Neural Network on fMRI 4 Regions

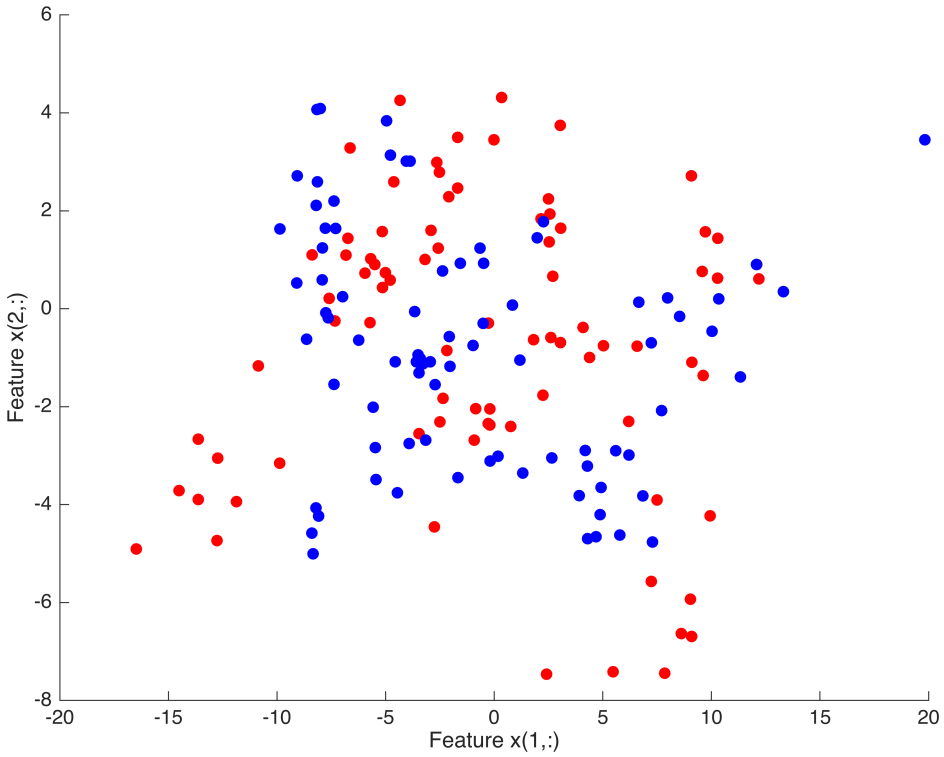
Lily Jiang (worked with Avery Clowes and Elias Wheatfall)

September 28, 2023

Task: Create your own neural network to analyze the data train4regions data. Pay attention to the dimensions and orientation of the data. You'll need `t` (the answers) to be numbers instead of categories (see the trainIsFace variable, which is a logical indicator of whether or not the trial is a face (1) or house (0)).

Configure variables and network

```
load('fMRI4regionsNN.mat');

t = trainIsFace;
x = train4regions;

% Plot data to get an overview
figure;
hold on;
plot(x(1,t==0),x(2,t==0),'r.','MarkerSize',20);
plot(x(1,t==1),x(2,t==1),'b.','MarkerSize',20);
xlabel('Feature x(1,:)');
ylabel('Feature x(2,:)');
hold off;
```




```
trainFcn = 'trainbr';  % trainlm and trainscg
hiddenLayerSize = [3];

net = patternnet(hiddenLayerSize,trainFcn);
net = configure(net,x,t);

% Divide data (note: only need valRatio for trainscg)
net.divideParam.trainRatio = 0.6;
net.divideParam.testRatio = 0.4;
```

Train the network using the train data

```
[net,tr] = train(net,x,t);
```

```
Warning: Performance function replaced with squared error performance.
Warning: Error occurred while executing the listener callback for event TrainingUpdated defined for
class nnet.guis.NNTrainToolModel:
Operands to the logical AND (&&) and OR (||) operators must be convertible to logical scalar
values. Use the ANY or ALL functions to reduce operands to logical scalar values.

)
                if (~isempty(fig) && ishandle(fig))

Error in nnet.guis.TrainToolDialogFactory/displayPlotIfOpen (line 30)
            this.PlotDisplayer.displayPlotIfOpen(plotData);

Error in nnet.guis.StandaloneTrainToolView/updateTraining (line 378)
            this.DialogFactory.displayPlotIfOpen(this.PlotData);
```

