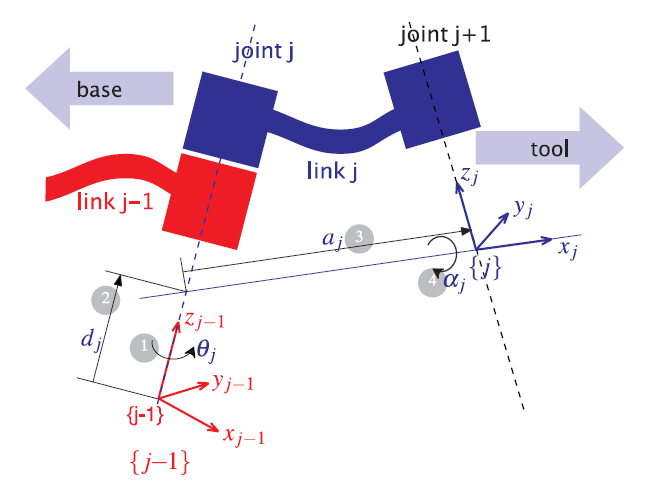
* The denotation of symbols in the vector can be found in Figure 1-1 (Corke, 2013, p. 138).

Figure -1

* The performance of robot in a given space is defined by its performance in every one of the voxels:
  + divide the predetermined space into voxels of equal volume
  + find a data point to represent the voxel
* Components of the test (For a 6 degrees-of-freedom robot):
  + Distance between the actual point of end-effector and the ideal point of the voxel based on the numerical approach of the inverse kinematics of the robot.
  + Manipulability of the robot in terms of Yoshikawa’s manipulability measure (a scalar) at different joint configurations
  + Joint speed at performing linear motions between voxels (x-direction and y-direction)
* Components of the test (For an under-actuated robot):
  + Whether the robot can reach the voxel
  + Manipulability of the robot for the voxels that are approachable.
* Evaluation primarily based on functions from Peter Corke’s Robotics Toolbox in MATLAB
  + Generate manipulator with a random (in an acceptable range) with modified D-H convention
  + Generate voxels that are stored in a matrix
  + Evaluate the performance of the robot that is then stored in a vector.
  + Output the two vectors in the form of a pair

III. Applications

* Although it has been proven mathematically that a 6-DOF manipulator is possible to reach every single position in the task-space, other factors like link collision and singularities could still create awkward situations (Corke, 2013, p. 150). So obviously some are better at performing tasks in a given space than others.
* For under-actuated rigid-link manipulators, it is useful to find out if a exists for a given space
* Since both the input and the output are vectors, they can be fed into an artificial neural network to look for a pattern, which means that an optimized result could be obtained.
* However, this unconventional approach might require a modified network structure.

References

Corke, P. I. (2013). *Robotics, vision and control: Fundamental algorithms in MATLAB*.

Exploring the possibility of using quaternions to represent poses

Date: 10/24/17

Alexander Liao

Idea 1

classdef VectorQuaternion

properties

t

q

end

methods

function r = VectorQuaternion(inT,inQ)

if size(inT)== [3 1]

r.t = inT;

else

error('t has to be a 3\*1 vector');

end

try

Quaternion(inQ);

catch

error('q has to be a unit Quaternion');

end

if inQ.norm==1

r.q= inQ;

else

error('q has to be a unit Quaternion');

end

end

function r = poseCompose(inVQ1,inVQ2)

if and(isQuaternion(inVQ1.q),isQuaternion(inVQ2.q))

r = VectorQuaternion([0;0;0],UnitQuaternion);

r.q=(inVQ1.q\*inVQ2.q);

q1 = inVQ1.q;

r.t=(inVQ1.t+(q1.R)\*inVQ2.t);

else

error('Only quaternion inputs are allowed');

end

end

function r = poseNegate(inVQ)

if isQuaternion(inVQ.q)

r = VectorQuaternion([0;0;0],UnitQuaternion);

q0= inVQ.q;

q\_inv= q0.inv;

t0= inVQ.t;

r.t=-(q\_inv.R)\*t0;

r.q=q\_inv;

else

error('Only quaternion input is allowed');

end

end

function r = VQtrans(inPt,inVQ)

if and(isQuaternion(inVQ.q),size(inPt)== [3 1])

q0= inVQ.q;

t0= inVQ.t;

r=-(q0.R)\*inPt+t0;

else

error('inputs must have the following form: desired point, quaternion');

end

end

end

end

function logic = isQuaternion(inQ)

try

determine = Quaternion(inQ)

logic = true();

catch

logic = false();

end

end

end

function r = poseNegate(inVQ)

if isQuaternion(inVQ.q)

r = VectorQuaternion([0;0;0],UnitQuaternion);

q0= inVQ.q;

q\_inv= q0.inv;

t0= inVQ.t;

r.t=-(q\_inv.R)\*t0;

r.q=q\_inv;

else

error('Only quaternion input is allowed');

end

end

function r = VQtrans(inPt,inVQ)

if and(isQuaternion(inVQ.q),size(inPt)== [3 1])

q0= inVQ.q;

t0= inVQ.t;

r=-(q0.R)\*inPt+t0;

else

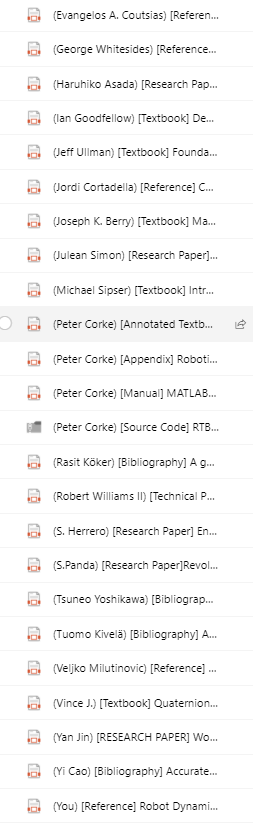
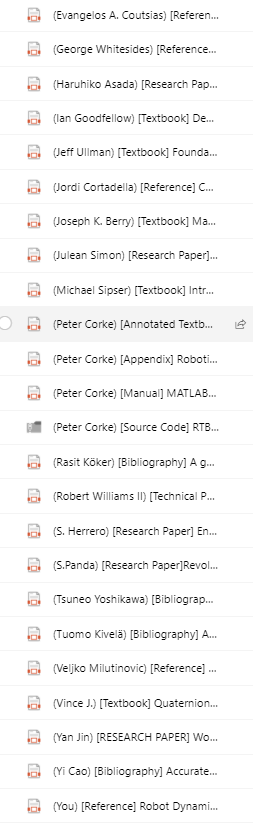
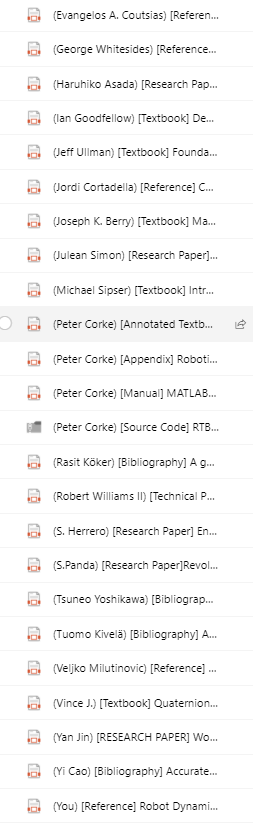
error('inputs must have the following form: desired point, quaternion');

end

end

end

end

Quaternion idea failed; starting literature research on web

Date: 10/25/17

Alexander Liao

Idea 1

***Goal: Train a neural network that can predict the manipulability map of manipulator given its kinematic structure***

Date: 10/29/17

Alexander Liao

Idea 2

First attempt of creating a script to generate random 6-DOF manipulators

**Code:**

D=10\*round(rand(1,6),3);

A=10\*round(rand(1,6),3);

alpha=zeros(1,6);

r1=rand(1,6)\*10;

%r2=rand(1,5)\*10;

r3=rand(1,6)\*10;

logic = 0;

for i = 1:5

if and(r1(i)>3, logic==0)

D(i)=0;

A(i)=0;

D(i+1)=0;

A(i+1)=0;

alpha(i)=0;

logic=1;

end

%if 6>r3(i)>3

% alpha(i)=pi/2;

%elseif r3(i)>6

% alpha(i)=-pi/2;

%end

end

lt=[0 0 0 0 0 0];

%lD=50\*round(rand(1,5),3);

%lA=50\*round(rand(1,5),3);

%lD(round(rand(1)\*5))=0;

%la=pi+pi/2\*-(rand(1,5));

%Creating the SerialLink object

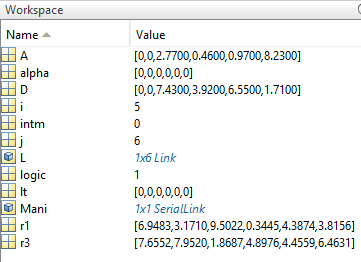
for j = 1:6

L(j)=Link([0 D(j) A(j) alpha(j)]);

end

intm = 0;

Mani=SerialLink(L);



Further improvements

Date: 10/30/17

Alexander Liao

Idea 2

**Scalar field of sum of manipulability measures in the trajectory** (transl(0.5,0,0),transl(0.5,0.5,0),10) **of a 6-DOF manipulator with random link lengths:**

times=5000;

answer=zeros(1,times);

error=answer;

matrix = zeros(18,times);

L=struct();

parfor me = 1:times

D=[ 0 0 0.2+0.5\*rand() 0.2+0.5\*rand() 0 0];

A=[ 0 0.2+0.5\*rand() 0 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

%{

D=[ 0 0 0 rand() rand() 0 ];

A=[ 0 0 rand() 0 0 0 ];

alpha=[ pi/2 pi/2 0 -pi/2 pi/2 -pi/2 ];

for j = 1:6

L(j)=Link([0 D(j) A(j) alpha(j)]);

end

%}

l1=Link([0 D(1) A(1) alpha(1)]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)]);

l4=Link([0 D(4) A(4) alpha(4)]);

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

Mn=SerialLink([l1,l2,l3,l4,l5,l6]);

ger=[0 0 0 0 0 0];

intm=0;

%step=0:pi/4:pi/2

traj= ctraj(transl(0.5,0,0),transl(0.5,0.5,0),10);

traj1=traj(:,:,1);

qMn=zeros(10,6);

logic=1;

logic2=1;

ger=Mn.ikine(traj1,'rlimit',500,'ilimit',500);

if sum(ger)==0

answer(me)=0;

logic=0;

end

if logic==1

qMn(1,:)=ger;

for i = 2:10

ger=Mn.ikine(traj(:,:,i),'rlimit',200,'q0',qMn(i-1,:));

if sum(ger)==0

logic2=0;

else

qMn(i,:)=ger;

end

end

if logic2==1

in=Mn.maniplty(qMn);

intm=sum(in);

%intm = M.maniplty([0 pi/4 pi/4 0 pi/4 pi/4]);

answer(me)=intm;

%error(me)=sum(err1);

end

end

matrix(:,me)=[D,A,alpha];

end

gee=zeros(1,6);

for t = 1:times

if answer(t)==max(answer)

gee=matrix(:,t);

end

end

nD=gee(1:6,1);

nA=gee(7:12,1);

nAlpha=gee(13:18,1);

for nj = 1:6

nL(nj)=Link([0 nD(nj) nA(nj) nAlpha(nj)]);

end

nM=SerialLink(nL);

q0=[0 0 0 0 0 0];

%nM.plot(q0);

%nM.teach();

scatter3(matrix(3,:),matrix(4,:),matrix(8,:),7.5,answer,'filled')

D=[0 0 0 0.15 0.4318 0];

A=[0 0 0.4318 0.0203 0 0];

alpha=[pi/2 0 -pi/2 pi/2 -pi/2 0];

for j = 1:6

L(j)=Link([0 D(j) A(j) alpha(j)]);

end

intm = 0;

M=SerialLink(L);

intm=0;

%step=0:pi/4:pi/2

traj= ctraj(transl(0.5,0,0),transl(0.5,0.5,0),10);

traj1=traj(:,:,1);

qMn=zeros(10,6);

logic=1;

logic2=1;

ger=Mn.ikine(traj1,'rlimit',500,'ilimit',500);

if sum(ger)==0

answer(me)=0;

logic=0;

end

if logic==1

qMn(1,:)=ger;

for i = 2:10

ger=Mn.ikine(traj(:,:,i),'rlimit',200,'q0',qMn(i-1,:));

if sum(ger)==0

logic2=0;

else

qMn(i,:)=ger;

end

end

if logic2==1

in=Mn.maniplty(qMn);

intm=sum(in);

%intm = M.maniplty([0 pi/4 pi/4 0 pi/4 pi/4]);

answer(me)=intm;

%error(me)=sum(err1);

end

end

matrix(:,me)=[D,A,alpha];

end

gee=zeros(1,6);

for t = 1:times

if answer(t)==max(answer)

gee=matrix(:,t);

end

end

nD=gee(1:6,1);

nA=gee(7:12,1);

nAlpha=gee(13:18,1);

for nj = 1:6

nL(nj)=Link([0 nD(nj) nA(nj) nAlpha(nj)]);

end

nM=SerialLink(nL);

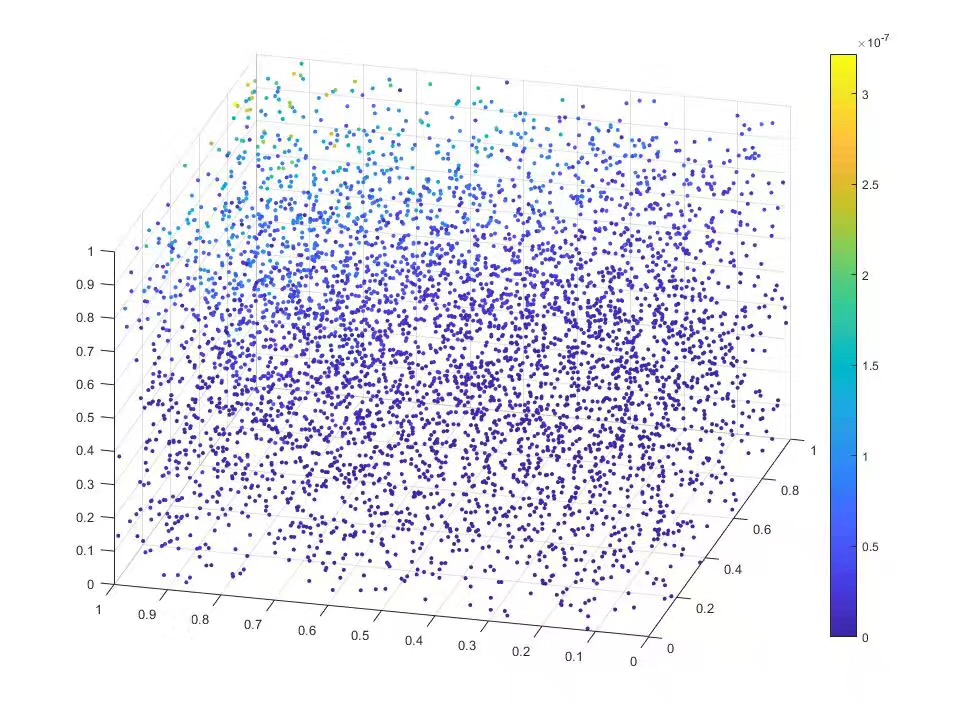
q0=[0 0 0 0 0 0];

%nM.plot(q0);

%nM.teach();

scatter3(matrix(3,:),matrix(4,:),matrix(8,:),7.5,answer,'filled')

**Visualization**



Manipulability measures of a given manipulator in vector form

Date: 10/31/17

Alexander Liao

Idea 2

**I/O:**

in =

1.0e-06 \*

0

0.1001

0

0.0954

0.0126

0

0.0245

0.0925

0.0873

0.1195

>>

**Code:**

D=[ 0 0 0.4793 1.3315 0 0];

A=[ 0 1.1765 0 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 D(1) A(1) alpha(1)]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)]);

l4=Link([0 D(4) A(4) alpha(4)]);

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

Mn=SerialLink([l1,l2,l3,l4,l5,l6]);

intm=0;

traj= ctraj(transl(0.5,0,0),transl(0.5,1,0),10);

qMn=Mn.ikine6s(traj);

in=Mn.maniplty(qMn)

intm=sum(in);

%intm = M.maniplty([0 pi/4 pi/4 0 pi/4 pi/4]);

**Visualization algorithm of the scope of the manipulability map:**

D=[ 0 0 rand() rand() 0 0];

A=[ 0 rand() 0 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 D(1) A(1) alpha(1)]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)]);

l4=Link([0 D(4) A(4) alpha(4)]);

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

Mn=SerialLink([l1,l2,l3,l4,l5,l6]);

xmin=0.2;

xmax=0.6;

ymin=-0.2;

ymax=0.2;

zmin=-0.4;

zmax=0;

q1=Mn.ikine6s(transl(xmin,ymin,zmin));

q2=Mn.ikine6s(transl(xmin,ymax,zmin));

q3=Mn.ikine6s(transl(xmax,xmin,zmin));

q4=Mn.ikine6s(transl(xmax,ymax,zmin));

q5=Mn.ikine6s(transl(xmin,ymin,zmax));

q6=Mn.ikine6s(transl(xmin,ymax,zmax));

q7=Mn.ikine6s(transl(xmax,ymin,zmax));

q8=Mn.ikine6s(transl(xmax,ymax,zmax));

mat=[q1;q2;q3;q4;q5;q6;q7;q8];

difmat=zeros(2,6);

for i=1:6

difmat(1,i)=min(mat(:,i));

difmat(2,i)=max(mat(:,i));

end

x1=[xmin xmin xmax xmax];

y1=[ymin ymax ymax ymin];

z1=[zmin zmin zmin zmin];

x2=[xmin xmin xmax xmax];

y2=[ymin ymax ymax ymin];

z2=[zmax zmax zmax zmax];

x3=[xmin xmin xmin xmin];

y3=[ymin ymax ymax ymin];

z3=[zmax zmax zmin zmin];

x4=[xmax xmax xmax xmax];

y4=[ymin ymax ymax ymin];

z4=[zmax zmax zmin zmin];

x5=[xmin xmax xmax xmin];

y5=[ymin ymin ymin ymin];

z5=[zmax zmax zmin zmin];

x6=[xmin xmax xmax xmin];

y6=[ymax ymax ymax ymax];

z6=[zmax zmax zmin zmin];

Mn.plot(qn);

hold on

patch(x1,y1,z1,'blue','facealpha',.25)

hold on

patch(x2,y2,z2,'blue','facealpha',.25)

hold on

patch(x3,y3,z3,'red','facealpha',.25)

hold on

patch(x4,y4,z4,'red','facealpha',.25)

hold on

patch(x5,y5,z5,'yellow','facealpha',.25)

hold on

patch(x6,y6,z6,'yellow','facealpha',.25)

hold on

diff=(difmat(2,:)-difmat(1,:))/20

x2=[xmin xmin xmax xmax];

y2=[ymin ymax ymax ymin];

z2=[zmax zmax zmax zmax];

x3=[xmin xmin xmin xmin];

y3=[ymin ymax ymax ymin];

z3=[zmax zmax zmin zmin];

x4=[xmax xmax xmax xmax];

y4=[ymin ymax ymax ymin];

z4=[zmax zmax zmin zmin];

x5=[xmin xmax xmax xmin];

y5=[ymin ymin ymin ymin];

z5=[zmax zmax zmin zmin];

x6=[xmin xmax xmax xmin];

y6=[ymax ymax ymax ymax];

z6=[zmax zmax zmin zmin];

Mn.plot(qn);

hold on

patch(x1,y1,z1,'blue','facealpha',.25)

hold on

patch(x2,y2,z2,'blue','facealpha',.25)

hold on

patch(x3,y3,z3,'red','facealpha',.25)

hold on

patch(x4,y4,z4,'red','facealpha',.25)

hold on

patch(x5,y5,z5,'yellow','facealpha',.25)

hold on

patch(x6,y6,z6,'yellow','facealpha',.25)

hold on

diff=(difmat(2,:)-difmat(1,:))/20

Improvements

Date: 11/1/17

Alexander Liao

Idea 2

**Scalar map algorithm version 2:**

times=100;

answer=zeros(1,times);

error=answer;

matrix = zeros(18,times);

parfor me =1:times

D=[ 0 0 rand() rand() 0 0];

A=[ 0 rand() 0 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 D(1) A(1) alpha(1)],'m',0,'l',[0.066,0,0;0,0.086,0;0,0,0.0125],[-0.0203,-0.0141,0.07]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)],'m',A(2)\*40);

l4=Link([0 D(4) A(4) alpha(4)],'m',D(3)\*40);

l5=Link([0 D(5) A(5) alpha(5)],'m',D(4)\*20);

l6=Link([0 D(6) A(6) alpha(6)]);

Mn=SerialLink([l1,l2,l3,l4,l5,l6]);

qtraj=ctraj(transl(0.5,0,0),transl(0.5,0.5,0),25);

traj=Mn.ikine6s(qtraj);

vec=Mn.maniplty(traj,'asada');

intm=sum(vec);

answer(me)=intm;

matrix(:,me)=[D,A,alpha];

end

gee=zeros(1,6);

for t = 1:times

if answer(t)==max(answer)

gee=matrix(:,t);

end

end

nD=gee(1:6,1);

nA=gee(7:12,1);

nAlpha=gee(13:18,1);

for nj = 1:6

nL(nj)=Link([0 nD(nj) nA(nj) nAlpha(nj)]);

end

nM=SerialLink(nL);

q0=[0 0 0 0 0 0];

%nM.plot(q0);

%nM.teach();

scatter3(matrix(3,:),matrix(4,:),matrix(8,:),7.5,answer,'filled')

for nj = 1:6

nL(nj)=Link([0 nD(nj) nA(nj) nAlpha(nj)]);

end

nM=SerialLink(nL);

q0=[0 0 0 0 0 0];

%nM.plot(q0);

%nM.teach();

scatter3(matrix(3,:),matrix(4,:),matrix(8,:),7.5,answer,'filled')

**Experimenting with kinematics structure of 6-DOF manipulators**

D=[ 0 0 14.7313 14.7713 0 0];

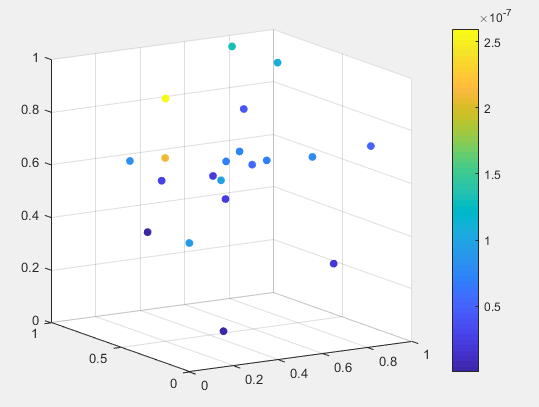
A=[ 14.7029 0 0 0 0 0];

alpha=[ pi/2 pi/2 -pi/2 pi/2 -pi/2 0];

D=[ 0 14.7313 0 14.7713 0 0];

A=[ 14.7029 0 0 0 0 0];

alpha=[ pi/2 -pi/2 pi/2 pi/2 -pi/2 0];



Proposal 3rd draft

Date: 11/2/17

Alexander Liao

Idea 2

A Portable Algorithm for Kinematic Evaluation of Robotic Manipulators Generated by Neural Network and Its Application in Optimization

Alexander Liao

Introduction

* Goal: design a test that could reflect properties of a manipulator’s kinematics model and mimic it by a neural network.
* Neural Networks are often used in research for robot control system (since 2001)
* Pure kinematics model of a serial-link manipulator is less taken care of compared to the dynamics model
* Yet the kinematic model of robot itself is significant as well-idealize other factors:
* *The performance of the manipulator is a function of the parameters that define the kinematics model*
* Yet traditional optimization includes arduous work in multivariable calculus (an optimization attempt of a specific redundant 8-DOF manipulator was done by NASA)
* Thus, it is reasonable to first find a way to describe the model, then use ANNs to mimic it
* Advantages of neural network: the process of LSTM/CNN/RNN/MLP is faster and more portable than analytical Jacobian/tensor arithmetic

Method

* Prerequisite:
  + Rigid-body
  + Serial-link
  + All-revolute
  + Standard D-H parameters
  + Functions based on MATLAB Robotics Toolbox (RTB) by professor Peter Corke
  + Neural network code based on Tensorflow
* 1.Designing the evaluation algorithm
  + 6-DOF with Spherical Wrist
    - Only three configurations are possible:

|  |  |  |  |
| --- | --- | --- | --- |
| j | d | a | alpha |
| 1 | 0 | 0 |  |
| 2 | 0 |  | 0 |
| 3 |  | 0 |  |
| 4 |  | 0 |  |
| 5 | 0 | 0 |  |
| 6 | 0 | 0 | 0 | |

|  |  |  |  |
| --- | --- | --- | --- |
| j | d | a | alpha |
| 1 | 0 |  |  |
| 2 | 0 | 0 |  |
| 3 |  | 0 |  |
| 4 |  | 0 |  |
| 5 | 0 | 0 |  |
| 6 | 0 | 0 | 0 |

|  |  |  |  |
| --- | --- | --- | --- |
| j | d | a | alpha |
| 1 | 0 |  |  |
| 2 |  | 0 |  |
| 3 | 0 | 0 |  |
| 4 |  | 0 |  |
| 5 | 0 | 0 |  |
| 6 | 0 | 0 | 0 |

* + - Input：
      * d-vector
      * a-vector
      * alpha-vector
    - Target space for evaluation:
    - Evaluation
      * Reachability
      * Manipulability
      * Joint-Space Usage
      * Linearity
* 2.Using Neural Networks to mimic the test
* 3.Optimization

**The orientation of the manipulator end-effector when performing Cartesian linear movement between nodes in the cuboid partitions:**

x1=[xmin xmin xmax xmax];

y1=[ymin ymax ymax ymin];

z1=[zmin zmin zmin zmin];

x2=[xmin xmin xmax xmax];

y2=[ymin ymax ymax ymin];

z2=[zmax zmax zmax zmax];

x3=[xmin xmin xmin xmin];

y3=[ymin ymax ymax ymin];

z3=[zmax zmax zmin zmin];

x4=[xmax xmax xmax xmax];

y4=[ymin ymax ymax ymin];

z4=[zmax zmax zmin zmin];

x5=[xmin xmax xmax xmin];

y5=[ymin ymin ymin ymin];

z5=[zmax zmax zmin zmin];

x6=[xmin xmax xmax xmin];

y6=[ymax ymax ymax ymax];

z6=[zmax zmax zmin zmin];

**Initialization:**

%Initialization

clear all

numData=100;

%Target Space

spc\_x1=0.2;

xmin=spc\_x1;

spc\_x2=0.6;

xmax=spc\_x2;

spc\_y1=-0.2;

ymin=spc\_y1;

spc\_y2=0.2;

ymax=spc\_y2;

spc\_z1=-0.4;

zmin=spc\_z1;

spc\_z2=0;

zmax=spc\_z2;

%Specifications for Voxels

vxl\_interpVal=10;

vxl\_num=10;

vxl\_zLayerHeight=0.025;

%Final Result

performanceVector=[];

performanceMatrix=[];

inputMatrix=[];

for num=1:numData

rawdata=[];

performanceVector=[];

link\_D=[ 0 0 0.2290 0.9133 0 0];

link\_A=[ 0 0.1524 0 0 0 0];

link\_alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 link\_D(1) link\_A(1) link\_alpha(1)]);

l2=Link([0 link\_D(2) link\_A(2) link\_alpha(2)]);

l3=Link([0 link\_D(3) link\_A(3) link\_alpha(3)]);

l4=Link([0 link\_D(4) link\_A(4) link\_alpha(4)]);

l5=Link([0 link\_D(5) link\_A(5) link\_alpha(5)]);

l6=Link([0 link\_D(6) link\_A(6) link\_alpha(6)]);

linkL=[l1,l2,l3,l4,l5,l6];

mdl\_puma560;

link\_M=SerialLink(p560);

for z=spc\_z1:vxl\_zLayerHeight:spc\_z2

if z==spc\_z2

disp('\*');

else

%Invoking the surface function for at the height "z"

logic=0;

while logic==0

[surfPlan,SizeZ] = surfaceRobotTest(linkL,link\_M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

logic=1;

end

[SizeX,SizeY]=size(surfPlan);

columnImage=surfPlan;

performanceVector=vertcat(performanceVector,columnImage);

end

end

inputVector=vertcat(link\_D',link\_A');

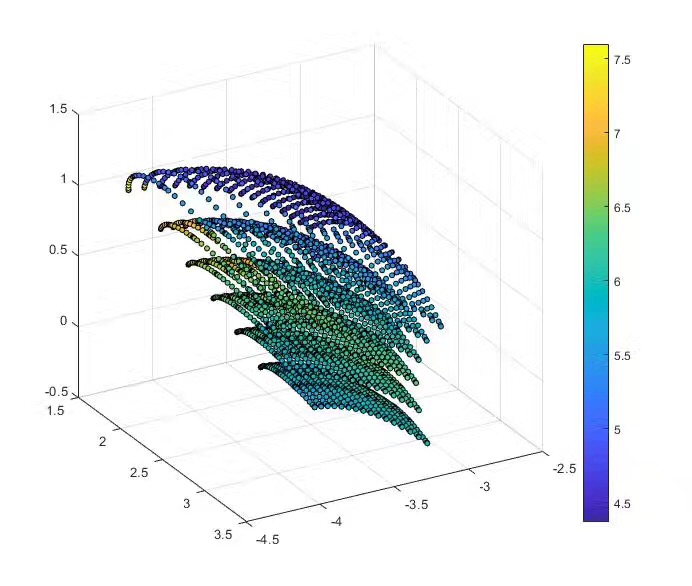
inputMatrix=horzcat(inputMatrix,inputVector);

performanceMatrix=horzcat(performanceMatrix,performanceVector);

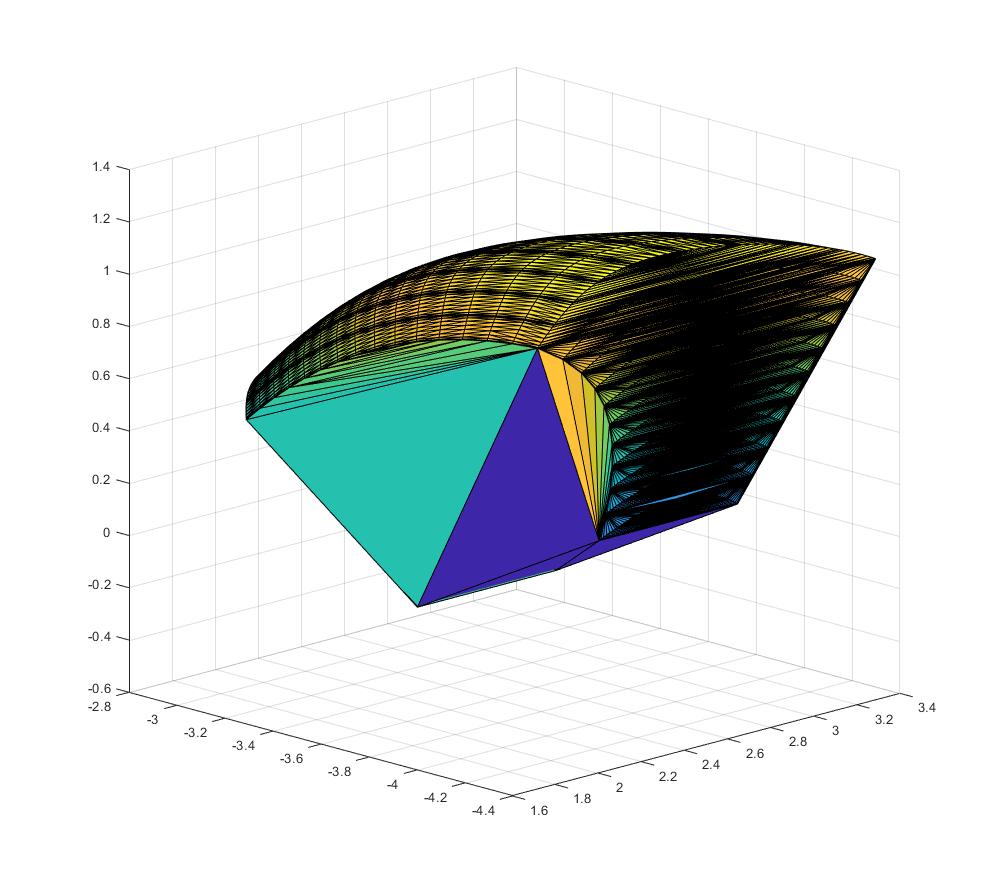
end

scatter3(performanceMatrix(:,1),performanceMatrix(:,2),performanceMatrix(:,3),15,(abs(performanceMatrix(:,4))+abs(performanceMatrix(:,5))+abs(performanceMatrix(:,6))),'filled','MarkerEdgeColor','k')

**Visualization for PUMA 560:**



**Convex hull:**



Further investigation of using convex hull volume to evaluate a manipulator

Date: 11/3/17

Alexander Liao

Idea 2

Attempt to use forward kinematics with uniform sampling of joint angles to map between joint space and workspace, failed due to the unachievable requirement on computational power

***Goal: Using neural network to predict the workspace of manipulator in the form of a binary map***

D=[ 0 0 0.4793 1.4315 0 0];

A=[ 0 1.0765 0.05 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 D(1) A(1) alpha(1)]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)]);

l4=Link([0 D(4) A(4) alpha(4)]);

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

Mn=SerialLink([l1,l2,l3,l4,l5,l6]);

final=[];

parfor i=1:62

i2=-pi+i\*0.1

for j=-pi/2:0.1:pi/2

for k = -pi/2:0.1:pi/2

intm=Mn.fkine([i2 j k 0 0 0]);

final=horzcat(final,intm.t);

end

end

end

%try

%[~,vol]=convhull(performanceVector(:,1),performanceVector(:,2),performanceVector(:,3));

%hullV=horzcat(hullV,vol);

%catch

% hullV=horzcat(hullV,0);

%end

Date: 11/4/17

Alexander Liao

Idea 3 (final)

Attempt to reimplement Castelli’s method in MATLAB

%Initialization

clear all

numData=500;

%Target Space

xmin=0.2;

xmax=0.6;

ymin=-0.2;

ymax=0.2;

zmin=-0.4;

zmax=0;

%Specifications for Voxels

itpVal=4;

%Final Result

perfmat=[];

performanceMatrix=[];

inputMatrix=[];

coordinateData=[];

parfor num=1:numData

%for num=1:numData

rawdata=[];

perfmat=[];

surfPlan=[];

intm=[];

%D=[ 0 0 round(rand(),4) round(rand(),4) 0 0];

%A=[ 0 round(rand(),4) round(rand(),3)/10 0 0 0];

D=[0 0 rand() rand() 0 0];

A=[0 rand() rand()/10 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 D(1) A(1) alpha(1)]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)]);

l4=Link([0 D(4) A(4) alpha(4)]);

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

linkL=[l1 l2 l3 l4 l5 l6];

M=SerialLink([l1,l2,l3,l4,l5,l6]);

for z=zmin:(zmax-zmin)/itpVal:zmax

%if z==spc\_z2

% disp('\*');

%else

%Invoking the surface function for at the height "z"

%logic=0;

%while logic==0

% [surfPlan,SizeZ] = surfaceRobotTest(linkL,M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

%logic=1;

surfPlan=[];

for i=xmin:(xmax-xmin)/itpVal:xmax

for j=ymin:(ymax-ymin)/itpVal:ymax

try

intm=M.ikine6s(transl(i,j,z));

catch

bool=0;

end

if all(intm.\*1==intm)

bool=1;

if bool==[]

bool=0;

end

else

bool=0;

end

if bool==[]

bool=0;

end

%coordinateData= horzcat(coordinateData,[i;j;z]);

surfPlan=horzcat(surfPlan,bool);

%size(surfPlan)

end

end

%end

[SizeX,~]=size(surfPlan);

