





Multilayer Perceptron and Applications



Lecture 5

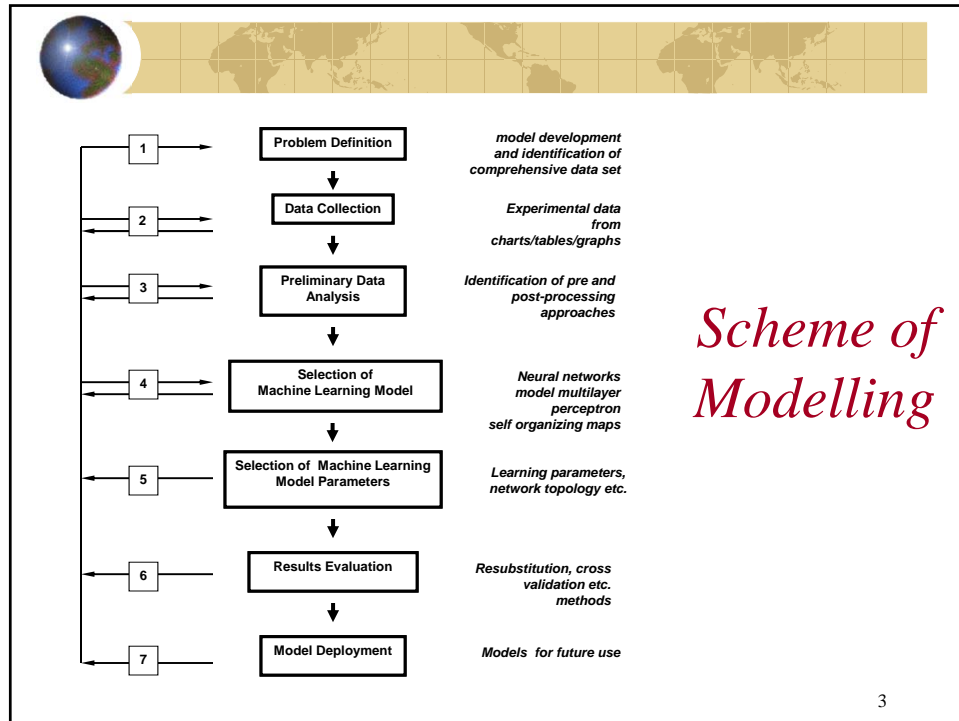
1



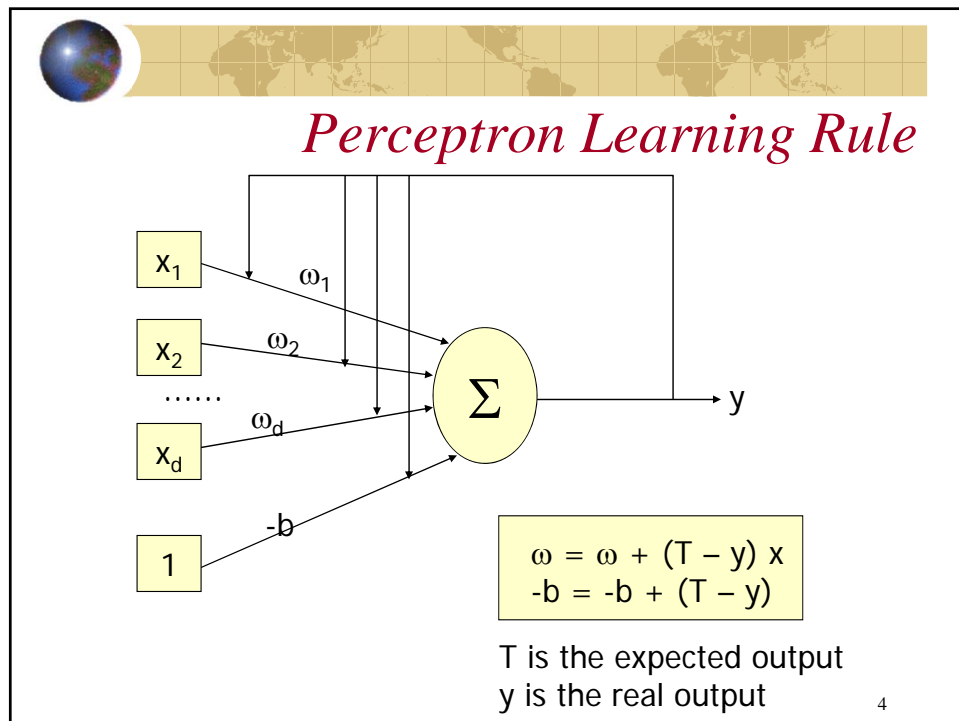
Recap and Ahead

- ✦ Scheme of Neural Networks Modelling
- ✦ Perceptron Model
- ✦ Multilayer Perceptron

