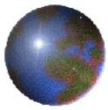
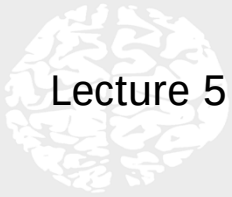


Multilayer Perceptron and Applications



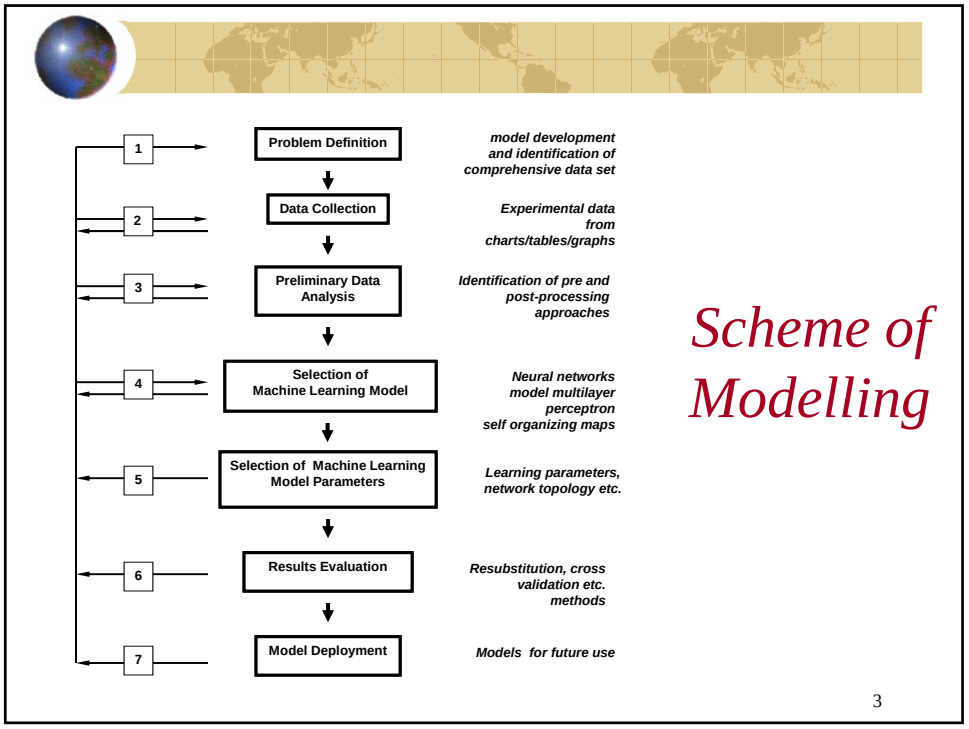
Lecture 5

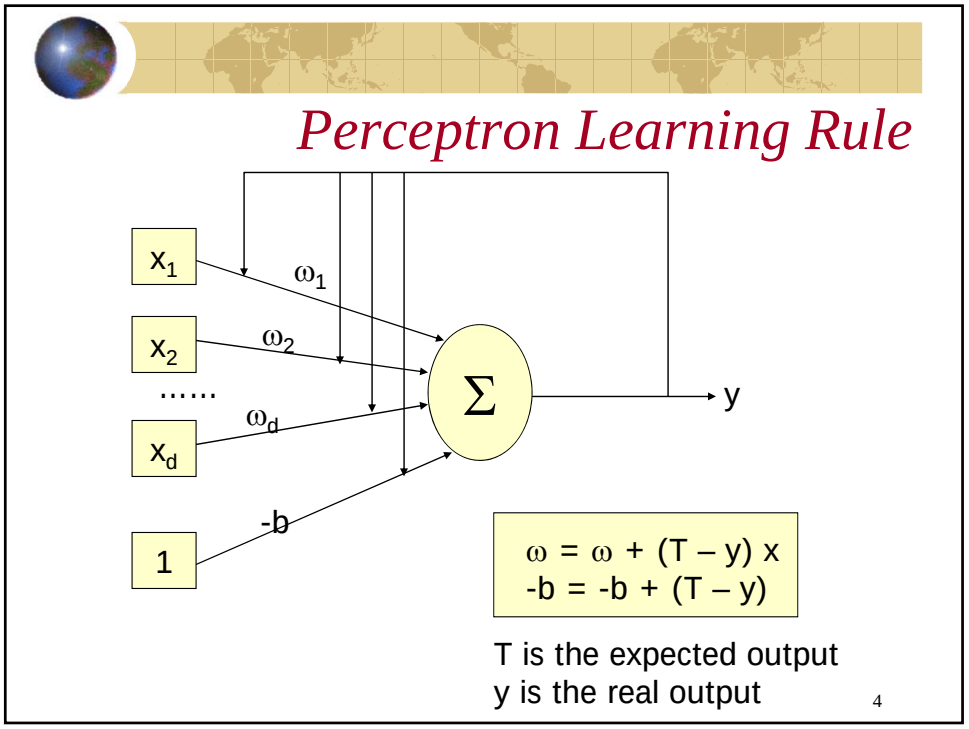
1

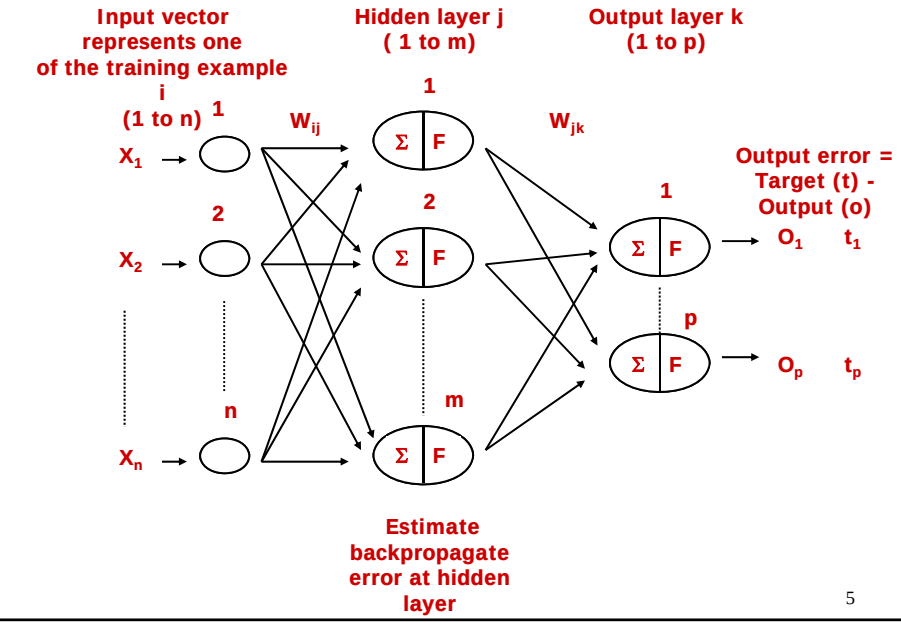
Recap and Ahead

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

2

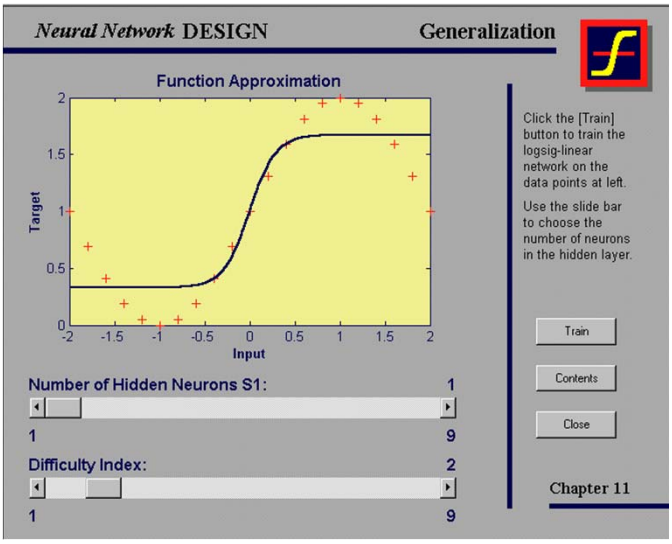

1
Problem Definition
model development and identification of comprehensive data set
2
Data Collection
Experimental data from charts/tables/graphs
3
Preliminary Data Analysis
Identification of pre and post-processing approaches
4
Selection of Machine Learning Model
Neural networks model multilayer perceptron self organizing maps
5
Selection of Machine Learning Model Parameters
Learning parameters, network topology etc.
6
Results Evaluation
Resubstitution, cross validation etc. methods
7
Model Deployment
Models for future use
Scheme of Modelling
3


Perceptron Learning Rule
x1
x2
.....
xd
1
ω1
ω2
ωd
-b
Σ
y
ω = ω + (T – y) x
-b = -b + (T – y)
T is the expected output
y is the real output
4