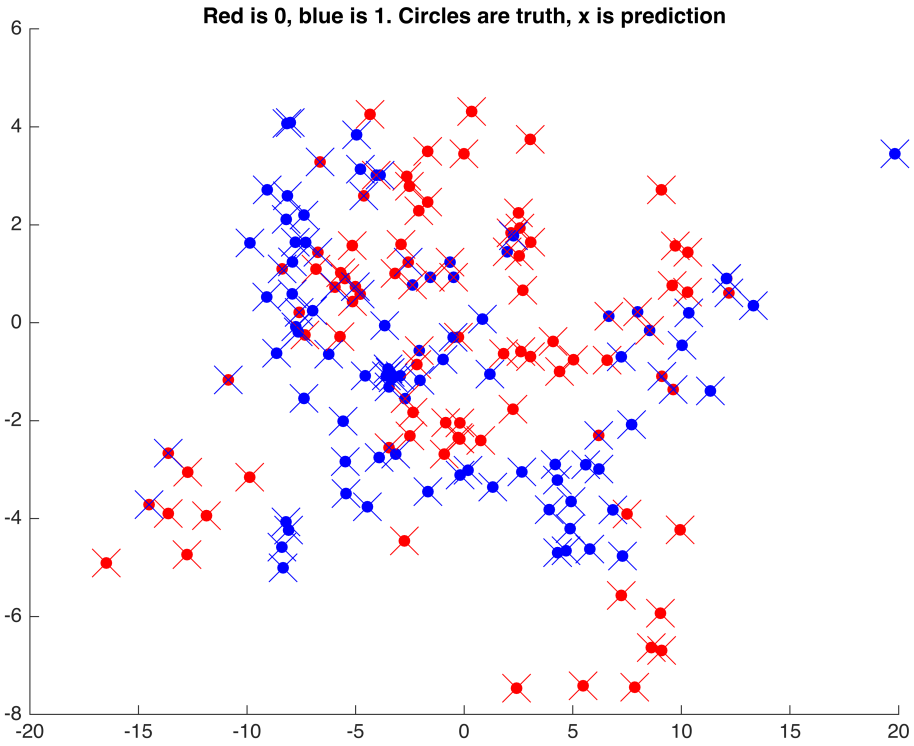
```
Error in nnet.guis.StandaloneTrainToolPresenter/updateTrainTool (line 93)
            this.StandaloneTrainToolView.updateTraining(this.TrainToolModel.Epoch,...

Error in nnet.guis.StandaloneTrainToolPresenter>@(varargin)this.updateTrainTool(varargin{:}) (line
57)
            this.TrainToolModelListeners{end+1} = addlistener(this.TrainToolModel,
"TrainingUpdated", @this.updateTrainTool);

Error in nnet.guis.NNTrainToolModel/updateValues (line 138)
            this.notify("TrainingUpdated");

Error in nnet.train.TrainToolFeedback/updateOutsideSPMDImpl (line 100)
                this.TrainToolModel.updateValues(statusValues, net, tr, data);

Error in nnet.train.FeedbackHandler/updateOutsideSPMD (line 40)
        this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.MultiFeedback/updateOutsideSPMDImpl (line 47)

this.Handlers{i}.updateOutsideSPMD(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.FeedbackHandler/update (line 25)
      this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.trainNetwork>trainNetworkInMainThread (line 60)
        feedback.update(archNet,tr, ...

Error in nnet.train.trainNetwork (line 27)
    [archNet,tr] = trainNetworkInMainThread(archNet,rawData,calcLib,calcNet,tr,feedback,localFcns);

Error in trainbr>train_network (line 174)
[archNet,tr] = nnet.train.trainNetwork(archNet,rawData,calcLib,calcNet,tr,localfunctions);

Error in trainbr (line 67)
            [out1,out2] = train_network(varargin{2:end});

Error in network/train (line 380)
    [net,tr] = feval(trainFcn,'apply',net,data,calcLib,calcNet,tr);

Error in LiveEditorEvaluationHelperE828947011 (line 24)
[net,tr] = train(net,x,t);
Warning: Error occurred while executing the listener callback for event TrainingUpdated defined for
class nnet.guis.NNTrainToolModel:
Operands to the logical AND (&&) and OR (||) operators must be convertible to logical scalar
values. Use the ANY or ALL functions to reduce operands to logical scalar values.