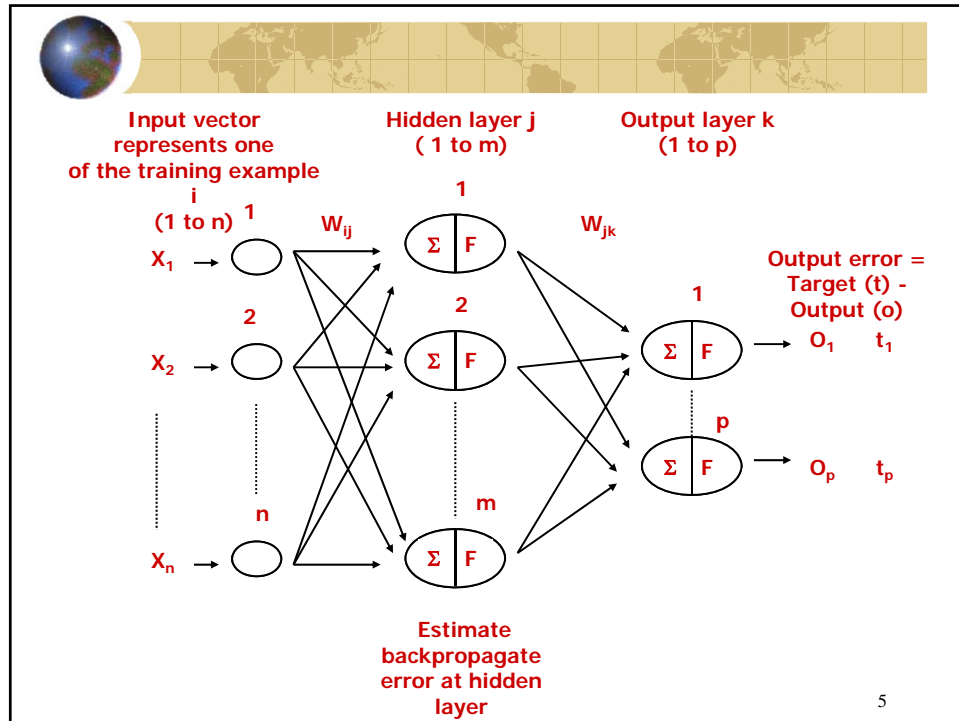
2



3



4



5

Generalization

Neural Network DESIGN **Generalization**

Function Approximation

Number of Hidden Neurons S1: 1

Difficulty Index: 2


Click the [Train] button to train the logsig-linear network on the data points at left.

Use the slide bar to choose the number of neurons in the hidden layer.


Chapter 11

21 Examples – Architecture 1-1-1

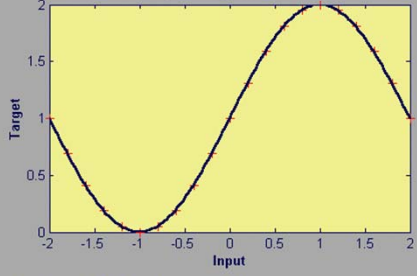
6



Generalization

Neural Network DESIGN
Generalization


Function Approximation



Number of Hidden Neurons S1: 4

1

9

Difficulty Index: 2

1

9

Click the [Train] button to train the logsig-linear network on the data points at left.

Use the slide bar to choose the number of neurons in the hidden layer.