5

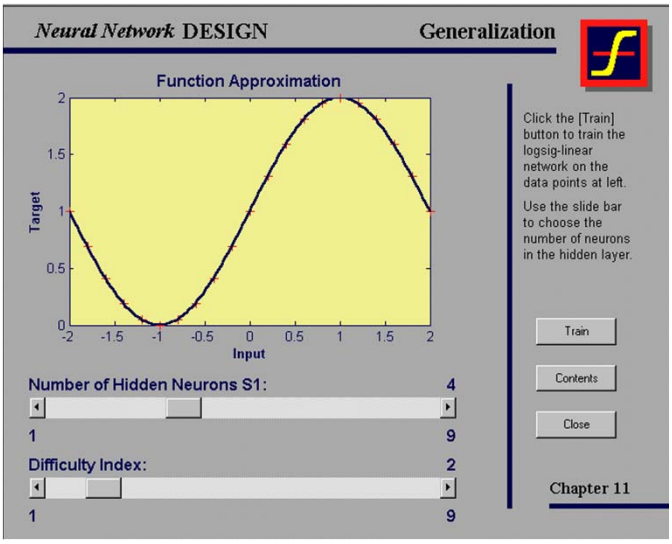
Generalization



21 Examples – Architecture 1-1-1

6

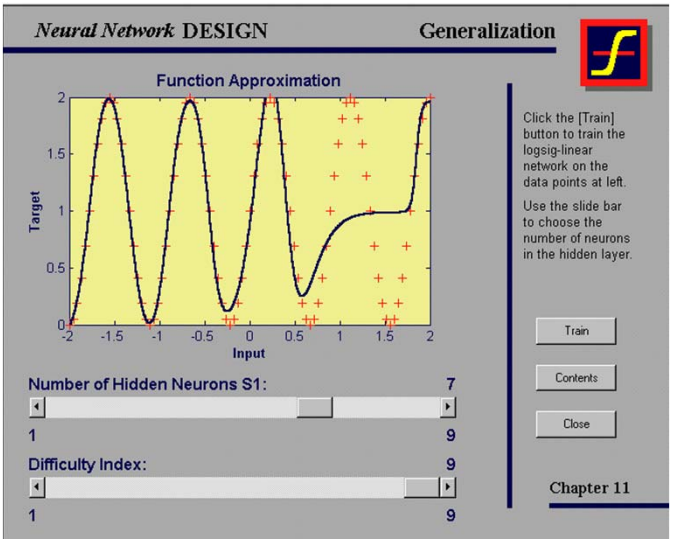
Generalization



21 Examples – Architecture 1-4-1

7

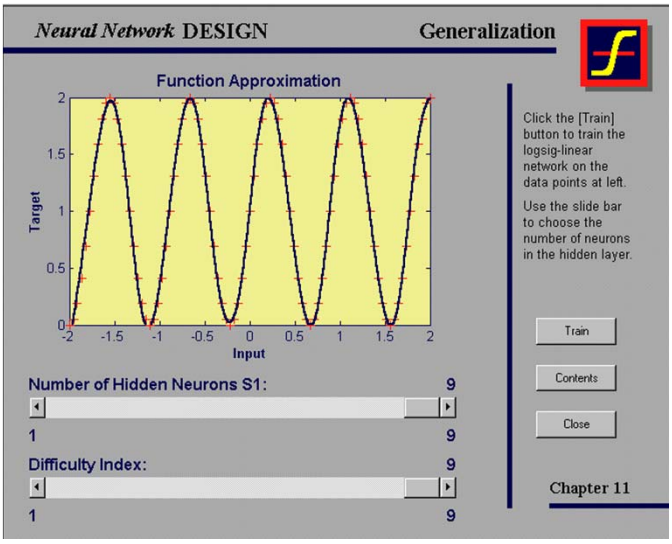
Generalization



90 Examples – Architecture 1-7-1

8

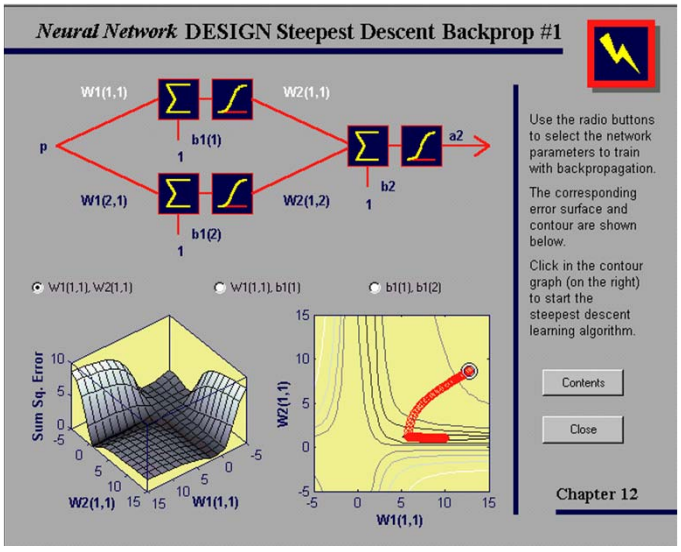
Generalization



90 Examples – Architecture 1-9-1

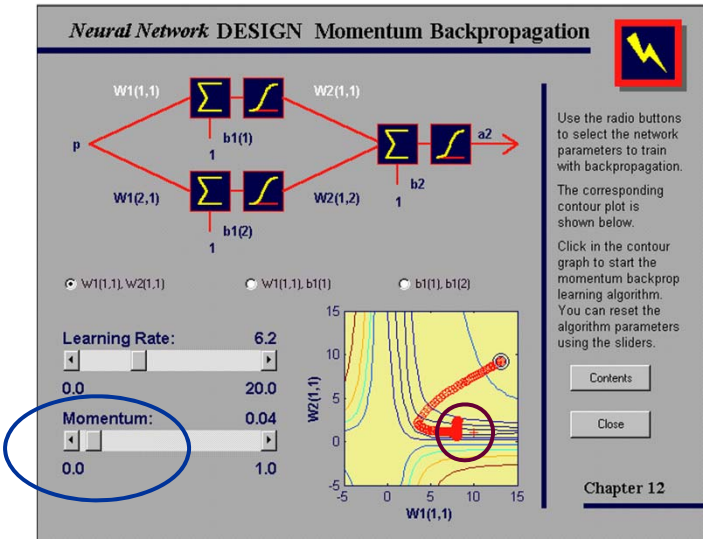