%{

for i = 1:SizeX

if ~all(surfPlan(i,:).\*1==surfPlan(i,:))

reachL=0;

else

reachL=1;

end

end

%}

%columnImage=surfPlan;

perfmat=horzcat(perfmat,surfPlan);

%end

end

try

performanceMatrix=vertcat(performanceMatrix,perfmat);

inputVector=vertcat(D(3:4)',A(2:3)',xmin,xmax,ymin,ymax,zmin,zmax);

inputMatrix=vertcat(inputMatrix,inputVector');

catch

end

end

d=[];

a=neural5(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=neru4(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

linkL=[l1 l2 l3 l4 l5 l6];

M=SerialLink([l1,l2,l3,l4,l5,l6]);

for z=zmin:(zmax-zmin)/itpVal:zmax

%if z==spc\_z2

% disp('\*');

%else

%Invoking the surface function for at the height "z"

%logic=0;

%while logic==0

% [surfPlan,SizeZ] = surfaceRobotTest(linkL,M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

%logic=1;

surfPlan=[];

for i=xmin:(xmax-xmin)/itpVal:xmax

for j=ymin:(ymax-ymin)/itpVal:ymax

try

intm=M.ikine6s(transl(i,j,z));

catch

bool=0;

end

if all(intm.\*1==intm)

bool=1;

if bool==[]

bool=0;

end

else

bool=0;

end

if bool==[]

bool=0;

end

%coordinateData= horzcat(coordinateData,[i;j;z]);

surfPlan=horzcat(surfPlan,bool);

%size(surfPlan)

end

end

%end

[SizeX,~]=size(surfPlan);

%{

for i = 1:SizeX

if ~all(surfPlan(i,:).\*1==surfPlan(i,:))

reachL=0;

else

reachL=1;

end

end

%}

%columnImage=surfPlan;

perfmat=horzcat(perfmat,surfPlan);

%end

end

try

performanceMatrix=vertcat(performanceMatrix,perfmat);

inputVector=vertcat(D(3:4)',A(2:3)',xmin,xmax,ymin,ymax,zmin,zmax);

inputMatrix=vertcat(inputMatrix,inputVector');

catch

end

end

d=[];

a=neural5(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=neru4(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}

%end

[SizeX,~]=size(surfPlan);

%{

for i = 1:SizeX

if ~all(surfPlan(i,:).\*1==surfPlan(i,:))

reachL=0;

else

reachL=1;

end

end

%}

%columnImage=surfPlan;

perfmat=horzcat(perfmat,surfPlan);

%end

end

try

performanceMatrix=vertcat(performanceMatrix,perfmat);

inputVector=vertcat(D(3:4)',A(2:3)',xmin,xmax,ymin,ymax,zmin,zmax);

inputMatrix=vertcat(inputMatrix,inputVector');

catch

end

end

d=[];

a=neural5(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=neru4(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}

1. Attempt to use forward kinematics joint space search method. Abandoned due to high computational cost

Date: 11/5/17

Alexander Liao

Idea 3 (final)

1. Cartesian linear trajectory planning for 6-DOF arm with spherical wrist

D=[ 0 0 0.4793 1.4315 0 0];

A=[ 0 1.0765 0.05 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 D(1) A(1) alpha(1)]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)]);

l4=Link([0 D(4) A(4) alpha(4)]);

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

Mn=SerialLink([l1,l2,l3,l4,l5,l6]);

final=[];

parfor i=1:62

i2=-pi+i\*0.1

for j=-pi/2:0.1:pi/2

for k = -pi/2:0.1:pi/2

intm=Mn.fkine([i2 j k 0 0 0]);

final=horzcat(final,intm.t);

end

end

end

%Trajectory Planning for a line

function [linPlan,SizeZ] = linearRobotTest(L,M,interpVal,numVxl,terminal1,terminal2)

linVoxel=trinterp(terminal1,terminal2,numVxl);

[~,~,SizeZ]=size(linVoxel);

linPlan=zeros((SizeZ-1)\*interpVal,numel(L));

for i=1:SizeZ-1

intm=ctraj(linVoxel(:,:,i),linVoxel(:,:,i+1),interpVal);

ptPlan=M.ikine6s(intm);

index1=1+(i-1)\*interpVal;

index2=i\*interpVal;

linPlan(index1:index2,:)=ptPlan(:,:);

end

end

Using the MATLAB neural network toolbox to train data generated from the former scripts

Date: 11/6/17

Alexander Liao

Idea 3 (final)

function [y1] = RobotTest1(x1)

x1\_step1.keep = [1 2 3 4];

x1\_step2.xoffset = [5.90318136701325e-05;4.34334412752338e-05;9.77198810546733e-05;4.15630604533963e-05];

x1\_step2.gain = [2.00012319856925;2.00020952641606;2.00019854125312;20.008884450653];

x1\_step2.ymin = -1;

% Layer 1

b1 = [-4.2111134575487181309;-3.5567818840090552612;3.4266865864341884418;-0.8925772303867109958;4.400605991782107651;-1.1076507547425888944;-0.48563328903356794974;1.9505567287489016248;3.7891576910278370605;4.1024929712171180896];

IW1\_1 = [0.23698897572914937038 -0.84171426351152611733 0.14966972354667829048 0.48034682846524695554;-0.12339004258713216766 0.052960482513756304557 -0.29892756388066848983 -0.6740146917666646198;-0.040852616001215535935 0.15691991600313298649 0.31786688395363044135 -0.34729016858231503972;5.31886466321291973 -1.3144457826098903119 1.48979713115856649 -0.042178282396482143224;2.2046172998506055052 2.8223609691977618041 2.4817242307950522218 0.057230217764130404678;-1.6518595991411273438 0.86705437217034930786 -0.35338664811033770885 0.029347906802240367879;-2.1169950325689925741 0.8255606542426033867 -1.2659585382849058988 0.015930661777038276211;0.98482066385006994391 -1.5737483394783504664 1.4934001609300460167 -0.032741686816116659375;0.78097144387124706189 -0.18027686209956689245 0.30267749052907155782 0.15507152842617485944;0.13001320735781191074 -0.16794833314698498494 0.42870435000562334693 -0.46701341538071489135];

% Layer 2

b2 = [0.20301884013972409937;0.50730471376385477544;-0.221787313818108206;0.1863141292709220298;-0.2255677712622557729;0.11959270716025405257;-0.30541488070137517985;-0.82404264962696427421;-0.053100072918462921934;-1.3436692428892091922;-0.83747635085078542261;-0.091640419998204256102;0.62783768804853556933;0.44378342815856103298;-0.72039133166363245042;0.23907904500623194943;-0.40490180003762576977;0.023091064326665002027;-0.045732736459054137979;0.24495903742517041723;-0.53819887919784337171;-0.24083350435780775944;-0.65734172611872909719;0.41525782324546500757;0.35576657031833175404;0.55902187367202282875;-0.33986347550247109073;-0.28216232834707599686;-0.89226140566530531828;0.25683806814209675373;-0.57314687858597834769;-0.73307441498024705773;0.099407792538488373713;-0.096226487731696758177;0.64247314717993175837;-0.70715023973919954869;-0.19886429428096866201;-0.17883217689339142575;-0.92443071584361791171;-0.66779635469704745621;-0.64904682761155163551;0.44502811775020911789;-0.77242293644640025452;0.20003429975748049374;0.41535158496445628851;-0.58390726853029195631;-0.37239017294337450892;0.41834891628498643845;-0.10770027289094248613;-0.18519777915793703138;-0.44743945014597918952;-0.99413293222960275042;-0.42280435808952349097;-0.23659081502454654133;0.5840028190640341732;-0.13716682928466827907;-0.62212230472731622211;-0.072943459202218202675;-0.56964124652762360146;-0.50479518960159741603;-0.74060717619607840945;0.053922277207157941203;-0.59523748515909868928;-1.1150449795511883089;-0.85484324546357293162;-0.83127283334303303519;-0.20638502546502968116;0.23379704837866316369;-0.59385737563185658772;-0.56679831802865321411;-0.37805965196660668015;-0.33762518652425627108;-0.17231270074862778396;-0.1334185073005514921;-0.34042520164161660379;0.39736081339790058076;-0.60928636847835693224;-0.77594617893994843882;-1.3088376480915417943;-0.99795309814012644889;-0.72872639420111628983;-0.30699767602977706682;-0.76061475714218707012;-0.39792270345430991174;-0.86591666117182219953;-0.41632923732060389543;-0.22438543942720087787;0.16451587784558677208;0.083732763425259953971;-0.399194266798001407;0.5985797946933982816;0.15498726000904602951;-0.54746023205161054026;-0.45306160325771616115;-0.6390929106768649115;-1.0443161315147770907;-0.88024291859264058857;0.71216256023267709985;-0.7254839070249412547;-0.45898647092092981215;0.092453652078971479411;-0.6541153965736735687;-0.46813758895979062924;0.015313042110065781809;0.44788399298119557779;0.22535852143433526829;-0.67217554177860405762;-0.58275986554492886782;0.06797576241789698992;-0.41442678211589834003;-0.17287344329323084402;-0.21675312755428832734;0.047466587593139264456;-0.19085959376968170131;-1.0183671073764637427;-1.0398087416646535353;-0.52185061449494940522;0.40459635380083275313;-0.11478258231211492524;0.092384822564310589699;0.021836272558584564341;-0.63060933197534663197;-0.27017721034651193124;-0.46825346641071791121;-1.3172501791127224635];

LW2\_1 = [0.044497832052447311435 -0.40253405182179785582 -0.78177563505978064917 0.26592438952059715973 0.6092408988688458038 0.9640454027664908665 0.88098680112783589458 1.4995122230871027469 -0.66490045501415395712 -0.66443740318135280365;-0.10846498282148568648 0.89575695113845554829 -0.48906172385064156094 0.36723448019156079702 0.39282588089124270692 0.94091368738513891934 0.78244309545969847886 1.2790882750527319267 -0.60074438720086087429 0.053189996094627642331;0.46329677620897413703 0.91298370635432057885 0.68019740924403671034 0.33332571984168585244 0.29600969108220842596 0.96626709815643885282 0.62417853168077108705 1.1557130759367308936 -0.16832769560855243007 -0.11113799583722211439;0.46843244900589803281 0.22950406081898336308 -0.71063725622504758661 0.35548196010666061051 0.36958297921078581139 0.97532816695448065758 0.74022285671111121008 1.2652886160858349829 -0.5944754138612842187 0.53795070367705111192;-0.0039299355647654148418 -0.1306862721336686517 -0.49545004918252216752 0.34079932080029351482 0.59355952399587819102 0.9883376122643035 0.91050249684009276763 1.4697093231790903101 -0.089152565402892389179 -0.83959787573554667262;0.39389528525206707332 -0.012374956317702547753 -1.028822181687399695 0.16912194304628047625 0.860890476793758741 0.99272301457508849154 0.8759595601015291999 1.579963403746351025 0.16444973366446258289 -0.64468868742892271317;0.44609403322384205692 0.055635704981933452318 0.56128862013977431911 0.22249258443988559342 0.75295115908545096062 0.96417277930100875327 0.90736508924798642273 1.5627993079662556575 -1.2077441231322403326 -0.24123404497833283999;0.55371486730022390077 0.6214549443679444618 0.33096227505161818216 0.29121293533859365921 0.632977854536109108 1.0167771637042677391 0.87366466077342652685 1.4900080826391548516 -0.36662122825736609411 0.48902731073047944754;0.58899392665080507747 -0.62071028207271039534 -0.19015528353994312627 0.26437268038630457045 0.69710512478440245232 1.0099368402618167373 0.88509535159110319658 1.5300791543886365087 -0.87854477136797159975 -0.52865279880212412422;0.72864635689467505131 -0.36352199446135968763 -0.2697718092388445843 0.13150652916540001014 0.81013101063149250969 1.0536996241951712694 0.7758735056894960902 1.5378681349738494433 -0.024607815830051879558 0.31700340573511498476;-0.058729157859711673961 -0.057432418046311370374 -1.2071216324009221843 -0.24869151724239191292 0.96727132471664423186 1.1188581333089400172 0.35664568947787994579 1.4304229362671019299 0.20770589245584036853 -0.01252514463530009399;0.69569857198292317513 0.48348354182712760529 0.14065477347733010283 -0.05130273790958156388 0.96030678331295937777 1.024531005781052162 0.64667790174356820643 1.5120244055616696155 -1.0780359133283965445 0.41299377699755707161;0.31225717149922693761 0.46223011735055763438 -0.89944972066061013027 -0.0035949451630336564517 0.92317372309578116241 1.0504163129621657546 0.67417419474563222703 1.5341678647708436589 0.4062067526539006046 -1.133481114322977712;-0.47892170382173676613 0.37055833626635525935 -0.92343668207121465397 -0.045489967904485048567 0.96178265570074938928 1.0288440585773388491 0.65260725218855375473 1.5231463221400800556 -0.99101744395326518688 -0.44096406443316404911;-0.24157591362468194829 0.32660916835039210948 -0.39976097824438128203 -0.23199888402964022327 1.0020672251703424127 1.0670668441249748781 0.41696843928541932334 1.4425702055880504915 -0.25860225166290773391 -0.32002339952257274902;-0.0080787272187477741914 0.51417302437784839775 -0.77819604823081167666 -0.70949976314469698213 0.97866954495722824348 1.2208432266929283294 -0.3549419344964534484 1.0738262883447629026 0.016086677299527511048 -0.47926715667471636584;0.88266296225127027775 -0.24493818993484539615 0.52436022420547079292 -0.58047579644964220069 0.97425869639902284991 1.187826780534197546 -0.13730368220064431695 1.1751568247967283387 -0.28995817694431719191 -0.76337258037070865324;0.28335146456161641737 1.1796779390131328924 -0.0043039852181831657341 -0.50503111925187871289 1.0092974875236429 1.1279706834303062646 0.014923602535668880134 1.2530583043334959648 -0.025364174414193148277 -0.20139362760586682066;0.67361556383444542995 0.31813742650877385731 -0.18480652810220049576 -0.55593376361965829435 1.0030951175659306163 1.1518964326421212707 -0.076991790879053778607 1.2025449722370675776 -0.038101309175098754811 -0.36259070470233634165;-0.23610083617890589847 0.82307951016547686862 -0.85953247628933115987 -0.69023713742060477383 0.9993628964761293032 1.1917987715594389186 -0.3084102217428861259 1.0974315667551928222 -0.23552672422316317524 -0.10978380828824550741;0.61594683613692202684 -0.37321835655916857366 0.071738363828961010382 -0.94013889686756701991 0.99273764093985239487 1.2631190061682067149 -0.84336814221344380549 0.80433561419033416939 -0.67643599153536304591 0.090210575244220145286;-0.3164592914076840291 -0.1372789200104261309 -0.029738195421712930455 -0.89528131349976747266 1.0144713629588395509 1.2171485589779234004 -0.69676526916471437367 0.87704956678719592222 -0.58653509945703596884 -0.98821306123357677276;0.11757074848379438226 0.27942098730810166485 0.6561909842955436778 -0.90844202019466491205 0.98777890975050075539 1.2513095962774702929 -0.72097854855158904908 0.86898428485105139174 -0.55998352627852432395 -0.40355054371224136078;0.35838880976432108127 0.63116167580441728813 0.23197084155916763981 -0.9368491500292156493 0.96254933345416460178 1.2895617086654556083 -0.80767879635068196009 0.83017442575417021988 -0.81838900863710539735 -0.14548937631130190451;0.95295460408049159629 -0.4350499591289274659 0.35709350775750048346 -0.96470704700522746933 0.95874386808770961643 1.310143471065015941 -0.91140438196693551731 0.78092795427263617114 -0.77100379443251032541 -0.6651681558457368526;1.0604937814547177322 0.75547865037609629457 -0.061742726382572464539 0.36420989047047558351 0.45786400511606484276 0.84274664481501981861 0.97830911564892275578 1.5071972753638815945 -0.17899898713715906018 -0.016152583633694084925;0.44304014400798630291 0.55826508077465730739 -0.33727808132231790195 0.36289035125538360305 0.22527707983579711715 0.84145892377020981012 0.75872470960303384224 1.2523713124634618943 0.33516499236074148715 0.10229274212168691649;-0.28194985677391204426 0.2384032129379162479 0.18886786754461346027 0.36249960070560399705 0.19279237061377341167 0.79097894942424673559 0.69276977790838312199 1.1369116716123479627 -0.41188752017779006742 -0.73627035421569486662;-0.62291319521168475593 0.0089113279869906004971 -0.87674464497110726757 0.35720200820414260701 0.22606764940766069238 0.83848931938833004551 0.75147796031202451772 1.239140546099229967 -0.35152580235056501978 0.26887547582812626468;-0.17218710813354634603 0.29171732136462508178 -0.88628911573057100881 0.3772000754816833834 0.44120665045191215237 0.83630343308568111382 0.98091598581037386939 1.487278903838875177 0.31330282308452633844 -1.0578559875781023969;0.78271746561798150044 -0.067290980162992827807 -0.85387621834876104021 0.25748263594311276981 0.64129377795784525684 0.92321786715488163289 0.98685746627164538936 1.6273432935820668632 0.27291844239771162473 0.22860377564898709535;-0.38286694853753566736 0.038120946049144087409 -0.40140074299857742002 0.31560923988037942189 0.54716024422698350538 0.85265619313473473007 1.0276640504767646789 1.6002921136203649422 0.04453563857737227738 -0.8551176010790388915;1.0622490022419446287 0.64514276687846450198 0.29083039995100651298 0.36545270641158539293 0.49000287524234797942 0.84939880487029173484 1.0138670353890246734 1.5258535368342012184 0.073880521624296965899 -0.28945613840850120679;0.045102753760103322933 0.66880555249658246719 0.18404514179344932945 0.35856182400878000571 0.53766542851132781422 0.84270356884057617819 1.0530010045500910465 1.5702087051098061465 0.016964021005595474739 -0.971164582508792118;0.74247647522037063528 0.80520721589038468657 -0.79937544629756474013 0.26317923469142534554 0.65215466919241471544 0.91003422241068054888 1.0034249017757843614 1.6336002727075158436 -0.56736227871786626409 0.61082638191490301605;-0.12849527639424626613 0.34770263016748642615 -0.43814167445804624856 -0.12496303024114543967 0.89161541170912306242 0.99212527303057562733 0.60153159330860739296 1.5872126088027411761 -0.10720410171438082836 -0.34071832806132984484;-0.084017517855374784785 0.19367775551242344401 -0.3521128060666846582 0.060600468099221455054 0.83955255345162971281 0.91060395611066791144 0.85626772194626843415 1.6727556193851362831 -0.78891219493142816788 -0.3907484836473119616;-0.067820465206056584906 0.81870762815745823371 -0.39873076765794185361 0.12141638954054273514 0.79740926929117039723 0.87638619096920267193 0.93260319559591353666 1.668988259377864436 -0.70512806855598564315 0.22490841422457971688;0.3732193479166134864 0.0755743284901750495 0.12652295835727558893 0.051509452435655397884 0.82906313822440302896 0.9234542013543473038 0.83550708670290696478 1.6603905735256003773 -0.028814978381302432109 -0.54305538544241593879;0.29653533253788172397 -0.12710718648713703605 -0.12607091420128815895 -0.13049862995704122892 0.87783609568342557683 1.0052174223472511994 0.58158666627533728288 1.5850662879324080023 -0.254741433023346453 -0.57571839758802845211;-0.17425672167900685405 0.80783333032368942472 -0.50517578881289415538 -0.59656540096916410576 0.98768376750350705962 1.1025966463415939334 -0.066687135914803505332 1.3005521620413602601 -0.44931081149188273338 0.53650433842372602378;0.61995816208229315158 0.52769693902332259761 -0.11147363037098317884 -0.40021705870471946387 1.0085796040348402602 0.99535905456443152239 0.27485120837793514115 1.440832908584177785 -0.012514710405709178129 -0.9938581256057108515;0.24999340639517103613 0.26978411516927913727 -1.0663547258719145994 -0.37170787540979505215 0.98805721297810555903 1.0071053175649362643 0.30389369199784610487 1.451511768850543227 0.018060409800917262557 0.52925685038483560874;0.52887453573930964801 0.68558761014970370784 0.56915146132686567082 -0.40144275569567677842 1.0209857049536934515 0.97523297222884797186 0.287888801644097303 1.4320203802240094593 -0.38291979771049183823 -1.0041207837805592451;0.84834836060750107301 0.38267713533469399634 -0.5383587257556029515 -0.60377416536702799288 0.97962595835942389844 1.1146599218376702645 -0.084047106178881850203 1.2939483727443104044 -0.40861535423225486818 0.076399624087324619071;-0.18165808255404253257 -0.1911084717893678786 -0.87065637028597553382 -0.85414403512090897319 1.0402267687163038179 1.1898511143156953462 -0.59527674962148025006 0.98103770828426906103 -0.25495040417075187644 -0.12811050335504192699;0.61788144002676748112 -0.19843939308620492379 -0.42542781985196737038 -0.81980846309684207718 1.0107817990035932176 1.194198447698699761 -0.5093091601464226903 1.0479197091498422267 -0.25541087724550398663 -0.033944135693942285859;0.37509121687177882087 -0.085125103887215489151 -0.49940128475267847596 -0.82032241068591094102 0.98901247216736043466 1.2114215793466260873 -0.5111847886650877637 1.0502495992899973931 -0.82298813460170450185 -0.29864214269644617783;0.2813393893009508151 0.1379116586155084978 -0.49909235761023867939 -0.82161632785606852902 1.0042565539718231182 1.2094672085209234869 -0.52053037895105258581 1.0486478885976155961 -0.18547571219783204333 -0.28678824947196862594;0.3503259696403749901 0.83137286196262494276 -0.37912246007071964682 -0.88643485097932717132 1.0035116072553884603 1.2425717641597031626 -0.6765295492744685113 0.94395321681485189202 0.24890463364588449879 0.096106074903194560477;-0.29808710133049964863 -0.2670940973374262839 0.40810026551190992095 0.38009742926002437757 0.30367087369703360533 0.73321012346632641332 0.93797071615876925765 1.390180852286152513 -0.53862529970574180016 -1.3879015676557260317;-0.3883147313866197603 0.13209023829728583355 0.37354402854220941643 0.34193679398890125531 0.091043161793143992377 0.73654372226743891616 0.68242173083158585989 1.1184002221988837977 0.3037475859964867686 -1.0683727982375632592;0.17426807777698230528 -0.31239573075478338504 -0.88799057921241664193 0.3248452498756916329 0.052418767865236491621 0.67508589394721751908 0.60049947443885642873 0.99221448897077890727 -0.55163012521504961594 0.63750411354325031699;0.87953628928171512236 0.21621847029353477576 0.13671160129821863238 0.34713793549967558727 0.098373804385108953863 0.73107115048899795617 0.69548608580682502733 1.1228842767708571149 0.05833000496325787404 -0.0033917483058024007481;0.7110266323021764423 -0.035667137105605407899 -0.49045318720571984272 0.3636803201970842947 0.27001209167291101432 0.77275041154271573163 0.88014150074183206129 1.3649520164276820466 -0.19305683336711582099 -0.57665026226808868692;-0.29062344177136367751 0.066918265011326458214 -0.48204479509837616646 0.29520418552016491898 0.474500838857329299 0.80321699067828333796 1.0154249198708062973 1.5990930113977470661 -0.58444805969409852064 -0.59359064045355203199;-0.1154491983240730768 0.4524241083540304631 0.28765041085047177161 0.38599272539361889622 0.4015594125997411501 0.66340067055686680053 1.119470425129649005 1.5558316765777813195 -0.36278757808159434184 -0.5214643943008867577;0.29725257994597614752 0.093459018435617643994 0.55337756463208698232 0.37692006815873801973 0.29308721925423097954 0.74883972767118722746 0.96598518049255177598 1.4332743750441043762 -0.77307226599296385849 -0.70635414416186348419;-0.55044819866906491423 -0.26327894689028508157 -0.3909799119262499234 0.40065555490705928587 0.3780494029723844851 0.68761671238868671274 1.099624588948536319 1.5289023884267478604 -0.59369558624794149804 -0.77525712296809456969;0.015401175491335076378 1.1381542282646324171 0.66702399567532977276 0.30342379276199343829 0.48819552530920284905 0.77855834045482164019 1.0431251822241656146 1.6050326441466453709 -0.096762438893696983699 -0.5058441100895872955;-0.57016306668682203984 0.5331600276517811654 -0.41127844393321616456 0.010997054021869109852 0.75220027707611603063 0.86621501552595481233 0.82873715023122951351 1.682115029214195312 0.28134077182926869876 -0.94997532924230509987;0.83243457769214335151 0.22947419700417645561 0.041210815437348426171 0.15791822696100882295 0.63564512850802012967 0.84454068491968037335 0.95121935747349539714 1.6667175971727636874 -0.047300920801233208024 -0.67643016148687917788;-0.12065762634234855621 -0.56937171186187540695 0.013265371149530195277 0.22035524959939525869 0.62847665108829464664 0.79240481206937229963 1.0469252446595467276 1.6973741685475143282 -0.94280742116916349538 -0.88981847982892747773;0.46758300854996692753 -0.026390411752992400107 -0.31171646385386753142 0.1603272629978515218 0.6372068306859691722 0.84976085863252037722 0.95454950549464234744 1.6685440146153200924 -0.019124561001212236899 0.19624988020824860047;-0.31861733361953764598 0.2884641129828279249 -0.075654721423700152516 -0.0099677811089809789658 0.72598589985494332844 0.90406988011203093247 0.77330714353903684533 1.6564982215686359091 0.22985161473698459411 -1.0671138918369860171;0.57610939292756946362 0.53296837054308487946 -0.12718299617802947266 -0.43198731398235445944 0.95849025757807060355 0.99383189099833701974 0.23309010534899637923 1.4530791606420452311 -0.033703837501107329622 0.31258587967347417624;-0.31554140958698689845 -0.31362215208796667687 -0.84541702615983993496 -0.35113453632864938259 0.86225708333954553808 1.0165320733781804119 0.30894652172423470171 1.5145740160567244814 -0.90191514344408896253 -0.43181563996636934677;0.098980919214199949985 0.14077426580263885381 -0.69278079382612789416 -0.26955076084597145991 0.86882923595099970093 0.97711790473765769427 0.44119773247270466232 1.5607153770554607064 -0.34470992243094106255 -0.751126083961051072;0.58457303990933984217 0.65097419700710723589 0.71003938764584884069 -0.30604569175075169163 0.93641381034844461961 0.90526630786374395754 0.45183237744672882785 1.5537382682905167552 -0.11914151775209667894 -0.62906723452449297973;0.69132824353142074969 -0.35173639488158980893 -0.76507767112565172596 -0.44221431849445197448 0.94443467632437616555 1.0155319985997459664 0.20460572146806346727 1.4444911073570665394 -0.09390522347372984302 6.7229349394411111289e-05;0.058448012651020994634 -0.54054025621003454205 -1.0421040484307284579 -0.82538081343176117333 0.97487938853136757444 1.207041912318242538 -0.5390869571281531325 1.059674213318220648 -0.66979218766520787209 0.14093868052133176616;-0.26065265484947219843 -0.010410488018133988095 -0.38509999404652672794 -0.74446423796912963855 0.98702387932183444086 1.1362023938035825665 -0.32918898512569821913 1.1896258307881741878 -0.70377378217429398255 -0.44530005448519055511;0.27274385147566626575 0.39390736176315033212 0.066861312356798305312 -0.7302954418034437456 0.97692095643857768117 1.1322933167030402313 -0.29413866301457969321 1.2172203226072946247 -0.39569167549773492931 -0.45165680656586548736;1.0642566734277139062 0.19188862131605496919 0.048578111966619236251 -0.7598879357534159551 0.97739734971367719929 1.1451775465783564645 -0.35748218004389242797 1.1665688452081024451 -0.47568673173384612429 0.23884754608435176948;-0.54578345002016670495 -0.13649587260673842759 -0.64196229024512563299 -0.81775756539005195478 0.98217796801708456833 1.1989895051473999921 -0.52077791106001591892 1.0707837345145707619 0.0054483654352273170121 -1.1849402874701355781;0.67676206014703665925 -0.40405397233875628427 -0.29114640079010517537 0.37663400165833571531 0.17138728099150779549 0.66943750304753146807 0.86858628634105072841 1.2735978688920535085 -0.69537987199136541694 -0.41678157905593338217;-0.070426893130506346141 -0.62898918595300390422 0.015853973401605572086 0.29870320230443697662 -0.014348419283018578468 0.57477688835447571236 0.56848046018316600314 0.91244548779535816774 -0.37093997462135530618 -0.77651782287796111692;0.81764006183960280527 0.28850792736074815092 0.88878563600714821646 0.25337641648847736286 -0.038903916475402706976 0.53402198084494412189 0.43423065143643885255 0.75863092458525438477 0.58269320239811117634 -0.58307491132743693996;-0.41869118819593142966 -0.76148441690321688746 -0.84376910446949171529 0.29669984671808974364 -0.016842244692237492293 0.58493355620956899443 0.56189571776199886965 0.91077153607241856381 0.11289616945084603172 -0.17611541125416932396;0.19615254511105340018 0.76868943668711298134 0.38167506492864000656 0.36821407233714775753 0.15154025202322785049 0.69728590874875751027 0.83713227227383646412 1.2650325390537253689 0.37904774855564465907 -0.046021441571447808949;-0.29587838592967002915 0.3404595990029418151 -0.0038333192124644505094 0.34811676375851174914 0.34536416449537016282 0.70008621807306492535 1.0601624656076154007 1.5516985217747407688 -0.85213040038343712546 0.1358665330128047688;0.77857117768247618983 -0.23086246148021311031 -0.13715622848400940703 0.41036905390425448825 0.33654007402447849717 0.59601430379459618969 1.0805165377607066635 1.4447367279969900444 -0.57373796775609653409 0.062943296642337845381;-1.0861817796064345831 -0.1115696932332351371 -0.45121295685892642835 0.37234346747979174541 0.2264995001617856607 0.6841804545336155341 0.90170072472721818357 1.3232975917782019426 -0.58665788137251007051 -0.7326707370481149173;0.77597173784599859925 -0.15497097287874025962 -0.36110153016255902569 0.34368746556079776688 0.24107884248084018863 0.73721729290092663511 0.88459912572358390115 1.3712216695555627943 -0.40335921649521216947 0.43752360600229001086;0.58558348487527789317 -0.064614179760463935631 0.02022979772091780884 0.36603131084095413827 0.37420469299396585949 0.65209084835458119844 1.1168824120175804282 1.5661818053291827191 -0.63878309873814020925 0.46818302902052311154;0.37993141441217720411 0.58600354570908652629 -0.49157099048349045534 0.10175871847225813338 0.62582969208650329751 0.83516703978616424475 0.90430577006673995566 1.6760166360894288573 0.47628020356291944637 -0.29492339193072913961;-0.34357665914099844162 0.19509525136902811093 -0.16259292479402323583 0.21959748608353024668 0.52651236741464657598 0.77653118280434751952 1.0121120622090196139 1.6615538413520880567 -0.95255189620089386615 -0.4536494548126083215;0.16070291439117725951 0.32668070806523497041 -0.89680903529006217312 0.29900679565218046818 0.5308914386893022197 0.68205927427684565068 1.1399596157424374265 1.6846693464012911789 -0.9622729473728099947 0.48174382894467637772;0.17118653385758769714 -0.0084059357920857839114 -0.72978941359113302934 0.21581882025393611668 0.51507016712367847955 0.79893354637775049198 0.9934513040814325624 1.6602413973094698463 -0.49275725115770968587 -0.3266444414648901895;0.9611053390116707229 0.13985688743503549292 -0.15398904573916011307 0.092476204527824554247 0.61151592980272007072 0.85823089753123660284 0.87687679020164854826 1.6671915050078531806 -0.039789467879386128391 0.025462563228097267326;0.1924031890071427886 0.27178752821074236845 -0.6264493322241104778 -0.39784462010151128153 0.85217279226352138366 1.00771348386146542 0.25350202517037789818 1.5081107692876651871 -0.64513261116772113724 -0.61116643265855641332;0.6421159241267382356 0.11899367042594123645 -0.30207834504640118656 -0.23203102439263498247 0.82162828394942533095 0.91090210122390324887 0.52500914634998363528 1.5974238225667807267 -0.68536277373807608093 -0.20442688168934483595;-0.14887106915830017329 -0.013269041974663303707 -0.21886910692482550167 -0.19276791110166802135 0.7788246566726887421 0.93247633329841372873 0.55170344121757119993 1.6062931648190563738 -0.65796230380293219131 -0.49986619878242743997;-0.37898665860531455252 -0.13784210745766181661 -0.53716229643799595639 -0.24466012730224140359 0.80141542192183923277 0.94271029826702112953 0.48571426416881957611 1.5857084752110990333 -0.74349857928596985168 -0.54903700095789331748;-0.26043053694817841492 1.2688495123439571532 0.27131477204711346163 -0.38081435285279791048 0.88644221091504826759 0.95578842130492169815 0.31375595926393906598 1.5170289869729813859 -0.48538390062975927952 0.064758685481377115112;-0.0084796468111631578823 0.006331692439609789419 0.26638434566186891539 -0.75887385820567998529 0.97951311941966645591 1.1308495968586320668 -0.35805208790534426289 1.1699277585061049756 -0.10982357564724495869 -0.68678654678203199246;0.72555640793955278323 0.41806543547814312145 0.39426693315314065291 -0.683795205206388923 0.98441806870545711661 1.0757427185847572293 -0.18063471919145271394 1.2903634143277999957 0.00087472101999338538157 -0.056258953461486904679;0.16224808585980385334 0.62905527162822072462 -0.25243421095260304421 -0.6623308488244304959 0.98000170629635141584 1.0553770336733099278 -0.13001061310879652444 1.3058046896446158236 -0.81595762135222216216 -0.55851790503444420644;-0.056183639539850199762 0.42260786444733222655 0.08459844196498597646 -0.66527776358533585732 1.0033071486451989873 1.0486287772042393041 -0.13756661356812829866 1.3123950259879952895 -0.15712837987087049929 -0.55677102010340395744;-0.52031622797020038451 -0.35155073867905495266 -0.91583749353049481723 -0.73254712946775124571 1.0090826305064335422 1.0868993833972948604 -0.29422277603359420217 1.2023847040859043656 -0.94724941371734017181 -0.1788753547416353229;0.93454825653084738768 -0.11497143169655750505 0.41370912836604578633 0.35767374667953555356 0.10701116914239412747 0.65354552360832451896 0.78529613113178731165 1.1839592350476721982 -0.25815583898105015637 -0.63109324202085093081;0.60024910622725036191 -0.10667926087265140744 0.47819264595174870713 0.23898525499809070149 -0.065233762075681600567 0.56924531689872082119 0.41493178733519547885 0.76933378448159861485 -0.40763633372527480203 0.11651489881256628378;0.28924472569677878164 0.83369761022555144425 0.27316601897008835342 0.23530551919951750439 -0.032807429305132543296 0.42081354145371935305 0.414955219750257287 0.66160427564051316196 0.29940717098126223839 0.0031492514330214325599;0.42343677194490941806 -0.27991980832091795106 -0.68255494830198881751 0.24736641558859434609 -0.055573610430434287888 0.56077451951347900838 0.43424947198816182814 0.78067195294449653886 0.033846745398182435938 -0.20162026140006622521;0.052627062688791352574 0.61309739056293111048 0.019306221258091543075 0.3529526452315082663 0.095475205202836088691 0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

