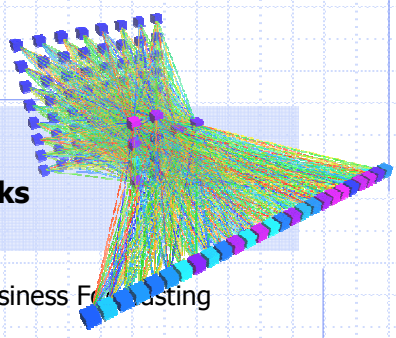
Business Forecasting with Artificial Neural Networks



IBF Tutorial 2004 – Institute of Business Forecasting
Boston, August 5th 2004

Sven F. Crone
University of Hamburg, Institute of Information Systems
Lancaster University Management School, Centre for Forecasting
E-Mail: crone@bis-lab.com

What you may expect from this session …

- Simple back propagation algorithm [Rumelhart et al. 1982]

$$E_p = C(t_{pj}, o_{pj})\ o_{pj} = f_j(net_{pj}) \qquad \Delta_p w_{ji} \propto -\frac{\partial C(t_{pj}, o_{pj})}{\partial w_{ji}}$$

$$\frac{\partial C(t_{pj}, o_{pj})}{\partial w_{ji}} = \frac{\partial C(t_{pj}, o_{pj})}{\partial net_{pj}} \frac{\partial net_{pj}}{\partial w_{ji}}$$

$$\delta_{pj} = -\frac{\partial C(t_{pj}, o_{pj})}{\partial net_{pj}}$$

$$\delta_{pj} = -\frac{\partial C(t_{pj}, o_{pj})}{\partial net_{pj}} = \frac{\partial C(t_{pj}, o_{pj})}{\partial o_{pj}} \frac{\partial o_{pj}}{\partial net_{pj}}$$

$$\frac{\partial o_{pt}}{\partial net_{pj}} = f_j'(net_{pj})$$

$$\delta_{pj} = \frac{\partial C(t_{pj}, o_{pj})}{\partial o_{pj}} f_j'(net_{pj})$$

$$\sum_k \frac{\partial C(t_{pj}, o_{pj})}{\partial net_{pk}} \frac{\partial net_{pk}}{\partial o_{pj}} = \sum_k \frac{\partial C(t_{pj}, o_{pj})}{\partial net_{pk}} \frac{\partial \sum_i w_{ki} o_{pi}}{\partial o_{pj}}$$

$$= \sum_k \frac{\partial C(t_{pj}, o_{pj})}{\partial net_{pk}} w_{kj} = -\sum_k \delta_{pj} w_{kj}$$

$$\delta_{pj} = f_j'(net_{pj}) \sum_k \delta_{pj} w_{kj}$$

$$\delta_{pj} = \begin{cases} \frac{\partial C(t_{pj}, o_{pj})}{\partial o_{pj}} f_j'(net_{pj}) & \text{if unit } j \text{ is in the output layer} \\ f_j'(net_{pj}) \sum_k \delta_{pk} w_{pjk} & \text{if unit } j \text{ is in a hidden layer} \end{cases}$$

→ „How to …“ on Neural Network Forecasting **without Maths!**

→ **CD-Start-Up Kit for** Neural Network Forecasting
- → 20+ software simulators
- → datasets
- → literature & faq

→ slides, data & additional info on:
www.bis-lab.de/IBF2004.htm
www.neural-forecasting.com

Agenda

Business Forecasting with Artificial Neural Networks

1. Introduction to Neural Networks
2. Application of Neural Networks for Business Forecasting
3. Hands-on exercises in Neural Network forecasting
4. Tips & Tricks for Improving Neural Network based forecasts
5. Q&A and Discussion

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Research & Consultant-Profile: Sven F. Crone

Position: Senior Consultant | **Nationality: German** | **Born: 1971**

Languages

- German
- English

Education

2004	Post Doc Researcher at Int. Centre for Forecasting, Lancaster University, UK
2003	Research Fellow at the George Mason Uni, USA
2003	Visiting Scientist at the Stellenbosch Business School, USB, South Africa.
2000-2004	Research & Teaching Assistant University of Hamburg, PhD-thesis on Forecasting in Inventory Management using ANN
1992-1997	University of Hamburg MBA equiv. (Dipl.-Kfm.) in Business Administration

Work Experience

2004 - ...	Research Associate, Lancaster University, United Kingdom
2000-2004	Research & Teaching Assistant University of Hamburg, Prof. Preßmar & Voß ; Various projects in industry & trade
1996-2000	CEO RSG Software GmbH. Management & IT-Consultant for Retail & Wholesale Projects in Germany & UK & Hungary.