9

Steepest Descent BP



10

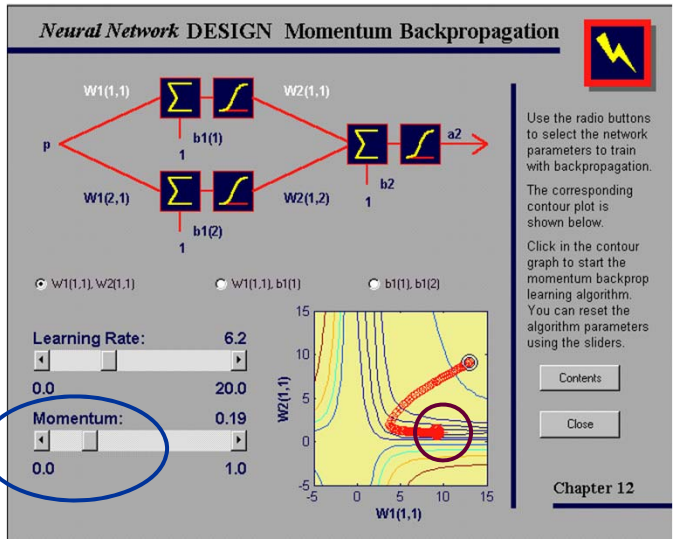
Momentum BP



Non-converged Solution

11

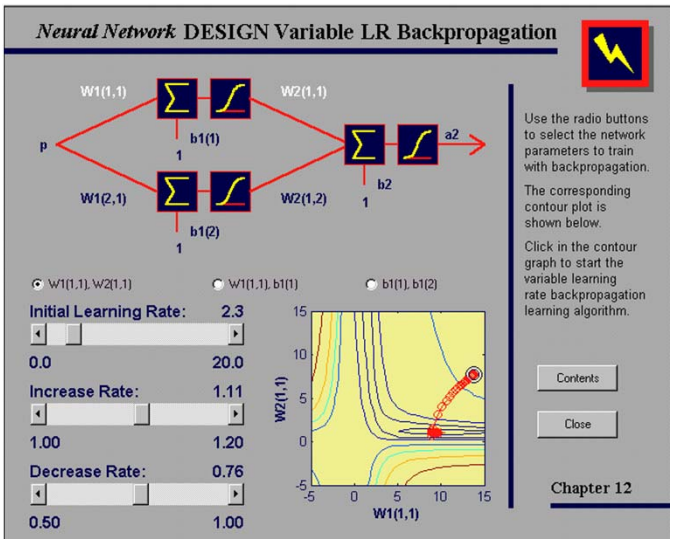
Momentum BP



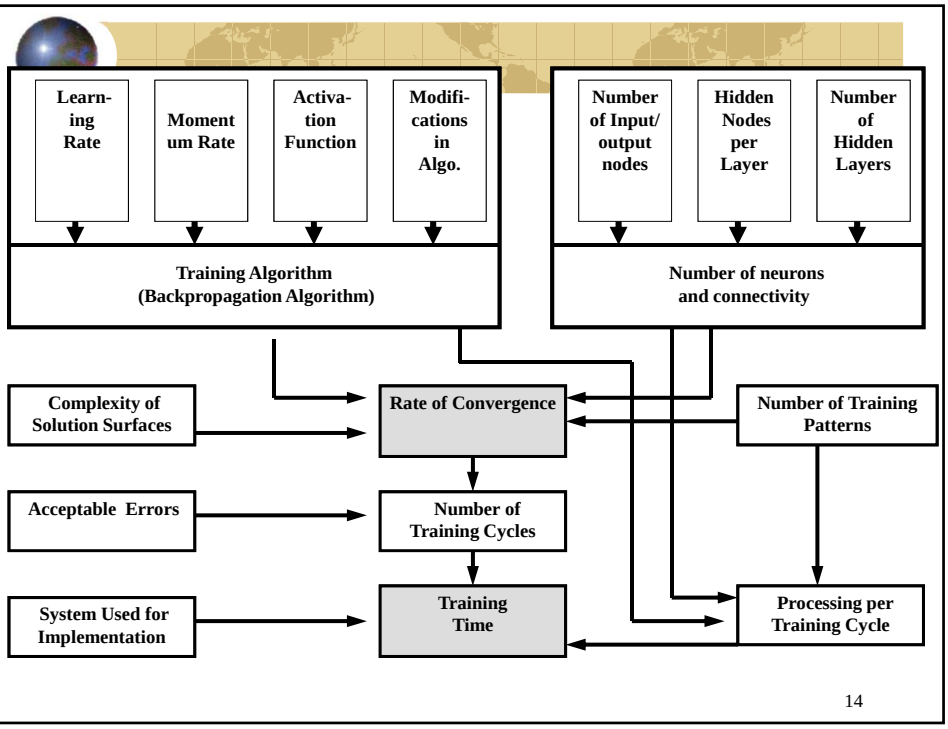
Converged Solution

12

Variable Learning Rate



13



14

Home Work

Perceptron and Multilayer Perceptron

Examples in MATLAB +

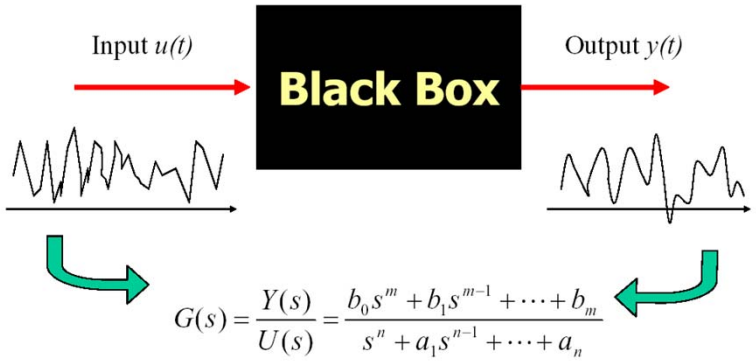
Neural Networks Tool Box Environment

15

System Identification

16

System Identification



$$G(s) = \frac{Y(s)}{U(s)} = \frac{b_0 s^m + b_1 s^{m-1} + \cdots + b_m}{s^n + a_1 s^{n-1} + \cdots + a_n}$$

17

Physical modeling

Pros
1. Physical insight and knowledge
2. Modeling a conceived system before hardware is built

Cons
1. Often leads to high system order with too many parameters
2. Input-output model has a complex parameter structure
3. Not convenient for parameter tuning
4. Complex system; too difficult to analyze

Comparison → Black Box

Pros
1. Close to the actual input-output behavior
2. Convenient structure for parameter tuning
3. Useful for complex systems; too difficult to build physical model

Cons
1. No direct connection to physical parameters
2. No solid ground to support a model structure
3. Not available until an actual system has been built