)
                if (~isempty(fig) && ishandle(fig))

Error in nnet.guis.TrainToolDialogFactory/displayPlotIfOpen (line 30)
            this.PlotDisplayer.displayPlotIfOpen(plotData);

Error in nnet.guis.StandaloneTrainToolView/updateTraining (line 378)
            this.DialogFactory.displayPlotIfOpen(this.PlotData);

Error in nnet.guis.StandaloneTrainToolPresenter/updateTrainTool (line 93)
            this.StandaloneTrainToolView.updateTraining(this.TrainToolModel.Epoch,...

Error in nnet.guis.StandaloneTrainToolPresenter>@(varargin)this.updateTrainTool(varargin{:}) (line
57)
            this.TrainToolModelListeners{end+1} = addlistener(this.TrainToolModel,
"TrainingUpdated", @this.updateTrainTool);
```

```
Error in nnet.guis.NNTrainToolModel/updateValues (line 138)
            this.notify("TrainingUpdated");

Error in nnet.train.TrainToolFeedback/updateOutsideSPMDImpl (line 100)
                this.TrainToolModel.updateValues(statusValues, net, tr, data);

Error in nnet.train.FeedbackHandler/updateOutsideSPMD (line 40)
        this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.MultiFeedback/updateOutsideSPMDImpl (line 47)

this.Handlers{i}.updateOutsideSPMD(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.FeedbackHandler/update (line 25)
      this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.trainNetwork>trainNetworkInMainThread (line 60)
        feedback.update(archNet,tr, ...

Error in nnet.train.trainNetwork (line 27)
    [archNet,tr] = trainNetworkInMainThread(archNet,rawData,calcLib,calcNet,tr,feedback,localFcns);

Error in trainbr>train_network (line 174)
[archNet,tr] = nnet.train.trainNetwork(archNet,rawData,calcLib,calcNet,tr,localfunctions);

Error in trainbr (line 67)
            [out1,out2] = train_network(varargin{2:end});

Error in network/train (line 380)
    [net,tr] = feval(trainFcn,'apply',net,data,calcLib,calcNet,tr);

Error in LiveEditorEvaluationHelperE828947011 (line 24)
[net,tr] = train(net,x,t);
```