Train


Contents

Close


Chapter 11

21 Examples – Architecture 1-4-1

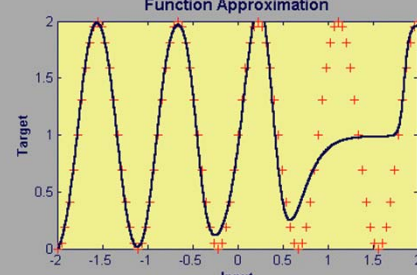
7



Generalization

Neural Network DESIGN
Generalization


Function Approximation



Number of Hidden Neurons S1: 7

1

9

Difficulty Index: 9

1

9

Click the [Train] button to train the logsig-linear network on the data points at left.

Use the slide bar to choose the number of neurons in the hidden layer.

Train


Contents

Close


Chapter 11

90 Examples – Architecture 1-7-1

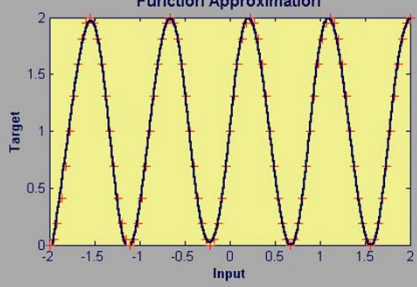
8



Generalization

Neural Network DESIGN
Generalization


Function Approximation



Target

Input

Number of Hidden Neurons S1: 9


Difficulty Index: 9

Click the [Train] button to train the logsig-linear network on the data points at left. Use the slide bar to choose the number of neurons in the hidden layer.


Chapter 11

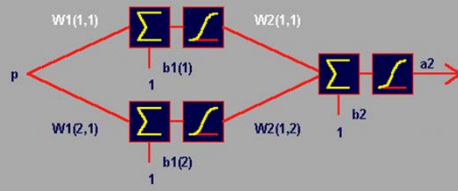
90 Examples – Architecture 1-9-1

9

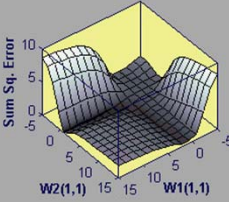
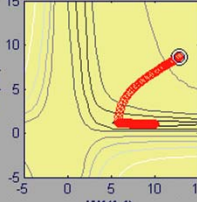


Steepest Descent BP

Neural Network DESIGN Steepest Descent Backprop #1




☒ $W1(1,1), W2(1,1)$
☐ $W1(1,1), b1(1)$
☐ $b1(1), b1(2)$

Use the radio buttons to select the network parameters to train with backpropagation. The corresponding error surface and contour are shown below. Click in the contour graph (on the right) to start the steepest descent learning algorithm.

Chapter 12

10

The screenshot displays the 'Neural Network DESIGN' software interface for 'Momentum Backpropagation'. The network architecture is a simple feedforward network with one input node (p), two hidden nodes (1 and 2), and one output node (a2). Weights are labeled as $W1(1,1)$, $W1(2,1)$, $W2(1,1)$, and $W2(1,2)$. Biases are labeled as $b1(1)$, $b1(2)$, and $b2$. The interface includes radio buttons to select parameters for training with backpropagation: $W1(1,1), W2(1,1)$ (selected), $W1(1,1), b1(1)$, and $b1(1), b1(2)$. Sliders for 'Learning Rate' (0.0 to 6.2) and 'Momentum' (0.0 to 0.04) are shown, with the 'Momentum' slider circled in blue. A contour plot shows the error landscape with axes $W1(1,1)$ and $W2(1,1)$, with a red path indicating the training trajectory that has not converged to a minimum. A red lightning bolt icon in the top right corner indicates a non-converged solution. Text on the right explains the radio buttons and the contour plot, and provides instructions to click to start the algorithm or reset parameters.

Neural Network DESIGN Momentum Backpropagation

Use the radio buttons to select the network parameters to train with backpropagation. The corresponding contour plot is shown below.

Click in the contour graph to start the momentum backprop learning algorithm. You can reset the algorithm parameters using the sliders.

☒ $W1(1,1), W2(1,1)$ ☐ $W1(1,1), b1(1)$ ☐ $b1(1), b1(2)$

Learning Rate: 6.2
 0.0 20.0

Momentum: 0.04
 0.0 1.0

Contour plot showing $W2(1,1)$ vs $W1(1,1)$. The red path indicates the training trajectory, which is not converging to a minimum.