0.10770027289094248613;-0.18519777915793703138;-0.44743945014597918952;-0.99413293222960275042;-0.42280435808952349097;-0.23659081502454654133;0.5840028190640341732;-0.13716682928466827907;-0.62212230472731622211;-0.072943459202218202675;-0.56964124652762360146;-0.50479518960159741603;-0.74060717619607840945;0.053922277207157941203;-0.59523748515909868928;-1.1150449795511883089;-0.85484324546357293162;-0.83127283334303303519;-0.20638502546502968116;0.23379704837866316369;-0.59385737563185658772;-0.56679831802865321411;-0.37805965196660668015;-0.33762518652425627108;-0.17231270074862778396;-0.1334185073005514921;-0.34042520164161660379;0.39736081339790058076;-0.60928636847835693224;-0.77594617893994843882;-1.3088376480915417943;-0.99795309814012644889;-0.72872639420111628983;-0.30699767602977706682;-0.76061475714218707012;-0.39792270345430991174;-0.86591666117182219953;-0.41632923732060389543;-0.22438543942720087787;0.16451587784558677208;0.083732763425259953971;-0.399194266798001407;0.5985797946933982816;0.15498726000904602951;-0.54746023205161054026;-0.45306160325771616115;-0.6390929106768649115;-1.0443161315147770907;-0.88024291859264058857;0.71216256023267709985;-0.7254839070249412547;-0.45898647092092981215;0.092453652078971479411;-0.6541153965736735687;-0.46813758895979062924;0.015313042110065781809;0.44788399298119557779;0.22535852143433526829;-0.67217554177860405762;-0.58275986554492886782;0.06797576241789698992;-0.41442678211589834003;-0.17287344329323084402;-0.21675312755428832734;0.047466587593139264456;-0.19085959376968170131;-1.0183671073764637427;-1.0398087416646535353;-0.52185061449494940522;0.40459635380083275313;-0.11478258231211492524;0.092384822564310589699;0.021836272558584564341;-0.63060933197534663197;-0.27017721034651193124;-0.46825346641071791121;-1.3172501791127224635];

LW2\_1 = [0.044497832052447311435 -0.40253405182179785582 -0.78177563505978064917 0.26592438952059715973 0.6092408988688458038 0.9640454027664908665 0.88098680112783589458 1.4995122230871027469 -0.66490045501415395712 -0.66443740318135280365;-0.10846498282148568648 0.89575695113845554829 -0.48906172385064156094 0.36723448019156079702 0.39282588089124270692 0.94091368738513891934 0.78244309545969847886 1.2790882750527319267 -0.60074438720086087429 0.053189996094627642331;0.46329677620897413703 0.91298370635432057885 0.68019740924403671034 0.33332571984168585244 0.29600969108220842596 0.96626709815643885282 0.62417853168077108705 1.1557130759367308936 -0.16832769560855243007 -0.11113799583722211439;0.46843244900589803281 0.22950406081898336308 -0.71063725622504758661 0.35548196010666061051 0.36958297921078581139 0.97532816695448065758 0.74022285671111121008 1.2652886160858349829 -0.5944754138612842187 0.53795070367705111192;-0.0039299355647654148418 -0.1306862721336686517 -0.49545004918252216752 0.34079932080029351482 0.59355952399587819102 0.9883376122643035 0.91050249684009276763 1.4697093231790903101 -0.089152565402892389179 -0.83959787573554667262;0.39389528525206707332 -0.012374956317702547753 -1.028822181687399695 0.16912194304628047625 0.860890476793758741 0.99272301457508849154 0.8759595601015291999 1.579963403746351025 0.16444973366446258289 -0.64468868742892271317;0.44609403322384205692 0.055635704981933452318 0.56128862013977431911 0.22249258443988559342 0.75295115908545096062 0.96417277930100875327 0.90736508924798642273 1.5627993079662556575 -1.2077441231322403326 -0.24123404497833283999;0.55371486730022390077 0.6214549443679444618 0.33096227505161818216 0.29121293533859365921 0.632977854536109108 1.0167771637042677391 0.87366466077342652685 1.4900080826391548516 -0.36662122825736609411 0.48902731073047944754;0.58899392665080507747 –

0.62071028207271039534 -0.19015528353994312627 0.26437268038630457045 0.69710512478440245232 1.0099368402618167373 0.88509535159110319658 1.5300791543886365087 -0.87854477136797159975 -0.52865279880212412422;0.72864635689467505131 -0.36352199446135968763 -0.2697718092388445843 0.13150652916540001014 0.81013101063149250969 1.0536996241951712694 0.7758735056894960902 1.5378681349738494433 -0.024607815830051879558 0.31700340573511498476;-0.058729157859711673961 -0.057432418046311370374 -1.2071216324009221843 -0.24869151724239191292 0.96727132471664423186 1.1188581333089400172 0.35664568947787994579 1.4304229362671019299 0.20770589245584036853 -0.01252514463530009399;0.69569857198292317513 0.48348354182712760529 0.14065477347733010283 -0.05130273790958156388 0.96030678331295937777 1.024531005781052162 0.64667790174356820643 1.5120244055616696155 -1.0780359133283965445 0.41299377699755707161;0.31225717149922693761 0.46223011735055763438 -0.89944972066061013027 -0.0035949451630336564517 0.92317372309578116241 1.0504163129621657546 0.67417419474563222703 1.5341678647708436589 0.4062067526539006046 -1.133481114322977712;-0.47892170382173676613 0.37055833626635525935 -0.92343668207121465397 -0.045489967904485048567 0.96178265570074938928 1.0288440585773388491 0.65260725218855375473 1.5231463221400800556 -0.99101744395326518688 -0.44096406443316404911;-0.24157591362468194829 0.32660916835039210948 -0.39976097824438128203 -0.23199888402964022327 1.0020672251703424127 1.0670668441249748781 0.41696843928541932334 1.4425702055880504915 -0.25860225166290773391 -0.32002339952257274902;-0.0080787272187477741914 0.51417302437784839775 -0.77819604823081167666 -0.70949976314469698213 0.97866954495722824348 1.2208432266929283294 -0.3549419344964534484 1.0738262883447629026 0.016086677299527511048 -0.47926715667471636584;0.88266296225127027775 -0.24493818993484539615 0.52436022420547079292 -0.58047579644964220069 0.97425869639902284991 1.187826780534197546 -0.13730368220064431695 1.1751568247967283387 -0.28995817694431719191 -0.76337258037070865324;0.28335146456161641737 1.1796779390131328924 -0.0043039852181831657341 -0.50503111925187871289 1.0092974875236429 1.1279706834303062646 0.014923602535668880134 1.2530583043334959648 -0.025364174414193148277 -0.20139362760586682066;0.67361556383444542995 0.31813742650877385731 -0.18480652810220049576 -0.55593376361965829435 1.0030951175659306163 1.1518964326421212707 -0.076991790879053778607 1.2025449722370675776 -0.038101309175098754811 -0.36259070470233634165;-0.23610083617890589847 0.82307951016547686862 -0.85953247628933115987 -0.69023713742060477383 0.9993628964761293032 1.1917987715594389186 -0.3084102217428861259 1.0974315667551928222 -0.23552672422316317524 -0.10978380828824550741;0.61594683613692202684 -0.37321835655916857366 0.071738363828961010382 -0.94013889686756701991 0.99273764093985239487 1.2631190061682067149 -0.84336814221344380549 0.80433561419033416939 -0.67643599153536304591 0.090210575244220145286;-0.3164592914076840291 -0.1372789200104261309 -0.029738195421712930455 -0.89528131349976747266 1.0144713629588395509 1.2171485589779234004 -0.69676526916471437367 0.87704956678719592222 -0.58653509945703596884 -0.98821306123357677276;0.11757074848379438226 0.27942098730810166485 0.6561909842955436778 -0.90844202019466491205 0.98777890975050075539 1.2513095962774702929 -0.72097854855158904908 0.86898428485105139174 -0.55998352627852432395 -0.40355054371224136078;0.35838880976432108127 0.63116167580441728813 0.23197084155916763981 -0.9368491500292156493 0.96254933345416460178 1.2895617086654556083 -0.80767879635068196009 0.83017442575417021988 -0.81838900863710539735 -0.14548937631130190451;0.95295460408049159629 -0.4350499591289274659 0.35709350775750048346 -0.96470704700522746933 0.95874386808770961643 1.310143471065015941 -0.91140438196693551731 0.78092795427263617114 -0.77100379443251032541 -0.6651681558457368526;1.0604937814547177322 0.75547865037609629457 -0.061742726382572464539 0.36420989047047558351 0.45786400511606484276 0.84274664481501981861 0.97830911564892275578 1.5071972753638815945 -0.17899898713715906018 -0.016152583633694084925;0.44304014400798630291 0.55826508077465730739 -0.33727808132231790195 0.36289035125538360305 0.22527707983579711715 0.84145892377020981012 0.75872470960303384224 1.2523713124634618943 0.33516499236074148715 0.10229274212168691649;-0.28194985677391204426 0.2384032129379162479 0.18886786754461346027 0.36249960070560399705 0.19279237061377341167 0.79097894942424673559 0.69276977790838312199 1.1369116716123479627 -0.41188752017779006742 -0.73627035421569486662;-0.62291319521168475593 0.0089113279869906004971 -0.87674464497110726757 0.35720200820414260701 0.22606764940766069238 0.83848931938833004551 0.75147796031202451772 1.239140546099229967 -0.35152580235056501978 0.26887547582812626468;-0.17218710813354634603 0.29171732136462508178 -0.88628911573057100881 0.3772000754816833834 0.44120665045191215237 0.83630343308568111382 0.98091598581037386939 1.487278903838875177 0.31330282308452633844 -1.0578559875781023969;0.78271746561798150044 -0.067290980162992827807 -0.85387621834876104021 0.25748263594311276981 0.64129377795784525684 0.92321786715488163289 0.98685746627164538936 1.6273432935820668632 0.27291844239771162473 0.22860377564898709535;-0.38286694853753566736 0.038120946049144087409 -0.40140074299857742002 0.31560923988037942189 0.54716024422698350538 0.85265619313473473007 1.0276640504767646789 1.6002921136203649422 0.04453563857737227738 -0.8551176010790388915;1.0622490022419446287 0.64514276687846450198 0.29083039995100651298 0.36545270641158539293 0.49000287524234797942 0.84939880487029173484 1.0138670353890246734 1.5258535368342012184 0.073880521624296965899 -0.28945613840850120679;0.045102753760103322933 0.66880555249658246719 0.18404514179344932945 0.35856182400878000571 0.53766542851132781422 0.84270356884057617819 1.0530010045500910465 1.5702087051098061465 0.016964021005595474739 -0.971164582508792118;0.74247647522037063528 0.80520721589038468657 -0.79937544629756474013 0.26317923469142534554 0.65215466919241471544 0.91003422241068054888 1.0034249017757843614 1.6336002727075158436 -0.56736227871786626409 0.61082638191490301605;-0.12849527639424626613 0.34770263016748642615 -0.43814167445804624856 -0.12496303024114543967 0.89161541170912306242 0.99212527303057562733 0.60153159330860739296 1.5872126088027411761 -0.10720410171438082836 -0.34071832806132984484;-0.084017517855374784785 0.19367775551242344401 -0.3521128060666846582 0.060600468099221455054 0.83955255345162971281 0.91060395611066791144 0.85626772194626843415 1.6727556193851362831 -0.78891219493142816788 -0.3907484836473119616;-0.067820465206056584906 0.81870762815745823371 -0.39873076765794185361 0.12141638954054273514 0.79740926929117039723 0.87638619096920267193 0.93260319559591353666 1.668988259377864436 -0.70512806855598564315 0.22490841422457971688;0.3732193479166134864 0.0755743284901750495 0.12652295835727558893 0.051509452435655397884 0.82906313822440302896 0.9234542013543473038 0.83550708670290696478 1.6603905735256003773 -0.028814978381302432109 -0.54305538544241593879;0.29653533253788172397 -0.12710718648713703605 -0.12607091420128815895 -0.13049862995704122892 0.87783609568342557683 1.0052174223472511994 0.58158666627533728288 1.5850662879324080023 -0.254741433023346453 -0.57571839758802845211;-0.17425672167900685405 0.80783333032368942472 -0.50517578881289415538 -0.59656540096916410576 0.98768376750350705962 1.1025966463415939334 -0.066687135914803505332 1.3005521620413602601 -0.44931081149188273338 0.53650433842372602378;0.61995816208229315158 0.52769693902332259761 -0.11147363037098317884 -0.40021705870471946387 1.0085796040348402602 0.99535905456443152239 0.27485120837793514115 1.440832908584177785 -0.012514710405709178129 -0.9938581256057108515;0.24999340639517103613 0.26978411516927913727 -1.0663547258719145994 -0.37170787540979505215 0.98805721297810555903 1.0071053175649362643 0.30389369199784610487 1.451511768850543227 0.018060409800917262557 0.52925685038483560874;0.52887453573930964801 0.68558761014970370784 0.56915146132686567082 -0.40144275569567677842 1.0209857049536934515 0.97523297222884797186 0.287888801644097303 1.4320203802240094593 -0.38291979771049183823 -1.0041207837805592451;0.84834836060750107301 0.38267713533469399634 -0.5383587257556029515 -0.60377416536702799288 0.97962595835942389844 1.1146599218376702645 -0.084047106178881850203 1.2939483727443104044 -0.40861535423225486818 0.076399624087324619071;-0.18165808255404253257 -0.1911084717893678786 -0.87065637028597553382 -0.85414403512090897319 1.0402267687163038179 1.1898511143156953462 -0.59527674962148025006 0.98103770828426906103 -0.25495040417075187644 -0.12811050335504192699;0.61788144002676748112 -0.19843939308620492379 -0.42542781985196737038 -0.81980846309684207718 1.0107817990035932176 1.194198447698699761 -0.5093091601464226903 1.0479197091498422267 -0.25541087724550398663 -0.033944135693942285859;0.37509121687177882087 -0.085125103887215489151 -0.49940128475267847596 -0.82032241068591094102 0.98901247216736043466 1.2114215793466260873 -0.5111847886650877637 1.0502495992899973931 -0.82298813460170450185 -0.29864214269644617783;0.2813393893009508151 0.1379116586155084978 -0.49909235761023867939 -0.82161632785606852902 1.0042565539718231182 1.2094672085209234869 -0.52053037895105258581 1.0486478885976155961 -0.18547571219783204333 -0.28678824947196862594;0.3503259696403749901 0.83137286196262494276 -0.37912246007071964682 -0.88643485097932717132 1.0035116072553884603 1.2425717641597031626 -0.6765295492744685113 0.94395321681485189202 0.24890463364588449879 0.096106074903194560477;-0.29808710133049964863 -0.2670940973374262839 0.40810026551190992095 0.38009742926002437757 0.30367087369703360533 0.73321012346632641332 0.93797071615876925765 1.390180852286152513 -0.53862529970574180016 -1.3879015676557260317;-0.3883147313866197603 0.13209023829728583355 0.37354402854220941643 0.34193679398890125531 0.091043161793143992377 0.73654372226743891616 0.68242173083158585989 1.1184002221988837977 0.3037475859964867686 -1.0683727982375632592;0.17426807777698230528 -0.31239573075478338504 -0.88799057921241664193 0.3248452498756916329 0.052418767865236491621 0.67508589394721751908 0.60049947443885642873 0.99221448897077890727 -0.55163012521504961594 0.63750411354325031699;0.87953628928171512236 0.21621847029353477576 0.13671160129821863238 0.34713793549967558727 0.098373804385108953863 0.73107115048899795617 0.69548608580682502733 1.1228842767708571149 0.05833000496325787404 -0.0033917483058024007481;0.7110266323021764423 -0.035667137105605407899 -0.49045318720571984272 0.3636803201970842947 0.27001209167291101432 0.77275041154271573163 0.88014150074183206129 1.3649520164276820466 -0.19305683336711582099 -0.57665026226808868692;-0.29062344177136367751 0.066918265011326458214 -0.48204479509837616646 0.29520418552016491898 0.474500838857329299 0.80321699067828333796 1.0154249198708062973 1.5990930113977470661 -0.58444805969409852064 -0.59359064045355203199;-0.1154491983240730768 0.4524241083540304631 0.28765041085047177161 0.38599272539361889622 0.4015594125997411501 0.66340067055686680053 1.119470425129649005 1.5558316765777813195 -0.36278757808159434184 -0.5214643943008867577;0.29725257994597614752 0.093459018435617643994 0.55337756463208698232 0.37692006815873801973 0.29308721925423097954 0.74883972767118722746 0.96598518049255177598 1.4332743750441043762 -0.77307226599296385849 -0.70635414416186348419;-0.55044819866906491423 -0.26327894689028508157 -0.3909799119262499234 0.40065555490705928587 0.3780494029723844851 0.68761671238868671274 1.099624588948536319 1.5289023884267478604 -0.59369558624794149804 -0.77525712296809456969;0.015401175491335076378 1.1381542282646324171 0.66702399567532977276 0.30342379276199343829 0.48819552530920284905 0.77855834045482164019 1.0431251822241656146 1.6050326441466453709 -0.096762438893696983699 -0.5058441100895872955;-0.57016306668682203984 0.5331600276517811654 -0.41127844393321616456 0.010997054021869109852 0.75220027707611603063 0.86621501552595481233 0.82873715023122951351 1.682115029214195312 0.28134077182926869876 -0.94997532924230509987;0.83243457769214335151 0.22947419700417645561 0.041210815437348426171 0.15791822696100882295 0.63564512850802012967 0.84454068491968037335 0.95121935747349539714 1.6667175971727636874 -0.047300920801233208024 -0.67643016148687917788;-0.12065762634234855621 -0.56937171186187540695 0.013265371149530195277 0.22035524959939525869 0.62847665108829464664 0.79240481206937229963 1.0469252446595467276 1.6973741685475143282 -0.94280742116916349538 -0.88981847982892747773;0.46758300854996692753 -0.026390411752992400107 -0.31171646385386753142 0.1603272629978515218 0.6372068306859691722 0.84976085863252037722 0.95454950549464234744 1.6685440146153200924 -0.019124561001212236899 0.19624988020824860047;-0.31861733361953764598 0.2884641129828279249 -0.075654721423700152516 -0.0099677811089809789658 0.72598589985494332844 0.90406988011203093247 0.77330714353903684533 1.6564982215686359091 0.22985161473698459411 -1.0671138918369860171;0.57610939292756946362 0.53296837054308487946 -0.12718299617802947266 -0.43198731398235445944 0.95849025757807060355 0.99383189099833701974 0.23309010534899637923 1.4530791606420452311 -0.033703837501107329622 0.31258587967347417624;-0.31554140958698689845 -0.31362215208796667687 -0.84541702615983993496 -0.35113453632864938259 0.86225708333954553808 1.0165320733781804119 0.30894652172423470171 1.5145740160567244814 -0.90191514344408896253 -0.43181563996636934677;0.098980919214199949985 0.14077426580263885381 -0.69278079382612789416 -0.26955076084597145991 0.86882923595099970093 0.97711790473765769427 0.44119773247270466232 1.5607153770554607064 -0.34470992243094106255 -0.751126083961051072;0.58457303990933984217 0.65097419700710723589 0.71003938764584884069 -0.30604569175075169163 0.93641381034844461961 0.90526630786374395754 0.45183237744672882785 1.5537382682905167552 -0.11914151775209667894 -0.62906723452449297973;0.69132824353142074969 -0.35173639488158980893 -0.76507767112565172596 -0.44221431849445197448 0.94443467632437616555 1.0155319985997459664 0.20460572146806346727 1.4444911073570665394 -0.09390522347372984302 6.7229349394411111289e-05;0.058448012651020994634 -0.54054025621003454205 -1.0421040484307284579 -0.82538081343176117333 0.97487938853136757444 1.207041912318242538 -0.5390869571281531325 1.059674213318220648 -0.66979218766520787209 0.14093868052133176616;-0.26065265484947219843 -0.010410488018133988095 -0.38509999404652672794 -0.74446423796912963855 0.98702387932183444086 1.1362023938035825665 -0.32918898512569821913 1.1896258307881741878 -0.70377378217429398255 -0.44530005448519055511;0.27274385147566626575 0.39390736176315033212 0.066861312356798305312 -0.7302954418034437456 0.97692095643857768117 1.1322933167030402313 -0.29413866301457969321 1.2172203226072946247 -0.39569167549773492931 -0.45165680656586548736;1.0642566734277139062 0.19188862131605496919 0.048578111966619236251 -0.7598879357534159551 0.97739734971367719929 1.1451775465783564645 -0.35748218004389242797 1.1665688452081024451 -0.47568673173384612429 0.23884754608435176948;-0.54578345002016670495 -0.13649587260673842759 -0.64196229024512563299 -0.81775756539005195478 0.98217796801708456833 1.1989895051473999921 -0.52077791106001591892 1.0707837345145707619 0.0054483654352273170121 -1.1849402874701355781;0.67676206014703665925 -0.40405397233875628427 -0.29114640079010517537 0.37663400165833571531 0.17138728099150779549 0.66943750304753146807 0.86858628634105072841 1.2735978688920535085 -0.69537987199136541694 -0.41678157905593338217;-0.070426893130506346141 -0.62898918595300390422 0.015853973401605572086 0.29870320230443697662 -0.014348419283018578468 0.57477688835447571236 0.56848046018316600314 0.91244548779535816774 -0.37093997462135530618 -0.77651782287796111692;0.81764006183960280527 0.28850792736074815092 0.88878563600714821646 0.25337641648847736286 -0.038903916475402706976 0.53402198084494412189 0.43423065143643885255 0.75863092458525438477 0.58269320239811117634 -0.58307491132743693996;-0.41869118819593142966 -0.76148441690321688746 -0.84376910446949171529 0.29669984671808974364 -0.016842244692237492293 0.58493355620956899443 0.56189571776199886965 0.91077153607241856381 0.11289616945084603172 -0.17611541125416932396;0.19615254511105340018 0.76868943668711298134 0.38167506492864000656 0.36821407233714775753 0.15154025202322785049 0.69728590874875751027 0.83713227227383646412 1.2650325390537253689 0.37904774855564465907 -0.046021441571447808949;-0.29587838592967002915 0.3404595990029418151 -0.0038333192124644505094 0.34811676375851174914 0.34536416449537016282 0.70008621807306492535 1.0601624656076154007 1.5516985217747407688 -0.85213040038343712546 0.1358665330128047688;0.77857117768247618983 -0.23086246148021311031 -0.13715622848400940703 0.41036905390425448825 0.33654007402447849717 0.59601430379459618969 1.0805165377607066635 1.4447367279969900444 -0.57373796775609653409 0.062943296642337845381;-1.0861817796064345831 -0.1115696932332351371 -0.45121295685892642835 0.37234346747979174541 0.2264995001617856607 0.6841804545336155341 0.90170072472721818357 1.3232975917782019426 -0.58665788137251007051 -0.7326707370481149173;0.77597173784599859925 -0.15497097287874025962 -0.36110153016255902569 0.34368746556079776688 0.24107884248084018863 0.73721729290092663511 0.88459912572358390115 1.3712216695555627943 -0.40335921649521216947 0.43752360600229001086;0.58558348487527789317 -0.064614179760463935631 0.02022979772091780884 0.36603131084095413827 0.37420469299396585949 0.65209084835458119844 1.1168824120175804282 1.5661818053291827191 -0.63878309873814020925 0.46818302902052311154;0.37993141441217720411 0.58600354570908652629 -0.49157099048349045534 0.10175871847225813338 0.62582969208650329751 0.83516703978616424475 0.90430577006673995566 1.6760166360894288573 0.47628020356291944637 -0.29492339193072913961;-0.34357665914099844162 0.19509525136902811093 -0.16259292479402323583 0.21959748608353024668 0.52651236741464657598 0.77653118280434751952 1.0121120622090196139 1.6615538413520880567 -0.95255189620089386615 -0.4536494548126083215;0.16070291439117725951 0.32668070806523497041 -0.89680903529006217312 0.29900679565218046818 0.5308914386893022197 0.68205927427684565068 1.1399596157424374265 1.6846693464012911789 -0.9622729473728099947 0.48174382894467637772;0.17118653385758769714 -0.0084059357920857839114 -0.72978941359113302934 0.21581882025393611668 0.51507016712367847955 0.79893354637775049198 0.9934513040814325624 1.6602413973094698463 -0.49275725115770968587 -0.3266444414648901895;0.9611053390116707229 0.13985688743503549292 -0.15398904573916011307 0.092476204527824554247 0.61151592980272007072 0.85823089753123660284 0.87687679020164854826 1.6671915050078531806 -0.039789467879386128391 0.025462563228097267326;0.1924031890071427886 0.27178752821074236845 -0.6264493322241104778 -0.39784462010151128153 0.85217279226352138366 1.00771348386146542 0.25350202517037789818 1.5081107692876651871 -0.64513261116772113724 -0.61116643265855641332;0.6421159241267382356 0.11899367042594123645 -0.30207834504640118656 -0.23203102439263498247 0.82162828394942533095 0.91090210122390324887 0.52500914634998363528 1.5974238225667807267 -0.68536277373807608093 -0.20442688168934483595;-0.14887106915830017329 -0.013269041974663303707 -0.21886910692482550167 -0.19276791110166802135 0.7788246566726887421 0.93247633329841372873 0.55170344121757119993 1.6062931648190563738 -0.65796230380293219131 -0.49986619878242743997;-0.37898665860531455252 -0.13784210745766181661 -0.53716229643799595639 -0.24466012730224140359 0.80141542192183923277 0.94271029826702112953 0.48571426416881957611 1.5857084752110990333 -0.74349857928596985168 -0.54903700095789331748;-0.26043053694817841492 1.2688495123439571532 0.27131477204711346163 -0.38081435285279791048 0.88644221091504826759 0.95578842130492169815 0.31375595926393906598 1.5170289869729813859 -0.48538390062975927952 0.064758685481377115112;-0.0084796468111631578823 0.006331692439609789419 0.26638434566186891539 -0.75887385820567998529 0.97951311941966645591 1.1308495968586320668 -0.35805208790534426289 1.1699277585061049756 -0.10982357564724495869 -0.68678654678203199246;0.72555640793955278323 0.41806543547814312145 0.39426693315314065291 -0.683795205206388923 0.98441806870545711661 1.0757427185847572293 -0.18063471919145271394 1.2903634143277999957 0.00087472101999338538157 -0.056258953461486904679;0.16224808585980385334 0.62905527162822072462 -0.25243421095260304421 -0.6623308488244304959 0.98000170629635141584 1.0553770336733099278 -0.13001061310879652444 1.3058046896446158236 -0.81595762135222216216 -0.55851790503444420644;-0.056183639539850199762 0.42260786444733222655 0.08459844196498597646 -0.66527776358533585732 1.0033071486451989873 1.0486287772042393041 -0.13756661356812829866 1.3123950259879952895 -0.15712837987087049929 -0.55677102010340395744;-0.52031622797020038451 -0.35155073867905495266 -0.91583749353049481723 -0.73254712946775124571 1.0090826305064335422 1.0868993833972948604 -0.29422277603359420217 1.2023847040859043656 -0.94724941371734017181 -0.1788753547416353229;0.93454825653084738768 -0.11497143169655750505 0.41370912836604578633 0.35767374667953555356 0.10701116914239412747 0.65354552360832451896 0.78529613113178731165 1.1839592350476721982 -0.25815583898105015637 -0.63109324202085093081;0.60024910622725036191 -0.10667926087265140744 0.47819264595174870713 0.23898525499809070149 -0.065233762075681600567 0.56924531689872082119 0.41493178733519547885 0.76933378448159861485 -0.40763633372527480203 0.11651489881256628378;0.28924472569677878164 0.83369761022555144425 0.27316601897008835342 0.23530551919951750439 -0.032807429305132543296 0.42081354145371935305 0.414955219750257287 0.66160427564051316196 0.29940717098126223839 0.0031492514330214325599;0.42343677194490941806 -0.27991980832091795106 -0.68255494830198881751 0.24736641558859434609 -0.055573610430434287888 0.56077451951347900838 0.43424947198816182814 0.78067195294449653886 0.033846745398182435938 -0.20162026140006622521;0.052627062688791352574 0.61309739056293111048 0.019306221258091543075 0.3529526452315082663 0.095475205202836088691 0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