Explore the network and the graphs that appear (training plots)

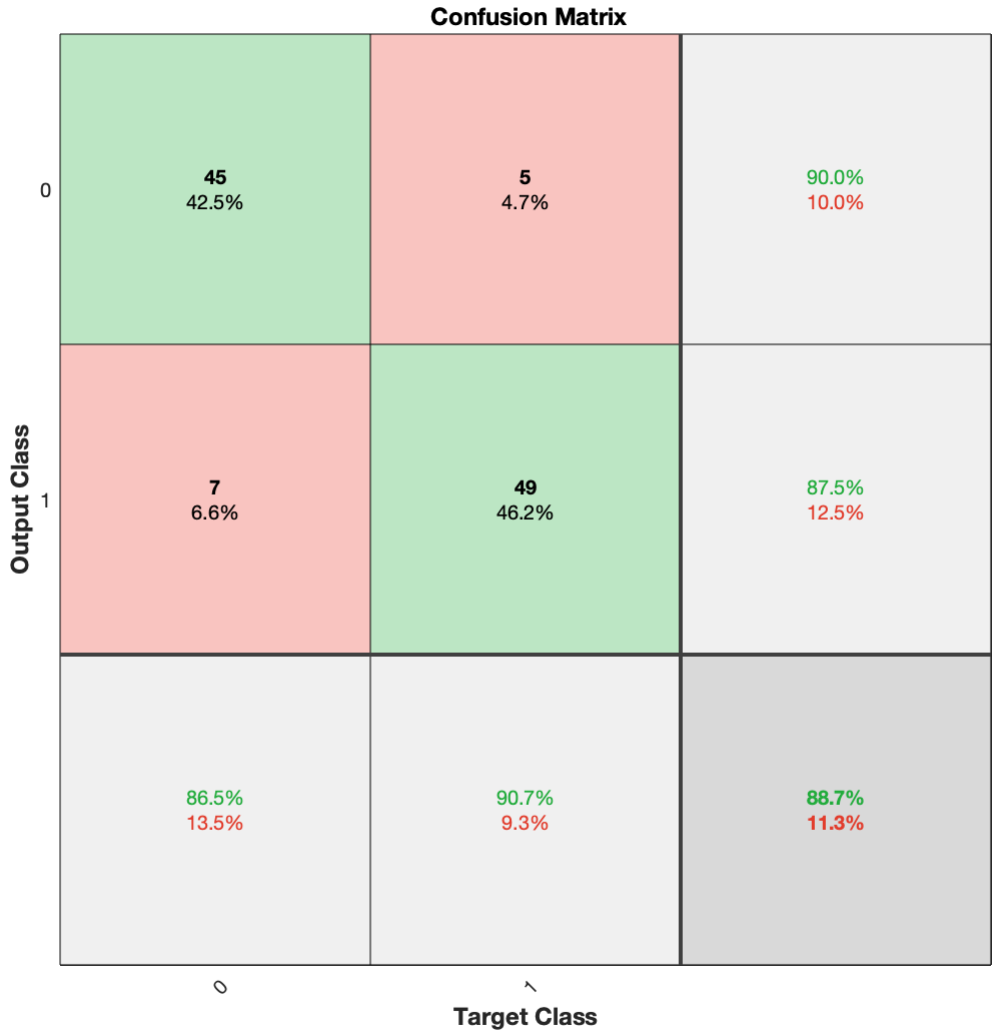
```
train_x = x;
output_y = net(train_x);
output_binary = double(output_y >= .5);

figure;
hold on;
plot(train_x(1,t==0),train_x(2,t==0),'r.','MarkerSize',20);
plot(train_x(1,t==1),train_x(2,t==1),'b.','MarkerSize',20);
```

```
plot(train_x(1,output_binary==0),train_x(2,output_binary==0),'rx','MarkerSiz
e',20);
plot(train_x(1,output_binary==1),train_x(2,output_binary==1),'bx','MarkerSiz
e',20);
hold off;
title('Red is 0, blue is 1. Circles are truth, x is prediction');
```



Calculate the accuracy and confusion matrix for the train data

```
plotconfusion(t(tr.trainInd), output_binary(tr.trainInd));
```



