Additional Material (Lab3-1)

Create your network

Time Delay Neural Network

IDNN in the lectures

```
net = timedelaynet(inputDelays,hiddenSizes,trainFcn)
```

`inputDelays`	Row vector of increasing 0 or positive delays (default = 1:2)
`hiddenSizes`	Row vector of one or more hidden layer sizes (default = 10)
`trainFcn`	Training function (default = `'trainlm'`)

Note: for input delays standard dependencies from present input are represented by a 0 delay. Thereby, use inputDelays = 0:4 for an input window of size 5 that spans from the present input to the input 5 steps before.

Layer Recurrent Neural Network (RNNs)

SRN with BPTT in the lectures

```
net = layrecnet(layerDelays,hiddenSizes,trainFcn)
```

`layerDelays`	Row vector of increasing positive delays (default = 1:2) – use layerDelays = 1
`hiddenSizes`	Row vector of one or more hidden layer sizes (default = 10)
`trainFcn`	Training function (default = `'trainlm'`)

Note: delays corresponding to feedback connections should be >0.

Nonlinear autoregressive with exogenous inputs (NARX)

```
net = narxnet(inputDelays,feedbackDelays,hiddenSizes,trainFcn)
```

`inputDelays`	Row vector of increasing 0 or positive delays (default = 1:2)
`feedbackDelays`	Row vector of increasing 0 or positive delays (default = 1:2)
`hiddenSizes`	Row vector of one or more hidden layer sizes (default = 10)
`trainFcn`	Training function (default = `'trainlm'`)

Note: the network should be trained and used in closeloop form.

In older versions of Matlab you should set it using the command, i.e.

```
net = closeloop(net)
```

From 2016a version of Matlab you need to specify the openloop ore closeloop option as a feedback mode when you create the NARX network, according to the following:

```
net = narxnet(inputDelays,feedbackDelays,hiddenSizes, feedbackMode,trainFcn)
```

`inputDelays`	Row vector of increasing 0 or positive delays (default = 1:2)
`feedbackDelays`	Row vector of increasing 0 or positive delays (default = 1:2)
`hiddenSizes`	Row vector of one or more hidden layer sizes (default = 10)
`feedbackMode`	An 'open' or 'closed' feedback mode
`trainFcn`	Training function (default = `'trainlm'`)

Customize your network

- Sizes of hidden layers, e.g.

```
net.layers{1}.size = 30;
```

- Training function (weight update rule), e.g.

```
net.trainFcn = 'traingd'; %gradient descent
net.trainFcn = 'traingdm'; %gradient descent with momentum
net.trainFcn = 'traingdx'; %gradient descent with momentum and adaptive
                           %learning rate
net.trainFcn = 'trainrp'; %rprop
net.trainFcn = 'trainlm'; % Levenberg-Marquardt optimization
```

- Training parameters, e.g.

```
net.trainParam.lr = 0.001: %learning rate for gradient descent alg.
net.trainParam.mc = 0.5; %momentum constant
net.trainParam.epochs = 1000; %maximum number of epochs
```

- Regularization, e.g.

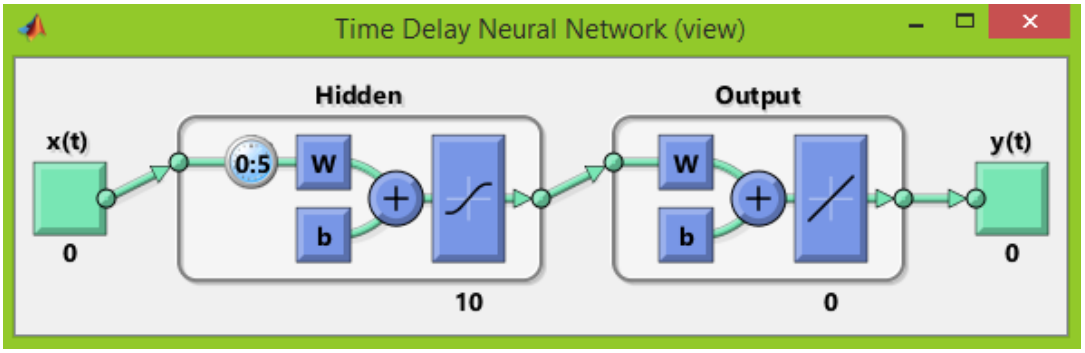
```
net.performParam.regularization = 0.1; %for weight decay regularization
```

- Data splitting (divide function), e.g.

```
net.divideFcn = 'dividerand';  %automatic split in tr, vl, ts sets
                               %not recommended!
net.divideFcn = 'dividetrain'; %all samples provided with train command
                               %are used for training
```

View your network's architecture using the command:

```
view(net)
```



Prepare the (time series) input for your network

preparets

Prepare input and target time series data for network simulation or training

Syntax

```
[Xs,Xi,Ai,Ts,EWs,shift] = preparets(net,Xnf,Tnf,Tf,EW)
```

Input:

`net`	Neural network
`Xnf`	Non-feedback inputs
`Tnf`	Non-feedback targets
`Tf`	Feedback targets
`EW`	Error weights (default = `{1}`)

Output:

`Xs`	Shifted inputs
`Xi`	Initial input delay states
`Ai`	Initial layer delay states
`Ts`	Shifted targets
`EWs`	Shifted error weights
`shift`	The number of timesteps truncated from the front of `X` and `T` in order to properly fill `Xi` and`Ai`.

e.g.

```
[delayedInput, initialInput, initialStates, delayedTarget] = preparets(net, input, target)
```

Train your network

train

Train neural network

collapse all in page

Syntax

```
[net,tr] = train(net,X,T,Xi,Ai,EW)
```

Input:

`net`	Network
`X`	Network inputs
`T`	Network targets (default = zeros)
`Xi`	Initial input delay conditions (default = zeros)
`Ai`	Initial layer delay conditions (default = zeros)
`EW`	Error weights

Output:

`net`	Newly trained network
`tr`	Training record (`epoch` and `perf`)

e.g.

```
[net,tr] = train(net, delayedInput, delayedTarget, initialInput); %for time delay
neural networks
```

Note: net and tr are two of the structures that you have to include in your assignment output.