18

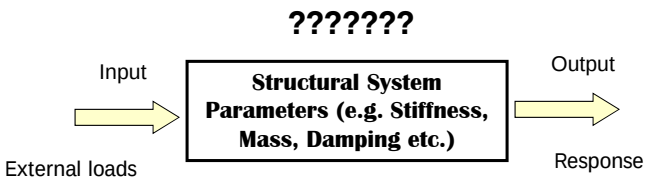
Demo

19

BP Based Condition Monitoring

20

Structural Identification



- Static Parameter Identification
- Dynamic Parameter Identification

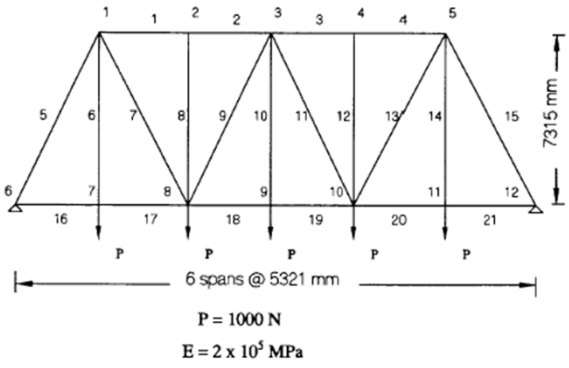
21

Static Parameter Identification

22

Problem Definition

23



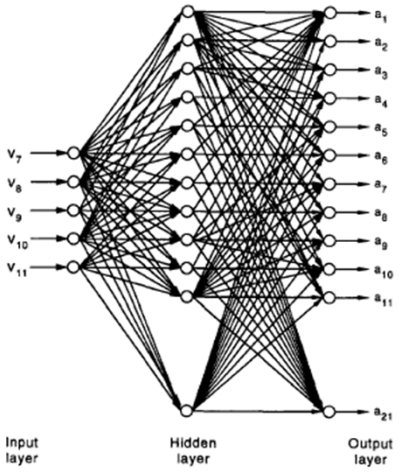
P = 1000 N

E = 2 x 10^5 MPa

40 Training Patterns / 10 Testing Patterns

24

Neural Networks Architecture



25

Example 1: Displacement Measurement Based Study

Architecture	Parameters						
	Input nodes	Hidden layers	Hidden nodes per layer	Output nodes	Learning parameter η	Momentum parameter α	Average system error (ASE)
5-15-21	5	1	15	21	0.9	0.7	0.01
5-15-15-21	5	2	15	21	0.9	0.7	0.01
5-15-15-15-21	5	3	15	21	0.9	0.7	0.01
5-21-21	5	1	21	21	0.9	0.7	0.01
5-21-21-21	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
5-21-21-21-21	5	3	21	21	0.9	0.7	0.01
5-25-21	5	1	25	21	0.9	0.7	0.01
5-25-25-21	5	2	25	21	0.9	0.7	0.01
5-25-25-25-21	5	3	25	21	0.9	0.7	0.01
5-30-21	5	1	30	21	0.9	0.7	0.01
5-30-30-21	5	2	30	21	0.9	0.7	0.01
5-30-30-30-21	5	3	30	21	0.9	0.7	0.01
5-35-21	5	1	35	21	0.9	0.7	0.01
5-35-35-21	5	2	35	21	0.9	0.7	0.01
5-35-35-35-21	5	3	35	21	0.9	0.7	0.01
5-40-21	5	1	40	21	0.9	0.7	0.01
5-40-40-21	5	2	40	21	0.9	0.7	0.01
5-40-40-40-21	5	3	40	21	0.9	0.7	0.01
5-45-21	5	1	45	21	0.9	0.7	0.01
5-45-45-21	5	2	45	21	0.9	0.7	0.01
5-45-45-45-21	5	3	45	21	0.9	0.7	0.01

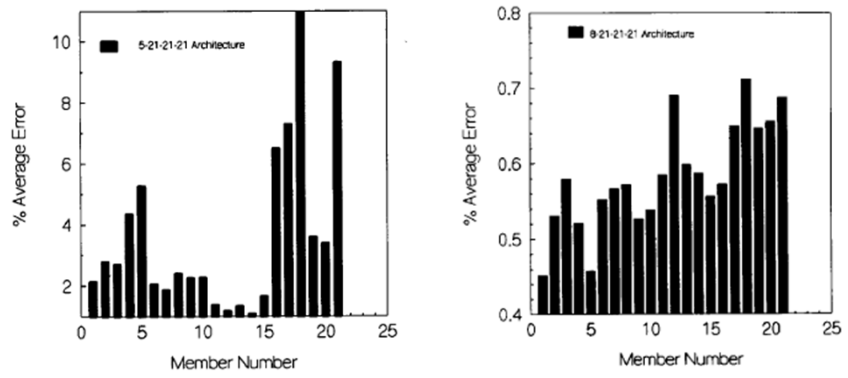
26

Example 2: Displacement/Strain Measurement Based Study

	Parameters						
Architecture	Input nodes	Hidden layers	Hidden nodes per layer	Output nodes	Learning parameter η	Momentum parameter α	Average system error (ASE)
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