Accuracy: 84.9%

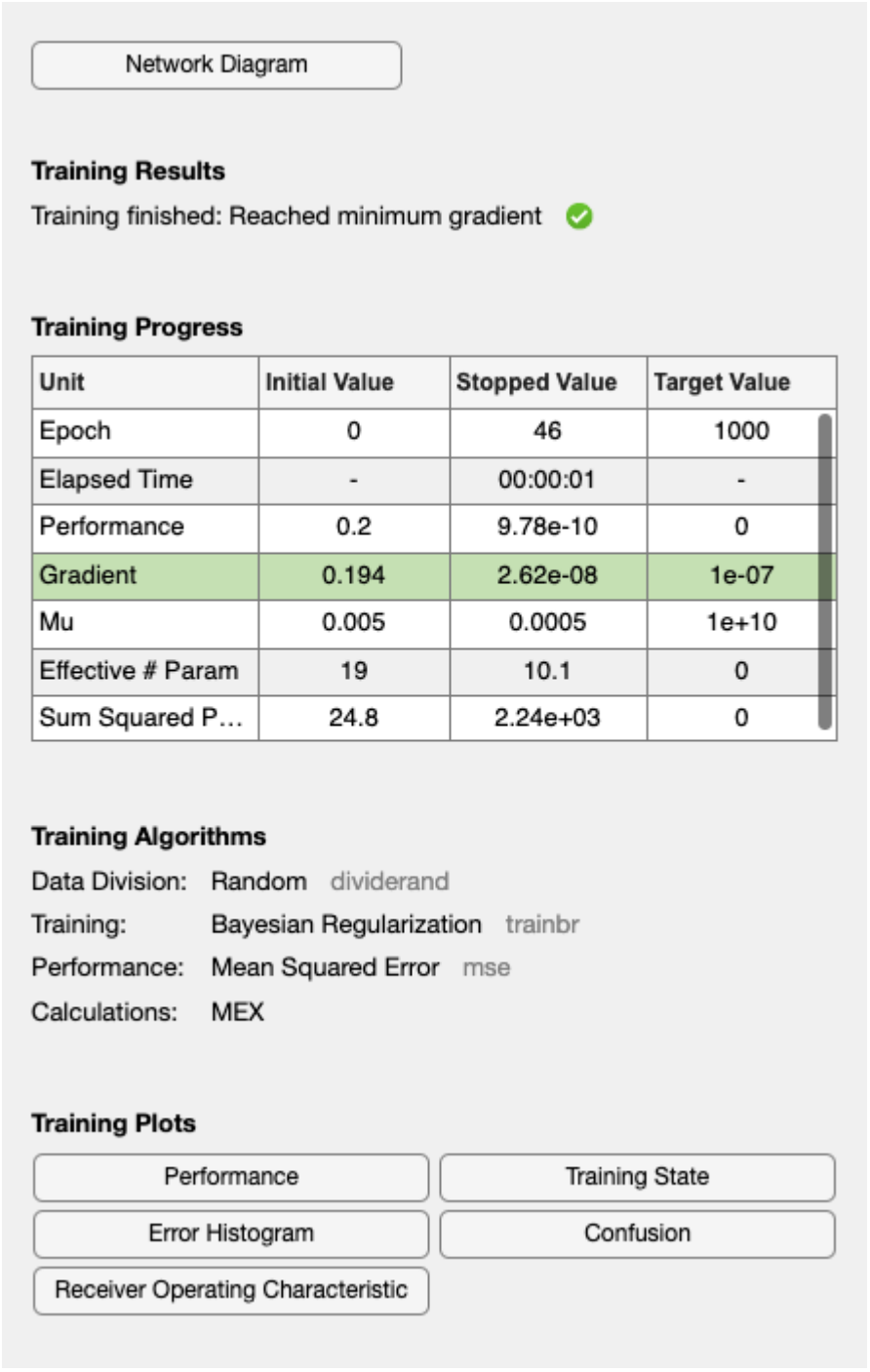
Test the network using the test data and calculate the accuracy and confusion matrix

```
t_test = testIsFace;
x_test = test4regions;

net_test = patternnet(hiddenLayerSize,trainFcn);
net_test = configure(net_test,x_test,t_test);

[net_test,tr_test] = train(net_test,x_test,t_test);
```

```
Warning: Performance function replaced with squared error performance.
Warning: Error occurred while executing the listener callback for event TrainingUpdated defined for
class nnet.guis.NNTrainToolModel:
```

```
Operands to the logical AND (&&) and OR (||) operators must be convertible to logical scalar
values. Use the ANY or ALL functions to reduce operands to logical scalar values.

)
                if (~isempty(fig) && ishandle(fig))

Error in nnet.guis.TrainToolDialogFactory/displayPlotIfOpen (line 30)
            this.PlotDisplayer.displayPlotIfOpen(plotData);

Error in nnet.guis.StandaloneTrainToolView/updateTraining (line 378)
            this.DialogFactory.displayPlotIfOpen(this.PlotData);

Error in nnet.guis.StandaloneTrainToolPresenter/updateTrainTool (line 93)
            this.StandaloneTrainToolView.updateTraining(this.TrainToolModel.Epoch,...

Error in nnet.guis.StandaloneTrainToolPresenter>@(varargin)this.updateTrainTool(varargin{:}) (line
57)
            this.TrainToolModelListeners{end+1} = addlistener(this.TrainToolModel,
"TrainingUpdated", @this.updateTrainTool);

Error in nnet.guis.NNTrainToolModel/updateValues (line 138)
            this.notify("TrainingUpdated");

Error in nnet.train.TrainToolFeedback/updateOutsideSPMDImpl (line 100)