0.62071028207271039534 -0.19015528353994312627 0.26437268038630457045 0.69710512478440245232 1.0099368402618167373 0.88509535159110319658 1.5300791543886365087 -0.87854477136797159975 -0.52865279880212412422;0.72864635689467505131 -0.36352199446135968763 -0.2697718092388445843 0.13150652916540001014 0.81013101063149250969 1.0536996241951712694 0.7758735056894960902 1.5378681349738494433 -0.024607815830051879558 0.31700340573511498476;-0.058729157859711673961 -0.057432418046311370374 -1.2071216324009221843 -0.24869151724239191292 0.96727132471664423186 1.1188581333089400172 0.35664568947787994579 1.4304229362671019299 0.20770589245584036853 -0.01252514463530009399;0.69569857198292317513 0.48348354182712760529 0.14065477347733010283 -0.05130273790958156388 0.96030678331295937777 1.024531005781052162 0.64667790174356820643 1.5120244055616696155 -1.0780359133283965445 0.41299377699755707161;0.31225717149922693761 0.46223011735055763438 -0.89944972066061013027 -0.0035949451630336564517 0.92317372309578116241 1.0504163129621657546 0.67417419474563222703 1.5341678647708436589 0.4062067526539006046 -1.133481114322977712;-0.47892170382173676613 0.37055833626635525935 -0.92343668207121465397 -0.045489967904485048567 0.96178265570074938928 1.0288440585773388491 0.65260725218855375473 1.5231463221400800556 -0.99101744395326518688 -0.44096406443316404911;-0.24157591362468194829 0.32660916835039210948 -0.39976097824438128203 -0.23199888402964022327 1.0020672251703424127 1.0670668441249748781 0.41696843928541932334 1.4425702055880504915 -0.25860225166290773391 -0.32002339952257274902;-0.0080787272187477741914 0.51417302437784839775 -0.77819604823081167666 -0.70949976314469698213 0.97866954495722824348 1.2208432266929283294 -0.3549419344964534484 1.0738262883447629026 0.016086677299527511048 -0.47926715667471636584;0.88266296225127027775 -0.24493818993484539615 0.52436022420547079292 -0.58047579644964220069 0.97425869639902284991 1.187826780534197546 -0.13730368220064431695 1.1751568247967283387 -0.28995817694431719191 -0.76337258037070865324;0.28335146456161641737 1.1796779390131328924 -0.0043039852181831657341 -0.50503111925187871289 1.0092974875236429 1.1279706834303062646 0.014923602535668880134 1.2530583043334959648 -0.025364174414193148277 -0.20139362760586682066;0.67361556383444542995 0.31813742650877385731 -0.18480652810220049576 -0.55593376361965829435 1.0030951175659306163 1.1518964326421212707 -0.076991790879053778607 1.2025449722370675776 -0.038101309175098754811 -0.36259070470233634165;-0.23610083617890589847 0.82307951016547686862 -0.85953247628933115987 -0.69023713742060477383 0.9993628964761293032 1.1917987715594389186 -0.3084102217428861259 1.0974315667551928222 -0.23552672422316317524 -0.10978380828824550741;0.61594683613692202684 -0.37321835655916857366 0.071738363828961010382 -0.94013889686756701991 0.99273764093985239487 1.2631190061682067149 -0.84336814221344380549 0.80433561419033416939 -0.67643599153536304591 0.090210575244220145286;-0.3164592914076840291 -0.1372789200104261309 -0.029738195421712930455 -0.89528131349976747266 1.0144713629588395509 1.2171485589779234004 -0.69676526916471437367 0.87704956678719592222 -0.58653509945703596884 -0.98821306123357677276;0.11757074848379438226 0.27942098730810166485 0.6561909842955436778 -0.90844202019466491205 0.98777890975050075539 1.2513095962774702929 -0.72097854855158904908 0.86898428485105139174 -0.55998352627852432395 -0.40355054371224136078;0.35838880976432108127 0.63116167580441728813 0.23197084155916763981 -0.9368491500292156493 0.96254933345416460178 1.2895617086654556083 -0.80767879635068196009 0.83017442575417021988 -0.81838900863710539735 -0.14548937631130190451;0.95295460408049159629 -0.4350499591289274659 0.35709350775750048346 -0.96470704700522746933 0.95874386808770961643 1.310143471065015941 -0.91140438196693551731 0.78092795427263617114 -0.77100379443251032541 -0.6651681558457368526;1.0604937814547177322 0.75547865037609629457 -0.061742726382572464539 0.36420989047047558351 0.45786400511606484276 0.84274664481501981861 0.97830911564892275578 1.5071972753638815945 -0.17899898713715906018 -0.016152583633694084925;0.44304014400798630291 0.55826508077465730739 -0.33727808132231790195 0.36289035125538360305 0.22527707983579711715 0.84145892377020981012 0.75872470960303384224 1.2523713124634618943 0.33516499236074148715 0.10229274212168691649;-0.28194985677391204426 0.2384032129379162479 0.18886786754461346027 0.36249960070560399705 0.19279237061377341167 0.79097894942424673559 0.69276977790838312199 1.1369116716123479627 -0.41188752017779006742 -0.73627035421569486662;-0.62291319521168475593 0.0089113279869906004971 -0.87674464497110726757 0.35720200820414260701 0.22606764940766069238 0.83848931938833004551 0.75147796031202451772 1.239140546099229967 -0.35152580235056501978 0.26887547582812626468;-0.17218710813354634603 0.29171732136462508178 -0.88628911573057100881 0.3772000754816833834 0.44120665045191215237 0.83630343308568111382 0.98091598581037386939 1.487278903838875177 0.31330282308452633844 -1.0578559875781023969;0.78271746561798150044 -0.067290980162992827807 -0.85387621834876104021 0.25748263594311276981 0.64129377795784525684 0.92321786715488163289 0.98685746627164538936 1.6273432935820668632 0.27291844239771162473 0.22860377564898709535;-0.38286694853753566736 0.038120946049144087409 -0.40140074299857742002 0.31560923988037942189 0.54716024422698350538 0.85265619313473473007 1.0276640504767646789 1.6002921136203649422 0.04453563857737227738 -0.8551176010790388915;1.0622490022419446287 0.64514276687846450198 0.29083039995100651298 0.36545270641158539293 0.49000287524234797942 0.84939880487029173484 1.0138670353890246734 1.5258535368342012184 0.073880521624296965899 -0.28945613840850120679;0.045102753760103322933 0.66880555249658246719 0.18404514179344932945 0.35856182400878000571 0.53766542851132781422 0.84270356884057617819 1.0530010045500910465 1.5702087051098061465 0.016964021005595474739 -0.971164582508792118;0.74247647522037063528 0.80520721589038468657 -0.79937544629756474013 0.26317923469142534554 0.65215466919241471544 0.91003422241068054888 1.0034249017757843614 1.6336002727075158436 -0.56736227871786626409 0.61082638191490301605;-0.12849527639424626613 0.34770263016748642615 -0.43814167445804624856 -0.12496303024114543967 0.89161541170912306242 0.99212527303057562733 0.60153159330860739296 1.5872126088027411761 -0.10720410171438082836 -0.34071832806132984484;-0.084017517855374784785 0.19367775551242344401 -0.3521128060666846582 0.060600468099221455054 0.83955255345162971281 0.91060395611066791144 0.85626772194626843415 1.6727556193851362831 -0.78891219493142816788 -0.3907484836473119616;-0.067820465206056584906 0.81870762815745823371 -0.39873076765794185361 0.12141638954054273514 0.79740926929117039723 0.87638619096920267193 0.93260319559591353666 1.668988259377864436 -0.70512806855598564315 0.22490841422457971688;0.3732193479166134864 0.0755743284901750495 0.12652295835727558893 0.051509452435655397884 0.82906313822440302896 0.9234542013543473038 0.83550708670290696478 1.6603905735256003773 -0.028814978381302432109 -0.54305538544241593879;0.29653533253788172397 -0.12710718648713703605 -0.12607091420128815895 -0.13049862995704122892 0.87783609568342557683 1.0052174223472511994 0.58158666627533728288 1.5850662879324080023 -0.254741433023346453 -0.57571839758802845211;-0.17425672167900685405 0.80783333032368942472 -0.50517578881289415538 -0.59656540096916410576 0.98768376750350705962 1.1025966463415939334 -0.066687135914803505332 1.3005521620413602601 -0.44931081149188273338 0.53650433842372602378;0.61995816208229315158 0.52769693902332259761 -0.11147363037098317884 -0.40021705870471946387 1.0085796040348402602 0.99535905456443152239 0.27485120837793514115 1.440832908584177785 -0.012514710405709178129 -0.9938581256057108515;0.24999340639517103613 0.26978411516927913727 -1.0663547258719145994 -0.37170787540979505215 0.98805721297810555903 1.0071053175649362643 0.30389369199784610487 1.451511768850543227 0.018060409800917262557 0.52925685038483560874;0.52887453573930964801 0.68558761014970370784 0.56915146132686567082 -0.40144275569567677842 1.0209857049536934515 0.97523297222884797186 0.287888801644097303 1.4320203802240094593 -0.38291979771049183823 -1.0041207837805592451;0.84834836060750107301 0.38267713533469399634 -0.5383587257556029515 -0.60377416536702799288 0.97962595835942389844 1.1146599218376702645 -0.084047106178881850203 1.2939483727443104044 -0.40861535423225486818 0.076399624087324619071;-0.18165808255404253257 -0.1911084717893678786 -0.87065637028597553382 -0.85414403512090897319 1.0402267687163038179 1.1898511143156953462 -0.59527674962148025006 0.98103770828426906103 -0.25495040417075187644 -0.12811050335504192699;0.61788144002676748112 -0.19843939308620492379 -0.42542781985196737038 -0.81980846309684207718 1.0107817990035932176 1.194198447698699761 -0.5093091601464226903 1.0479197091498422267 -0.25541087724550398663 -0.033944135693942285859;0.37509121687177882087 -0.085125103887215489151 -0.49940128475267847596 -0.82032241068591094102 0.98901247216736043466 1.2114215793466260873 -0.5111847886650877637 1.0502495992899973931 -0.82298813460170450185 -0.29864214269644617783;0.2813393893009508151 0.1379116586155084978 -0.49909235761023867939 -0.82161632785606852902 1.0042565539718231182 1.2094672085209234869 -0.52053037895105258581 1.0486478885976155961 -0.18547571219783204333 -0.28678824947196862594;0.3503259696403749901 0.83137286196262494276 -0.37912246007071964682 -0.88643485097932717132 1.0035116072553884603 1.2425717641597031626 -0.6765295492744685113 0.94395321681485189202 0.24890463364588449879 0.096106074903194560477;-0.29808710133049964863 -0.2670940973374262839 0.40810026551190992095 0.38009742926002437757 0.30367087369703360533 0.73321012346632641332 0.93797071615876925765 1.390180852286152513 -0.53862529970574180016 -1.3879015676557260317;-0.3883147313866197603 0.13209023829728583355 0.37354402854220941643 0.34193679398890125531 0.091043161793143992377 0.73654372226743891616 0.68242173083158585989 1.1184002221988837977 0.3037475859964867686 -1.0683727982375632592;0.17426807777698230528 -0.31239573075478338504 -0.88799057921241664193 0.3248452498756916329 0.052418767865236491621 0.67508589394721751908 0.60049947443885642873 0.99221448897077890727 -0.55163012521504961594 0.63750411354325031699;0.87953628928171512236 0.21621847029353477576 0.13671160129821863238 0.34713793549967558727 0.098373804385108953863 0.73107115048899795617 0.69548608580682502733 1.1228842767708571149 0.05833000496325787404 -0.0033917483058024007481;0.7110266323021764423 -0.035667137105605407899 -0.49045318720571984272 0.3636803201970842947 0.27001209167291101432 0.77275041154271573163 0.88014150074183206129 1.3649520164276820466 -0.19305683336711582099 -0.57665026226808868692;-0.29062344177136367751 0.066918265011326458214 -0.48204479509837616646 0.29520418552016491898 0.474500838857329299 0.80321699067828333796 1.0154249198708062973 1.5990930113977470661 -0.58444805969409852064 -0.59359064045355203199;-0.1154491983240730768 0.4524241083540304631 0.28765041085047177161 0.38599272539361889622 0.4015594125997411501 0.66340067055686680053 1.119470425129649005 1.5558316765777813195 -0.36278757808159434184 -0.5214643943008867577;0.29725257994597614752 0.093459018435617643994 0.55337756463208698232 0.37692006815873801973 0.29308721925423097954 0.74883972767118722746 0.96598518049255177598 1.4332743750441043762 -0.77307226599296385849 -0.70635414416186348419;-0.55044819866906491423 -0.26327894689028508157 -0.3909799119262499234 0.40065555490705928587 0.3780494029723844851 0.68761671238868671274 1.099624588948536319 1.5289023884267478604 -0.59369558624794149804 -0.77525712296809456969;0.015401175491335076378 1.1381542282646324171 0.66702399567532977276 0.30342379276199343829 0.48819552530920284905 0.77855834045482164019 1.0431251822241656146 1.6050326441466453709 -0.096762438893696983699 -0.5058441100895872955;-0.57016306668682203984 0.5331600276517811654 -0.41127844393321616456 0.010997054021869109852 0.75220027707611603063 0.86621501552595481233 0.82873715023122951351 1.682115029214195312 0.28134077182926869876 -0.94997532924230509987;0.83243457769214335151 0.22947419700417645561 0.041210815437348426171 0.15791822696100882295 0.63564512850802012967 0.84454068491968037335 0.95121935747349539714 1.6667175971727636874 -0.047300920801233208024 -0.67643016148687917788;-0.12065762634234855621 -0.56937171186187540695 0.013265371149530195277 0.22035524959939525869 0.62847665108829464664 0.79240481206937229963 1.0469252446595467276 1.6973741685475143282 -0.94280742116916349538 -0.88981847982892747773;0.46758300854996692753 -0.026390411752992400107 -0.31171646385386753142 0.1603272629978515218 0.6372068306859691722 0.84976085863252037722 0.95454950549464234744 1.6685440146153200924 -0.019124561001212236899 0.19624988020824860047;-0.31861733361953764598 0.2884641129828279249 -0.075654721423700152516 -0.0099677811089809789658 0.72598589985494332844 0.90406988011203093247 0.77330714353903684533 1.6564982215686359091 0.22985161473698459411 -1.0671138918369860171;0.57610939292756946362 0.53296837054308487946 -0.12718299617802947266 -0.43198731398235445944 0.95849025757807060355 0.99383189099833701974 0.23309010534899637923 1.4530791606420452311 -0.033703837501107329622 0.31258587967347417624;-0.31554140958698689845 -0.31362215208796667687 -0.84541702615983993496 -0.35113453632864938259 0.86225708333954553808 1.0165320733781804119 0.30894652172423470171 1.5145740160567244814 -0.90191514344408896253 -0.43181563996636934677;0.098980919214199949985 0.14077426580263885381 -0.69278079382612789416 -0.26955076084597145991 0.86882923595099970093 0.97711790473765769427 0.44119773247270466232 1.5607153770554607064 -0.34470992243094106255 -0.751126083961051072;0.58457303990933984217 0.65097419700710723589 0.71003938764584884069 -0.30604569175075169163 0.93641381034844461961 0.90526630786374395754 0.45183237744672882785 1.5537382682905167552 -0.11914151775209667894 -0.62906723452449297973;0.69132824353142074969 -0.35173639488158980893 -0.76507767112565172596 -0.44221431849445197448 0.94443467632437616555 1.0155319985997459664 0.20460572146806346727 1.4444911073570665394 -0.09390522347372984302 6.7229349394411111289e-05;0.058448012651020994634 -0.54054025621003454205 -1.0421040484307284579 -0.82538081343176117333 0.97487938853136757444 1.207041912318242538 -0.5390869571281531325 1.059674213318220648 -0.66979218766520787209 0.14093868052133176616;-0.26065265484947219843 -0.010410488018133988095 -0.38509999404652672794 -0.74446423796912963855 0.98702387932183444086 1.1362023938035825665 -0.32918898512569821913 1.1896258307881741878 -0.70377378217429398255 -0.44530005448519055511;0.27274385147566626575 0.39390736176315033212 0.066861312356798305312 -0.7302954418034437456 0.97692095643857768117 1.1322933167030402313 -0.29413866301457969321 1.2172203226072946247 -0.39569167549773492931 -0.45165680656586548736;1.0642566734277139062 0.19188862131605496919 0.048578111966619236251 -0.7598879357534159551 0.97739734971367719929 1.1451775465783564645 -0.35748218004389242797 1.1665688452081024451 -0.47568673173384612429 0.23884754608435176948;-0.54578345002016670495 -0.13649587260673842759 -0.64196229024512563299 -0.81775756539005195478 0.98217796801708456833 1.1989895051473999921 -0.52077791106001591892 1.0707837345145707619 0.0054483654352273170121 -1.1849402874701355781;0.67676206014703665925 -0.40405397233875628427 -0.29114640079010517537 0.37663400165833571531 0.17138728099150779549 0.66943750304753146807 0.86858628634105072841 1.2735978688920535085 -0.69537987199136541694 -0.41678157905593338217;-0.070426893130506346141 -0.62898918595300390422 0.015853973401605572086 0.29870320230443697662 -0.014348419283018578468 0.57477688835447571236 0.56848046018316600314 0.91244548779535816774 -0.37093997462135530618 -0.77651782287796111692;0.81764006183960280527 0.28850792736074815092 0.88878563600714821646 0.25337641648847736286 -0.038903916475402706976 0.53402198084494412189 0.43423065143643885255 0.75863092458525438477 0.58269320239811117634 -0.58307491132743693996;-0.41869118819593142966 -0.76148441690321688746 -0.84376910446949171529 0.29669984671808974364 -0.016842244692237492293 0.58493355620956899443 0.56189571776199886965 0.91077153607241856381 0.11289616945084603172 -0.17611541125416932396;0.19615254511105340018 0.76868943668711298134 0.38167506492864000656 0.36821407233714775753 0.15154025202322785049 0.69728590874875751027 0.83713227227383646412 1.2650325390537253689 0.37904774855564465907 -0.046021441571447808949;-0.29587838592967002915 0.3404595990029418151 -0.0038333192124644505094 0.34811676375851174914 0.34536416449537016282 0.70008621807306492535 1.0601624656076154007 1.5516985217747407688 -0.85213040038343712546 0.1358665330128047688;0.77857117768247618983 -0.23086246148021311031 -0.13715622848400940703 0.41036905390425448825 0.33654007402447849717 0.59601430379459618969 1.0805165377607066635 1.4447367279969900444 -0.57373796775609653409 0.062943296642337845381;-1.0861817796064345831 -0.1115696932332351371 -0.45121295685892642835 0.37234346747979174541 0.2264995001617856607 0.6841804545336155341 0.90170072472721818357 1.3232975917782019426 -0.58665788137251007051 -0.7326707370481149173;0.77597173784599859925 -0.15497097287874025962 -0.36110153016255902569 0.34368746556079776688 0.24107884248084018863 0.73721729290092663511 0.88459912572358390115 1.3712216695555627943 -0.40335921649521216947 0.43752360600229001086;0.58558348487527789317 -0.064614179760463935631 0.02022979772091780884 0.36603131084095413827 0.37420469299396585949 0.65209084835458119844 1.1168824120175804282 1.5661818053291827191 -0.63878309873814020925 0.46818302902052311154;0.37993141441217720411 0.58600354570908652629 -0.49157099048349045534 0.10175871847225813338 0.62582969208650329751 0.83516703978616424475 0.90430577006673995566 1.6760166360894288573 0.47628020356291944637 -0.29492339193072913961;-0.34357665914099844162 0.19509525136902811093 -0.16259292479402323583 0.21959748608353024668 0.52651236741464657598 0.77653118280434751952 1.0121120622090196139 1.6615538413520880567 -0.95255189620089386615 -0.4536494548126083215;0.16070291439117725951 0.32668070806523497041 -0.89680903529006217312 0.29900679565218046818 0.5308914386893022197 0.68205927427684565068 1.1399596157424374265 1.6846693464012911789 -0.9622729473728099947 0.48174382894467637772;0.17118653385758769714 -0.0084059357920857839114 -0.72978941359113302934 0.21581882025393611668 0.51507016712367847955 0.79893354637775049198 0.9934513040814325624 1.6602413973094698463 -0.49275725115770968587 -0.3266444414648901895;0.9611053390116707229 0.13985688743503549292 -0.15398904573916011307 0.092476204527824554247 0.61151592980272007072 0.85823089753123660284 0.87687679020164854826 1.6671915050078531806 -0.039789467879386128391 0.025462563228097267326;0.1924031890071427886 0.27178752821074236845 -0.6264493322241104778 -0.39784462010151128153 0.85217279226352138366 1.00771348386146542 0.25350202517037789818 1.5081107692876651871 -0.64513261116772113724 -0.61116643265855641332;0.6421159241267382356 0.11899367042594123645 -0.30207834504640118656 -0.23203102439263498247 0.82162828394942533095 0.91090210122390324887 0.52500914634998363528 1.5974238225667807267 -0.68536277373807608093 -0.20442688168934483595;-0.14887106915830017329 -0.013269041974663303707 -0.21886910692482550167 -0.19276791110166802135 0.7788246566726887421 0.93247633329841372873 0.55170344121757119993 1.6062931648190563738 -0.65796230380293219131 -0.49986619878242743997;-0.37898665860531455252 -0.13784210745766181661 -0.53716229643799595639 -0.24466012730224140359 0.80141542192183923277 0.94271029826702112953 0.48571426416881957611 1.5857084752110990333 -0.74349857928596985168 -0.54903700095789331748;-0.26043053694817841492 1.2688495123439571532 0.27131477204711346163 -0.38081435285279791048 0.88644221091504826759 0.95578842130492169815 0.31375595926393906598 1.5170289869729813859 -0.48538390062975927952 0.064758685481377115112;-0.0084796468111631578823 0.006331692439609789419 0.26638434566186891539 -0.75887385820567998529 0.97951311941966645591 1.1308495968586320668 -0.35805208790534426289 1.1699277585061049756 -0.10982357564724495869 -0.68678654678203199246;0.72555640793955278323 0.41806543547814312145 0.39426693315314065291 -0.683795205206388923 0.98441806870545711661 1.0757427185847572293 -0.18063471919145271394 1.2903634143277999957 0.00087472101999338538157 -0.056258953461486904679;0.16224808585980385334 0.62905527162822072462 -0.25243421095260304421 -0.6623308488244304959 0.98000170629635141584 1.0553770336733099278 -0.13001061310879652444 1.3058046896446158236 -0.81595762135222216216 -0.55851790503444420644;-0.056183639539850199762 0.42260786444733222655 0.08459844196498597646 -0.66527776358533585732 1.0033071486451989873 1.0486287772042393041 -0.13756661356812829866 1.3123950259879952895 -0.15712837987087049929 -0.55677102010340395744;-0.52031622797020038451 -0.35155073867905495266 -0.91583749353049481723 -0.73254712946775124571 1.0090826305064335422 1.0868993833972948604 -0.29422277603359420217 1.2023847040859043656 -0.94724941371734017181 -0.1788753547416353229;0.93454825653084738768 -0.11497143169655750505 0.41370912836604578633 0.35767374667953555356 0.10701116914239412747 0.65354552360832451896 0.78529613113178731165 1.1839592350476721982 -0.25815583898105015637 -0.63109324202085093081;0.60024910622725036191 -0.10667926087265140744 0.47819264595174870713 0.23898525499809070149 -0.065233762075681600567 0.56924531689872082119 0.41493178733519547885 0.76933378448159861485 -0.40763633372527480203 0.11651489881256628378;0.28924472569677878164 0.83369761022555144425 0.27316601897008835342 0.23530551919951750439 -0.032807429305132543296 0.42081354145371935305 0.414955219750257287 0.66160427564051316196 0.29940717098126223839 0.0031492514330214325599;0.42343677194490941806 -0.27991980832091795106 -0.68255494830198881751 0.24736641558859434609 -0.055573610430434287888 0.56077451951347900838 0.43424947198816182814 0.78067195294449653886 0.033846745398182435938 -0.20162026140006622521;0.052627062688791352574 0.61309739056293111048 0.019306221258091543075 0.3529526452315082663 0.095475205202836088691 0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

0.35709350775750048346 -0.96470704700522746933 0.95874386808770961643 1.310143471065015941 -0.91140438196693551731 0.78092795427263617114 -0.77100379443251032541 -0.6651681558457368526;1.0604937814547177322 0.75547865037609629457 -0.061742726382572464539 0.36420989047047558351 0.45786400511606484276 0.84274664481501981861 0.97830911564892275578 1.5071972753638815945 -0.17899898713715906018 -0.016152583633694084925;0.44304014400798630291 0.55826508077465730739 -0.33727808132231790195 0.36289035125538360305 0.22527707983579711715 0.84145892377020981012 0.75872470960303384224 1.2523713124634618943 0.33516499236074148715 0.10229274212168691649;-0.28194985677391204426 0.2384032129379162479 0.18886786754461346027 0.36249960070560399705 0.19279237061377341167 0.79097894942424673559 0.69276977790838312199 1.1369116716123479627 -0.41188752017779006742 -0.73627035421569486662;-0.62291319521168475593 0.0089113279869906004971 -0.87674464497110726757 0.35720200820414260701 0.22606764940766069238 0.83848931938833004551 0.75147796031202451772 1.239140546099229967 -0.35152580235056501978 0.26887547582812626468;-0.17218710813354634603 0.29171732136462508178 -0.88628911573057100881 0.3772000754816833834 0.44120665045191215237 0.83630343308568111382 0.98091598581037386939 1.487278903838875177 0.31330282308452633844 -1.0578559875781023969;0.78271746561798150044 -0.067290980162992827807 -0.85387621834876104021 0.25748263594311276981 0.64129377795784525684 0.92321786715488163289 0.98685746627164538936 1.6273432935820668632 0.27291844239771162473 0.22860377564898709535;-0.38286694853753566736 0.038120946049144087409 -0.40140074299857742002 0.31560923988037942189 0.54716024422698350538 0.85265619313473473007 1.0276640504767646789 1.6002921136203649422 0.04453563857737227738 -0.8551176010790388915;1.0622490022419446287 0.64514276687846450198 0.29083039995100651298 0.36545270641158539293 0.49000287524234797942 0.84939880487029173484 1.0138670353890246734 1.5258535368342012184 0.073880521624296965899 -0.28945613840850120679;0.045102753760103322933 0.66880555249658246719 0.18404514179344932945 0.35856182400878000571 0.53766542851132781422 0.84270356884057617819 1.0530010045500910465 1.5702087051098061465 0.016964021005595474739 -0.971164582508792118;0.74247647522037063528 0.80520721589038468657 -0.79937544629756474013 0.26317923469142534554 0.65215466919241471544 0.91003422241068054888 1.0034249017757843614 1.6336002727075158436 -0.56736227871786626409 0.61082638191490301605;-0.12849527639424626613 0.34770263016748642615 -0.43814167445804624856 -0.12496303024114543967 0.89161541170912306242 0.99212527303057562733 0.60153159330860739296 1.5872126088027411761 -0.10720410171438082836 -0.34071832806132984484;-0.084017517855374784785 0.19367775551242344401 -0.3521128060666846582 0.060600468099221455054 0.83955255345162971281 0.91060395611066791144 0.85626772194626843415 1.6727556193851362831 -0.78891219493142816788 -0.3907484836473119616;-0.067820465206056584906 0.81870762815745823371 -0.39873076765794185361 0.12141638954054273514 0.79740926929117039723 0.87638619096920267193 0.93260319559591353666 1.668988259377864436 -0.70512806855598564315 0.22490841422457971688;0.3732193479166134864 0.0755743284901750495 0.12652295835727558893 0.051509452435655397884 0.82906313822440302896 0.9234542013543473038 0.83550708670290696478 1.6603905735256003773 -0.028814978381302432109 -0.54305538544241593879;0.29653533253788172397 -0.12710718648713703605 -0.12607091420128815895 -0.13049862995704122892 0.87783609568342557683 1.0052174223472511994 0.58158666627533728288 1.5850662879324080023 -0.254741433023346453 -0.57571839758802845211;-0.17425672167900685405 0.80783333032368942472 -0.50517578881289415538 -0.59656540096916410576 0.98768376750350705962 1.1025966463415939334 -0.066687135914803505332

1.3005521620413602601 -0.44931081149188273338 0.53650433842372602378;0.61995816208229315158 0.52769693902332259761 -0.11147363037098317884 -0.40021705870471946387 1.0085796040348402602 0.99535905456443152239 0.27485120837793514115 1.440832908584177785 -0.012514710405709178129 -0.9938581256057108515;0.24999340639517103613 0.26978411516927913727 -1.0663547258719145994 -0.37170787540979505215 0.98805721297810555903 1.0071053175649362643 0.30389369199784610487 1.451511768850543227 0.018060409800917262557 0.52925685038483560874;0.52887453573930964801 0.68558761014970370784 0.56915146132686567082 -0.40144275569567677842 1.0209857049536934515 0.97523297222884797186 0.287888801644097303 1.4320203802240094593 -0.38291979771049183823 -1.0041207837805592451;0.84834836060750107301 0.38267713533469399634 -0.5383587257556029515 -0.60377416536702799288 0.97962595835942389844 1.1146599218376702645 -0.084047106178881850203 1.2939483727443104044 -0.40861535423225486818 0.076399624087324619071;-0.18165808255404253257 -0.1911084717893678786 -0.87065637028597553382 -0.85414403512090897319 1.0402267687163038179 1.1898511143156953462 -0.59527674962148025006 0.98103770828426906103 -0.25495040417075187644 -0.12811050335504192699;0.61788144002676748112 -0.19843939308620492379 -0.42542781985196737038 -0.81980846309684207718 1.0107817990035932176 1.194198447698699761 -0.5093091601464226903 1.0479197091498422267 -0.25541087724550398663 -0.033944135693942285859;0.37509121687177882087 -0.085125103887215489151 -0.49940128475267847596 -0.82032241068591094102 0.98901247216736043466 1.2114215793466260873 -0.5111847886650877637 1.0502495992899973931 -0.82298813460170450185 -0.29864214269644617783;0.2813393893009508151 0.1379116586155084978 -0.49909235761023867939 -0.82161632785606852902 1.0042565539718231182 1.2094672085209234869 -0.52053037895105258581 1.0486478885976155961 -0.18547571219783204333 -0.28678824947196862594;0.3503259696403749901 0.83137286196262494276 -0.37912246007071964682 -0.88643485097932717132 1.0035116072553884603 1.2425717641597031626 -0.6765295492744685113 0.94395321681485189202 0.24890463364588449879 0.096106074903194560477;-0.29808710133049964863 -0.2670940973374262839 0.40810026551190992095 0.38009742926002437757 0.30367087369703360533 0.73321012346632641332 0.93797071615876925765 1.390180852286152513 -0.53862529970574180016 -1.3879015676557260317;-0.3883147313866197603 0.13209023829728583355 0.37354402854220941643 0.34193679398890125531 0.091043161793143992377 0.73654372226743891616 0.68242173083158585989 1.1184002221988837977 0.3037475859964867686 -1.0683727982375632592;0.17426807777698230528 -0.31239573075478338504 -0.88799057921241664193 0.3248452498756916329 0.052418767865236491621 0.67508589394721751908 0.60049947443885642873 0.99221448897077890727 -0.55163012521504961594 0.63750411354325031699;0.87953628928171512236 0.21621847029353477576 0.13671160129821863238 0.34713793549967558727 0.098373804385108953863 0.73107115048899795617 0.69548608580682502733 1.1228842767708571149 0.05833000496325787404 -0.0033917483058024007481;0.7110266323021764423 -0.035667137105605407899 -0.49045318720571984272 0.3636803201970842947 0.27001209167291101432 0.77275041154271573163 0.88014150074183206129 1.3649520164276820466 -0.19305683336711582099 -0.57665026226808868692;-0.29062344177136367751 0.066918265011326458214 -0.48204479509837616646 0.29520418552016491898 0.474500838857329299 0.80321699067828333796 1.0154249198708062973 1.5990930113977470661 -0.58444805969409852064 -0.59359064045355203199;-0.1154491983240730768 0.4524241083540304631 0.28765041085047177161 0.38599272539361889622 0.4015594125997411501 0.66340067055686680053 1.119470425129649005 1.5558316765777813195 -0.36278757808159434184 -0.5214643943008867577;0.29725257994597614752 0.093459018435617643994 0.55337756463208698232 0.37692006815873801973 0.29308721925423097954 0.74883972767118722746 0.96598518049255177598 1.4332743750441043762 -0.77307226599296385849 -0.70635414416186348419;-0.55044819866906491423 -0.26327894689028508157 -0.3909799119262499234 0.40065555490705928587 0.3780494029723844851 0.68761671238868671274 1.099624588948536319 1.5289023884267478604 -0.59369558624794149804 -0.77525712296809456969;0.015401175491335076378 1.1381542282646324171 0.66702399567532977276 0.30342379276199343829 0.48819552530920284905 0.77855834045482164019 1.0431251822241656146 1.6050326441466453709 -0.096762438893696983699 -0.5058441100895872955;-0.57016306668682203984 0.5331600276517811654 -0.41127844393321616456 0.010997054021869109852 0.75220027707611603063 0.86621501552595481233 0.82873715023122951351 1.682115029214195312 0.28134077182926869876 -0.94997532924230509987;0.83243457769214335151 0.22947419700417645561 0.041210815437348426171 0.15791822696100882295 0.63564512850802012967 0.84454068491968037335 0.95121935747349539714 1.6667175971727636874 -0.047300920801233208024 -0.67643016148687917788;-0.12065762634234855621 -0.56937171186187540695 0.013265371149530195277 0.22035524959939525869 0.62847665108829464664 0.79240481206937229963 1.0469252446595467276 1.6973741685475143282 -0.94280742116916349538 -0.88981847982892747773;0.46758300854996692753 -0.026390411752992400107 -0.31171646385386753142 0.1603272629978515218 0.6372068306859691722 0.84976085863252037722 0.95454950549464234744 1.6685440146153200924 -0.019124561001212236899 0.19624988020824860047;-0.31861733361953764598 0.2884641129828279249 -0.075654721423700152516 -0.0099677811089809789658 0.72598589985494332844 0.90406988011203093247 0.77330714353903684533 1.6564982215686359091 0.22985161473698459411 -1.0671138918369860171;0.57610939292756946362 0.53296837054308487946 -0.12718299617802947266 -0.43198731398235445944 0.95849025757807060355 0.99383189099833701974 0.23309010534899637923 1.4530791606420452311 -0.033703837501107329622 0.31258587967347417624;-0.31554140958698689845 -0.31362215208796667687 -0.84541702615983993496 -0.35113453632864938259 0.86225708333954553808 1.0165320733781804119 0.30894652172423470171 1.5145740160567244814 -0.90191514344408896253 -0.43181563996636934677;0.098980919214199949985 0.14077426580263885381 -0.69278079382612789416 -0.26955076084597145991 0.86882923595099970093 0.97711790473765769427 0.44119773247270466232 1.5607153770554607064 -0.34470992243094106255 -0.751126083961051072;0.58457303990933984217 0.65097419700710723589 0.71003938764584884069 -0.30604569175075169163 0.93641381034844461961 0.90526630786374395754 0.45183237744672882785 1.5537382682905167552 -0.11914151775209667894 -0.62906723452449297973;0.69132824353142074969 -0.35173639488158980893 -0.76507767112565172596 -0.44221431849445197448 0.94443467632437616555 1.0155319985997459664 0.20460572146806346727 1.4444911073570665394 -0.09390522347372984302 6.7229349394411111289e-05;0.058448012651020994634 -0.54054025621003454205 -1.0421040484307284579 -0.82538081343176117333 0.97487938853136757444 1.207041912318242538 -0.5390869571281531325 1.059674213318220648 -0.66979218766520787209 0.14093868052133176616;-0.26065265484947219843 -0.010410488018133988095 -0.38509999404652672794 -0.74446423796912963855 0.98702387932183444086 1.1362023938035825665 -0.32918898512569821913 1.1896258307881741878 -0.70377378217429398255 -0.44530005448519055511;0.27274385147566626575 0.39390736176315033212 0.066861312356798305312 -0.7302954418034437456 0.97692095643857768117 1.1322933167030402313 -0.29413866301457969321 1.2172203226072946247 -0.39569167549773492931 -0.45165680656586548736;1.0642566734277139062 0.19188862131605496919 0.048578111966619236251 -0.7598879357534159551 0.97739734971367719929 1.1451775465783564645 -0.35748218004389242797 1.1665688452081024451 -0.47568673173384612429 0.23884754608435176948;-0.54578345002016670495 -0.13649587260673842759 -0.64196229024512563299 -0.81775756539005195478 0.98217796801708456833 1.1989895051473999921 -0.52077791106001591892 1.0707837345145707619 0.0054483654352273170121 -1.1849402874701355781;0.67676206014703665925 -0.40405397233875628427 -0.29114640079010517537 0.37663400165833571531 0.17138728099150779549 0.66943750304753146807 0.86858628634105072841 1.2735978688920535085 -0.69537987199136541694 -0.41678157905593338217;-0.070426893130506346141 -0.62898918595300390422 0.015853973401605572086 0.29870320230443697662 -0.014348419283018578468 0.57477688835447571236 0.56848046018316600314 0.91244548779535816774 -0.37093997462135530618 -0.77651782287796111692;0.81764006183960280527 0.28850792736074815092 0.88878563600714821646 0.25337641648847736286 -0.038903916475402706976 0.53402198084494412189 0.43423065143643885255 0.75863092458525438477 0.58269320239811117634 -0.58307491132743693996;-0.41869118819593142966 -0.76148441690321688746 -0.84376910446949171529 0.29669984671808974364 -0.016842244692237492293 0.58493355620956899443 0.56189571776199886965 0.91077153607241856381 0.11289616945084603172 -0.17611541125416932396;0.19615254511105340018 0.76868943668711298134 0.38167506492864000656 0.36821407233714775753 0.15154025202322785049 0.69728590874875751027 0.83713227227383646412 1.2650325390537253689 0.37904774855564465907 -0.046021441571447808949;-0.29587838592967002915 0.3404595990029418151 -0.0038333192124644505094 0.34811676375851174914 0.34536416449537016282 0.70008621807306492535 1.0601624656076154007 1.5516985217747407688 -0.85213040038343712546 0.1358665330128047688;0.77857117768247618983 -0.23086246148021311031 -0.13715622848400940703 0.41036905390425448825 0.33654007402447849717 0.59601430379459618969 1.0805165377607066635 1.4447367279969900444 -0.57373796775609653409 0.062943296642337845381;-1.0861817796064345831 -0.1115696932332351371 -0.45121295685892642835 0.37234346747979174541 0.2264995001617856607 0.6841804545336155341 0.90170072472721818357 1.3232975917782019426 -0.58665788137251007051 -0.7326707370481149173;0.77597173784599859925 -0.15497097287874025962 -0.36110153016255902569 0.34368746556079776688 0.24107884248084018863 0.73721729290092663511 0.88459912572358390115 1.3712216695555627943 -0.40335921649521216947 0.43752360600229001086;0.58558348487527789317 -0.064614179760463935631 0.02022979772091780884 0.36603131084095413827 0.37420469299396585949 0.65209084835458119844 1.1168824120175804282 1.5661818053291827191 -0.63878309873814020925 0.46818302902052311154;0.37993141441217720411 0.58600354570908652629 -0.49157099048349045534 0.10175871847225813338 0.62582969208650329751 0.83516703978616424475 0.90430577006673995566 1.6760166360894288573 0.47628020356291944637 -0.29492339193072913961;-0.34357665914099844162 0.19509525136902811093 -0.16259292479402323583 0.21959748608353024668 0.52651236741464657598 0.77653118280434751952 1.0121120622090196139 1.6615538413520880567 -0.95255189620089386615 -0.4536494548126083215;0.16070291439117725951 0.32668070806523497041 -0.89680903529006217312 0.29900679565218046818 0.5308914386893022197 0.68205927427684565068 1.1399596157424374265 1.6846693464012911789 -0.9622729473728099947 0.48174382894467637772;0.17118653385758769714 -0.0084059357920857839114 -0.72978941359113302934 0.21581882025393611668 0.51507016712367847955 0.79893354637775049198 0.9934513040814325624 1.6602413973094698463 -0.49275725115770968587 -0.3266444414648901895;0.9611053390116707229 0.13985688743503549292 -0.15398904573916011307 0.092476204527824554247 0.61151592980272007072 0.85823089753123660284 0.87687679020164854826 1.6671915050078531806 -0.039789467879386128391 0.025462563228097267326;0.1924031890071427886 0.27178752821074236845 -0.6264493322241104778 -0.39784462010151128153 0.85217279226352138366 1.00771348386146542 0.25350202517037789818 1.5081107692876651871 -0.64513261116772113724 -0.61116643265855641332;0.6421159241267382356 0.11899367042594123645 -0.30207834504640118656 -0.23203102439263498247 0.82162828394942533095 0.91090210122390324887 0.52500914634998363528 1.5974238225667807267 -0.68536277373807608093 -0.20442688168934483595;-0.14887106915830017329 -0.013269041974663303707 -0.21886910692482550167 -0.19276791110166802135 0.7788246566726887421 0.93247633329841372873 0.55170344121757119993 1.6062931648190563738 -0.65796230380293219131 -0.49986619878242743997;-0.37898665860531455252 -0.13784210745766181661 -0.53716229643799595639 -0.24466012730224140359 0.80141542192183923277 0.94271029826702112953 0.48571426416881957611 1.5857084752110990333 -0.74349857928596985168 -0.54903700095789331748;-0.26043053694817841492 1.2688495123439571532 0.27131477204711346163 -0.38081435285279791048 0.88644221091504826759 0.95578842130492169815 0.31375595926393906598 1.5170289869729813859 -0.48538390062975927952 0.064758685481377115112;-0.0084796468111631578823 0.006331692439609789419 0.26638434566186891539 -0.75887385820567998529 0.97951311941966645591 1.1308495968586320668 -0.35805208790534426289 1.1699277585061049756 -0.10982357564724495869 -0.68678654678203199246;0.72555640793955278323 0.41806543547814312145 0.39426693315314065291 -0.683795205206388923 0.98441806870545711661 1.0757427185847572293 -0.18063471919145271394 1.2903634143277999957 0.00087472101999338538157 -0.056258953461486904679;0.16224808585980385334 0.62905527162822072462 -0.25243421095260304421 -0.6623308488244304959 0.98000170629635141584 1.0553770336733099278 -0.13001061310879652444 1.3058046896446158236 -0.81595762135222216216 -0.55851790503444420644;-0.056183639539850199762 0.42260786444733222655 0.08459844196498597646 -0.66527776358533585732 1.0033071486451989873 1.0486287772042393041 -0.13756661356812829866 1.3123950259879952895 -0.15712837987087049929 -0.55677102010340395744;-0.52031622797020038451 -0.35155073867905495266 -0.91583749353049481723 -0.73254712946775124571 1.0090826305064335422 1.0868993833972948604 -0.29422277603359420217 1.2023847040859043656 -0.94724941371734017181 -0.1788753547416353229;0.93454825653084738768 -0.11497143169655750505 0.41370912836604578633 0.35767374667953555356 0.10701116914239412747 0.65354552360832451896 0.78529613113178731165 1.1839592350476721982 -0.25815583898105015637 -0.63109324202085093081;0.60024910622725036191 -0.10667926087265140744 0.47819264595174870713 0.23898525499809070149 -0.065233762075681600567 0.56924531689872082119 0.41493178733519547885 0.76933378448159861485 -0.40763633372527480203 0.11651489881256628378;0.28924472569677878164 0.83369761022555144425 0.27316601897008835342 0.23530551919951750439 -0.032807429305132543296 0.42081354145371935305 0.414955219750257287 0.66160427564051316196 0.29940717098126223839 0.0031492514330214325599;0.42343677194490941806 -0.27991980832091795106 -0.68255494830198881751 0.24736641558859434609 -0.055573610430434287888 0.56077451951347900838 0.43424947198816182814 0.78067195294449653886 0.033846745398182435938 -0.20162026140006622521;0.052627062688791352574 0.61309739056293111048 0.019306221258091543075 0.3529526452315082663 0.095475205202836088691 0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