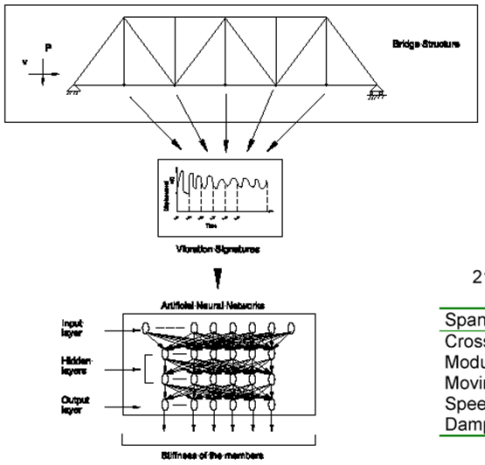
Vibration Signature Analysis

29

Problem Definition

30

Vibration Signature Analysis – At a Glance

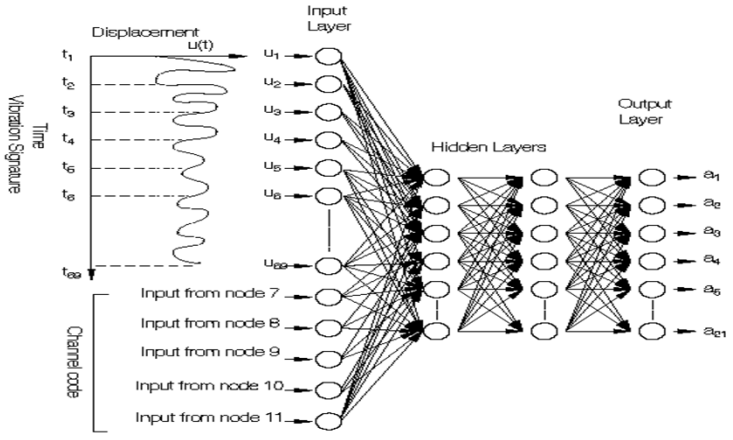


21 bar Truss Structure and Loading Parameters

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

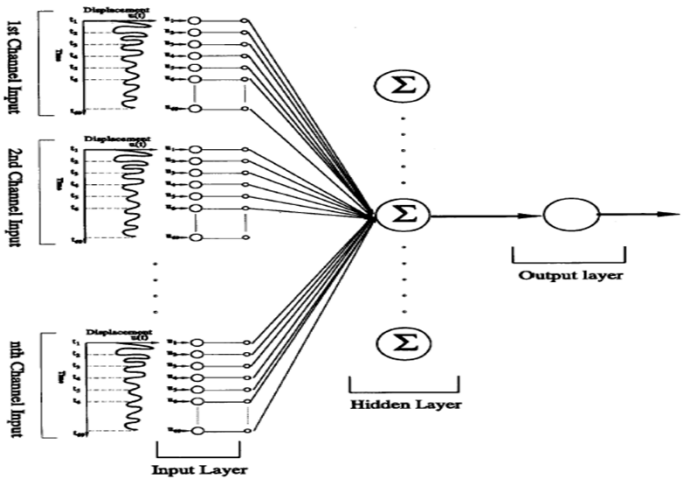
31

Traditional Neural Networks



32

Time Delay Neural Networks



33

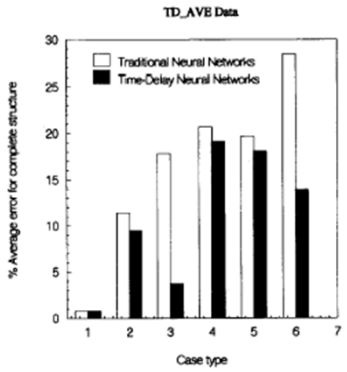
Cases

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

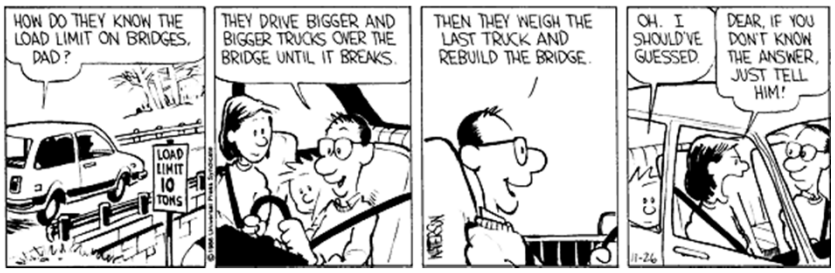
Type of network and architecture	Training samples	Testing samples	Iterations	CPU time taken for training in min:s
TNNs 69-(21-21)-21	16 × 5 = 80	5 × 5 = 25	211	16:09.20
TDNNs 345-(21-21)-21	16	5	2030	97:39.62

34

Complete Structure Performance



35



36