                this.TrainToolModel.updateValues(statusValues, net, tr, data);

Error in nnet.train.FeedbackHandler/updateOutsideSPMD (line 40)
        this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.MultiFeedback/updateOutsideSPMDImpl (line 47)

this.Handlers{i}.updateOutsideSPMD(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.FeedbackHandler/update (line 25)
      this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.trainNetwork>trainNetworkInMainThread (line 60)
        feedback.update(archNet,tr, ...

Error in nnet.train.trainNetwork (line 27)
    [archNet,tr] = trainNetworkInMainThread(archNet,rawData,calcLib,calcNet,tr,feedback,localFcns);

Error in trainbr>train_network (line 174)
[archNet,tr] = nnet.train.trainNetwork(archNet,rawData,calcLib,calcNet,tr,localfunctions);

Error in trainbr (line 67)
            [out1,out2] = train_network(varargin{2:end});

Error in network/train (line 380)
    [net,tr] = feval(trainFcn,'apply',net,data,calcLib,calcNet,tr);

Error in LiveEditorEvaluationHelperE828947011 (line 44)
[net_test,tr_test] = train(net_test,x_test,t_test);
Warning: Error occurred while executing the listener callback for event TrainingUpdated defined for
class nnet.guis.NNTrainToolModel:
Operands to the logical AND (&&) and OR (||) operators must be convertible to logical scalar
values. Use the ANY or ALL functions to reduce operands to logical scalar values.

)
                if (~isempty(fig) && ishandle(fig))

Error in nnet.guis.TrainToolDialogFactory/displayPlotIfOpen (line 30)
            this.PlotDisplayer.displayPlotIfOpen(plotData);
```