Chapter 12


The screenshot displays the 'Neural Network DESIGN Momentum Backpropagation' window. The interface includes a diagram of a neural network with two input nodes (1 and 2), two hidden nodes (1 and 2), and one output node (1). Weights are labeled $w1(1,1)$, $w1(2,1)$, $w2(1,1)$, and $w2(1,2)$. Biases are labeled $b1(1)$, $b1(2)$, $b2$, and $a2$. The network diagram shows the flow from input p through the hidden nodes to the output $a2$.

Below the diagram, there are radio buttons for selecting parameters to train: $w1(1,1), w2(1,1)$ (selected), $w1(1,1), b1(1)$, and $b1(1), b1(2)$.

The 'Learning Rate' is set to 6.2, and the 'Momentum' is set to 0.19. Both have associated sliders.

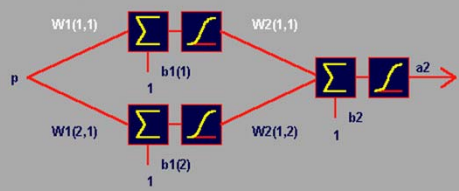
A contour plot shows the error surface for the selected parameters. The x-axis is $w1(1,1)$ and the y-axis is $w2(1,1)$. A red path indicates the training trajectory, starting from a point near (10, 10) and moving towards a minimum near (5, 5). A red circle highlights the current position on the path.

On the right side, there is a 'Contents' button and a 'Close' button. At the bottom right, it says 'Chapter 12'.



Variable Learning Rate

Neural Network DESIGN Variable LR Backpropagation



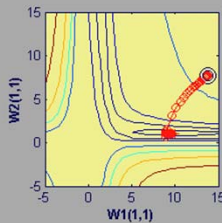
☒ W1(1,1), W2(1,1)
 ☐ W1(1,1), b1(1)
 ☐ b1(1), b1(2)

Initial Learning Rate: 2.3

Increase Rate: 1.11

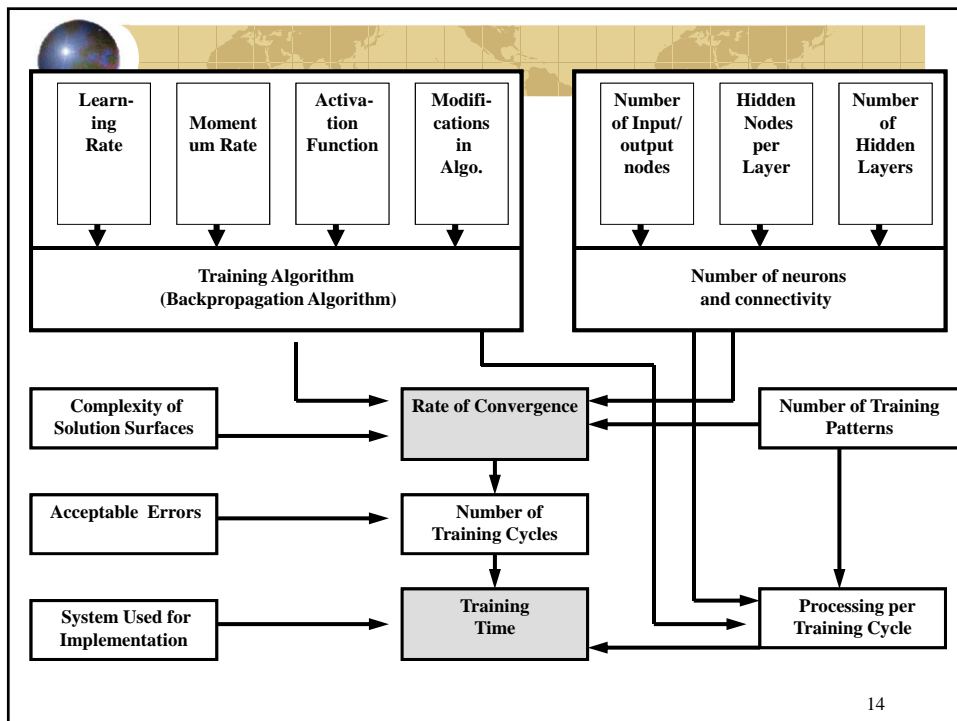
Decrease Rate: 0.76

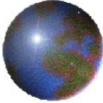

Use the radio buttons to select the network parameters to train with backpropagation. The corresponding contour plot is shown below. Click in the contour graph to start the variable learning rate backpropagation learning algorithm.