1.3005521620413602601 -0.44931081149188273338 0.53650433842372602378;0.61995816208229315158 0.52769693902332259761 -0.11147363037098317884 -0.40021705870471946387 1.0085796040348402602 0.99535905456443152239 0.27485120837793514115 1.440832908584177785 -0.012514710405709178129 -0.9938581256057108515;0.24999340639517103613 0.26978411516927913727 -1.0663547258719145994 -0.37170787540979505215 0.98805721297810555903 1.0071053175649362643 0.30389369199784610487 1.451511768850543227 0.018060409800917262557 0.52925685038483560874;0.52887453573930964801 0.68558761014970370784 0.56915146132686567082 -0.40144275569567677842 1.0209857049536934515 0.97523297222884797186 0.287888801644097303 1.4320203802240094593 -0.38291979771049183823 -1.0041207837805592451;0.84834836060750107301 0.38267713533469399634 -0.5383587257556029515 -0.60377416536702799288 0.97962595835942389844 1.1146599218376702645 -0.084047106178881850203 1.2939483727443104044 -0.40861535423225486818 0.076399624087324619071;-0.18165808255404253257 -0.1911084717893678786 -0.87065637028597553382 -0.85414403512090897319 1.0402267687163038179 1.1898511143156953462 -0.59527674962148025006 0.98103770828426906103 -0.25495040417075187644 -0.12811050335504192699;0.61788144002676748112 -0.19843939308620492379 -0.42542781985196737038 -0.81980846309684207718 1.0107817990035932176 1.194198447698699761 -0.5093091601464226903 1.0479197091498422267 -0.25541087724550398663 -0.033944135693942285859;0.37509121687177882087 -0.085125103887215489151 -0.49940128475267847596 -0.82032241068591094102 0.98901247216736043466 1.2114215793466260873 -0.5111847886650877637 1.0502495992899973931 -0.82298813460170450185 -0.29864214269644617783;0.2813393893009508151 0.1379116586155084978 -0.49909235761023867939 -0.82161632785606852902 1.0042565539718231182 1.2094672085209234869 -0.52053037895105258581 1.0486478885976155961 -0.18547571219783204333 -0.28678824947196862594;0.3503259696403749901 0.83137286196262494276 -0.37912246007071964682 -0.88643485097932717132 1.0035116072553884603 1.2425717641597031626 -0.6765295492744685113 0.94395321681485189202 0.24890463364588449879 0.096106074903194560477;-0.29808710133049964863 -0.2670940973374262839 0.40810026551190992095 0.38009742926002437757 0.30367087369703360533 0.73321012346632641332 0.93797071615876925765 1.390180852286152513 -0.53862529970574180016 -1.3879015676557260317;-0.3883147313866197603 0.13209023829728583355 0.37354402854220941643 0.34193679398890125531 0.091043161793143992377 0.73654372226743891616 0.68242173083158585989 1.1184002221988837977 0.3037475859964867686 -1.0683727982375632592;0.17426807777698230528 -0.31239573075478338504 -0.88799057921241664193 0.3248452498756916329 0.052418767865236491621 0.67508589394721751908 0.60049947443885642873 0.99221448897077890727 -0.55163012521504961594 0.63750411354325031699;0.87953628928171512236 0.21621847029353477576 0.13671160129821863238 0.34713793549967558727 0.098373804385108953863 0.73107115048899795617 0.69548608580682502733 1.1228842767708571149 0.05833000496325787404 -0.0033917483058024007481;0.7110266323021764423 -0.035667137105605407899 -0.49045318720571984272 0.3636803201970842947 0.27001209167291101432 0.77275041154271573163 0.88014150074183206129 1.3649520164276820466 -0.19305683336711582099 -0.57665026226808868692;-0.29062344177136367751 0.066918265011326458214 -0.48204479509837616646 0.29520418552016491898 0.474500838857329299 0.80321699067828333796 1.0154249198708062973 1.5990930113977470661 -0.58444805969409852064 -0.59359064045355203199;-0.1154491983240730768 0.4524241083540304631 0.28765041085047177161 0.38599272539361889622 0.4015594125997411501 0.66340067055686680053 1.119470425129649005 1.5558316765777813195 -0.36278757808159434184 -0.5214643943008867577;0.29725257994597614752 0.093459018435617643994 0.55337756463208698232 0.37692006815873801973 0.29308721925423097954 0.74883972767118722746 0.96598518049255177598 1.4332743750441043762 -0.77307226599296385849 -0.70635414416186348419;-0.55044819866906491423 -0.26327894689028508157 -0.3909799119262499234 0.40065555490705928587 0.3780494029723844851 0.68761671238868671274 1.099624588948536319 1.5289023884267478604 -0.59369558624794149804 -0.77525712296809456969;0.015401175491335076378 1.1381542282646324171 0.66702399567532977276 0.30342379276199343829 0.48819552530920284905 0.77855834045482164019 1.0431251822241656146 1.6050326441466453709 -0.096762438893696983699 -0.5058441100895872955;-0.57016306668682203984 0.5331600276517811654 -0.41127844393321616456 0.010997054021869109852 0.75220027707611603063 0.86621501552595481233 0.82873715023122951351 1.682115029214195312 0.28134077182926869876 -0.94997532924230509987;0.83243457769214335151 0.22947419700417645561 0.041210815437348426171 0.15791822696100882295 0.63564512850802012967 0.84454068491968037335 0.95121935747349539714 1.6667175971727636874 -0.047300920801233208024 -0.67643016148687917788;-0.12065762634234855621 -0.56937171186187540695 0.013265371149530195277 0.22035524959939525869 0.62847665108829464664 0.79240481206937229963 1.0469252446595467276 1.6973741685475143282 -0.94280742116916349538 -0.88981847982892747773;0.46758300854996692753 -0.026390411752992400107 -0.31171646385386753142 0.1603272629978515218 0.6372068306859691722 0.84976085863252037722 0.95454950549464234744 1.6685440146153200924 -0.019124561001212236899 0.19624988020824860047;-0.31861733361953764598 0.2884641129828279249 -0.075654721423700152516 -0.0099677811089809789658 0.72598589985494332844 0.90406988011203093247 0.77330714353903684533 1.6564982215686359091 0.22985161473698459411 -1.0671138918369860171;0.57610939292756946362 0.53296837054308487946 -0.12718299617802947266 -0.43198731398235445944 0.95849025757807060355 0.99383189099833701974 0.23309010534899637923 1.4530791606420452311 -0.033703837501107329622 0.31258587967347417624;-0.31554140958698689845 -0.31362215208796667687 -0.84541702615983993496 -0.35113453632864938259 0.86225708333954553808 1.0165320733781804119 0.30894652172423470171 1.5145740160567244814 -0.90191514344408896253 -0.43181563996636934677;0.098980919214199949985 0.14077426580263885381 -0.69278079382612789416 -0.26955076084597145991 0.86882923595099970093 0.97711790473765769427 0.44119773247270466232 1.5607153770554607064 -0.34470992243094106255 -0.751126083961051072;0.58457303990933984217 0.65097419700710723589 0.71003938764584884069 -0.30604569175075169163 0.93641381034844461961 0.90526630786374395754 0.45183237744672882785 1.5537382682905167552 -0.11914151775209667894 -0.62906723452449297973;0.69132824353142074969 -0.35173639488158980893 -0.76507767112565172596 -0.44221431849445197448 0.94443467632437616555 1.0155319985997459664 0.20460572146806346727 1.4444911073570665394 -0.09390522347372984302 6.7229349394411111289e-05;0.058448012651020994634 -0.54054025621003454205 -1.0421040484307284579 -0.82538081343176117333 0.97487938853136757444 1.207041912318242538 -0.5390869571281531325 1.059674213318220648 -0.66979218766520787209 0.14093868052133176616;-0.26065265484947219843 -0.010410488018133988095 -0.38509999404652672794 -0.74446423796912963855 0.98702387932183444086 1.1362023938035825665 -0.32918898512569821913 1.1896258307881741878 -0.70377378217429398255 -0.44530005448519055511;0.27274385147566626575 0.39390736176315033212 0.066861312356798305312 -0.7302954418034437456 0.97692095643857768117 1.1322933167030402313 -0.29413866301457969321 1.2172203226072946247 -0.39569167549773492931 -0.45165680656586548736;1.0642566734277139062 0.19188862131605496919 0.048578111966619236251 -0.7598879357534159551 0.97739734971367719929 1.1451775465783564645 -0.35748218004389242797 1.1665688452081024451 -0.47568673173384612429 0.23884754608435176948;-0.54578345002016670495 -0.13649587260673842759 -0.64196229024512563299 -0.81775756539005195478 0.98217796801708456833 1.1989895051473999921 -0.52077791106001591892 1.0707837345145707619 0.0054483654352273170121 -1.1849402874701355781;0.67676206014703665925 -0.40405397233875628427 -0.29114640079010517537 0.37663400165833571531 0.17138728099150779549 0.66943750304753146807 0.86858628634105072841 1.2735978688920535085 -0.69537987199136541694 -0.41678157905593338217;-0.070426893130506346141 -0.62898918595300390422 0.015853973401605572086 0.29870320230443697662 -0.014348419283018578468 0.57477688835447571236 0.56848046018316600314 0.91244548779535816774 -0.37093997462135530618 -0.77651782287796111692;0.81764006183960280527 0.28850792736074815092 0.88878563600714821646 0.25337641648847736286 -0.038903916475402706976 0.53402198084494412189 0.43423065143643885255 0.75863092458525438477 0.58269320239811117634 -0.58307491132743693996;-0.41869118819593142966 -0.76148441690321688746 -0.84376910446949171529 0.29669984671808974364 -0.016842244692237492293 0.58493355620956899443 0.56189571776199886965 0.91077153607241856381 0.11289616945084603172 -0.17611541125416932396;0.19615254511105340018 0.76868943668711298134 0.38167506492864000656 0.36821407233714775753 0.15154025202322785049 0.69728590874875751027 0.83713227227383646412 1.2650325390537253689 0.37904774855564465907 -0.046021441571447808949;-0.29587838592967002915 0.3404595990029418151 -0.0038333192124644505094 0.34811676375851174914 0.34536416449537016282 0.70008621807306492535 1.0601624656076154007 1.5516985217747407688 -0.85213040038343712546 0.1358665330128047688;0.77857117768247618983 -0.23086246148021311031 -0.13715622848400940703 0.41036905390425448825 0.33654007402447849717 0.59601430379459618969 1.0805165377607066635 1.4447367279969900444 -0.57373796775609653409 0.062943296642337845381;-1.0861817796064345831 -0.1115696932332351371 -0.45121295685892642835 0.37234346747979174541 0.2264995001617856607 0.6841804545336155341 0.90170072472721818357 1.3232975917782019426 -0.58665788137251007051 -0.7326707370481149173;0.77597173784599859925 -0.15497097287874025962 -0.36110153016255902569 0.34368746556079776688 0.24107884248084018863 0.73721729290092663511 0.88459912572358390115 1.3712216695555627943 -0.40335921649521216947 0.43752360600229001086;0.58558348487527789317 -0.064614179760463935631 0.02022979772091780884 0.36603131084095413827 0.37420469299396585949 0.65209084835458119844 1.1168824120175804282 1.5661818053291827191 -0.63878309873814020925 0.46818302902052311154;0.37993141441217720411 0.58600354570908652629 -0.49157099048349045534 0.10175871847225813338 0.62582969208650329751 0.83516703978616424475 0.90430577006673995566 1.6760166360894288573 0.47628020356291944637 -0.29492339193072913961;-0.34357665914099844162 0.19509525136902811093 -0.16259292479402323583 0.21959748608353024668 0.52651236741464657598 0.77653118280434751952 1.0121120622090196139 1.6615538413520880567 -0.95255189620089386615 -0.4536494548126083215;0.16070291439117725951 0.32668070806523497041 -0.89680903529006217312 0.29900679565218046818 0.5308914386893022197 0.68205927427684565068 1.1399596157424374265 1.6846693464012911789 -0.9622729473728099947 0.48174382894467637772;0.17118653385758769714 -0.0084059357920857839114 -0.72978941359113302934 0.21581882025393611668 0.51507016712367847955 0.79893354637775049198 0.9934513040814325624 1.6602413973094698463 -0.49275725115770968587 -0.3266444414648901895;0.9611053390116707229 0.13985688743503549292 -0.15398904573916011307 0.092476204527824554247 0.61151592980272007072 0.85823089753123660284 0.87687679020164854826 1.6671915050078531806 -0.039789467879386128391 0.025462563228097267326;0.1924031890071427886 0.27178752821074236845 -0.6264493322241104778 -0.39784462010151128153 0.85217279226352138366 1.00771348386146542 0.25350202517037789818 1.5081107692876651871 -0.64513261116772113724 -0.61116643265855641332;0.6421159241267382356 0.11899367042594123645 -0.30207834504640118656 -0.23203102439263498247 0.82162828394942533095 0.91090210122390324887 0.52500914634998363528 1.5974238225667807267 -0.68536277373807608093 -0.20442688168934483595;-0.14887106915830017329 -0.013269041974663303707 -0.21886910692482550167 -0.19276791110166802135 0.7788246566726887421 0.93247633329841372873 0.55170344121757119993 1.6062931648190563738 -0.65796230380293219131 -0.49986619878242743997;-0.37898665860531455252 -0.13784210745766181661 -0.53716229643799595639 -0.24466012730224140359 0.80141542192183923277 0.94271029826702112953 0.48571426416881957611 1.5857084752110990333 -0.74349857928596985168 -0.54903700095789331748;-0.26043053694817841492 1.2688495123439571532 0.27131477204711346163 -0.38081435285279791048 0.88644221091504826759 0.95578842130492169815 0.31375595926393906598 1.5170289869729813859 -0.48538390062975927952 0.064758685481377115112;-0.0084796468111631578823 0.006331692439609789419 0.26638434566186891539 -0.75887385820567998529 0.97951311941966645591 1.1308495968586320668 -0.35805208790534426289 1.1699277585061049756 -0.10982357564724495869 -0.68678654678203199246;0.72555640793955278323 0.41806543547814312145 0.39426693315314065291 -0.683795205206388923 0.98441806870545711661 1.0757427185847572293 -0.18063471919145271394 1.2903634143277999957 0.00087472101999338538157 -0.056258953461486904679;0.16224808585980385334 0.62905527162822072462 -0.25243421095260304421 -0.6623308488244304959 0.98000170629635141584 1.0553770336733099278 -0.13001061310879652444 1.3058046896446158236 -0.81595762135222216216 -0.55851790503444420644;-0.056183639539850199762 0.42260786444733222655 0.08459844196498597646 -0.66527776358533585732 1.0033071486451989873 1.0486287772042393041 -0.13756661356812829866 1.3123950259879952895 -0.15712837987087049929 -0.55677102010340395744;-0.52031622797020038451 -0.35155073867905495266 -0.91583749353049481723 -0.73254712946775124571 1.0090826305064335422 1.0868993833972948604 -0.29422277603359420217 1.2023847040859043656 -0.94724941371734017181 -0.1788753547416353229;0.93454825653084738768 -0.11497143169655750505 0.41370912836604578633 0.35767374667953555356 0.10701116914239412747 0.65354552360832451896 0.78529613113178731165 1.1839592350476721982 -0.25815583898105015637 -0.63109324202085093081;0.60024910622725036191 -0.10667926087265140744 0.47819264595174870713 0.23898525499809070149 -0.065233762075681600567 0.56924531689872082119 0.41493178733519547885 0.76933378448159861485 -0.40763633372527480203 0.11651489881256628378;0.28924472569677878164 0.83369761022555144425 0.27316601897008835342 0.23530551919951750439 -0.032807429305132543296 0.42081354145371935305 0.414955219750257287 0.66160427564051316196 0.29940717098126223839 0.0031492514330214325599;0.42343677194490941806 -0.27991980832091795106 -0.68255494830198881751 0.24736641558859434609 -0.055573610430434287888 0.56077451951347900838 0.43424947198816182814 0.78067195294449653886 0.033846745398182435938 -0.20162026140006622521;0.052627062688791352574 0.61309739056293111048 0.019306221258091543075 0.3529526452315082663 0.095475205202836088691 0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

0.093459018435617643994 0.55337756463208698232 0.37692006815873801973 0.29308721925423097954 0.74883972767118722746 0.96598518049255177598 1.4332743750441043762 -0.77307226599296385849 -0.70635414416186348419;-0.55044819866906491423 -0.26327894689028508157 -0.3909799119262499234 0.40065555490705928587 0.3780494029723844851 0.68761671238868671274 1.099624588948536319 1.5289023884267478604 -0.59369558624794149804 -0.77525712296809456969;0.015401175491335076378 1.1381542282646324171 0.66702399567532977276 0.30342379276199343829 0.48819552530920284905 0.77855834045482164019 1.0431251822241656146 1.6050326441466453709 -0.096762438893696983699 -0.5058441100895872955;-0.57016306668682203984 0.5331600276517811654 -0.41127844393321616456 0.010997054021869109852 0.75220027707611603063 0.86621501552595481233 0.82873715023122951351 1.682115029214195312 0.28134077182926869876 -0.94997532924230509987;0.83243457769214335151 0.22947419700417645561 0.041210815437348426171 0.15791822696100882295 0.63564512850802012967 0.84454068491968037335 0.95121935747349539714 1.6667175971727636874 -0.047300920801233208024 -0.67643016148687917788;-0.12065762634234855621 -0.56937171186187540695 0.013265371149530195277 0.22035524959939525869 0.62847665108829464664 0.79240481206937229963 1.0469252446595467276 1.6973741685475143282 -0.94280742116916349538 -0.88981847982892747773;0.46758300854996692753 -0.026390411752992400107 -0.31171646385386753142 0.1603272629978515218 0.6372068306859691722 0.84976085863252037722 0.95454950549464234744 1.6685440146153200924 -0.019124561001212236899 0.19624988020824860047;-0.31861733361953764598 0.2884641129828279249 -0.075654721423700152516 -0.0099677811089809789658 0.72598589985494332844 0.90406988011203093247 0.77330714353903684533 1.6564982215686359091 0.22985161473698459411 -1.0671138918369860171;0.57610939292756946362 0.53296837054308487946 -0.12718299617802947266 -0.43198731398235445944 0.95849025757807060355 0.99383189099833701974 0.23309010534899637923 1.4530791606420452311 -0.033703837501107329622 0.31258587967347417624;-0.31554140958698689845 -0.31362215208796667687 -0.84541702615983993496 -0.35113453632864938259 0.86225708333954553808 1.0165320733781804119 0.30894652172423470171 1.5145740160567244814 -0.90191514344408896253 -0.43181563996636934677;0.098980919214199949985 0.14077426580263885381 -0.69278079382612789416 -0.26955076084597145991 0.86882923595099970093 0.97711790473765769427 0.44119773247270466232 1.5607153770554607064 -0.34470992243094106255 -0.751126083961051072;0.58457303990933984217 0.65097419700710723589 0.71003938764584884069 -0.30604569175075169163 0.93641381034844461961 0.90526630786374395754 0.45183237744672882785 1.5537382682905167552 -0.11914151775209667894 -0.62906723452449297973;0.69132824353142074969 -0.35173639488158980893 -0.76507767112565172596 -0.44221431849445197448 0.94443467632437616555 1.0155319985997459664 0.20460572146806346727 1.4444911073570665394 -0.09390522347372984302 6.7229349394411111289e-05;0.058448012651020994634 -0.54054025621003454205 -1.0421040484307284579 -0.82538081343176117333 0.97487938853136757444 1.207041912318242538 -0.5390869571281531325 1.059674213318220648 -0.66979218766520787209 0.14093868052133176616;-0.26065265484947219843 -0.010410488018133988095 -0.38509999404652672794 -0.74446423796912963855 0.98702387932183444086 1.1362023938035825665 -0.32918898512569821913 1.1896258307881741878 -0.70377378217429398255 -0.44530005448519055511;0.27274385147566626575 0.39390736176315033212 0.066861312356798305312 -0.7302954418034437456 0.97692095643857768117 1.1322933167030402313 -0.29413866301457969321 1.2172203226072946247 -0.39569167549773492931 -0.45165680656586548736;1.0642566734277139062 0.19188862131605496919 0.048578111966619236251 -0.7598879357534159551 0.97739734971367719929 1.1451775465783564645 -0.35748218004389242797 1.1665688452081024451 -0.47568673173384612429 0.23884754608435176948;-0.54578345002016670495 -0.13649587260673842759 -0.64196229024512563299 -0.81775756539005195478 0.98217796801708456833 1.1989895051473999921 -0.52077791106001591892 1.0707837345145707619 0.0054483654352273170121 -1.1849402874701355781;0.67676206014703665925 -0.40405397233875628427 -0.29114640079010517537 0.37663400165833571531 0.17138728099150779549 0.66943750304753146807 0.86858628634105072841 1.2735978688920535085 -0.69537987199136541694 -0.41678157905593338217;-0.070426893130506346141 -0.62898918595300390422 0.015853973401605572086 0.29870320230443697662 -0.014348419283018578468 0.57477688835447571236 0.56848046018316600314 0.91244548779535816774 -0.37093997462135530618 -0.77651782287796111692;0.81764006183960280527 0.28850792736074815092 0.88878563600714821646 0.25337641648847736286 -0.038903916475402706976 0.53402198084494412189 0.43423065143643885255 0.75863092458525438477 0.58269320239811117634 -0.58307491132743693996;-0.41869118819593142966 -0.76148441690321688746 -0.84376910446949171529 0.29669984671808974364 -0.016842244692237492293 0.58493355620956899443 0.56189571776199886965 0.91077153607241856381 0.11289616945084603172 -0.17611541125416932396;0.19615254511105340018 0.76868943668711298134 0.38167506492864000656 0.36821407233714775753 0.15154025202322785049 0.69728590874875751027 0.83713227227383646412 1.2650325390537253689 0.37904774855564465907 -0.046021441571447808949;-0.29587838592967002915 0.3404595990029418151 -0.0038333192124644505094 0.34811676375851174914 0.34536416449537016282 0.70008621807306492535 1.0601624656076154007 1.5516985217747407688 -0.85213040038343712546 0.1358665330128047688;0.77857117768247618983 -0.23086246148021311031 -0.13715622848400940703 0.41036905390425448825 0.33654007402447849717 0.59601430379459618969 1.0805165377607066635 1.4447367279969900444 -0.57373796775609653409 0.062943296642337845381;-1.0861817796064345831 -0.1115696932332351371 -0.45121295685892642835 0.37234346747979174541 0.2264995001617856607 0.6841804545336155341 0.90170072472721818357 1.3232975917782019426 -0.58665788137251007051 -0.7326707370481149173;0.77597173784599859925 -0.15497097287874025962 -0.36110153016255902569 0.34368746556079776688 0.24107884248084018863 0.73721729290092663511 0.88459912572358390115 1.3712216695555627943 -0.40335921649521216947 0.43752360600229001086;0.58558348487527789317 -0.064614179760463935631 0.02022979772091780884 0.36603131084095413827 0.37420469299396585949 0.65209084835458119844 1.1168824120175804282 1.5661818053291827191 -0.63878309873814020925 0.46818302902052311154;0.37993141441217720411 0.58600354570908652629 -0.49157099048349045534 0.10175871847225813338 0.62582969208650329751 0.83516703978616424475 0.90430577006673995566 1.6760166360894288573 0.47628020356291944637 -0.29492339193072913961;-0.34357665914099844162 0.19509525136902811093 -0.16259292479402323583 0.21959748608353024668 0.52651236741464657598 0.77653118280434751952 1.0121120622090196139 1.6615538413520880567 -0.95255189620089386615 -0.4536494548126083215;0.16070291439117725951 0.32668070806523497041 -0.89680903529006217312 0.29900679565218046818 0.5308914386893022197 0.68205927427684565068 1.1399596157424374265 1.6846693464012911789 -0.9622729473728099947 0.48174382894467637772;0.17118653385758769714 -0.0084059357920857839114 -0.72978941359113302934 0.21581882025393611668 0.51507016712367847955 0.79893354637775049198 0.9934513040814325624 1.6602413973094698463 -0.49275725115770968587 -0.3266444414648901895;0.9611053390116707229 0.13985688743503549292 -0.15398904573916011307 0.092476204527824554247 0.61151592980272007072 0.85823089753123660284 0.87687679020164854826 1.6671915050078531806 -0.039789467879386128391 0.025462563228097267326;0.1924031890071427886 0.27178752821074236845 -0.6264493322241104778 -0.39784462010151128153 0.85217279226352138366 1.00771348386146542 0.25350202517037789818 1.5081107692876651871 -0.64513261116772113724 -0.61116643265855641332;0.6421159241267382356 0.11899367042594123645 -0.30207834504640118656 -0.23203102439263498247 0.82162828394942533095 0.91090210122390324887 0.52500914634998363528 1.5974238225667807267 -0.68536277373807608093 -0.20442688168934483595;-0.14887106915830017329 -0.013269041974663303707 -0.21886910692482550167 -0.19276791110166802135 0.7788246566726887421 0.93247633329841372873 0.55170344121757119993 1.6062931648190563738 -0.65796230380293219131 -0.49986619878242743997;-0.37898665860531455252 -0.13784210745766181661 -0.53716229643799595639 -0.24466012730224140359 0.80141542192183923277 0.94271029826702112953 0.48571426416881957611 1.5857084752110990333 -0.74349857928596985168 -0.54903700095789331748;-0.26043053694817841492 1.2688495123439571532 0.27131477204711346163 -0.38081435285279791048 0.88644221091504826759 0.95578842130492169815 0.31375595926393906598 1.5170289869729813859 -0.48538390062975927952 0.064758685481377115112;-0.0084796468111631578823 0.006331692439609789419 0.26638434566186891539 -0.75887385820567998529 0.97951311941966645591 1.1308495968586320668 -0.35805208790534426289 1.1699277585061049756 -0.10982357564724495869 -0.68678654678203199246;0.72555640793955278323 0.41806543547814312145 0.39426693315314065291 -0.683795205206388923 0.98441806870545711661 1.0757427185847572293 -0.18063471919145271394 1.2903634143277999957 0.00087472101999338538157 -0.056258953461486904679;0.16224808585980385334 0.62905527162822072462 -0.25243421095260304421 -0.6623308488244304959 0.98000170629635141584 1.0553770336733099278 -0.13001061310879652444 1.3058046896446158236 -0.81595762135222216216 -0.55851790503444420644;-0.056183639539850199762 0.42260786444733222655 0.08459844196498597646 -0.66527776358533585732 1.0033071486451989873 1.0486287772042393041 -0.13756661356812829866 1.3123950259879952895 -0.15712837987087049929 -0.55677102010340395744;-0.52031622797020038451 -0.35155073867905495266 -0.91583749353049481723 -0.73254712946775124571 1.0090826305064335422 1.0868993833972948604 -0.29422277603359420217 1.2023847040859043656 -0.94724941371734017181 -0.1788753547416353229;0.93454825653084738768 -0.11497143169655750505 0.41370912836604578633 0.35767374667953555356 0.10701116914239412747 0.65354552360832451896 0.78529613113178731165 1.1839592350476721982 -0.25815583898105015637 -0.63109324202085093081;0.60024910622725036191 -0.10667926087265140744 0.47819264595174870713 0.23898525499809070149 -0.065233762075681600567 0.56924531689872082119 0.41493178733519547885 0.76933378448159861485 -0.40763633372527480203 0.11651489881256628378;0.28924472569677878164 0.83369761022555144425 0.27316601897008835342 0.23530551919951750439 -0.032807429305132543296 0.42081354145371935305 0.414955219750257287 0.66160427564051316196 0.29940717098126223839 0.0031492514330214325599;0.42343677194490941806 -0.27991980832091795106 -0.68255494830198881751 0.24736641558859434609 -0.055573610430434287888 0.56077451951347900838 0.43424947198816182814 0.78067195294449653886 0.033846745398182435938 -0.20162026140006622521;0.052627062688791352574 0.61309739056293111048 0.019306221258091543075 0.3529526452315082663 0.095475205202836088691 0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

0.97739734971367719929 1.1451775465783564645 -0.35748218004389242797 1.1665688452081024451 -0.47568673173384612429 0.23884754608435176948;-0.54578345002016670495 -0.13649587260673842759 -0.64196229024512563299 -0.81775756539005195478 0.98217796801708456833 1.1989895051473999921 -0.52077791106001591892 1.0707837345145707619 0.0054483654352273170121 -1.1849402874701355781;0.67676206014703665925 -0.40405397233875628427 -0.29114640079010517537 0.37663400165833571531 0.17138728099150779549 0.66943750304753146807 0.86858628634105072841 1.2735978688920535085 -0.69537987199136541694 -0.41678157905593338217;-0.070426893130506346141 -0.62898918595300390422 0.015853973401605572086 0.29870320230443697662 -0.014348419283018578468 0.57477688835447571236 0.56848046018316600314 0.91244548779535816774 -0.37093997462135530618 -0.77651782287796111692;0.81764006183960280527 0.28850792736074815092 0.88878563600714821646 0.25337641648847736286 -0.038903916475402706976 0.53402198084494412189 0.43423065143643885255 0.75863092458525438477 0.58269320239811117634 -0.58307491132743693996;-0.41869118819593142966 -0.76148441690321688746 -0.84376910446949171529 0.29669984671808974364 -0.016842244692237492293 0.58493355620956899443 0.56189571776199886965 0.91077153607241856381 0.11289616945084603172 -0.17611541125416932396;0.19615254511105340018 0.76868943668711298134 0.38167506492864000656 0.36821407233714775753 0.15154025202322785049 0.69728590874875751027 0.83713227227383646412 1.2650325390537253689 0.37904774855564465907 -0.046021441571447808949;-0.29587838592967002915 0.3404595990029418151 -0.0038333192124644505094 0.34811676375851174914 0.34536416449537016282 0.70008621807306492535 1.0601624656076154007 1.5516985217747407688 -0.85213040038343712546 0.1358665330128047688;0.77857117768247618983 -0.23086246148021311031 -0.13715622848400940703 0.41036905390425448825 0.33654007402447849717 0.59601430379459618969 1.0805165377607066635 1.4447367279969900444 -0.57373796775609653409 0.062943296642337845381;-1.0861817796064345831 -0.1115696932332351371 -0.45121295685892642835 0.37234346747979174541 0.2264995001617856607 0.6841804545336155341 0.90170072472721818357 1.3232975917782019426 -0.58665788137251007051 -0.7326707370481149173;0.77597173784599859925 -0.15497097287874025962 -0.36110153016255902569 0.34368746556079776688 0.24107884248084018863 0.73721729290092663511 0.88459912572358390115 1.3712216695555627943 -0.40335921649521216947 0.43752360600229001086;0.58558348487527789317 -0.064614179760463935631 0.02022979772091780884 0.36603131084095413827 0.37420469299396585949 0.65209084835458119844 1.1168824120175804282 1.5661818053291827191 -0.63878309873814020925 0.46818302902052311154;0.37993141441217720411 0.58600354570908652629 -0.49157099048349045534 0.10175871847225813338 0.62582969208650329751 0.83516703978616424475 0.90430577006673995566 1.6760166360894288573 0.47628020356291944637 -0.29492339193072913961;-0.34357665914099844162 0.19509525136902811093 -0.16259292479402323583 0.21959748608353024668 0.52651236741464657598 0.77653118280434751952 1.0121120622090196139 1.6615538413520880567 -0.95255189620089386615 -0.4536494548126083215;0.16070291439117725951 0.32668070806523497041 -0.89680903529006217312 0.29900679565218046818 0.5308914386893022197 0.68205927427684565068 1.1399596157424374265 1.6846693464012911789 -0.9622729473728099947 0.48174382894467637772;0.17118653385758769714 -0.0084059357920857839114 -0.72978941359113302934 0.21581882025393611668 0.51507016712367847955 0.79893354637775049198 0.9934513040814325624 1.6602413973094698463 -0.49275725115770968587 -0.3266444414648901895;0.9611053390116707229 0.13985688743503549292 -0.15398904573916011307 0.092476204527824554247 0.61151592980272007072 0.85823089753123660284 0.87687679020164854826 1.6671915050078531806 -0.039789467879386128391 0.025462563228097267326;0.1924031890071427886 0.27178752821074236845 -0.6264493322241104778 -0.39784462010151128153 0.85217279226352138366 1.00771348386146542 0.25350202517037789818 1.5081107692876651871 -0.64513261116772113724 -0.61116643265855641332;0.6421159241267382356 0.11899367042594123645 -0.30207834504640118656 -0.23203102439263498247 0.82162828394942533095 0.91090210122390324887 0.52500914634998363528 1.5974238225667807267 -0.68536277373807608093 -0.20442688168934483595;-0.14887106915830017329 -0.013269041974663303707 -0.21886910692482550167 -0.19276791110166802135 0.7788246566726887421 0.93247633329841372873 0.55170344121757119993 1.6062931648190563738 -0.65796230380293219131 -0.49986619878242743997;-0.37898665860531455252 -0.13784210745766181661 -0.53716229643799595639 -0.24466012730224140359 0.80141542192183923277 0.94271029826702112953 0.48571426416881957611 1.5857084752110990333 -0.74349857928596985168 -0.54903700095789331748;-0.26043053694817841492 1.2688495123439571532 0.27131477204711346163 -0.38081435285279791048 0.88644221091504826759 0.95578842130492169815 0.31375595926393906598 1.5170289869729813859 -0.48538390062975927952 0.064758685481377115112;-0.0084796468111631578823 0.006331692439609789419 0.26638434566186891539 -0.75887385820567998529 0.97951311941966645591 1.1308495968586320668 -0.35805208790534426289 1.1699277585061049756 -0.10982357564724495869 -0.68678654678203199246;0.72555640793955278323 0.41806543547814312145 0.39426693315314065291 -0.683795205206388923 0.98441806870545711661 1.0757427185847572293 -0.18063471919145271394 1.2903634143277999957 0.00087472101999338538157 -0.056258953461486904679;0.16224808585980385334 0.62905527162822072462 -0.25243421095260304421 -0.6623308488244304959 0.98000170629635141584 1.0553770336733099278 -0.13001061310879652444 1.3058046896446158236 -0.81595762135222216216 -0.55851790503444420644;-0.056183639539850199762 0.42260786444733222655 0.08459844196498597646 -0.66527776358533585732 1.0033071486451989873 1.0486287772042393041 -0.13756661356812829866 1.3123950259879952895 -0.15712837987087049929 -0.55677102010340395744;-0.52031622797020038451 -0.35155073867905495266 -0.91583749353049481723 -0.73254712946775124571 1.0090826305064335422 1.0868993833972948604 -0.29422277603359420217 1.2023847040859043656 -0.94724941371734017181 -0.1788753547416353229;0.93454825653084738768 -0.11497143169655750505 0.41370912836604578633 0.35767374667953555356 0.10701116914239412747 0.65354552360832451896 0.78529613113178731165 1.1839592350476721982 -0.25815583898105015637 -0.63109324202085093081;0.60024910622725036191 -0.10667926087265140744 0.47819264595174870713 0.23898525499809070149 -0.065233762075681600567 0.56924531689872082119 0.41493178733519547885 0.76933378448159861485 -0.40763633372527480203 0.11651489881256628378;0.28924472569677878164 0.83369761022555144425 0.27316601897008835342 0.23530551919951750439 -0.032807429305132543296 0.42081354145371935305 0.414955219750257287 0.66160427564051316196 0.29940717098126223839 0.0031492514330214325599;0.42343677194490941806 -0.27991980832091795106 -0.68255494830198881751 0.24736641558859434609 -0.055573610430434287888 0.56077451951347900838 0.43424947198816182814 0.78067195294449653886 0.033846745398182435938 -0.20162026140006622521;0.052627062688791352574 0.61309739056293111048 0.019306221258091543075 0.3529526452315082663 0.095475205202836088691