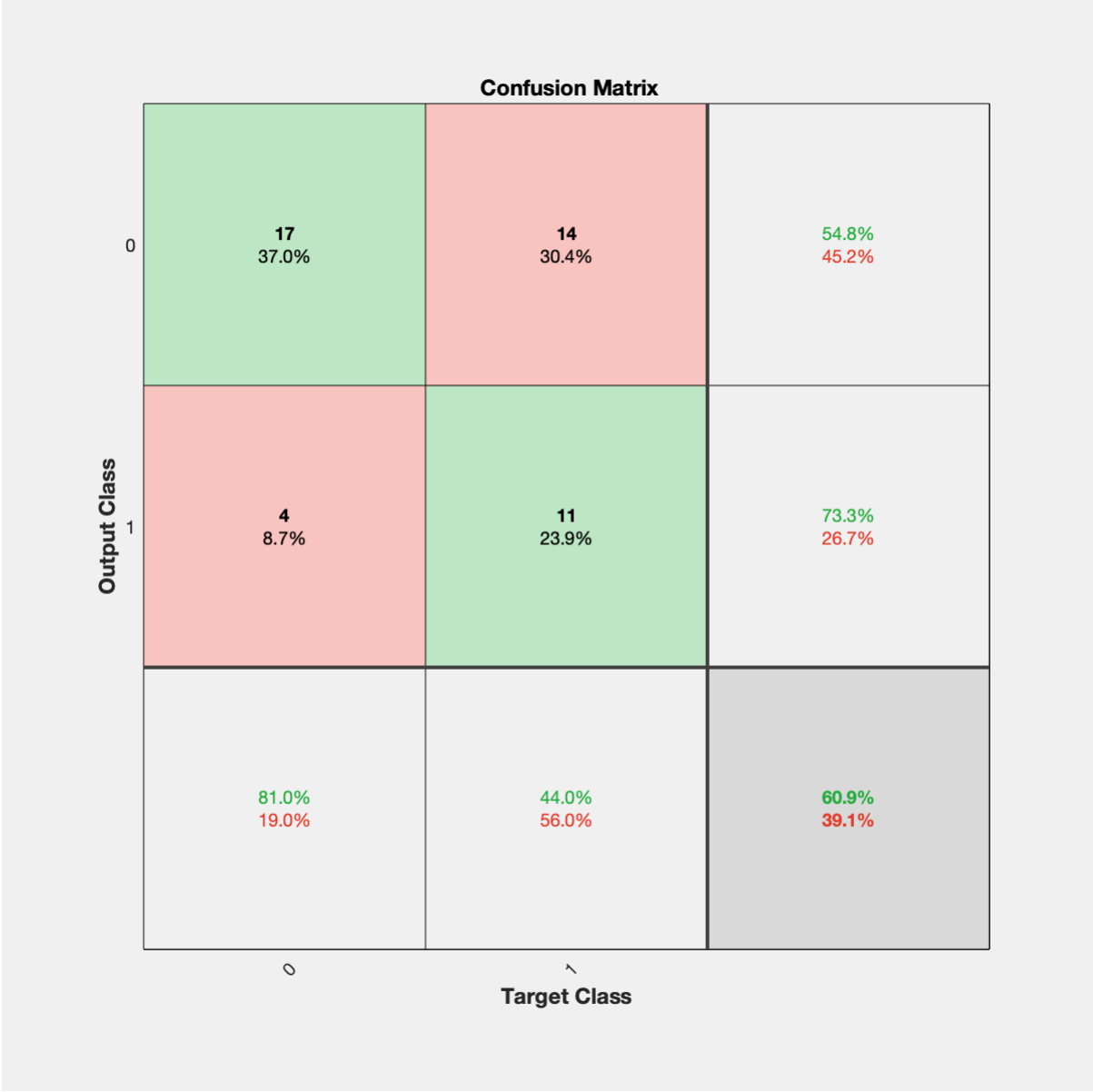
```
Error in nnet.guis.StandaloneTrainToolView/updateTraining (line 378)
            this.DialogFactory.displayPlotIfOpen(this.PlotData);

Error in nnet.guis.StandaloneTrainToolPresenter/updateTrainTool (line 93)
            this.StandaloneTrainToolView.updateTraining(this.TrainToolModel.Epoch,...

Error in nnet.guis.StandaloneTrainToolPresenter>@(varargin)this.updateTrainTool(varargin{:}) (line
57)
            this.TrainToolModelListeners{end+1} = addlistener(this.TrainToolModel,
"TrainingUpdated", @this.updateTrainTool);

Error in nnet.guis.NNTrainToolModel/updateValues (line 138)
            this.notify("TrainingUpdated");

Error in nnet.train.TrainToolFeedback/updateOutsideSPMDImpl (line 100)
                this.TrainToolModel.updateValues(statusValues, net, tr, data);

Error in nnet.train.FeedbackHandler/updateOutsideSPMD (line 40)
        this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.MultiFeedback/updateOutsideSPMDImpl (line 47)

this.Handlers{i}.updateOutsideSPMD(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.FeedbackHandler/update (line 25)
      this.updateOutsideSPMDImpl(net,tr,options,data,calcLib,calcNet,bestNet,status,statusValues);

Error in nnet.train.trainNetwork>trainNetworkInMainThread (line 60)
        feedback.update(archNet,tr, ...

Error in nnet.train.trainNetwork (line 27)
    [archNet,tr] = trainNetworkInMainThread(archNet,rawData,calcLib,calcNet,tr,feedback,localFcns);

Error in trainbr>train_network (line 174)
[archNet,tr] = nnet.train.trainNetwork(archNet,rawData,calcLib,calcNet,tr,localfunctions);

Error in trainbr (line 67)
            [out1,out2] = train_network(varargin{2:end});

Error in network/train (line 380)
    [net,tr] = feval(trainFcn,'apply',net,data,calcLib,calcNet,tr);

Error in LiveEditorEvaluationHelperE828947011 (line 44)
[net_test,tr_test] = train(net_test,x_test,t_test);
```




```
output_y_test = net(x_test);
output_binary_test = double(output_y_test >= .5);
```

Get the confusion matrix:

```
plotconfusion(t_test(tr_test.trainInd),
output_binary_test(tr_test.trainInd));
```



Accuracy: 60.9%