Chapter 12

13





Home Work

Perceptron and Multilayer Perceptron

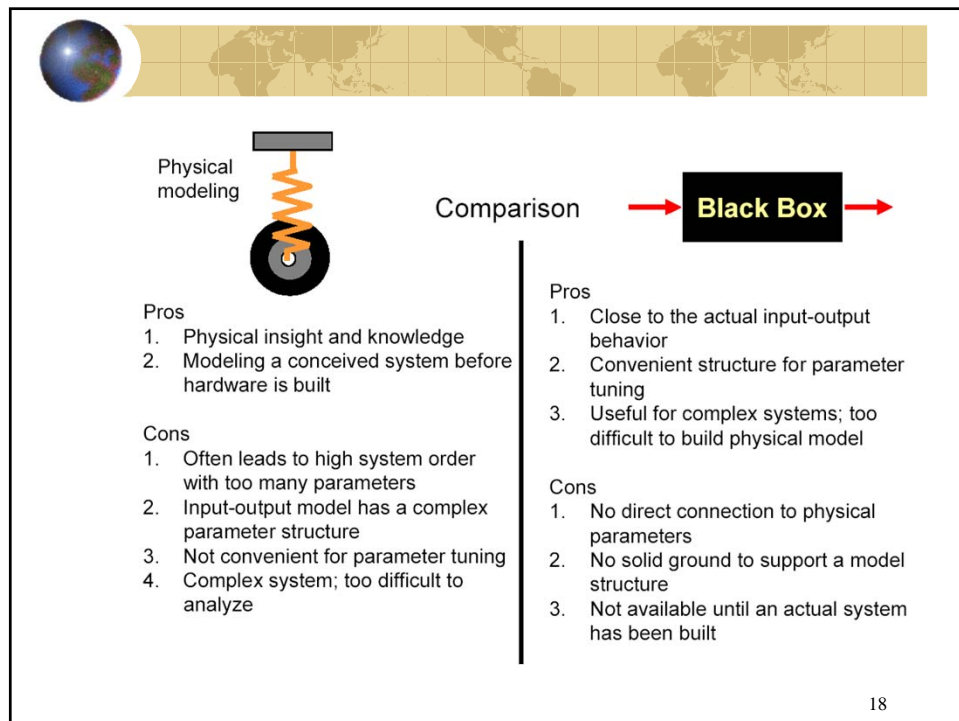
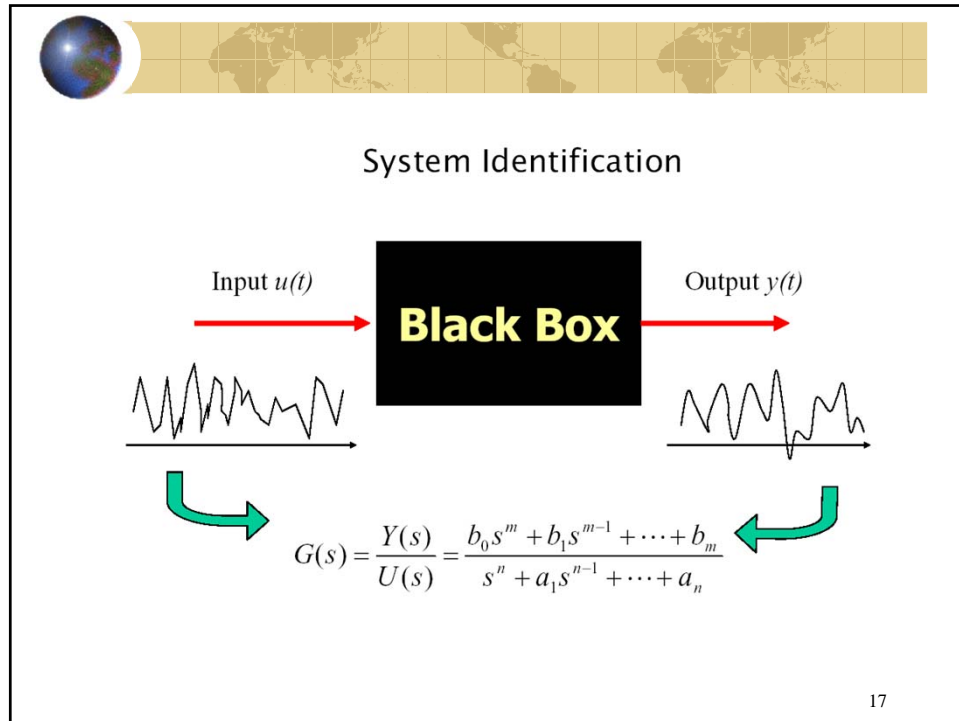
Examples in MATLAB +
Neural Networks Tool Box Environment