0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

0.66728931505709776495 0.76584247913353420412 1.1846053682544419594 -0.15933927554200016941 -0.83309997130526047826;-0.52491754444596905316 -0.0084382279434236286825 -1.1843261568071226097 0.36047598950905224147 0.30784594242670809683 0.68664506270578817837 1.0417908573636736058 1.5025353230164788521 0.095721721369064025065 -1.1209739341495315035;-0.40550669556289470341 0.17922203030749603303 -0.17860594949115946029 0.35662867587527874447 0.20259543857049261417 0.70494278948376631888 0.87539184067674924439 1.3245773250041681379 -0.65268256955240755435 -0.029304514863034196448;-0.62967730061970750288 0.02907065375780544525 -0.34078374863344557122 0.34598881074213566622 0.13724628445450029468 0.71309826642256790574 0.79952584925415803863 1.2483444691318741349 -0.39590824545689312641 -0.50493160878606457853;-0.13648875608896843259 0.91641477961471118352 -0.95031754692774406124 0.38682173903315258956 0.25004635934044622259 0.64394385907832463189 0.9640062985236442783 1.3538360694479394386 0.1128947840634397376 0.16803161498593044421;-0.16844759569688616541 0.88162887349667284909 -0.90266524230357458869 0.35594746374152319568 0.30210133275548595178 0.69555830892067638249 1.0291689976585540744 1.4956996984874963985 0.10886600172753702065 0.48038630054298359084;-0.18272150433548439707 1.041714899103027836 -0.26298933854231598684 0.11211800193666927872 0.58291587934156952056 0.8368578935579173983 0.89371181952047618058 1.663376924812262958 0.008130043994939510979 -0.37641314369174250221;-0.55596570641515574707 0.89657887438595573748 -0.97655196643350183905 0.27846016028363185235 0.52350340109458559645 0.68885252442861444333 1.1125463699082334124 1.6712327835855302904 -0.23285379874286835089 0.081438772334270256859;1.0392599752688767012 0.14757011839237835216 -0.056666992573614058393 0.30400997747206465194 0.4826347387670635869 0.66303551569616014927 1.1322515534496200296 1.6450580199928164227 -0.76003510950118102762 0.30541742854187509115;0.97160247859661663661 0.56847886603274344619 -0.16388314738346390631 0.26944608760076582676 0.49701771422858764815 0.72700772315596029483 1.0740156282486958972 1.6664987721305224433 0.27656455727066803219 -0.027735290388858201832;0.37338658504881083733 -0.28977057583856841161 0.17124664225042898758 0.1170100204231538793 0.59043013424875123718 0.82417451216220627419 0.91032090374599383686 1.6685141270565784222 -1.0359738693012068289 0.29467335783669518223;0.56052544815552018953 -0.15771366714853335411 -0.24756510830833486358 -0.32577785285619076383 0.85087643019842185144 0.95193007530691620133 0.38248976976191073618 1.5411929822717769234 -0.24970973181617692194 0.16416121001063396778;0.0094909698596854861347 0.77216662318109430263 -0.044905473087330484427 -0.19689311499473996503 0.77768690242774030086 0.93179555158734272968 0.54758316831823705684 1.6095632386087430632 -0.23427422449232912505 -0.18133010971839838565;0.91829377544633972175 0.35961922548832847557 -1.0693527732870604652 -0.12124111894027565783 0.76028067565193691024 0.86108433704242648421 0.68163858333775562137 1.6484662411800259374 0.10177948549205460826 0.056199994209798147249;-0.031501501995131436784 0.010052250354338652591 -0.94310428105422106082 -0.1794645582711489884 0.80677140292620119766 0.88447896714443652311 0.60260437393871535416 1.6276273756937347237 -0.47144678371756820745 -0.30334763429651884215;-0.59589737462372449617 0.92851796562070443297 -0.58389285269436885795 -0.31286983457521633234 0.86936017770668061466 0.92657252413253055057 0.41742376281010512562 1.5577027510357084328 0.10733915589268047674 -1.0932604160677448224;0.74245989652152788452 0.40657067919107436893 -0.030911946065721923604 -0.71380514483412949023 1.0139945991680949788 1.0763417963983217263 -0.24511060209046467429 1.242093452557286426 0.044742644401023115575 -0.55307970122974370319;0.046444285533173826352 0.45058450257500692882 0.051708223951609739999 -0.6537936207516741316 0.98763552055294945298 1.047404751395025313 -0.11301041569191103142 1.3149338208867922262 -0.63392526304119911629 -0.0060294115798133710721;-0.24833941939010381605 0.71056752155228508627 -0.43949697482509841873 -0.6078442779513356653 0.98609962482994195643 1.0267011175007096924 -0.029579280312307342643 1.3544323757950069709 -0.22540019174081821207 -0.34634944443486326282;0.1745038632512841692 0.78063944485863678846 0.14157697393514687145 -0.6649860792650695851 0.96725541399355230432 1.0754435029302740201 -0.14865011520553078617 1.3054657530746698324 0.37058023773979753557 -0.7736925138335324359;-0.31470426896772668579 0.54008218518632267191 -0.0090800779837170216696 -0.73874662941552515782 0.97674525602930073465 1.1272825223914557657 -0.3184745780091697287 1.2154948782597811974 -0.3553344437934319866 0.29930469946004689685];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2;2];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Dimensions

Q = size(x1,1); % samples

% Input 1

x1 = x1';

xp1 = removeconstantrows\_apply(x1,x1\_step1);

xp1 = mapminmax\_apply(xp1,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

y1 = mapminmax\_reverse(a2,y1\_step1);

y1 = y1';

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

try

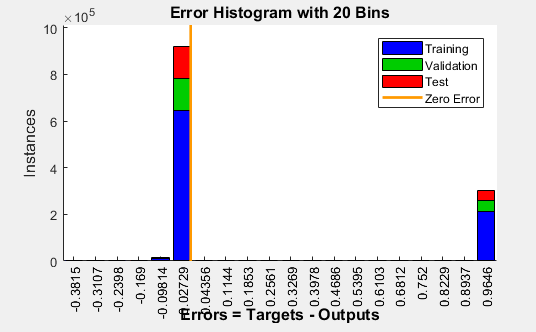
[~,vol]=convhull(performanceVector(:,1),performanceVector(:,2),performanceVector(:,3));

hullV=horzcat(hullV,vol);

catch

hullV=horzcat(hullV,0);

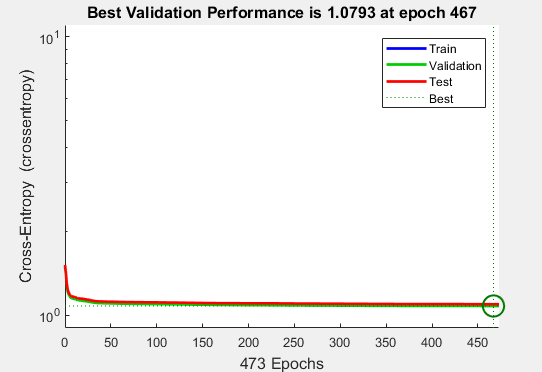
end



Error bin on

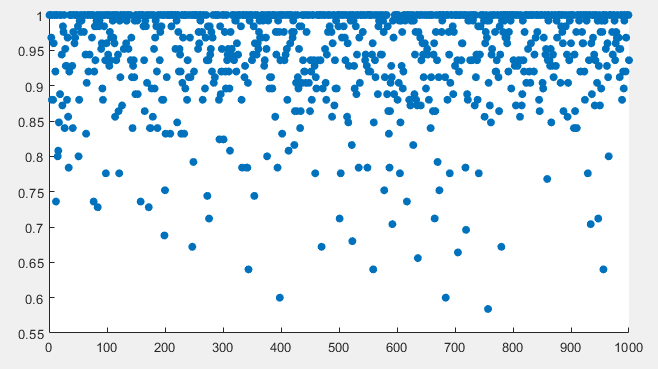
Test/Vlidation

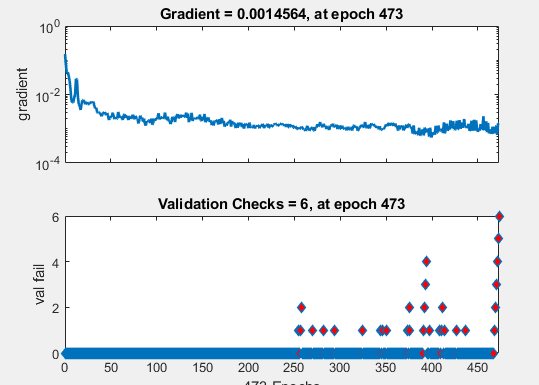
/Training set



Percentage

Accuracy of different test samples





14 models trained, including 3 manipulability prediction models

Date: 11/7/17

Alexander Liao

Idea 3 (final)

function [Y,Xf,Af] = mani1(X,~,~)

% ===== NEURAL NETWORK CONSTANTS =====

% Input 1

x1\_step1.keep = [1 2 3 4];

x1\_step2.xoffset = [5.90318136701325e-05;4.34334412752338e-05;2.14918317015145e-06;1.83852642646537e-05];

x1\_step2.gain = [2.00012319856925;2.00020952641606;2.00000738017723;20.0042458476643];

x1\_step2.ymin = -1;

% Layer 1

b1 = [-4.713067541036823016;-4.9660892040430857364;4.9324247896655419865;-4.2796050150304054682;-4.1527867817152710472;4.1092602798447703805;4.3503414943086431421;1.951995604841571641;2.3069944544242924067;1.9901552408222153989;-2.218309858103696186;1.3512562212215732949;2.7130290799187308792;-2.1955426525577927954;2.3149108347942837227;-2.3004754150013515535;-4.9139114683836417896;2.3060118954111303857;3.2447263360177083236;3.3512911878683309119;4.426767537418831111;-2.6257938978023518395;4.7619836099418160202;4.7903053232738210809;5.0582330954824383795];

IW1\_1 = [0.26076594092256100144 0.45151596560338186359 -0.0090912745291757499772 0.019242619922154199225;0.56141413401318052134 -0.040686596708401141786 0.07775059584977143945 -0.18376994426782558567;-0.4061644516726500842 0.63866112212746373178 0.35989850153301133906 0.2999143041717338698;0.39394161192424886897 -0.067574640477852887521 -0.38639228551105003762 -0.087611654548758507999;-1.2007644198204034947 -0.32397238063391708973 -0.46868377347124112742 -0.02527660432129228904;0.0030948079780288842086 0.29869525846305061689 0.65391939373766005961 0.29199727408844794452;-0.40113766891037055951 0.6095316973954718609 -0.21204908945373643347 -0.11777705598448984237;1.0631773075117163518 -0.56687363196025231105 -1.731254341488661419 0.12089782416520396258;1.1392095138780355956 -0.73768643401795974679 -1.5202259698570368407 0.12097230363830961675;1.0605603044034075388 -0.53575450765026144673 -1.8379517225337351771 0.11058008926656028026;-1.0305864260575905433 0.81090295668313627786 1.4783217556389101066 -0.10511319908764304998;1.2294357194387015575 -0.6014324957911670877 -0.91833620890129374903 0.036350994084469435974;1.4506955780285795132 -1.1170379431245025525 -1.7061446153113377644 0.069074452260570781692;-1.0649887121067400653 0.77661035788833854276 1.046897158505649017 -0.041696929845386823676;1.005389301601370855 -1.553904848771650693 -0.66503002953139778164 0.029024355950504083373;-1.1852805637601520061 1.0973262408930002376 1.2680846485082233333 -0.077030710942710425848;1.3498115799725622921 1.6497378695397222348 0.082528726628022811007 -0.055900989970307207733;1.0618420582198293545 -0.56592172116225658574 -1.3721379246999272361 0.02072450282693365925;1.258747209835081593 -0.85108674055901811784 -1.8426593266008148841 -0.0006959785748908459569;1.6007666553201387316 -1.4227837946842170069 -1.4681459579441193952 0.020306371481635322046;-0.19922186896266813605 0.18247082279179169251 0.12906582843319805431 -0.2722529116678262251;-1.9115004200958358727 -0.10428932154577447156 0.55521895984106861555 -0.049500602628398254756;0.16763286365645169163 -0.25400340555650280372 0.40342277229321121812 -0.06884854431630184346;0.12562891262526243441 -0.62979542488172601811 -0.12614291137617159033 -0.2255768045725881632;-0.50812561214958307243 0.14118350221406372746 0.61663239670249980762 -0.039450249300931820862];

% Layer 2

b2 = [-0.087534435932126009039;0.75745297311714299138;-0.034734034184943557433;0.1094782483108567156;0.17127588642366844973;-0.86443562121045136593;0.14312578712504031575;-0.16863373617828023021;-0.34937691052810904146;0.45765533653787321411;0.53357850609872703451;-0.64637170450360970086;0.18115925601907748033;0.85447370411766110365;-0.50289340934203052846;-0.68246619288928866975;-0.20581537366691168844;0.66283361517333727608;-0.061406740351640801134;-0.44634511782732011476;-0.10082393326863396676;0.031926213885077263377;-0.12983847836482298455;-1.0360292954841909818;-0.070097340490818740855;0.44843456220508381982;-0.075288531199642447223;-0.80493224934417728633;-0.058165341853377273973;-0.15924845532247455804;-0.25882506186977682905;0.59784586865750455331;-0.0026630029070452876545;-0.64675291970280346376;-0.48895472943977552616;-0.033324489605331450437;-0.4030164211131443408;1.0104407263271824036;-0.42818509252064812509;-0.50198158194903863549;-0.68161837578714812302;0.37207246943246680138;-0.94553858178483396468;0.89900468759395646412;-0.69990386817476990533;-0.89099908602035926553;0.33461859996211429369;-0.82291324509883945204;-0.39305788444920941593;0.058000254834281089744;0.72120111361538308259;0.72470755472875691972;0.20967849386603734652;-0.1806020753899459097;-0.38865491856682710115;0.040832166380138520956;-0.48067405496382664687;0.70564329628885502643;0.32692102941436784747;0.33988714577900475122;0.59270599428658521379;-0.19010495889633266531;-0.05431408061143302296;0.26686595296141241151;0.53623493274706213185;0.0037716606467446452816;0.22085710667604435686;0.2339671576392218233;0.01310106727538815595;-0.077892462052137567685;-0.33917618236935498377;0.50017542225070554807;-0.95068905538563697188;0.44046988625871713596;-1.2771726507064791178;0.095761722730170667495;-0.058202366932327644078;-0.8963381496109656954;0.53537945234832517993;0.15269569756215778389;0.27612419439928304055;-0.22878562674848912373;0.8109156978346950817;-0.092258431519165781665;0.81183612436903684895;0.28740043868867648502;-0.21358588615084789231;0.64876057360576444566;-0.23587592389460018683;0.21601659827309524498;-0.46127620020725895733;0.50880202845964528358;-0.66446634274570592904;-1.2791060204923647703;0.021851817114895834976;0.120548197266266921;0.56756652902575477349;-0.40699618394012099243;0.28268858360184384582;-0.48300415102230431774;-0.034231484630901240496;0.80407962923639886288;0.86130774427019196615;-0.75876535666190703111;0.19135304906112515777;-0.28257434723921642794;-0.0017083245270079197228;-0.56506302582551259928;0.52816655216523034078;0.69851761262198230895;-0.10389953721728524549;0.21049788111844597305;0.76102888155485570731;0.29211096913541312325;-0.16257418829536104954;-0.34815995196686189139;-0.0048552872457966536612;-0.69895255347776596988;-0.42622866275058118868;-0.74621845672644238068;-0.27829567718074937899;-0.48091744687139414971;0.47999559617730741534;-1.0143215074374059004;-0.40745797173596998153];

