Test9

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General Introduction

This test is designed to achieve contrast invariant response in spatially structured networks with synaptic plasticity.

This is based on the results shown in the Bernaez-Timon et al., manuscript (in preparation)

The features tested are : Distance Connectivity, SpatialGaussianStimulus, PowerLawSynapse and Heatmap recording.

Warning: The simulations can take hours to run.

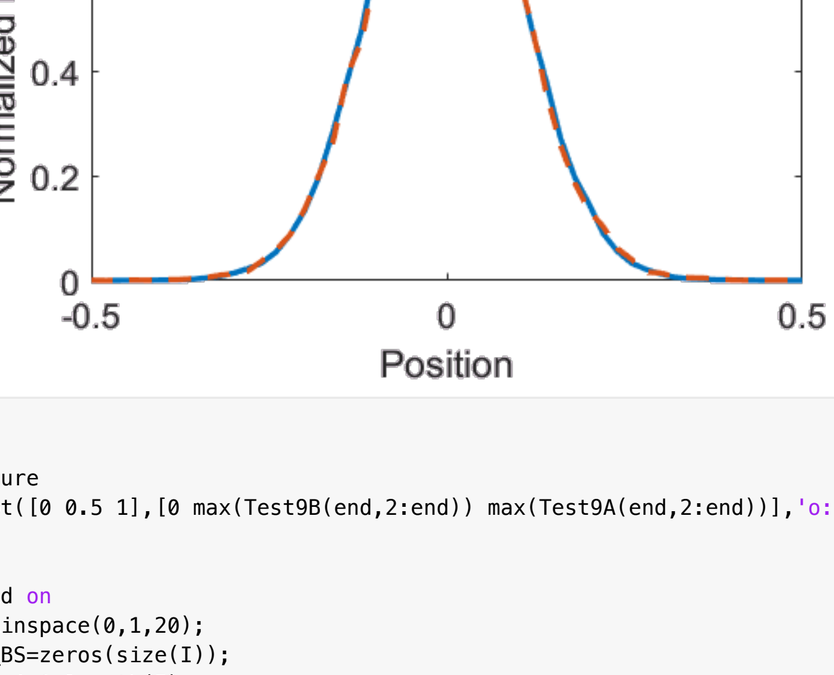
This Live Script runs with Matlab

Figures

```
%% Import Data
base_path    = 'C:/Users/ekelmansp/Documents';
project_name1  = 'Test9A';%For the simulation at high input level. project_name is an identifier of the folder(s) containing the simulation data. The date suffix does not need to be included
project_name2  = 'Test9B';%For the simulation at low input level. Idem

%% Import data Simulation1
folderlist=dir([base_path filesep project_name1 '_20*']);
folder_name=folderlist(end).name;
cd([base_path filesep folder_name])
filename = [project_name1 '_HeatmapRate_Pop0.dat'];

delimiter = '\t';
startRow = 14;
formatEl='%f';
formatSpec=formatEl;%the first column is time;
for i=1:51
formatSpec=[formatSpec formatEl];%Each of the 500 recoreded neurons has 3 sources of inputs: recurrent E and I and feedforward
end
formatSpec=[formatSpec '%[^\n\r]'];

fileID = fopen(filename,'r');
dataArray = textscan(fileID, formatSpec, 'Delimiter', delimiter, 'EmptyValue' ,NaN,'HeaderLines' ,startRow-1, 'ReturnOnError', false, 'EndOfLine', '\r\n');
fclose(fileID);
Test9A = [dataArray{1:end-1}];

%% Import data Simulation2

folderlist=dir([base_path filesep project_name2 '_20*']);
folder_name=folderlist(end).name;
cd([base_path filesep folder_name])
filename = [project_name2 '_HeatmapRate_Pop0.dat'];

fileID = fopen(filename,'r');
dataArray = textscan(fileID, formatSpec, 'Delimiter', delimiter, 'EmptyValue' ,NaN,'HeaderLines' ,startRow-1, 'ReturnOnError', false, 'EndOfLine', '\r\n');
fclose(fileID);
Test9B = [dataArray{1:end-1}];
clearvars filename delimiter startRow formatSpec fileID dataArray ans folder_name formatEl i;
```

```
%% Analysis
figure
plot(linspace(-0.5,0.5,51),Test9A(end,2:end)./max(Test9A(end,2:end)),'LineWidth',2.5)
hold on
plot(linspace(-0.5,0.5,51),Test9B(end,2:end)./max(Test9B(end,2:end)),'--','LineWidth',2.5)
title('Check Contrast Invariance')
legend('Simulation1','Simulation2')
xlabel('Position')
ylabel('Normalized Firing rate')
set(gca,'FontSize',16)
```


```
figure
plot([0 0.5 1],[0 max(Test9B(end,2:end)) max(Test9A(end,2:end))],'o:','LineWidth',2.5)


hold on
I=linspace(0,1,20);
nu_BS=zeros(size(I));
for i=1:length(I)
    nu_BS(i)=max(SpaceBalanced([2 -10 5 -12],0.16,0.1,0.05,0.8,I(i),-0.5));
end
plot(I,nu_BS,'k','LineWidth',2.5)

title('Check nonlinearity')
xlabel('Input strength')
ylabel('Peak firing rate')
legend('Simulation','Balanced State Theory')
axis tight
set(gca,'FontSize',16)
```




```
function [nu,X,nu_I]=SpaceBalanced(J,Sstim,SconE,pexE,fracE,mu,k)
Xlim=4*sqrt(Sstim^2-SconE^2);
X=[-1:0.02:1]*Xlim;
X=linspace(-Xlim,Xlim,1e4+1);
J=abs(J);
b=(J(2)-J(4))/(J(1)*J(4)-J(2)*J(3));
c=(J(1)-J(3))/(J(1)*J(4)-J(2)*J(3));

nu=mu*b*Sstim/(pexE*fracE*sqrt(Sstim^2-SconE^2)).*exp(-X.^2/(2*Sstim^2-2*SconE^2));
nu=nu.^(inv(1+k));

SconI=SconE;
pexI=pexE;
nu_I=mu*c*Sstim/(pexI*(1-fracE)*sqrt(Sstim^2-SconI^2)).*exp(-X.^2/(2*Sstim^2-2*SconI^2));

end
```

The first figure illustrates contrast invariance: the firing rate profiles have different amplitudes depending on the input srtength, but the normalized profiles are identical.

The second figure shows how the peak firing rate (at x=0) changes as a function of the input strength. Due to the power law synaptic plasticity rule, the network response is nonlinear as a function of the input strength. As a comparison, the theoretical solution from the balanced state theory follows the same trend.