15





System Identification

16









Demo

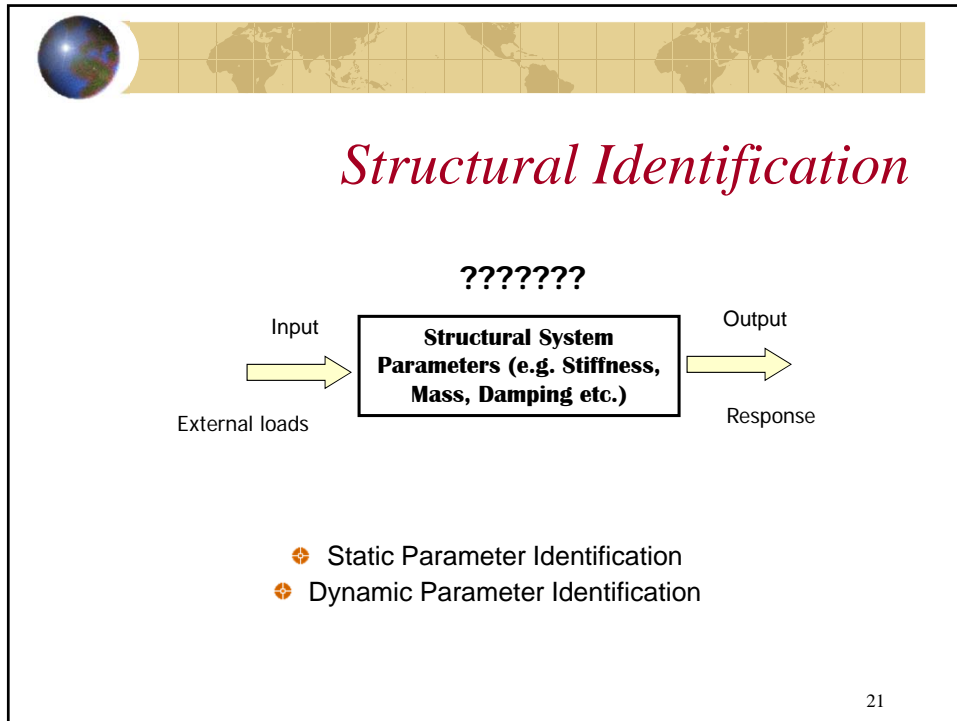
19





*BP Based
Condition Monitoring*

20

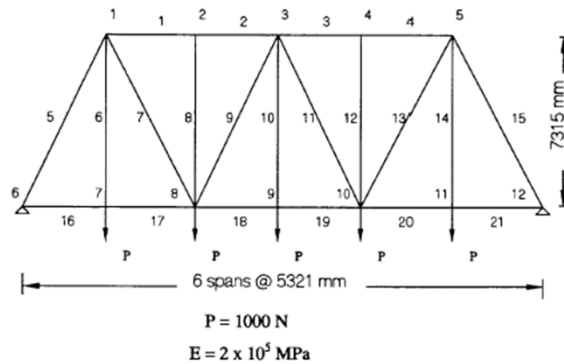




Problem Definition



23

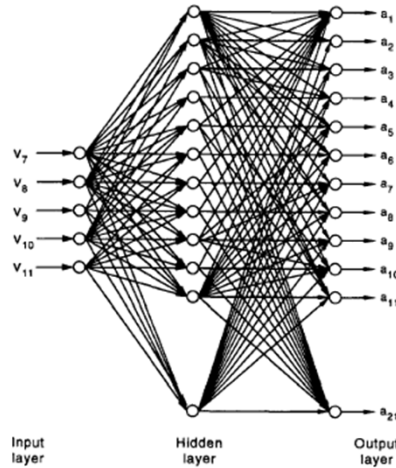


40 Training Patterns / 10 Testing Patterns

24



Neural Networks Architecture



25



Example 1: Displacement Measurement Based Study

Architecture	Parameters						Average system error (ASE)
	Input nodes	Hidden layers	Hidden nodes per layer	Output nodes	Learning parameter η	Momentum parameter α	
S-15-21	5	1	15	21	0.9	0.7	0.01
S-15-15-21	5	2	15	21	0.9	0.7	0.01
S-15-15-15-21	5	3	15	21	0.9	0.7	0.01
S-21-21	5	1	21	21	0.9	0.7	0.01
S-21-21-21	5	2	21	21	0.7, 0.8 0.9, 0.95	0.0, 0.1, 0.2 0.3, 0.4, 0.5 0.6, 0.7, 0.8 0.9, 0.95	0.01
S-21-21-21-21	5	3	21	21	0.9	0.7	0.01
S-25-21	5	1	25	21	0.9	0.7	0.01