LW2\_1 = [-0.94979029035089168609 0.69493682878738316511 -0.073476634493424911043 -0.19068974410043029732 0.2710191414385506592 -0.26172528269225936448 -0.26260374907338684958 1.2235836825597681266 0.40860404258623844731 -0.35574088653212282418 -0.58103898384939534072 -1.0347446874594883326 0.22068722516999364491 0.0016177129902145183371 1.9783518714709864561 1.6849916649843104111 1.6364676129149542394 -0.19277607355899761821 -0.51376813051605985105 -1.7148448456832532383 -0.64496770957640958688 -0.11512780526029273154 1.2317777587068594602 0.36071623942677372154 1.1507681656535022618;0.51442331090957416073 -0.24732363649868807642 0.51299441794500433289 0.2833460290326118014 -0.11702553893170551669 -0.38617605215417000197 0.882856555076120042 0.50624278113478771157 1.0217805619160902353 0.02638672978961163762 0.14441185835024802908 -0.63900143112207208329 0.47567011487003690862 -0.24971159216394980818 1.1621682944835234341 1.4085190285730651016 0.68950018724920181246 0.065516723197163950765 -0.93742485078841297774 -1.6117411452780754377 0.26694498816377670858 0.36070714776120971212 0.10175439367757611875 -0.70060283246861709827 0.26213548707779493752;-0.37261346506886661167 -0.77763528811265347773 0.26728900544682143714 0.1115196036025582621 0.80781943023541347149 0.73212816149776105412 -0.45350742742731059431 0.53186801577735542956 -0.10394016767183700267 -0.3192709564970365177 -0.85667008762105667508 -0.3187813049393323217 0.49532452365465168276 -0.10106795346214159093 0.73057177249428739696 1.3761472443836961776 1.2728859089230015744 -0.47187665886301644047 0.66174981229639262548 -1.6446103591666321186 0.83448333270533892048 0.21309760852990292102 -0.17967211165977078902 0.45914402098097950589 -0.54573826761350086034;0.038779657678953548261 -0.50494644440160041388 0.13023026472744175797 -0.18479906124302347692 0.20461243875378948287 0.48250247571723248186 -0.51890802558601456518 -0.26216317696089475042 0.58507080894188545628 0.66013207993653000294 -0.28175711009827575371 -0.75877275045874070791 -0.71365703324756335491 -0.12013825319475383846 1.0452997609783860611 0.25207140516100584593 0.49977816135572439293 0.34798105116741190335 -0.05803296248455221823 -1.7654457661486013809 -0.27027945925783225523 0.31559455215801851535 -0.48486335185724471764 0.38950491682485011147 0.26806878287559549046;-0.25894624639786673059 0.12556642992423550087 0.0028329679901025347187 0.69882137389653564696 0.4652177063850718719 -0.34193291598012282018 0.34151912595375899517 0.80676897041544093359 0.52886488850859236788 0.22493265843166929119 -0.32761821893220344215 -1.2569656927004451141 -1.3063799986402087061 -0.085251136835224311517 2.5553447615295938888 1.0807578178182939421 -0.1025251223389408578 0.67231821598094920756 -0.094769237523332217066 -1.9467143509117890154 0.16132159906695184293 -0.16197512277422937421 -0.97203188625770053921 0.46750904230090417624 0.41733029952872191526;0.1448957292324553614 0.21686253152694223711 0.35947755559974603479 0.16424777022488806777 0.48921117797106972169 0.88191787777358165989 0.26688501903969213958 0.49401886709390291363 0.38550339413990908355 0.64603060567421100036 -0.00025013723329087706165 -1.2689304955263409624 -0.40852306949253675006 0.58716944222982381252 2.7877039149777713689 1.931133734236268662 0.63764152158272213722 0.77867157272279263758 -0.84557160420026766801 -0.97232121205173727141 0.11131674664618659842 -0.69540904598297692552 0.46399859906374157914 -1.0235496898944687061 0.6791237736018519433;-0.44539678563376827736 -0.44765310795556528811 -0.58176803920172626139 0.29075572971244484366 0.75395456814494643538 -0.84270029127706658212 0.77175799868828764971 0.33650318893205533044 -0.17542189706790561887 0.46193807422518556871 -0.4719780196978300979 -0.94644220671616208218 -0.14901919290760087811 0.39926657892316202991 2.1450914684667337085 1.7579119364855211316 1.1093880203993093936 0.79259048188591052497 -0.52480693576078840668 -1.0817867174196822422 0.49895408455266415659 -0.27850253487280079989 0.41931983071883843772 0.5182119042890438454 -0.13001727140741736743;0.075782015011241460334 -0.010852569591629671747 -0.56739238161593741339 0.06069794847226950979 0.83658222923044189834 0.55988515994687748645 0.080990412270318376531 0.64016949919897048193 -0.26853112380220578448 0.25814358655462765757 0.027204284323755177633 -1.0918752662893147498 0.47097402218854966804 -0.63825453187319225457 2.0823193553691314861 1.5844761346342568498 0.12823687609838438362 0.43550859563406951747 -0.57680254001121744611 -1.9919927807198809511 0.67482482523688380738 -0.26717220287859394512 0.15880758867640465404 0.10727409269081016052 -0.022910212831546605122;0.29860923145384798971 0.32656340229911662298 1.0236849239233694053 0.81556932280174210259 -0.93689928563119440064 0.519704192910258711 -0.34748978672923680477 1.2557980856815518234 -0.17559664707539601736 -0.012675632652981405971 0.15845791478250997875 -1.1876255657642063035 -0.13251889503745181709 0.097876369058578119309 2.1846751723773834009 1.371244068280693007 -0.033717119908103207471 0.71176491992857449098 -0.34649518454989935989 -1.4776656182116725269 -0.95878166232036465821 -0.2122577468731696726 0.50327297528690162487 0.11123068686723802667 -0.45047210960832478888;0.19429223005182424955 -0.78228772867185847328 -0.45330068971826931179 -0.79778691672497703546 0.26532360672030308457 0.25928227641568402095 -0.47609739813331874991 0.41183612600021490824 0.41785328761150725141 0.49817104568751369165 -0.31575830984442526672 -1.0577600809189149356 -0.15189431622200827432 0.79864656425380764482 2.3454230056869040943 1.7652907269499504839 1.2107490917443983758 -0.13137486852365723444 -0.3802914824964752083 -0.70733913893454958277 -0.097818842212697793004 -0.62946971312631916362 0.43110406416606195101 -0.18702170244921897946 -0.4814415857701741519;0.089658069600942427724 -0.39304331198800568359 -0.77029279879418455224 0.29241968622196029548 0.15701533346372631428 -0.52556307317865247342 0.2926523975328220728 0.70255310213857846691 -0.61407631941784845964 0.77487079358931798545 0.0068596473245974582539 -1.5152270415426853933 -0.85514371992919502308 -0.36731666837929893843 2.5033638089860201781 1.2011502854298758969 0.037243718045676360573 0.3040928606643773513 -1.5799494019750379703 -0.080542561949275351396 0.19957903331386836476 -1.2534521623311858374 0.011763646995464491218 -0.97123787439660624887 0.36744071117829352202;-0.63921873847750965147 -0.37882330011725157126 -0.064730794198977481546 -0.31043924185591592613 0.54991916138953422788 0.08757615821232286879 -0.19417424582352349471 0.80065580462806662521 -0.407513207519136611 0.5720629421126059988 0.042399414130853761706 -1.3709822333359766855 0.09157212644727227846 0.068241037908310639426 2.3720984047295230468 1.8072642025912424302 0.52561442972741145852 0.26284379372992350277 -1.3972339792597119335 -0.29833854896195538542 0.12625928120549179123 -1.0498471019010122696 -0.32761211024117398161 0.50659123057186705719 -0.50697139133950519518;-0.20318411273290148955 -0.24681825549394800778 0.37267920450854313819 -0.28423335301490915139 -0.0051172937351654408655 -0.44267620512191335758 -0.43247589184591023193 0.47972685220360716807 -0.27133612802149720267 0.7825383527245132198 0.78631465831487856732 -1.3487162678534134752 0.073122167431590848197 0.05790829426078029224 2.2656673088849363928 1.0057231762725915569 0.93713003460964672264 0.31848768848824027256 -1.095362459807600386 -0.59327100865014192888 0.74148734537439375814 -0.97806616947354041436 0.14247793418802048859 -0.72682674363313259924 -0.39744087931213939457;0.69696207275295929406 -0.1824202944501698842 0.44479589987989787137 0.093865011865125788648 -0.17689417093541329185 -0.59131471923948264457 0.49263670443757490158 0.25699959701909330656 -0.41120834949742895992 1.0320507616182961197 0.49780897683274760723 -1.5343422257829104627 0.54935758578788107531 0.12685155386169957858 2.5432126050906687098 1.4289634971536397945 0.98803288671402178522 0.32179001071092794284 -1.1945729304889098898 -0.88546601653610157445 0.47281679799453429913 -1.1345779410310310453 -0.58087558477316558747 -0.31723244650590970428 -0.14481012946822208187;-0.75458742549586710346 -0.10164016306648906984 -0.57849917054718202891 -0.13289526417411540171 0.24667570367907692974 -0.44050604449984415156 -0.61821268531944817415 1.2660307992458641468 -0.046508995922637810794 0.082019753265469716452 -0.18090448901710218244 -1.5782110015994572638 -0.93034495805822958747 -0.029663811081873086434 2.4397583294339657556 1.3861270682979991431 0.58962936489373873883 0.2485078835105145878 -1.4131131115763964079 -0.096068608036141672768 0.15626932117023825675 -1.5801509343011626019 -0.65025863977604037025 0.22261848313066540106 0.88547535386224873744;0.66250043286999560355 -0.70557649073639472359 -0.41455091594835635771 -0.017942547583064932804 -0.24541613388682698149 0.26590436020890678703 -0.21649733741941065701 1.0081433622361204439 -0.47606539420016003028 0.62487672161098795076 0.16161505754776689381 -1.587495736284593173 -0.73278603703699562999 -0.00142910502162146456 1.7919082000885353523 0.30585635472107142174 -0.29909088598816258031 -1.4100744179871125272 -1.9015097198826025338 1.4667154298889208963 -0.41764020455552597344 -1.7445574825384584372 0.27610285013050939185 0.60823819665806277968 -1.0898191058223236638;0.25355800893863944534 -0.30344541911465938711 -0.054055870122625269969 0.37116023846007506481 0.14131996020843690109 -0.9185096517805253491 0.32230444893984200316 1.4116520686701323761 -0.69928544420350868815 -0.15000202076804827755 -0.94359706814324162405 -1.5707224768631140588 -0.37337456577578392869 0.83359886506797731265 1.6947442680287745365 0.9230679280467073422 -0.13303772597347118811 -0.34090013169066074594 -2.2544592285982916202 1.3605083125754575679 -0.49700779517253407258 -1.65142964402241188 0.20875945907653270517 -0.033779895516886523921 0.56047437170111991112;1.1281159962662214991 0.54972238901637715536 0.66899454479654674177 0.8117816516990218334 0.32811881555162564217 -0.44871614203711396307 0.216090383762809507 1.2993266225129374014 -0.99957839981853302547 0.3249833695365398345 -0.22662871406069887148 -1.7787545161253175419 -0.78357084014707101272 0.16618997960270154302 2.0214308352087200227 0.50836119708698201958 -0.050020788530360835167 -0.16114616107516455124 -2.1000692326616832162 1.1829593337192387814 0.52472517815114771977 -1.6510127476405869196 -0.35816838881562057528 0.61687083784584195723 -0.34796701785366052073;-0.69759073546415506506 -0.7974067941948472793 -0.54569149239659653361 -0.35037551213510303993 -0.20938954324302505583 -0.4967959276056009843 -0.44711280603765002351 0.89837416709928819003 -0.73635244252241638385 0.3727299262580879291 0.039094513750211355718 -1.6449385212216445229 -0.44260679956735660134 0.71243527418244256832 2.1884492453782531385 0.22155791336451449713 0.22685680068118166397 0.046893581994750348219 -2.0699471600801340188 0.71034060632239215405 -0.071635241714980132932 -1.7402918759496046608 -0.17382343725176663263 -0.69112130756082712502 -0.44923448425493733849;-0.28700290382427240399 0.63712062462681484654 0.59667189283559884938 0.28068216996804029595 0.29623837176036083019 0.0055314801306711137638 -0.078416172246530732592 0.26747070591701133102 -0.05247443984733329847 0.92213266433714080605 -0.31129130463992948918 -1.55393263705089546 -0.28993318212473101481 0.33203698316123053669 1.988075694457207776 1.0528283348291644916 0.26253329424668891967 -0.82515348403201638217 -2.2708226783670437676 1.1453216673523833879 0.4025935828724419574 -1.6620935412072574966 0.28879323849366222987 -0.47162622298293382928 -0.039960852950580376397;-0.67668298913912183767 0.32675413039405276638 0.24308136003036584505 -0.079576801822165851852 0.15371273430478765709 -0.89983559116417122237 -0.61586535442762702086 0.32010103556416680259 -0.97839806143599161725 0.69640417375758545404 -0.36152090629974764635 -1.4147811902703899545 -0.095190742292852223438 0.70927425773970187439 0.53480651382890798118 -1.3265479585851165378 -0.16670356731089711055 -2.405817880041988932 -1.671593403963441915 1.7531070225854232802 -0.73189202897602056996 -2.1164210199682416125 0.16443589807375230682 0.16270993014061216342 0.48784350595685682661;0.61534094355435509094 -0.2041381915024908511 -0.25111280168492089437 0.42567779885805329121 -0.19796110572329245203 0.41792947405267966143 -0.3001832328038145925 0.77466384635855811691 -0.53085862686493734408 0.5479133346932606452 -0.3488620828047751532 -1.6245904692191259766 -0.79564857068421357411 0.20089732984038452535 0.89544381411657025804 -0.82165746120241867079 -0.13886628230620515212 -2.6050898330032019601 -1.8234698180479411711 2.2852265899776029734 0.85909250423035299349 -2.1960893533787846366 -0.34397306448292663816 -0.84046703934394606517 -0.38075055576897898213;-1.0496111254985891481 0.038114044043929852512 -0.33603093249168830559 0.45509448514963690702 -0.43812420894865305998 -0.64160272035940468793 -0.032186300852098906344 0.88622325367343302016 -0.75110676401579690165 0.27019872879131262566 -0.72420294019555164766 -1.4693220905044572788 -0.34012339922729156738 0.38268383579272557959 1.1120726355120078566 -0.081356826073510496444 -0.37260567399420757573 -1.715905213452364686 -2.1446474891409201824 1.5966377210808002651 -0.76825604246924783514 -1.9880320817991765647 -0.36131459603178323059 0.4522030812641141817 -0.40476438168144812657;0.64726783925144393272 -0.53645331746003344087 -0.11077067140076256313 -0.3356800798190650581 0.35786635575826086786 -0.61806306215273998372 0.055422260253771296612 -0.0054319552269370564163 -0.44910598412438085258 1.238335593167939841 -0.31253274620148174812 -1.4273020405599670113 -0.91491503417009212296 -0.035376524434977879574 1.0459940468319395279 -0.53546506432135432263 -0.42837404502220716163 -2.7346527713815236282 -1.4273031404101486075 2.0221179315377972863 0.54638900075549212687 -2.0297896593710222923 -1.0269698251973109482 -0.17432013066636803389 0.80687896076120990685;0.88699969673667455883 0.23495413434004774889 -0.18688494452219858721 0.3871742727235396031 -0.64709221993677568108 -0.54218671815106223022 0.025137649851837792769 0.39272829931175129436 -0.90363048491199937651 0.59743265776401066613 -0.61187369484728992841 -1.5406850940194409816 -0.96328866866831397431 0.46023341696323055716 0.52597945182082328497 -1.5885273758856139903 -0.24613901134339372101 -2.3260467946892431357 -1.7457429537149031784 2.3191021590320333168 0.32574870415633638832 -2.2824647584271073875 -0.28285655227586886662 0.12306870194597108181 -0.1665726503166687078;0.34266700504754254997 0.46765000285213120801 -0.31526594475905539428 -0.22847802095264635458 -0.14381676000608167865 0.40949729933592898812 0.17062910542208947762 0.43381329112108885093 0.67265028843493268607 -0.087884406018601729516 -0.75745950739387690742 -0.24036192079153018142 0.96460306051189337317 0.43407636044271963316 1.4374981431589659575 2.1459299681141197347 0.38412975428464229966 -1.0171933890202100592 -0.48599887990624240919 -1.4216614722722047404 0.37362872498204047211 0.13998372939289141503 0.28858136989652727333 0.17991200953083058556 -0.017610394857562924886;-0.99220481631890089513 -0.045479252536005591867 0.29609214133466987828 -0.052456829435931794092 0.17877913925898822334 -0.73426113482334531835 -0.48825971287550956612 0.040553986181638593256 0.0041081072219468980911 0.64481224106726531264 -0.33450155850974233607 -0.16613682321992581659 0.28323793899024818366 -0.50913545888692901542 1.1310700446864643265 2.0032515675762110341 -0.44346750815249591504 -0.52849421682386898969 -0.40043641845132155188 -0.54430049363573274057 -0.55323309362710659798 0.56863428166393537033 -0.44230183727186678233 -0.19895063693600806287 1.1242949070539087764;-0.2553653526427964171 0.033260831945968093171 -0.45402091953222500909 0.63251241808922820109 0.30417112415534491854 1.0547431831972997607 0.35344164457666271684 0.30622141758938170586 -0.63720754373683263783 0.73178242208659494139 0.78484989528276194459 -0.058607416553276753257 0.53292776074276360099 -0.093978679338769841034 0.53938886237331085116 0.18692194434702871786 0.50138009640324854299 -1.1381566179998980903 0.16435271693820230343 -0.57266687251638259681 -0.49818706380079008644 0.87715531544319325086 0.48102878005181748389 1.0473379210523900973 0.92474345359915055553;-0.72575018014173853231 -0.75155558021272661495 -0.029252655037701212615 -0.688381827468854679 0.54339307617733823008 -0.16362053216528679722 -0.38310109277478932022 0.094619779037481768769 0.17571157618524996247 0.97537909974236991495 0.93512754475810822008 -0.68730548830828164242 0.66777304988879726544 0.078984930227058450236 1.0462568421341456038 0.54264859801033116238 0.30066445719988249552 0.28236434948273114731 -1.0870161190001790263 -1.4413458324748049666 0.63796300161970032061 0.31392498923352235574 -0.69982232651947506863 0.56694080761123710754 -0.37590207666472658099;0.25142409646883751018 -0.35119712437550959505 0.46372631808145337029 -0.66182178743465169823 0.50461021197285094164 -0.095977456841546002209 -0.36555628778719895244 -0.14023340252642985115 1.2121113070560649572 0.51458634884101417395 -0.27679199302381846115 -0.35145378453604042557 -0.024165002578246080889 0.67037764454454717988 1.0886484225048005392 1.3282234174876104138 -0.01377647196747388246 -0.19451056562532109684 -1.0214001122750455686 -0.68038805813370573095 1.0521665778995241691 0.087217919815653632831 -0.32568634600098317344 0.14859034802949117049 -0.56152173031651531065;-0.43635061431796373643 -0.037233056372421996505 -0.29543457756471541709 -0.97327934805664362283 0.2263787623319118425 -0.73474622503719611011 -0.20537244885792610427 0.63782664256184862239 0.22839442134568635479 0.54627896301034284399 0.3300148745742484957 -1.3184300854622712507 0.18990148580817398094 -0.47885452238043502149 2.1337383447669919789 1.5856527061569589687 1.2527857003756774912 0.29625726656016132532 -1.140573443069171411 -1.1248527789483271366 -0.58133783106380965133 -0.54714237552927558195 1.326915733904970196 -0.55973449866749414028 0.76582121559019444845;0.6625134240949931419 0.32093056262717323257 -0.29276645366699544093 0.67800005779158123431 0.23794780048168004405 -0.40589305575471346099 -0.3611750896386785592 0.39622947212950687668 -0.1389014676889112343 0.48767280322723305375 -0.16221312494808182159 -0.81211629039634847249 -0.17738638527291902824 -0.124149520095898247 1.3179579140429193984 0.93285142227582706909 0.12387873270844559914 0.44842972641899181419 -0.6795740727407272308 -0.99264726830208693809 0.43310357493142287444 0.022592265607893329687 0.88010205577696021262 0.36166811937905096741 0.62993451017055834829;-0.83127122498360417335 -0.47413993901193135505 0.46887718511990367221 0.08371368554669973705 0.59172921171167924825 -0.61709625011200730516 -0.50056454054286192434 -0.18842246917689103869 0.075318648629624840307 0.75884221924071937337 -0.47284388784874209488 -0.54662760883697103509 1.2504957520858919207 0.090147068529845733598 1.7483116982667585848 2.3676586390265055293 -0.14768946566898025208 -0.20401439673074114878 -1.072733120170938026 -1.2329978315391803001 1.075874095455455981 -0.052570522207119829705 -0.76738205261349701214 0.47604544623245059753 -0.5614084553528365662;-0.76756936909937512059 -0.52001778896601025259 -0.19315236039026661974 -0.34368489168835619774 -0.12254977188447803427 0.21360758471317578544 -0.18458672612205467845 0.040407790702726355259 0.18616982441991003494 0.54528697353866895092 -0.8235130818425709931 -1.0580694522875251362 0.17082310164748082393 -1.1240430759295165775 1.8646262575778558279 1.8225469266242153576 0.42117680947860514085 -0.046422900910139328068 -1.1305132413317122708 -1.6198204075540070246 0.061043166661588842137 -0.18233264386425904191 0.32538784140032034342 -0.57643926477414875187 -0.60202374009814774158;-0.61521014626582370965 1.0301870271946345081 0.5055753831148683819 0.36506914326835931961 -0.62030251327254570803 0.36957006413050730309 -0.23251241277062548174 0.42753120082833989679 0.31887963911252648064 0.90623993267186475631 -0.22586392924834661211 -1.2587795684252827133 -0.68831636212896296634 0.88979055099725168354 2.5651382448126893721 1.4723618553446111701 0.055955577564694401749 0.52434852984749202864 -0.55830325437661953991 -0.84688531494118512999 0.029441848650884061556 -0.4698701298566513862 0.37987840182751164697 -0.95072913215933629871 -0.12068330792016726538;-0.21097688401463102204 -0.36931501214558243307 0.39211649940033266315 0.61043469300659525256 -0.32701921499906771995 -0.25186893676089910921 -0.44714198186440362592 0.20445902088482403869 0.71363405864535534029 0.62703083081243260466 0.067895373582962645354 -1.2814324745624274815 -0.99254614835442900311 0.78895138280748933202 2.2687885501134514854 0.9367244827036212973 0.35954182043704152605 0.02356196669452927106 -0.6034328553102734638 0.025335599494238986856 -0.62057406375782298014 -1.314925564708519623 -0.76178994271647271219 0.47226168135625040678 -0.20358395997043982062;0.34125043625952483639 0.40869561961876582634 0.82756613785858379462 -0.1340680399260800737 0.25213760523217004783 -0.3841376847497520175 0.010168593540897370373 0.71141508058251923252 0.2022584618201536677 0.50013625259340765972 -0.79419888762439339036 -1.1939071893981472172 -0.37334530194622667088 0.09309961427084638419 2.3600118074592497663 2.469639750588803917 1.0272964109267821442 -0.37970964257089967475 -0.91078870255245347742 -0.085308169975802650153 -0.27830349586505004345 -0.82877560056019194956 0.88978723356903366426 0.01799318928139695753 0.32825684354882139759;0.028611686174858933646 0.61345465354079176112 -0.21771769831655432559 0.036926805495593344186 -0.084683126639329975305 -0.76935967694177154197 -0.41950405448581451484 0.79645728237792245974 -0.57501492355235117593 0.59236079795652474278 0.31286140203590590003 -1.4444328951288922802 -0.013096551675490297056 -0.70054631045640336495 1.7850766329998766224 0.68059205230223518424 -0.10896680437342023962 -0.28273962852777140276 -0.36949714476484352144 -1.1262277170193613074 0.6711585501775528817 -0.75351212269510103869 0.79449725388419933925 -0.58118828859992088809 -0.85300048356691049456;0.16674575556440726642 0.68365577922159626034 0.05120794444701186332 0.51360672910645222 0.61790180178197706695 0.37832339673970410976 0.90172840802520970449 1.4287947863891674594 -0.30099662260560650084 0.021391687981252589107 -0.73725192145757312279 -1.44360622347252332 -0.87562760961823393746 0.1975787812178473879 2.4050144171671345994 1.2028290874263620758 0.35359505183187933675 -0.34879222812417504107 -0.35204786750301098053 -0.81574787178088170592 0.43207019422876508097 -1.1585613757355095466 0.30866018044575438406 -0.89033942663987142296 0.37844408270121127069;-0.38436871497296687394 -0.49626736726839176805 -0.9219545038205255727 0.25158091078788202832 -0.45594950112118248775 0.52046531470876722381 0.19100125432366821254 1.0047240770986403113 -0.93330705216762632759 0.45173963291477814419 -0.20276084097690888486 -1.2906522286373789399 -0.25833356947153790495 0.18727480889888212245 2.0748151409377459942 1.2240682425002040734 0.18764280873981675768 0.19030544913471314494 -1.4120912630811350841 0.099835569029444015676 -0.36592699654937799192 -1.0647759488821744167 -0.82936705796880560992 -0.66417393684566172762 0.89840716231196537933;0.70607009656960162403 -0.51913142987985272381 0.65347318215211180892 1.1037880472230650053 0.18655077246998036378 -0.17068781038132854744 0.16979035951241214231 1.058049215713018798 -0.59581407525580487583 0.59554889903583796418 0.41905070701254903964 -1.6324017002236883567 -1.0159392076635735958 0.54109000328730783025 1.8165912497145326743 -0.28366662593565844519 0.31474125385628975993 -0.46984031336906373344 -1.2663320730543188297 0.69747120584864430448 -0.16249983840683501768 -1.7443278744359134169 -0.36285514269911051111 0.53110601600372564501 0.56194046452039858597;0.31475558088871008477 -0.19779120251209894588 0.56285350046237336841 -0.39943986007337572985 0.31964024872651203291 -0.91146548322814724408 -0.20911535186633378736 0.32191189165308592424 -0.75786557922819286492 1.0367232578314755642 0.17662812704284286403 -1.6598282806223747521 -0.3566951187020280245 0.78692465896566665684 2.1683530014566345656 0.065151013328470244734 0.28805702632554991416 -0.099409109624015265516 -1.0079102725798587681 0.0055099492447520138916 -0.28875289576964707772 -1.6308861362955024976 0.66648215039758007538 -0.2404301765925830614 -0.90000285319823214447;-0.10012438018377049775 0.35762527041098046698 0.27507095881317528141 -0.40323587563622403929 -0.95247810751394113016 0.51363477967561244064 -0.53884572487991166945 0.93887232204145720793 0.27385560590352875376 0.75625433426361743372 0.28225199251838245518 -1.423856241068468087 -1.0120443528344442718 0.9082565846638572804 2.3103127157433633876 0.49376821110727925346 0.68045542591090202311 -1.2231856261024212085 -0.64061456623029278123 0.29798573262311839338 -0.81339129778566199303 -1.3009384001031225608 0.39632136181485266846 0.078575945664661250856 -0.2702525414573057061;0.092836122570116003105 -0.81740704863670543556 -0.49794681443687460742 -0.67876160409851515887 -0.0044955554015342529331 -0.16663627942831835127 -0.76718380541002861861 0.69067735155165121963 -0.4224487220156293299 1.1158759592242422087 0.74460504325396936753 -1.7048158673235946914 -0.59074839555367908428 0.016982111210274722368 2.2127324956489866636 0.45821000407241313512 0.40006434875262936179 -0.23354528710689229087 -1.5439409574011055959 0.29744867385939116611 -0.87440187933417345967 -1.4046101560509651751 -0.17527603150543899502 -0.034385813955580463164 -0.40512180906241840317;-0.027922382132098792773 0.41060564814881933549 -0.11325603475887788263 -0.47838567076638360831 -0.17091162621743721806 -0.55424218163710303742 0.61391457838173735251 1.3454370888396416373 -0.32143562320600893578 0.11039168339449073608 0.59879047304515820027 -1.8434624112287558706 0.2293821921598222513 0.43127991676316279612 1.9420036110266389873 0.42440531989122531886 0.47798139678645445994 -0.40376791087906155342 -1.2876023714476960702 0.21054015250723526198 -0.11631795590583506039 -1.7818872956035329835 0.34993529315387150724 -0.7138427855653567411 0.097581505999568274312;-0.49760892776687681849 -0.45042311256881872872 -1.1529766691164595738 0.096379560136036365736 -0.32549416234694961148 0.069550417971588493482 0.292136294880339209 0.72189724879940775359 0.70976384469844178149 0.2944445126590871098 0.27566084610821450784 -1.7237509893304525654 -0.48350641452857306968 0.5485259216852207409 1.1356830808105038422 -0.29347362320305514505 -0.44365895894316459414 -1.4087620233863753505 -1.0422884773898586364 0.97638786962104473499 -0.7145663777102356784 -1.7498845897485229006 -0.75948342249492439837 0.30243105036460377066 -0.18298540090091200416;-0.37276547535849574588 0.19651147768539869998 -0.12859258428870043445 0.012344220864508786972 -0.14068892502798058253 -0.89361309753847883997 -0.00075857450027741967456 0.5475312491762792666 -1.1167251899786749814 0.85314441326978918134 -0.55244167910619801365 -1.7763717394196749666 -0.50975252472792165204 0.033324985578685267784 1.1666851545176148974 -0.16857757089816244322 0.19129366638237829679 -1.160618959871241751 -1.5505086680816289046 1.4425407803122514139 -0.34304107377747738994 -1.8666536871395305042 0.28761091349817236029 -0.51441818567082919778 -0.31956581853939902693;-0.59728557707291618506 -0.097699553991745985426 -0.39599538136265660659 -0.10543829036179509784 -0.33595246713805765326 -0.78290315276693112079 -0.46604953854073816188 0.94434192892905644001 -1.0839922806816428835 0.86560631115839148375 -0.29540852515689286495 -1.839402864056740583 -1.0580897038488688011 -0.40144313804203113349 1.1823997292566170714 -0.21784674663309169795 0.22574329854193644906 -1.6160409330494320823 -1.2432682637902510159 1.6644950934821154398 -0.65595558342705395649 -1.9155179132915021167 0.8125979910260869854 -0.58095947338465181442 0.330584445580216435;-0.47231103117273465219 0.71834028137978245265 -0.65031099879307419087 0.4511962829487751736 -0.45629110771289871362 0.32591561218212850015 -0.53666186772347834744 0.45972523886136912319 0.53637825019754192812 0.96120437192886265532 0.54026427565223833493 -1.7149529887738117484 -1.2407990266529140833 -0.30423529819404659946 1.1570452602778154017 -0.19663622735835981081 -0.83336321474466068526 -1.5096428871636651259 -1.4016418266277825833 1.6134585358422315338 -0.92043724886141753405 -1.6239319594915602174 0.26506602879899510139 -0.31167139053981679497 0.17558174435276457936;-0.27373076495225090454 0.43444808752745378566 -0.61920227662695748183 0.32395413280755680496 -0.37990357088705206667 0.35119825618016975444 0.049872263297710932306 0.33517244906148468964 -0.18045077083117491701 1.1667092415587447807 0.43847622553766013587 -1.7696060097100236863 -1.0703778489156670073 -0.22507631100305952598 1.0392347310474279176 -0.87987361690718224327 -0.39045589899642429987 -2.0055104436552562142 -0.91967890303664079354 1.4921481064590227383 -0.50891843087658239497 -1.855599973763631283 -0.8559493730710382442 -0.55929158381199195471 0.18745335517595440589;-0.050574081631943365589 0.88735552015423602157 -0.25473166399228086565 0.6509293200454138173 -0.51105310690369509796 -0.054042043192423838693 0.95504809559941017394 0.19371667715241230878 0.34767027140233108806 0.54992340388281835128 -0.20601375914900252329 -0.64336381741998249773 0.29262117193733588882 -0.099364899421180347128 1.3624110458310105809 1.374568365230456779 -0.19218560948553031764 -0.29680492923744222766 -0.32981924474015728022 -1.2417580680494908485 0.25414798067184390939 0.43541927413403130886 0.22923947534456134978 -0.36481481352389055761 -0.45488966331444258273;-1.1410743744974967129 0.53961958180504532301 -0.57832061138543733314 0.63625898731118302187 -0.84959814981732906247 0.66604662738069753125 -0.47450047272501882922 0.16335094571220315496 0.48865242404602210469 0.37960602578979107946 0.030754696786731251096 -0.28599447221443474731 -0.29778307439711942939 0.24617311562650456835 0.64953689883881826628 -0.3732666455296343444 0.41547094038128801197 -0.73359777280973459401 -0.58075079272053664603 -0.62182151347342295988 -0.34761326514309531799 0.47807351223296301601 -0.032509548660979291357 0.52764057232194450098 -0.63734771403618462049;1.0162428909299154878 -0.093609457927189346216 -0.011854729002023530263 1.1318387267032070653 -0.61808112423643501998 0.18453771589876336034 -0.59260384582701697287 -0.34225277692770966764 -0.10088972347016425535 0.75727110962270016703 0.5552860261715163448 -0.20917612488346862265 0.7385142836920246534 0.8401819220583950365 0.53951341654255580149 0.36886442805856151095 -0.41907218023187148281 -0.063936330140739183747 -0.88329500807584360178 0.26782481316164641338 0.052264501331234267112 0.21203738158909232747 0.67748176015533911887 0.60292931140418437597 0.11778134130717665684;0.86874890372026059016 0.3747563295283986573 -0.03889503315738670336 -0.63591532139671269608 0.27344905393957313899 0.60504641506537115703 -0.19950964117417607779 0.38362877356758567915 0.55479223590615978079 0.18405625941443942706 0.18671205271083832211 -0.27349318575701919709 0.73835951046499415096 0.96162960107631167972 0.78112011496773103847 0.70773824236742632898 0.12011126873029639994 -0.92252310015889382733 0.48775321957725570332 -0.66880320721372443771 -0.13419902842000588916 -0.21856618738743768815 -0.863272066108226932 0.22934317453574457057 0.97295494986113206792;-0.20389879985725395395 -0.73908695925513834268 0.5768777089953247561 -0.93003516249612094846 -0.62238934479002938627 -0.23579185264410015832 -0.52920354367183397581 -0.16690417463057760639 -0.57512125029224314687 1.0094148716103046315 -0.52526425321811698321 -0.54317286377322471225 0.69976369749535449749 0.39586026411219726873 1.3800279992572987986 1.0666130220730150047 0.60063188410426016084 -0.33450177476165710022 -0.98106492631819619543 -1.0944612791665409013 0.077224040714458055956 -0.2656561692909908956 -0.30807895477366697978 -0.30496431700418635824 -0.48719795746375199608;0.088918773384864410736 -0.88043273474174554849 0.35567933970010945366 0.47867864469274634676 0.050920578878572445025 0.41164002208654404402 0.082589620146463801897 0.11505315695299432599 0.26352992888408133254 0.96492924648971345469 0.015094863293576657806 -0.82296513810944560419 -0.058038492016078628566 1.2469055757738320978 1.8933036143267056861 1.2172821220559479904 -0.11077148610531392658 0.43243847233281895726 -0.69316024290832944921 -0.77544026280399269702 -0.65618633340824561451 -0.22637857765640451158 0.57230201802561853075 -0.48588800337002502339 -0.75659395466536871755;-0.3622243730778260673 0.39006668408489120203 0.28436771132157157016 -0.80716546410571510251 0.26063214356122615944 0.17204148226565588176 -0.085957479849679413464 -0.42240360281737177051 0.6328106782000185726 0.69301767584224716057 -0.52230182995830332082 -0.45592172873751407591 -0.052276357843351196897 -1.0754075625981889264 1.3699409892204046368 1.9147140901370571786 0.47718230965328500837 -0.28417322100053044043 -0.55281648673075411971 -1.0864782657786151709 -0.48320171047804466591 0.19690925902679190518 -0.66678391310793427849 -0.04182828555648357427 0.95117447435142010725;0.85210491259166043498 0.04563394830806869612 -0.85624311625965232597 0.022914300870258159232 -0.068886554581795059193 -0.055689387907681651979 0.71719831006820888852 0.46280742834396737528 0.51696973328327877617 0.3583895845786516654 1.0074448362044281513 -0.65438918003829738002 0.70064984613847880457 -0.36646003612448918574 1.2128546273864495575 0.97106329508730004907 -0.76423744070127486161 -0.45522150097753127929 -0.38447113746270872303 -0.77626249941743807881 0.27847369748049738414 0.37615828666183798168 0.080442868155827240706 -0.82624298318101629945 0.013339546406548209029;-0.24366991364512152751 -0.037607905258886804856 -0.77532898482457457412 -0.0017245929542848452073 -0.030440431922342903875 -0.74338904017127915846 -0.1997051586739422846 0.19648942450896048073 0.52704638871565379077 0.27117211565401183604 -0.22192943893272334965 -0.21559154494804211311 0.31775899359185766357 -0.14511791511827598633 0.92163793439064456425 1.5100904266180861235 0.38710234015609462643 -0.31098510647229671289 -0.95496112658889953373 -0.54068864457767429332 -0.40359254968606933511 0.34514206264012958769 0.65198388723389666399 0.7802701442797217446 0.74175888517292443147;-0.62416803288687427997 0.96966614975733844695 -0.47411405650376581278 0.79074788736136003564 0.12532095878480561946 0.42670028141472621241 0.35167833637227474686 1.7197692446815946443 -0.042645212018999227588 -0.23850268352615258682 0.7428570508906826575 -1.1708219220624314083 -0.12546788896954064185 0.038329274419819932274 2.1322459061813416881 1.195877796025652362 0.19747605009986568536 0.43153504712201407045 -0.15790849692876118837 -1.0758096913800019312 -0.1377597803036570423 -0.10235384960517222852 0.19090182115276024821 -0.17902855621556876264 0.32544270408568504171;0.53274754856553374616 0.1691950015100651683 0.057444836721342269759 -0.0080224902358605951203 -0.71242279867990565556 -0.22702640123077152956 -0.71336945368623849717 1.0619684654204548657 0.24145885047332205087 0.25182791090011169555 0.61521815179185668221 -1.27577104717958556 -0.33211752063262733881 0.153531341495299678 1.525905054228661184 0.58472575045907748681 -0.26708041562667211855 -0.37278437875059161621 0.34650357449470581273 -0.63584053009327079486 0.83545899065268436345 -0.51541505796546582818 -0.70977321518781955056 -0.48994237866626993982 -0.62999859348827524919;-0.19033201507147046172 0.25927493159230080577 0.22791583849490321123 -0.16349285979618419229 0.087682438383710301077 0.11614477683946586306 -0.11310477789843639829 0.52980295188073645019 -0.3581528892780512785 0.63954646278681182014 -0.13513324570482604381 -1.0551259440480724727 -0.57146184128481214426 0.61390895457649641287 1.6136514676139142033 0.48098228970984219233 0.3319856631977720629 -0.31885238705623086819 0.79276874105703787343 -0.76335124250987429484 0.34487077920139941334 -0.33325065120783536887 -0.23087383222752855261 -0.13375006240296957727 -0.6032872349055644623;-0.78921494381708479082 0.42780816546888139618 -0.012359871320936263381 0.16706403615917117533 0.43132419731766891147 0.58985785444718508153 -0.50756797411692344824 0.54391544320097040544 0.24808369353432471738 0.37496295469448737148 -0.066804949688903519922 -0.96553313368691762175 -0.87991654027127019777 0.096237451303561247218 1.3452922079319173942 0.70778947015234239259 0.14436700425053569652 0.096607350320287832535 0.38386826137805490911 -0.71840627869157192009 0.63165025938517405102 -0.11475759765403246992 0.041447237767427133615 -0.5879055862734913207 -0.54438721523662814139;-0.00052252198219566612855 0.66947594349889982812 0.48252122759319460155 0.67899627738134704646 0.70018538114506700953 -0.75893694020337654216 0.27371005163290224038 0.4849994859869083963 0.80742489873681733137 0.37628151925118547005 0.019931315281185232879 -1.0390264804764255402 -0.72439001535802438614 0.26326692255376993312 2.0415722979259776082 1.3653560049014523692 0.28538984513380294405 0.60677612527122715136 -0.92924425003989785665 -0.64259578601641309525 0.74278686710541064198 -0.38597286092431215554 -0.10316330104938636891 0.59559745182697443333 0.12824464041933245073;-0.30303885970491040158 0.52064599659804056131 0.14519876306851700609 0.40458018379263210873 -0.23169501817311746739 -0.79443021283648151964 0.26418621471535469469 0.22604150293568786578 -0.29953353339402827293 0.75479721958352952171 -0.30812372649423203086 -0.97490570124143538511 -1.1700243066075328713 0.33039018810461201481 1.6953503602501882597 0.93663309863621757589 0.7581582300308864486 0.21492698653866826319 0.14672584290969653553 0.14508650113626514466 0.20052048011384349113 -0.50496001933363088288 -0.16133066750169244852 -0.51873425308104037512 0.19151301976622431278;-0.32761898407182432624 -0.18982882887744834122 0.43479452078222835532 0.13582756120149219736 -0.12092197816147910727 -0.3750205367891180086 -0.31232243938124887306 0.41914647579227293228 -0.77050909753496654719 1.0628033475938118979 0.73685466554712708565 -1.8338097071572097008 -0.46820863175804855461 0.74250381112381158566 1.9905951692596619562 -0.18180680410664720736 0.079557477099049117575 0.40590475194138914139 0.30006916321812648896 -0.41322742372316173531 -0.19574730455996997014 -1.5095478853268475827 -1.0771772214038199955 -0.41728748318041020138 -0.41550169656245422578;1.1145472148640702681 -0.24691535461179306421 -0.1528506577787263343 -0.55567009623768115478 0.20035938363685854013 -0.051529831133319145553 0.40481412142846562308 0.36412057466544828221 -0.22938941804470347474 1.3210269642931526946 0.8695373349814368158 -1.8448825025492490148 -0.13205534115214462298 -0.37144861276746699019 2.4024403160237746135 1.1754334837239666101 0.87522919572948676414 0.055273400750377975343 -0.21034373364080324875 -0.68649470351718855365 0.56612843240945787127 -1.2094221311253554596 0.44701050655509955156 -0.37285631309952244061 -1.2738641825392338358;0.84204719384459858489 0.71800730212251118179 -0.3603173942942017316 0.090902110510758082906 0.50344658004836451148 0.63170153862178057835 -0.19372867020975947927 1.0592151154921516376 -0.64470464599648724668 0.51223212024046260726 0.13227626220202692853 -1.6280144584455793488 -0.49989184509287104552 0.32888991198529837767 2.1721971369190105072 0.98269650980461031864 -0.65445466301555654809 0.47166089564354185537 -0.286540351207902666 -0.32677717626370034187 -1.0898872742074663389 -1.0698845861449641781 -0.045036558947961324861 0.13398160129187289269 0.72884641431914687359;0.3960853408271345355 -0.72506668411443742084 -0.97206385625430091757 -0.23577688267684382417 -0.050907135417019522272 0.47415786644934015959 -0.3645417828383986647 0.43040095973021091913 0.05466029922747493025 1.0503775450684706971 0.86400948026481261266 -1.5662401968420935905 -0.33836264179658331885 -0.27844802276485608461 1.9798007987923453843 1.1148062296089964462 -0.06548042594600959887 -0.36852383242901998184 0.27118679873817752579 -0.25007447412164596212 -0.51068869036810315976 -1.0329879362436364953 -0.68712586157974664403 -0.18902915750365234526 -0.060343474764618022788;-0.17149788044422309419 0.51013136528390046198 -0.43843819242622655841 -0.18215396521603421931 -0.13402277790182776096 0.013455486759757299617 -0.10072793674465631286 0.81324132402357873772 -0.56388686419783828896 0.88584977398003517113 0.70854278661139002971 -1.6815014510513335289 -1.3006934150499953606 0.39429975922980425862 1.9759888985632771963 0.057097354865431208804 -0.59243614812548661686 0.36130527619984009746 0.36182043081443227006 0.056725343868640809575 0.44711896401523654188 -1.1378089803870155006 -0.31730294587710766718 -1.1795027502419850318 -0.80533074294968354234;-0.12389727116800865192 -0.24510216462707556939 0.2595758304995676724 0.81511173144881099439 0.49268165512474854095 -0.88550286530264088469 -0.27144687511806386837 0.64884093497999939526 -0.94972304641143989734 0.78614207052330820069 0.47649560058000917095 -2.0280396466342982542 -0.68261768535509992351 0.46162262365435408062 0.91448403918365772647 -1.1078575680693221184 -0.12302505798225406297 0.02189828312692609566 0.13386818420506466087 0.19796214599729730632 0.24444978695791877432 -1.8938435216092590618 0.7642729794012214084 -0.32476248204475882675 -0.75066229604417300525;-0.17120901379435382594 0.85669858915799201871 -0.25840017836752193769 -0.34241893210167057005 -0.50001896935889555973 -0.75910651436205023312 -0.25778945183568385824 0.37331972901354659733 -0.49564350778806653963 1.162504765551040542 0.161004775735246769 -2.0345510140150198097 -0.51618525302670537069 -0.23658676665884487145 1.4121342959473681677 0.42956332966238602866 0.19613452786327878474 -0.34088553996566611781 -0.13727877442546637665 0.51543060434548237936 -0.38940736319051838521 -1.5132886586561644648 0.28357380419679140138 -1.1098099547001525345 -0.088592159717692867127;0.50401678534656868536 0.2650238192403904236 -0.72828622410094479012 -0.18069450953877913557 -0.37402590208560243523 -0.68551445868631599723 -0.19312918571016812752 1.1955514133102957963 -0.16612912547182023815 0.16988051456669189809 0.31154372860127810263 -2.0134707719567397355 -1.3846047384552722104 0.17267047801472373836 1.3757642349744334531 -0.33774021545208698925 -0.76224598186864889193 0.25778218276984782298 0.15485347094346724184 0.26279277561049330103 -0.18440899873504676409 -1.7050530063060937991 -0.07072355167132002296 0.10749090505425587527 -0.2695117262063900232;-0.59564165441957572789 0.31801240394549906698 -0.72935673744063977963 0.64624705201767540519 -0.24978492195454618519 0.26522412187431720909 -0.36816075755695981675 0.81473465473958039951 -1.1638721371523796932 1.1512044411009652034 1.1593555077072690285 -2.0467675706740475761 -0.84999838595462651192 -0.59495089882763718681 1.1081818385674166993 -0.89959468322643332261 -0.48863629979610234688 -0.30854471767472357868 0.22655795044488463708 0.23763540829592658121 -0.49647565410874056058 -1.554136620667470714 -0.44095771395630217748 -1.1627074888899986416 0.055930870056717069128;-0.46910687352275165507 0.38507831765912314825 -1.191237382237457787 0.19230038399608143096 -0.41513354463224449997 0.2736969092407034454 -0.10279170762934920769 1.3395209347221854745 0.24058104459164253441 0.22363576849476898833 0.68198327298644378924 -2.2251750895445314704 -1.1675420479976847954 -0.06494947031862258191 1.3083259927233443776 -0.45538831382531103076 -1.0729546058867764913 -0.48932537293828204383 0.53339740343925745591 0.17991749363587841715 -0.46917608973866803401 -1.604579554974103095 -0.48924793892464080169 0.37397335334720199773 -0.90560613248666876895;-0.63923534805824222538 -0.85667978459856797269 -0.40319985532095620195 0.44850811695518771893 0.16222246621812350109 0.44476628301256809772 -0.35226963686532669628 0.8118068528069578571 0.34428335451892411179 -0.19950963268333377076 -0.049805272139638159801 -0.37924613553596792093 -0.39710420525699002825 -0.27494973635147423874 0.39822153308151103657 0.32795611918702627374 0.48593126019089194489 -0.66798041693478660275 -0.33359614536356313463 -0.32072928027047775679 -0.5286277401901631201 0.37469277344751966696 0.1687213768600842323 0.51326662067431094716 -0.24276662881328489596;0.16553194541267229889 0.22947947514886263276 0.015295960613140183529 -0.34248690235251061376 0.019981823431239543326 -0.59130491982640354109 0.2369995513157429623 -0.56111935703928994545 0.80923169448591070196 0.58137450264533807598 0.36104600575793110995 -0.35480196160906241065 -0.0096424846612236780191 -0.70480678133840601873 0.17828513246018296012 0.55768825696014345805 0.038477422527577458122 0.56720760733140984655 -0.41741220178899579585 -0.889299345715520273 -0.10735241007736544272 0.10731182000701497414 -0.37595387622730946919 0.97761083940831572381 -0.57982805787473556958;0.55107131862259595145 -0.80632122310574683155 -0.036905347245713829296 0.44610113804793694037 -0.80591981700148540568 0.34366132532842169622 0.44839857007992228732 0.27774378690752338228 -0.49150941823320914992 0.33930439164023012966 0.68129140727215242723 0.45089308361975599659 -0.57968534674617189228 -0.39525879076404718537 0.50113348099675592007 0.8729628559813191746 -0.23057041123043509057 -0.17043736435588896505 0.48997177537095304434 0.59791716352689550096 -1.0181269093242066859 1.0261139693880592105 -0.43650625637913709198 -0.085120938073834986892 0.61306909662536468453;0.17069829857346743851 -0.97397006455598067465 0.03513241203529188228 0.28007716580379427018 0.77299873733671031761 -0.65921205678253036453 0.0044210973234918007554 -0.27391482261657434938 0.068276401752298265801 1.1743440835963787627 0.11066509523374427892 -0.80013106124233068783 0.63046833754766473668 0.06872415377883710208 0.57161896868316885989 0.43458231358549964662 0.27157726552598560055 0.029179385324127317392 -0.71399260036170009158 -0.79110267785679289076 0.033618561643014847895 -0.097185090785677330505 0.90240282447414110756 -0.45615625245648672159 -0.24140769943646303575;-0.053477092980321203064 0.099344071736721800692 0.70987409028166503777 -0.085817320809958103078 0.49486917562117738179 -0.77866944420503558799 -0.13205330509144580509 0.315058934973509841 0.46470835922407927043 0.0012999375156637865518 0.34475878172520824094 -0.38125595767042963491 0.2116617029036293729 -0.08606469885635453787 1.1552201092378753255 1.3027471919667257261 -0.41656521341786439949 -0.075085740800672234885 -0.48235830425761477835 -0.048332846271753084066 -0.3793231466847037936 -0.21176974081784136206 0.70600355945561354964 -0.55398772017316044725 -0.50376409876065297855;0.33061869411073219194 -0.51957461767155987964 -0.18102644299938105976 -0.77796932312486533068 0.6272361479216504998 0.11009845714489982504 -0.84520111136484876724 0.5791967116111769176 -0.77370078314282275667 0.7428084862037485081 -0.30782042815919319345 -0.8496479682149932211 -0.38176224611992737312 0.79510300588859605941 1.698619545523382568 1.0223924953288370254 0.14305459501460779381 0.56822207408989433564 -0.25935056909553089177 -0.26579821272371956242 0.73248696767883203496 0.25614405509790555415 0.36401670363976951217 0.25022550125358894446 -1.200828157300049881;-0.11861190137925300969 0.92898542618692792061 0.61481668717665594048 -0.085326520903965252796 -0.5488571924761577181 -0.56532535308208842206 -1.1112866455898855467 0.56207926436983624008 -0.66883724615885553622 0.16264676314888498743 -0.0041792930776218470412 -0.84620326390459232879 0.1126659839584950723 -0.48401886817606865065 0.52417939629646348454 0.0098677145719968072102 -0.13806828470764828665 0.19524935316692210163 0.22195685563308706345 -1.1200278240583991796 -0.21670121533480865561 0.52759560931345894641 0.50000104578685500289 0.62821017148715663225 0.25123631845689414765;0.29864116893013481491 0.45912867583950800476 0.44854054095706935579 -0.33404765621879750626 0.50759063884858435234 0.49140696176284076602 -0.24012194495098942992 0.17323514476918919214 0.053242513805307992159 0.42114250331785657577 0.60945564913206340396 -0.14457405316174953835 0.37062119888722777628 1.376606734411959021 0.87825768638782719666 0.15854750407567202997 0.77663915616553991228 0.3436462072290852876 -0.32526392645936214043 -0.33924644511557960902 0.86269006140959936246 0.51396500481071327737 -0.45947786601205486967 -0.15090959652859470275 0.18978347131625250555;-0.41295434446194528855 0.6822642885088554543 0.75738320295653427383 -0.31750265582795123009 0.92834608974205512499 0.41573251430540653084 -0.53073054530326047029 0.21101937338372342423 0.182935821169494639 0.47319913508897726295 0.41787324645927831357 -0.014749328899819908606 0.0054716791143599860167 0.3312647237721606519 0.91656898257719388035 1.13575766766754227 -0.38344539453719639344 -0.80580684883793918249 0.71748642482544666699 0.099630627855920264602 -0.30778542067162528717 0.70616919711361458845 -0.12601395758073072328 0.2655770292968409052 -0.066408488412069699436;0.4889030151240283395 -0.58443184461893182835 -0.58935867795707663763 -0.52002203391567958235 1.0016930585915035934 0.13895236357019050133 0.15581831334579426818 0.068733247901649308087 -0.19369270026120380401 0.76291489242591181696 -0.59846578239584902192 -0.73399631730900460891 -0.50560221149592976531 1.3149807329758635976 1.5754166509038267652 0.45323362419506790788 0.18017816090773572379 0.040846633231543069686 -0.05780719790299484323 -0.5422438923418845258 -0.15030381513160062656 0.12123331709824991531 0.16855350405064817298 -0.7851029064611985131 0.67898705374526380218;-0.22051903874763637003 0.67087278607622702342 -0.04658605268450478204 1.0306299999976396009 1.1375697397303765612 0.12849308000139045283 0.51507398562321971003 0.57827480782195828102 -0.39723389433226830025 0.72149773343870704512 -0.0064326012044393816869 -1.0002951742484071929 -1.382915073481996826 0.52949614821329249459 2.1701523389768988537 0.78587342846421126552 -0.14146737058251232511 0.88104106019587280496 1.2215708955410462533 -1.0676016576665607882 0.1613001541346895662 0.025269665537486139112 0.34397064323489895399 -0.22162458863214107296 -0.031584149978762750266;-0.094406827325202974377 0.16916639092669064071 -0.55660881471535483822 -0.0066065694529794400519 0.78854627773472085739 -0.66830724711634426072 0.84043636750722061635 0.60241127736747002164 -0.89493125567476916604 0.76967753072689981675 0.5807000777364182964 -1.1979999046557194831 -0.056576262156051042307 -0.40018154339931621966 1.6769426726721401444 1.1768863852581015195 0.1471614526982295279 1.3010255644401496067 0.25294966537462171274 -0.9975778186507361367 0.75137342730917755507 0.069438229559367473098 0.10449799590094448198 -0.39750312276045229876 0.096466859005219840473;0.12806900869530385423 0.78626647692240403398 0.37512455522345966585 0.71087329810850363732 -0.0096672196732665478802 0.43227652589197568256 0.21785624810272932739 0.087208699945453715952 0.024822636390443068855 0.21388548255157854849 -1.3563905689769524265 -1.0098803324408274218 -0.39121627161963262731 0.190779008231105357 1.3757188630804468854 0.90484856668972946103 0.49985355778771012325 0.46050928072816449399 -0.27111396724569825079 -1.4733835545022091473 0.10649545669108141654 -0.25634860270284620665 -0.12103068952602599739 0.47863096269464650012 -0.57157588542418191757;0.63936477846116890333 0.38984869153906231976 0.11377928271319505404 -0.0050386185045042516592 -0.25039223163678747675 0.56827740206676002899 -0.37556707405998707161 -0.0053232063807896407362 0.019886636770166735144 1.3913485048400300315 0.55160681156927460211 -1.0743942886313393448 -1.0333990826587229339 0.59106212198640273314 1.7769379943133050137 0.34230499611804976468 0.06183669037814628483 0.63758071825191220405 0.54132125501222239095 -0.97224308371415391061 0.56175784092048963725 0.029093512701307805424 0.25571224587452012766 -0.6408937327074831769 -0.17680426278295247045;-0.45345781580928440357 1.0049269949299228788 -1.1306818134965197498 0.7954082627612051315 0.24319071018522872563 0.41362304197805827011 0.3377440377383648662 0.055995981275572627445 -0.7613103661575281178 1.339798277364232737 -0.52457749045756796313 -1.3141146660511802136 -0.88673215383346670748 0.19414235429844692304 2.1433278588669861797 1.2093444207703503146 -0.56936421506298573458 0.36916044170212342079 0.87328872070394736316 -0.8052925348179170717 0.10834885643366182206 -0.35967224906544742469 0.22607260453521274557 -1.1223277543768550579 0.48454342952953272095;0.88619352319180944022 -0.015268114674855641152 -0.48604531993136707024 -0.18773673759241427117 -0.44561613541351802192 -0.82577479603263959085 0.56457012031957354292 0.54761788992671123211 -0.4824829469345739974 0.95276006308750404994 0.95121741175875951235 -1.8464366299265890792 -0.90896102021437985563 1.1467553048095102675 2.2725377283375092219 0.19386526808588380733 0.0099594772637236171631 1.953700578665002352 0.8770164362546658543 -1.0638213852488398459 -0.11119124567944632664 -0.8603085012694953182 0.0052507567547054895957 -0.3104939420321244925 -0.0093232852514722602821;0.8498333240078933537 0.23326029334368494905 -0.71198933942144937426 0.77583841086648563934 -0.46942507773054548137 -0.39464858368028976621 0.1878808276563351809 1.4018559528688945282 -0.51298454537334381431 0.27855955100894674858 1.0201753799085444552 -1.4842007742057334863 -0.77096095618549909112 1.401504963373446655 2.179508437102347429 0.58214469970175941604 -1.1386868217614758425 1.2502719585313992745 1.381075538055908325 -0.71153385887975983959 0.47273013242154565683 -0.45783799883734627167 -1.3000876120909350409 -0.12514544968009963521 0.15192007678027405482;0.11682928171395982886 0.75507545229625872008 0.24836223749712188491 0.58829301045874282661 1.046503805374195295 -0.27410572460686194463 0.30440091983225348038 0.64799691734219944106 -1.2881834749917400185 0.76731481812260471376 0.20775963632474866993 -1.8120485474547378679 -0.96072673009054265769 0.27292455648467262019 2.024335166180121437 0.12769350690294659079 -0.5832813904184233067 2.04258616004024951 0.62184341133578302507 -1.2994432720677919768 0.37317156343301899346 -0.49782807284282276639 0.50321817362010645702 -0.90851864881131383367 0.69540521021798895607;0.18345422149933993117 -0.48775948180988193403 0.23685728795439883743 0.12800969119806837604 -0.003397917610717283033 -0.03550850364841082879 -0.69981155413625739659 0.99328732154291488055 0.065048201826096982425 0.55446098558230727527 0.35257560995272657633 -1.9026870217269238328 -0.81919433904169303151 0.055828061617885130219 2.609964066960393847 1.1982543838483099563 -0.62381534602477772822 0.7269024134285475558 0.88329279990864917327 -1.4789430749353051908 0.50836838372977466438 -0.69165304863446896988 -1.2016934670050847256 -0.4210371439258019377 0.36270358409106912001;0.3956109811728397152 -0.2390948431974249111 -0.70558613871342257262 -0.16222839253422235983 -0.2248434586872420371 -0.11917908073301840266 -0.040188564160239803602 0.71556716495663486022 -1.1161537073009959453 0.61149597444562631132 -0.090962185486394162015 -1.5927816787173689761 -1.1904832145932635612 0.91649751653017486053 1.3772758711425709954 0.051725116451549334184 0.17881227353249881662 1.2969181938745815152 1.6632824687184031287 -0.49359852143150884096 0.0094631969756064013288 -0.48779314604352269624 -0.16713698920422467853 -0.12065665848631253187 -0.83446508165116639599;0.072748571314635829266 -0.19321730194690153737 0.045497503292043904588 1.0426094352290813383 -0.20346843021332955415 0.10408716344909925422 -0.45369306970292749837 1.1101241541624142783 -0.14391079616008015107 0.25718299378027853486 0.67312751369923340405 -2.1610302734440605121 -0.19411713121308821206 0.56587917149409439066 1.0902753685969222008 -0.095083050453149811632 -1.4832323280190340409 1.0830513429725330266 0.66406987123025829067 -0.81605676059562670677 -0.62972435042030261432 -1.1898264902063766524 -1.0063595525326840541 0.25482233139784560283 -1.174089535246569227;0.094180269004572922387 -0.14144237919598709463 0.17303340349289242361 0.98077737776464524178 -0.038542688484926652948 -0.53590627644984378808 -0.41306225740904900512 1.3012165464907603507 -1.170212904505677054 0.34256135954099015128 0.55730206028314011046 -2.162103203175495203 -0.13228011740000605867 0.33491264842515322542 1.0965238685433944532 -0.26359447938979219117 -0.21015552165848630506 1.1705740821536290142 0.80935462396894108927 -0.9190713545514052063 -0.19131291152115328935 -1.3177454830165211686 -0.2718565193334359642 -0.47898099356116347058 -0.2297951124969644654;0.020342294302870184142 0.60922084031443990426 -0.85704840555194938823 -0.46005065521707272369 -0.046650929926492376576 -0.24109101786131392764 -0.61334815572437784148 0.88550484182308542014 -1.1056288869933812435 0.75820193737716679028 0.16455436777658902225 -2.07723764628473484 -0.7157322006512193413 0.27780929312615143534 1.4468910640263838996 -0.048245086292308232701 -0.47476330548884015936 1.2487877142506240702 0.80830646012787288335 -1.0159880108512231445 0.64654405337089138062 -1.0816894280938926798 0.53270264551147705756 -0.36347707110008131703 -0.97833381270434705002;0.78167601398132680046 0.76160245313944097134 0.14966450301655126465 0.3698304086831539772 -0.82836646388697232624 -0.87221776704975584327 0.72416181202477802881 0.55710714545374806494 -0.38732601804337518647 0.72793091666657827599 -0.46147925480887291849 -2.0752350192833719511 -0.54993564462992949871 0.74942161489073921832 1.6592176433130059188 0.67479746872469392738 -0.10364789634346179004 0.92857541465938953085 1.0641850972233146688 -1.0439989498690338543 -1.0703921640350919642 -1.2596273661797927623 -0.6084204891458927511 0.37658781635032417823 -0.19249672774142587151;0.73688314973509472239 -0.47065521629777068435 -0.54958657494576557134 -0.0046083163580912011106 0.70158951989238294011 0.125891855188051488 -0.21546580276136662047 0.095540727422737323216 0.27805618663097853016 0.93669122608564570065 -0.14003794025658333755 -2.0114823820249907449 -1.405742138862130286 0.67753094998174134833 1.0189247603939335374 -0.044902558586789799444 -0.074516625211482875879 1.0761187960414058118 0.90768875760471579017 -0.46555503066925746358 -1.0594024828726880116 -1.5615394027123010723 0.36223734542370450429 -0.27386497048181546177 0.47120010614653690117;0.22717276748875195325 -0.24373297896547849173 0.90380138955969646641 0.58779505201722326291 0.060755001309252418262 -0.50341181095591946981 -0.60450346675737887114 0.41662726833811558613 -0.12264407354935187577 -0.37876809040629855208 -0.82963393559890663553 -0.28224571929072167498 0.56701434519709847937 -0.075739434781858905321 0.48217161386638279774 1.2780337282310698654 -0.65018901135052309392 0.6584998725953015164 0.62863399172808687165 -1.177675425887951155 -0.0061355961667319625433 0.68799099814989861379 0.46110556333493396552 -0.50094841156201952437 -0.45475279339866264694;-0.39571045527275661158 -0.1005375870016980977 -0.84875228546254599671 0.38983028885197867908 0.5690420109107139357 -0.08644767544607571963 0.46475078328541025163 -0.43693384385668593284 0.028617748046562949821 0.40312957864390958074 -0.24356694912189505442 0.40481204090703226672 0.18628657812773147251 0.0098732953397159713138 0.007160906353512329521 0.49560505620956002426 0.461027650739704975 -0.1461428585305022676 0.19387186181493221149 -0.60702454745651768242 0.23255762425173820418 0.8845883664859396367 -0.095237799130546085813 0.66325735188324075331 -0.075171560825960104246;0.66274915578113524628 -0.12700082445477461901 -0.10080136045955381818 -0.63511059036505601583 -0.27711236421637203131 0.091232779227827451307 0.73646346966348108509 -0.19349835537073850622 0.44585686515008893238 0.50234091574356176668 0.88679161474074064131 -0.086586677874081183215 0.56624770674178359631 -0.22790083320232984443 0.21639485294535279469 0.38114406593124627864 0.21867881825823864972 -0.063014161029626675203 -0.47022860148351397491 0.23338059595531318591 -0.91154581086724062455 0.81010855893249211768 -0.54119548116753868339 -0.46133951615957424774 -0.1701522383072957556;-0.014768462422638312798 0.22739239616038345315 -0.076408983682566350426 0.64960960228918240844 -0.17852376922677315463 -0.47381560260075566982 0.11475568099799242361 0.47995997556661251782 -0.16369418315383685303 -0.58595223847102706483 0.05782431639572897103 -0.28339903165353147463 -0.73308418477745362907 -0.88119287963705617006 0.46383682140732063193 0.4808049198876876984 0.22853880782705265906 0.97307733973125609683 -0.059402196076629242005 -0.50052922361539320395 0.39464289544644437502 -0.79563017098844479591 -0.40965586959975608394 -0.35030426242449264063 0.74254230048254687979;-0.085300908079464304867 0.47360785444878045203 -0.26789469703277513091 1.1693673075832380359 -0.6624729150771239139 0.10160055562299682985 0.21435634207250406358 0.37753097495813581208 -0.18330571930789354984 0.12295689455200493889 0.12008501530714062178 -0.45149065313785663456 -0.017800871584116077784 -0.46768057013119662679 0.032282795504613666371 -0.70973762603129009197 -0.52624364700654469029 -0.13984316249507552921 -0.25305820462365286039 -1.1395481357394474653 0.56404566452024540446 0.38329871162654832739 0.31080947590119389901 -1.1748240721803209219 0.42438504794667419873;0.63867897701640097274 -0.63082069820611397226 0.68233645427978850684 -0.13210498884360261096 -0.80683467549685294884 0.087199334481170120981 -0.4341905659844993437 0.40855860102116581256 1.0656972776882689402 0.28044644882778663186 0.41786784007091026805 -0.55061678078231723887 -0.1902613965170917576 -1.0095303086231464107 0.76672396759410244016 1.4964194758365154669 0.18660382792265081675 -0.45381273860736670578 0.54428264554699179456 -1.0408835645794349833 -0.54775524970294053873 0.69772513974270322645 -0.6166819845761633001 -0.016089735679412131564 0.15276863819300132152;0.56857866417330049646 -0.31133831896135089057 -0.1218057153141750143 0.54746091579410838257 0.11459210266717941018 -0.45974718244612816642 1.0348650377993351412 0.12626695388815944998 -1.2310020242861277051 0.43025108378113746666 -0.52320784362125283273 -0.61856459178608180771 0.46080173331066692777 0.33754557248069405606 0.13254626151086804087 -0.20177577677344699092 0.22386731152834046799 0.9009805425350486674 -0.24752885149881836968 -1.1880775436526800348 0.085398136201133484358 0.17076921506731559952 0.56055402377951502046 0.07794482808677438701 -0.029493646717544081542;0.21185735847234887785 -0.8545244169205880036 0.44367035198917215144 0.29722798210439521638 -0.22978388328255239248 0.44963113116123326618 -0.017637733879626613792 0.79003859534747800097 0.88511775541094184216 -0.029488731392480312804 0.79651654293339990698 -0.51751159493184328841 -0.67802948692186637558 -0.81911195077017218136 0.077944677254697336544 0.085273560413673191172 0.78060650721226021442 -0.47885353833506871801 -0.21955157545336614899 0.14488297972125768753 -0.53474469037930882909 0.96520572761654332972 0.15726604093242835258 -0.4693243766374263215 0.75753588038966401808;0.37039518190002052034 1.0849649400754106665 -0.16373126968736786968 -0.580989408516291439 0.93962813542399503675 -0.88332133484922237265 0.24657372437291860678 -0.1777561865306444 -0.72519665062068017214 0.37018184318684660417 -0.6641524246000412024 -0.54022055184320005861 -0.18877714188424762898 0.93153344603785381839 0.89658741062384028631 0.17891649503911130625 -0.27534491827091683858 0.27333138338514012533 0.6231612102829977573 -0.48304351782773924384 0.81482084462815995707 -0.25841816134646578007 0.32264585133788836746 -0.55416136440674979013 0.33077532697231121217;0.37105284902144852754 -0.4067901001381964976 -1.0763601247309184661 -0.46975832536272033035 -0.50994274480090251433 -0.54665504221152971809 -0.95921628551816195962 0.025131832881001372332 0.42439543907671140044 0.50177304618150209148 0.21758025137437300711 -0.5632938056410462524 -0.56727685059369670206 0.36202406229127570558 0.59459549532531430494 0.17305062327435119518 -0.3709566840396719134 0.48689065509461387782 0.68071122268564232538 -0.78425029220922926054 -0.013343072327279614092 0.65283493919714230547 0.68642753369002806885 -0.78190986854649369153 0.20130054729530919011;-0.15738948181486717148 -0.32817733255650072266 -0.86662257150668275951 0.066766611402916342666 1.1306610490688417947 -0.61293465754065257212 0.1321079394086658032 0.73777121060075478987 -0.78931130849708663888 0.089962710797306333355 0.28908440380528982461 -1.0300995369966154946 -0.80932551811627095883 -0.19424439319126982073 1.2399861787671950797 0.23828599017660706538 -0.86715334055004622549 1.6264244511520502545 1.602434271560759349 -1.8189584910325162781 -0.73439631714259123729 0.10609492770291631403 -0.52291110454309353006 0.52651469969767450419 0.62460655765676798001;-0.14730103460340904231 -0.065526987146103721216 0.27997420662688815574 0.68775395196975896983 0.15705051575084066906 0.0089137987775522540407 0.1397262370409926846 0.24808276257922234898 -0.15658504269717185564 0.2550636734864452082 0.49319505578089301023 -0.9428344320018470226 -0.2770741690762351106 -0.58131287880311099947 0.89557468455428457244 0.56078948811278839237 -0.062102725746256547124 1.7578144601408487446 0.56739587255306678237 -1.6286033522855620781 -0.85618033236484403226 0.32566746809134605734 -0.61947373684469519972 0.56136900226695296556 -0.096767279048781323914;-0.049181051615922490028 -0.54631086830094932605 0.0020571790605217583035 0.57001705744383934782 0.41518306892647477424 -0.72746658111148654324 -0.62415955576382875503 -0.62660653239038399676 -0.066695882574459131042 0.69120443520652719016 -1.0725251591507236615 -0.71235929369042494397 -0.42624288203679472353 -0.61593563551928121047 0.94343875091715967418 1.1271265331008277766 0.7490270799362829246 0.71681900036082968342 0.427616567132704406 -1.4988227159015334866 0.032950723300906745172 0.17026874783197637475 0.65875846639513335745 -0.29332181050060324168 0.49447349724469269461;-0.439699399087756293 0.043608401853037381812 -0.68764687575589156232 0.59431645298907631592 0.97625810294027193237 -0.11220692515852807858 -0.11037115210214575034 -0.0047355187599890501832 0.35286067241973595454 0.48216075001303898562 0.45031929736609627168 -0.74732870780001692257 -0.34366082244948503721 0.020972253005365478623 0.84081925659099177039 1.094442246533684715 0.072431422825651556319 1.2355730480957829442 1.0938840770206303965 -0.99338703705774866748 0.5488311482786247808 0.23796247435505979428 0.48579145137596541071 -0.12681053620847498875 -0.17127637374514001478;0.89571311095423966631 -0.015238417642566655028 -0.5078578719042288192 -0.206833428444414269 -0.13578495021707001622 -0.92178846956398852175 -0.36567374132427055144 0.98131783945813555459 0.21507570717154103623 0.26321750856257414286 1.0450604307633615253 -1.2425254231591074117 -1.3416356722232689602 -0.10590121207215962007 1.5091464909167229269 1.0245588213797507393 -0.6862089298351026212 2.0469671098438566581 1.460080740863438864 -1.088942593739915754 0.35281656181178733256 0.21036123227407993452 -0.35136376573796035405 -0.22875801498716702431 0.39692090016779163486;-0.5760497135471318586 0.82531686636241696764 0.12203888171421041486 0.13956812911584665082 -0.065957722249315509089 -0.83269069573615950297 0.32463205953796325787 0.55271914189000892481 -1.0325184919582899301 0.98846402120281418036 1.016968346724504757 -2.1525527725995630135 -0.055327367083823651706 -0.57293060397355466407 1.8570923633687423937 0.45605964071081256384 -0.10454888577685357565 2.6258095707243889194 1.1906688600307524517 -2.7918185079615307487 0.48184070358847230775 -0.62019888344607931874 -0.89079877470490342883 -0.24509418220082956896 -0.33056895541265179927;-0.38818814848526267403 0.99447609599635200528 -0.92471525608301252674 -0.58233375368286588447 0.27841596423836112439 0.10881474046782328713 -0.054654357329127399578 1.1372828826681451453 -0.37734901726460301497 0.23082585043346254272 0.90160528831295005947 -1.8376661405261287552 0.0078879850078913057998 1.0056270420420019285 1.739112674665049818 0.5319953797698204756 -0.55964404683607804625 2.3889943045453616577 1.7749254625078283443 -2.3546099688868467048 -0.75997080626590474139 -0.45071458019585369792 -0.040000479676105440974 -0.61156141313351375377 0.26377232792891808222;-0.15532547206504992987 -0.51399150575226337789 -0.045549155753474006303 -0.22281199839915510896 0.73942068376188996304 -0.6759909483923463025 -0.46794352675717459933 0.32406265012250301538 0.079602279464766459438 0.43575523206344929372 0.42110617886407714083 -1.2358439661951072797 -1.5191249020724482133 -0.073092707439503745714 1.3170455887044898446 0.48991142855324021355 -0.056214530468892937032 2.1989841218167844872 1.7124699014892665883 -1.5892730470536187148 -0.35950008187870297061 -0.052043126040307398361 -0.91940830920100391488 0.44574858350650775618 0.58872901015009071468;-0.32374862623582645327 0.68891867717628818557 -0.75738043055688830663 -0.49459111769749958265 0.75062803752501494614 0.049527727499018396606 -0.7495346111417724444 0.60835104715062771064 -0.060619601890997770743 0.37432878440941724785 0.051425254218132904205 -1.4130274238677382748 -1.3327996979526857135 1.029349428309089598 1.4042249977125809135 0.34685178827127899348 -1.1083113552785808231 2.0503420910878977779 2.054502401618915286 -1.5752155962464731154 0.51889483540350966884 -0.20761317806869256097 -0.15197002014290764138 -0.73171808280221850573 -0.13454850306251298075;0.27527782171777764875 -0.0054209732494928985005 0.38965392367609452684 0.70949122512335882629 -0.49463670742622734 0.46941434534780046572 -0.77331993924182118594 0.028980343307425361632 -0.56730003908447568239 1.0208151201335311509 -0.36997251694643262798 -1.5203639125069206006 -0.49426254401291080942 0.4393051238083289789 1.4317917514930058598 1.3609120090377073709 -0.78431263877038071008 1.8984963058996278118 1.4214379311502809422 -1.4069878103004624936 -0.96364361982422419572 -0.3697891938647074328 -0.51602534594849713834 0.47659863185244483175 -0.39613826391009487882;-0.31005140229124450446 -0.17052039752179198873 -0.57455441950876806612 0.085480686743576117514 -0.56561689636895251532 -0.22274009937006611359 -0.72201620376814945601 0.58745801905292727163 -0.88489353517703428498 0.9099588366435643616 0.3277015740012286793 -2.4191550669617352121 -0.11795416088083106321 -0.60237662169705341597 1.3638939419341540304 0.56841798058350345713 -0.51398946146363611032 2.0108630749758913403 0.31242869206178996988 -1.6079088248738049316 0.27161239179843182923 -1.4136705979432273583 -0.51204013141268345244 -0.94069859482668760631 -0.79412448586899087033;1.1111231087672497342 0.23813011777872380992 -0.10983468128406548292 -0.091630816256737593339 -0.048158259068885052312 -0.21673953328942513474 0.61513172225183532227 0.79660288414367852461 -0.61359696837518262758 0.64708950187207769922 -0.10753684919071172799 -2.2423497446284086365 -0.12863120440682135337 -0.68091296825865088582 1.6743230468757879237 1.4928012923056905858 0.25785335962997013581 1.7070155759835694553 0.819393372420463173 -1.8179658109330143478 0.34241278491703963649 -1.2015405181819973635 0.25302849120926418358 -0.58219916750789690862 -0.70539597536265352673;0.18940617509271623353 1.1327139417716154401 -0.95848527439996011879 0.35410114480326732034 -0.53386302514764916172 -0.088475864922891528375 0.19754247845680683593 0.16652860687227546976 -0.44354310753006997992 1.35457745743823188 0.32367669907944407459 -2.1647537647440420194 -0.75912844270354906673 -0.53577319984656202045 1.5475111778106400706 0.841761506265435 -0.34160501085897232443 1.7365427617484465728 1.0974151620424186238 -1.5908626005258850178 -0.69557914014840904748 -1.0009327919788006955 0.17989863518739412918 0.23216062264843295715 -0.87675765467832578182;-0.10115064539097248786 0.46623689643199867083 -0.9067013558174499277 -0.18309735416394387619 0.22893192560890321396 -0.71627605939185035044 0.52612626368657944287 0.14989531472325431927 -0.092526429791989994733 0.69523407703189199491 -0.56128979413162927159 -2.0825045608281609333 -0.64178182003489403495 0.24143274339029402453 1.4546343141072421989 1.1608252976273571999 -0.47720478799147530991 2.5743590982764841257 0.73498624241693255588 -1.7310066670625310348 -0.87770038744787048923 -1.1743169404002802292 0.69964588951471562428 0.17856164388953701949 -0.3610315679597222438;0.60691015028116923613 0.68259955726902732387 -0.95693681352124271289 -0.85288753049514165472 -0.39900633202905572139 0.034813896234442351374 -0.17267153092265982717 0.82808736864861087756 -0.27183915666930585919 0.58158309347790571042 0.15388928601195908663 -2.255092396348551631 0.21698862552440803531 -0.25294515971055203662 1.4391006509671029345 1.1676661028123340724 -0.47703531400101556459 1.4844541943390705541 0.71988792163311654537 -1.8687034968236910792 -0.029727675639567071458 -1.1815573915859187704 -0.33991340469985142914 -0.33365973711413993152 -0.24448855086979459639];

