```
% Define number of inputs/outputs
n_inp = 2;
n_hn = 2;
n_out = 1;
```

```
% Define Activations
syms logsig(x)
logsig(x) = 1 ./ (1 + exp(-x));

syms tansig(x)
tansig(x) = 2 ./ (1 + exp(-2*x)) - 1;

syms sca_le(x)
sca_le(x) = (x - 0).* 2 + -1;
```

XOR/AND Network

```
X  = sym('X',     [n_inp 1],    'real');

IW = sym('IW',    [n_hn n_inp], 'real');
BI = sym('BI',    [n_inp 1],    'real');

LW = sym('LW',    [n_out n_hn], 'real');
BL = sym('BL',    [n_out 1],    'real');

tan_sig = tansig(IW*sca_le(X)+BI);
log_sig = logsig(LW*tan_sig+BL);

T = sym('T',  [n_out 1],         'real');
E = (log_sig - T).^2
```

E =

$$\left(T_1 - \frac{1}{e^{-\mathrm{BL}_1-\mathrm{LW}_1\left(\frac{2}{e^{-2\,\mathrm{BI}_1-2\,\mathrm{IW}_{1,1}\,(2X_1-1)-2\,\mathrm{IW}_{1,2}\,(2X_2-1)}+1}-1\right)-\mathrm{LW}_2\left(\frac{2}{e^{-2\,\mathrm{BI}_2-2\,\mathrm{IW}_{2,1}\,(2X_1-1)-2\,\mathrm{IW}_{2,2}\,(2X_2-1)}+1}-1\right)}+1}\right)^2$$

```
% Add Allias (names)
LOGSIG = sym('LOGSIG',  [n_out 1], 'real');
TANSIG = sym('TANSIG',  [n_hn  1], 'real');
X_IN   = sym('X_IN',    [n_inp 1], 'real');
T_OUT = sym('X_OUT',    [n_out 1], 'real');
```

```
% Estimate Jacobean Matrices (Signal Approximation Neural Network)
[JIW] = cell(n_hn,1);
vars = {log_sig, tan_sig, X, T};
alias = {LOGSIG, TANSIG, X_IN, T_OUT};

for i = 1:n_hn
    for j = 1:length(vars)
```

```
        JIW{i} = subs(jacobian(E, IW(:,i)'),...
            vars{j}, alias{j});
    end
end

for j = 1:length(vars)
    JBI = subs(jacobian(E, BI'),...
            vars{j}, alias{j});
end

[JLW] = cell(n_out,1);
for i = 1:n_out
    for j = 1:length(vars)
        JLW{i} = subs(jacobian(E, LW(:,i)'),...
             vars{j}, alias{j});
    end
end

for j = 1:length(vars)
    JBL = subs(jacobian(E, BL'),...
            vars{j}, alias{j})
end
```

JBL =

$$2\,\mathrm{LOGSIG}_1{}^2\,\mathrm{e}^{-\mathrm{BL}_1-\mathrm{LW}_1\left(\frac{2}{\mathrm{e}^{-2\,\mathrm{BI}_1-2\,\mathrm{IW}_{1,1}\,(2X_1-1)-2\,\mathrm{IW}_{1,2}\,(2X_2-1)}+1}-1\right)-\mathrm{LW}_2\left(\frac{2}{\mathrm{e}^{-2\,\mathrm{BI}_2-2\,\mathrm{IW}_{2,1}\,(2X_1-1)-2\,\mathrm{IW}_{2,2}\,(2X_2-1)}+1}\right.}$$

JBL =

$$-\frac{2\,\mathrm{e}^{-\mathrm{BL}_1-\mathrm{LW}_1\,\mathrm{TANSIG}_1-\mathrm{LW}_2\,\mathrm{TANSIG}_2}\left(T_1-\frac{1}{\mathrm{e}^{-\mathrm{BL}_1-\mathrm{LW}_1\,\mathrm{TANSIG}_1-\mathrm{LW}_2\,\mathrm{TANSIG}_2}+1}\right)}{\left(\mathrm{e}^{-\mathrm{BL}_1-\mathrm{LW}_1\,\mathrm{TANSIG}_1-\mathrm{LW}_2\,\mathrm{TANSIG}_2}+1\right)^2}$$

JBL =

$$-\frac{2\,\sigma_1\left(T_1-\frac{1}{\sigma_1+1}\right)}{(\sigma_1+1)^2}$$

where

$$\sigma_1=\mathrm{e}^{-\mathrm{BL}_1-\mathrm{LW}_1\left(\frac{2}{\mathrm{e}^{-2\,\mathrm{BI}_1-2\,\mathrm{IW}_{1,1}\,(2X_{\mathrm{IN1}}-1)-2\,\mathrm{IW}_{1,2}\,(2X_{\mathrm{IN2}}-1)}+1}-1\right)-\mathrm{LW}_2\left(\frac{2}{\mathrm{e}^{-2\,\mathrm{BI}_2-2\,\mathrm{IW}_{2,1}\,(2X_{\mathrm{IN1}}-1)-2\,\mathrm{IW}_{2,2}\,(2X_{\mathrm{IN2}}-1)}+1}\right.}$$

JBL =

$$-\frac{2\,\sigma_1\left(X_{\mathrm{OUT1}}-\frac{1}{\sigma_1+1}\right)}{(\sigma_1+1)^2}$$

where

$$\sigma_1 = \mathrm{e}^{-\mathrm{BL}_1-\mathrm{LW}_1\left(\frac{2}{\mathrm{e}^{-2\,\mathrm{BI}_1-2\,\mathrm{IW}_{1,1}\,(2X_1-1)-2\,\mathrm{IW}_{1,2}\,(2X_2-1)}+1}-1\right)-\mathrm{LW}_2\left(\frac{2}{\mathrm{e}^{-2\,\mathrm{BI}_2-2\,\mathrm{IW}_{2,1}\,(2X_1-1)-2\,\mathrm{IW}_{2,2}\,(2X_2-1)}+1}-1\right)}$$