S-25-25-21	5	2	25	21	0.9	0.7	0.01
S-25-25-25-21	5	3	25	21	0.9	0.7	0.01
S-30-21	5	1	30	21	0.9	0.7	0.01
S-30-30-21	5	2	30	21	0.9	0.7	0.01
S-30-30-30-21	5	3	30	21	0.9	0.7	0.01
S-35-21	5	1	35	21	0.9	0.7	0.01
S-35-35-21	5	2	35	21	0.9	0.7	0.01
S-35-35-35-21	5	3	35	21	0.9	0.7	0.01
S-40-21	5	1	40	21	0.9	0.7	0.01
S-40-40-21	5	2	40	21	0.9	0.7	0.01
S-40-40-40-21	5	3	40	21	0.9	0.7	0.01
S-45-21	5	1	45	21	0.9	0.7	0.01
S-45-45-21	5	2	45	21	0.9	0.7	0.01
S-45-45-45-21	5	3	45	21	0.9	0.7	0.01

26



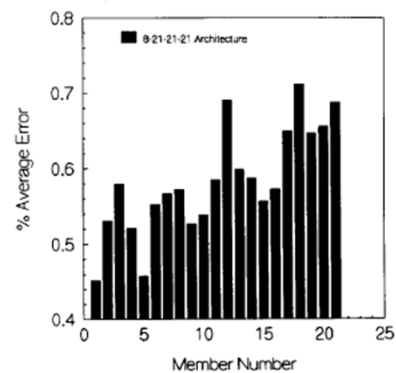
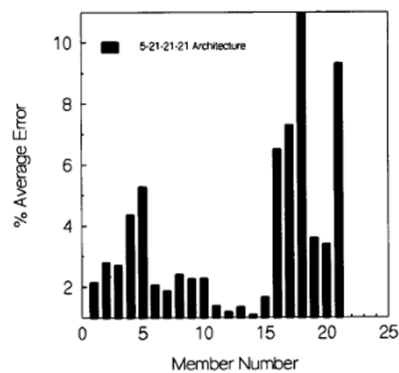
Example 2: Displacement/Strain Measurement Based Study

Architecture	Parameters						Average system error (ASE)
	Input nodes	Hidden layers	Hidden nodes per layer	Output nodes	Learning parameter η	Momentum parameter α	
8-21-21-21	8	2	21	21	0.9	0.7	0.01