% Output 1

y1\_step1.ymin = -1;

y1\_step1.gain = [19.8430846873881;25.1902297852514;28.0480043805873;25.1902297852515;19.8430846873881;15.4014213643285;17.587796255382;18.6052423789696;17.587796255382;15.4014213643285;12.8098359375956;13.6464356908205;14.0020385635065;13.6464356908205;12.8098359375956;11.1327961562979;11.5184475245726;11.6798900325227;11.5184475245726;11.132796156298;10.0263518607708;10.2529634177852;10.3501190645979;10.2529634177852;10.0263518607708;24.3085739439092;31.6367103728318;35.3669321427237;31.6367103728319;24.3085739439092;18.3591936694781;21.2323768325061;22.6071155078732;21.2323768325061;18.3591936694781;14.8716415185648;16.149707330217;16.5888266071274;16.149707330217;14.8716415185648;12.8000788732996;13.2510272096017;13.4449117424356;13.2510272096017;12.8000788732996;11.1531568910438;11.4425738999758;11.5685578032682;11.4425738999758;11.1531568910438;31.212296404562;42.6770051813765;48.1673283901317;42.6770051813765;31.212296404562;22.7659135886037;26.6947290312244;28.6742030350535;26.6947290312245;22.7659135886037;17.7529936793692;19.6008713201346;20.4390542768772;19.6008713201346;17.7529936793692;15.1439854378217;15.7923817259592;16.013075608594;15.7923817259592;15.1439854378217;12.7413370962304;13.0747835633085;13.2265692482126;13.0747835633085;12.7413370962304;41.8095072498824;61.0833904676167;72.2914102259972;61.0833904676167;41.8095072498824;29.8028292256988;35.065387557911;37.9256576261505;35.065387557911;29.8028292256988;21.9708633850535;24.2477557505819;25.3397138511227;24.247755750582;21.9708633850535;17.408378967788;19.688749848541;20.0505004696882;19.688749848541;17.408378967788;12.2289141323904;13.3119094529699;13.7159832833968;13.3119094529699;12.2289141323904;57.701581649538;89.7259104352578;113.152479033886;89.7259104352579;57.701581649538;32.8890905694871;45.3882853446809;51.7448296746395;45.388285344681;32.8890905694871;21.020850604828;24.7439973841522;26.3307882528371;24.7439973841522;21.020850604828;14.5909715722401;16.2399626504335;16.8762408799636;16.2399626504335;14.5909715722402;10.5359824104758;11.4247428707734;11.7571801183955;11.4247428707734;10.5359824104758];

y1\_step1.xoffset = [0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0];

% ===== SIMULATION ========

% Format Input Arguments

isCellX = iscell(X);

if ~isCellX

X = {X};

end

% Dimensions

TS = size(X,2); % timesteps

if ~isempty(X)

Q = size(X{1},1); % samples/series

else

Q = 0;

end

% Allocate Outputs

Y = cell(1,TS);

% Time loop

for ts=1:TS

% Input 1

X{1,ts} = X{1,ts}';

temp = removeconstantrows\_apply(X{1,ts},x1\_step1);

Xp1 = mapminmax\_apply(temp,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*Xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

Y{1,ts} = mapminmax\_reverse(a2,y1\_step1);

Y{1,ts} = Y{1,ts}';

end

% Final Delay States

Xf = cell(1,0);

Af = cell(2,0);

% Format Output Arguments

if ~isCellX

Y = cell2mat(Y);

end

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

% Allocate Outputs

Y = cell(1,TS);

% Time loop

for ts=1:TS

% Input 1

X{1,ts} = X{1,ts}';

temp = removeconstantrows\_apply(X{1,ts},x1\_step1);

Xp1 = mapminmax\_apply(temp,x1\_step2);

% Layer 1

a1 = tansig\_apply(repmat(b1,1,Q) + IW1\_1\*Xp1);

% Layer 2

a2 = repmat(b2,1,Q) + LW2\_1\*a1;

% Output 1

Y{1,ts} = mapminmax\_reverse(a2,y1\_step1);

Y{1,ts} = Y{1,ts}';

end

% Final Delay States

Xf = cell(1,0);

Af = cell(2,0);

% Format Output Arguments

if ~isCellX

Y = cell2mat(Y);

end

end

% ===== MODULE FUNCTIONS ========

% Map Minimum and Maximum Input Processing Function

function y = mapminmax\_apply(x,settings)

y = bsxfun(@minus,x,settings.xoffset);

y = bsxfun(@times,y,settings.gain);

y = bsxfun(@plus,y,settings.ymin);

end

% Remove Constants Input Processing Function

function y = removeconstantrows\_apply(x,settings)

y = x(settings.keep,:);

end

% Sigmoid Symmetric Transfer Function

function a = tansig\_apply(n,~)

a = 2 ./ (1 + exp(-2\*n)) - 1;

end

% Map Minimum and Maximum Output Reverse-Processing Function

function x = mapminmax\_reverse(y,settings)

x = bsxfun(@minus,y,settings.ymin);

x = bsxfun(@rdivide,x,settings.gain);

x = bsxfun(@plus,x,settings.xoffset);

end

Trying to apply Convolution neural network to solve the mapping problem:

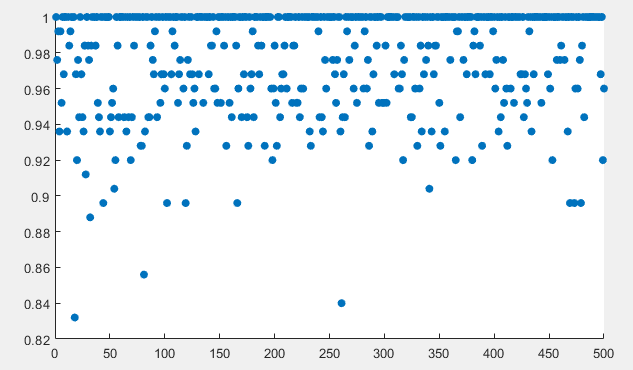
Date: 11/8/17

Alexander Liao

Idea 3 (final)

Abandoned due to the unwanted extra dimensionality that filters introduce

Extra precision achieved by increasing training set size and adjustments of model architecture



layers = [imageInputLayer([28 28 1])

convolution2dLayer(5,20)

reluLayer

maxPooling2dLayer(2,'Stride',2)

fullyConnectedLayer(10)

softmaxLayer

classificationLayer];

Revisions of the binary map method

%Initialization

%clear all

numData=10000;

itpVal=4;

%Final Result

perfmat=[];

performanceMatrix=[];

inputMatrix=[];

coordinateData=[];

parfor num=1:numData

%for num=1:numData

xmin=round(rand()/2,1);

xmax=xmin+0.4;

ymin=round(-rand()/2,1);

ymax=ymin+0.4;

zmin=round(-rand()/2,1);

zmax=zmin+0.4;

rawdata=[];

perfmat=[];

surfPlan=[];

intm=[];

%D=[ 0 0 round(rand(),4) round(rand(),4) 0 0];

%A=[ 0 round(rand(),4) round(rand(),3)/10 0 0 0];

D=[0 0 rand() rand() 0 0];

A=[0 rand() rand()/10 0 0 0];

alpha=[ pi/2 0 -pi/2 pi/2 -pi/2 0];

l1=Link([0 D(1) A(1) alpha(1)]);

l2=Link([0 D(2) A(2) alpha(2)]);

l3=Link([0 D(3) A(3) alpha(3)]);

l4=Link([0 D(4) A(4) alpha(4)]);

l5=Link([0 D(5) A(5) alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

linkL=[l1 l2 l3 l4 l5 l6];

M=SerialLink([l1,l2,l3,l4,l5,l6]);

for z=zmin:(zmax-zmin)/itpVal:zmax

%if z==spc\_z2

% disp('\*');

%else

%Invoking the surface function for at the height "z"

%logic=0;

%while logic==0

% [surfPlan,SizeZ] = surfaceRobotTest(linkL,M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

%logic=1;

surfPlan=[];

for i=xmin:(xmax-xmin)/itpVal:xmax

for j=ymin:(ymax-ymin)/itpVal:ymax

try

intm=M.ikine6s(transl(i,j,z));

catch

bool=0;

end

if all(intm.\*1==intm)

bool=1;

if bool==[]

bool=0;

end

else

bool=0;

end

if bool==[]

bool=0;

end

%coordinateData= horzcat(coordinateData,[i;j;z]);

surfPlan=horzcat(surfPlan,bool);

%size(surfPlan)

end

end

%end

[SizeX,~]=size(surfPlan);

%{

for i = 1:SizeX

if ~all(surfPlan(i,:).\*1==surfPlan(i,:))

reachL=0;

else

reachL=1;

end

end

%}

%columnImage=surfPlan;

perfmat=horzcat(perfmat,surfPlan);

%end

end

try

performanceMatrix=vertcat(performanceMatrix,perfmat);

inputVector=vertcat(D(3:4)',A(2:3)',xmin,xmax,ymin,ymax,zmin,zmax);

inputMatrix=vertcat(inputMatrix,inputVector');

catch

end

end

d=[];

a=neural4(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=S2(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}

alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

linkL=[l1 l2 l3 l4 l5 l6];

M=SerialLink([l1,l2,l3,l4,l5,l6]);

for z=zmin:(zmax-zmin)/itpVal:zmax

%if z==spc\_z2

% disp('\*');

%else

%Invoking the surface function for at the height "z"

%logic=0;

%while logic==0

% [surfPlan,SizeZ] = surfaceRobotTest(linkL,M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

%logic=1;

surfPlan=[];

for i=xmin:(xmax-xmin)/itpVal:xmax

for j=ymin:(ymax-ymin)/itpVal:ymax

try

intm=M.ikine6s(transl(i,j,z));

catch

bool=0;

end

if all(intm.\*1==intm)

bool=1;

if bool==[]

bool=0;

end

else

bool=0;

end

if bool==[]

bool=0;

end

%coordinateData= horzcat(coordinateData,[i;j;z]);

surfPlan=horzcat(surfPlan,bool);

%size(surfPlan)

end

end

%end

[SizeX,~]=size(surfPlan);

%{

for i = 1:SizeX

if ~all(surfPlan(i,:).\*1==surfPlan(i,:))

reachL=0;

else

reachL=1;

end

end

%}

%columnImage=surfPlan;

perfmat=horzcat(perfmat,surfPlan);

%end

end

try

performanceMatrix=vertcat(performanceMatrix,perfmat);

inputVector=vertcat(D(3:4)',A(2:3)',xmin,xmax,ymin,ymax,zmin,zmax);

inputMatrix=vertcat(inputMatrix,inputVector');

catch

end

end

d=[];

a=neural4(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=S2(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}

Date: 11/9/17

Alexander Liao

Idea 3 (final)

bool=0;

end

if bool==[]

bool=0;

end

%coordinateData= horzcat(coordinateData,[i;j;z]);

surfPlan=horzcat(surfPlan,bool);

%size(surfPlan)

end

end

%end

[SizeX,~]=size(surfPlan);

%{

for i = 1:SizeX

if ~all(surfPlan(i,:).\*1==surfPlan(i,:))

reachL=0;

else

reachL=1;

end

end

%}

%columnImage=surfPlan;

perfmat=horzcat(perfmat,surfPlan);

%end

end

try

performanceMatrix=vertcat(performanceMatrix,perfmat);

inputVector=vertcat(D(3:4)',A(2:3)',xmin,xmax,ymin,ymax,zmin,zmax);

inputMatrix=vertcat(inputMatrix,inputVector');

catch

end

end

d=[];

a=neural4(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=S2(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}

alpha(5)]);

l6=Link([0 D(6) A(6) alpha(6)]);

linkL=[l1 l2 l3 l4 l5 l6];

M=SerialLink([l1,l2,l3,l4,l5,l6]);

for z=zmin:(zmax-zmin)/itpVal:zmax

%if z==spc\_z2

% disp('\*');

%else

%Invoking the surface function for at the height "z"

%logic=0;

%while logic==0

% [surfPlan,SizeZ] = surfaceRobotTest(linkL,M,vxl\_interpVal,vxl\_num,spc\_x1,spc\_x2,spc\_y1,spc\_y2,z);

%logic=1;

surfPlan=[];

for i=xmin:(xmax-xmin)/itpVal:xmax

for j=ymin:(ymax-ymin)/itpVal:ymax

try

intm=M.ikine6s(transl(i,j,z));

catch

bool=0;

end

if all(intm.\*1==intm)

bool=1;

if bool==[]

bool=0;

end

else

bool=0;

end

if bool==[]

bool=0;

end

%coordinateData= horzcat(coordinateData,[i;j;z]);

surfPlan=horzcat(surfPlan,bool);

%size(surfPlan)

end

end

%end

[SizeX,~]=size(surfPlan);

%{

for i = 1:SizeX

if ~all(surfPlan(i,:).\*1==surfPlan(i,:))

reachL=0;

else

reachL=1;

end

end

%}

%columnImage=surfPlan;

perfmat=horzcat(perfmat,surfPlan);

%end

end

try

performanceMatrix=vertcat(performanceMatrix,perfmat);

inputVector=vertcat(D(3:4)',A(2:3)',xmin,xmax,ymin,ymax,zmin,zmax);

inputMatrix=vertcat(inputMatrix,inputVector');

catch

end

end

d=[];

a=neural4(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=S2(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}

catch

end

end

d=[];

a=neural4(inputMatrix');

b=round(a');

for i=1:numData

c=sum(b(i,:)==performanceMatrix(i,:))/125;

d=[d,c];

end

%{

for i =1:numData

a=S2(inputMatrix(i,:));

b=round(a);

c=sum(b==performanceMatrix(i,:))/125;

d=[d,c];

end

%}