27



Error Performance Study – Examples 1 and 2



28





*Dynamic Parameter
Identification*




Vibration Signature Analysis

29

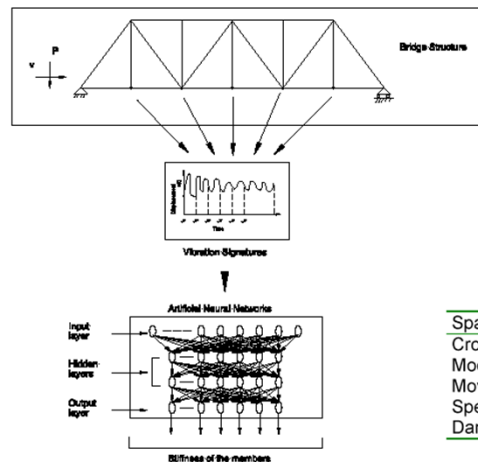


Problem Definition



30

Vibration Signature Analysis – At a Glance

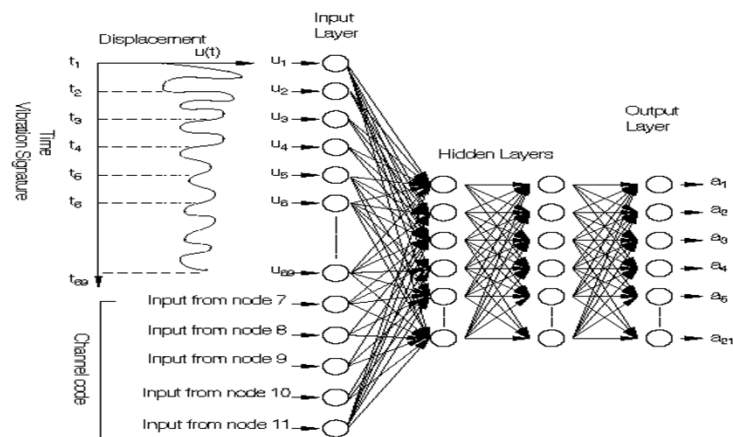


21 bar Truss Structure and Loading Parameters

Span of the Bridge	5321 mm
Cross-sectional area	10000 mm ²
Modulus of Elasticity	2 x 10 ⁵ N/ mm ²
Moving load P	1000 N
Speed of the load	16.67 m/s (60 kmph)
Damping	2% of the critical damping

31

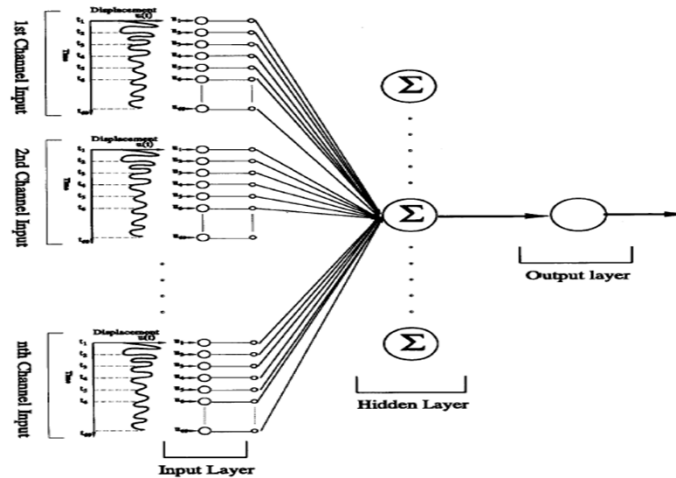
Traditional Neural Networks



32



Time Delay Neural Networks



33



Cases

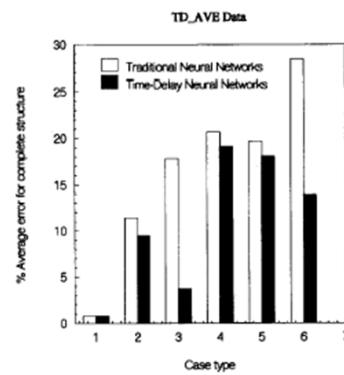
Case type	Input to the network available from node numbers	Remarks on input
Case 1	All the nodes (i.e. 7, 8, 9, 10 and 11)	All channels are functioning
Case 2	7, 8, 10 and 11	Only four channels are functioning
Case 3	8, 9 and 10	Only three channels are functioning
Case 4	8, 10 and 11	Only three channels are functioning
Case 5	7, 8 and 10	Only three channels are functioning
Case 6	8 and 10	Only two channels are functioning

Type of network and architecture	Training samples	Testing samples	Iterations	CPU time taken for training in min:s
TNNs 69-(21-21)-21	$16 \times 5 = 80$	$5 \times 5 = 25$	211	16:09.20
TDNNs 345-(21-21)-21	16	5	2030	97:39.62

34



Complete Structure Performance



35



36