Key-Projects

- Forecasting Methods in SAP APO-DP, bdf HAM, Sales Forecast Management & bdf Netherlands
- Automatic Model Selection in APO-DP, bdf HAM, Sales Forecast Management
- Sales Forecasts, AOLTimeWarner, GER
- Forecasting for Customer Relationship Management, Gruner & Jahr AG, GER
- Implementing a Forecast Strategy & Inventory Management in Vending Supply Chain, Mayfair Services, UK
- Inventory Management in Distributions-Center Logistics, Vendepac, UK

Method Competency

- SAP APO
  - SAP Curriculum PLM100, SCM200, SCM 220
- Inventory Management
  - Forecasting methods
  - Inventory Management
- Supply Chain Planning/ APS
  - Warehouse logistics
  - Distribution- / Supply logistics
- Business Information Systems

Problem Competency

- Demand Planning in Consumer Goods Industry
- Demand Planning in Retail & Wholesale

- Member of the IBF Institute of Business Forecasters
- Member of the International Institute of Forecasters IIF
- Member of IEEE; GOR, GI, ORSA ...

- Regular Presentations at ANN conferences of IEEE, INNS, APNNA

Sven F. Crone - Tel.+49.171.4910100 – eMail: crone@bis-lab.de – Internet: www.bis-lab.de

Research & Corporate Projects – B I³S Lab

Hamburg University: Institute of Information Systems
Lancaster University: Management Centre for Forecasting

- Core Competencies
  - Method competency: Forecasting & AI (Neural Nets, EA …)
  - Software competency: SAP APO DP, Finmatica, Forecast Pro …
- Services (Non Profit!)
  - Consultancy (→ process analysis, unbiased software selection etc.)
  - Research (→ prototype software, new application domains etc.)
  - Coaching (→ forecasting courses from Exp.Smooth to Neural Nets)
  - Forecasting competency: member / tutor
  - Selected references:

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   e. From biological to artificial Neural Network Structures
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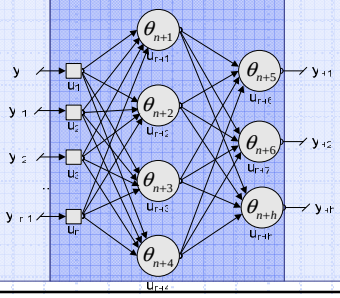
What are Artificial Neural Networks?

- Artificial Neural Networks (NN)
  - „a machine that is designed to *model* the way in which the brain performs a particular task …; the network is … implemented … or .. simulated in software on a digital computer." [Haykin98]
  - class of statistical methods for information processing consisting of large number of simple processing units (neurons), which exchange information of their activation via directed connections. [Zell97]

Input

- time series observation
- causal variables
- image data (pixel/bits)
- …

Processing

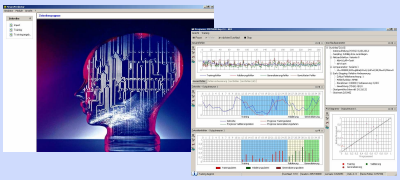


Output

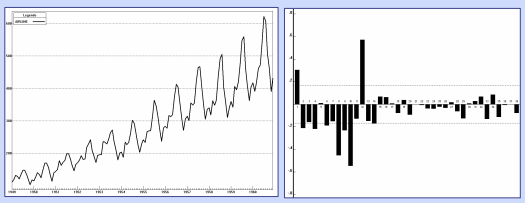
- time series prediction
- dependent variables
- class memberships
- class probabilities
- principal components
- …

Demonstration: Preview of Neural Network Forecasting

- Simualtion of NN in Business Forecasting with NeuroPredictor



- Airline Passenger Data Experiment
  - 3 layered NN: (12-8-1) 12 Input units - 8 hidden units – 1 output unit
  - 12 input lags t, t-1, …, t-11 (past 12 observations) → time series prediction
  - t+1 forecast → single step ahead forecast

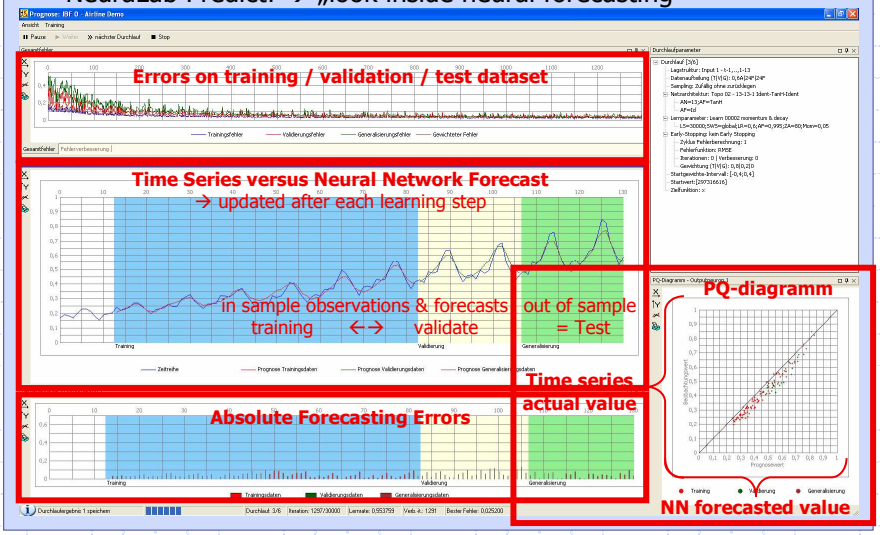


→ **Benchmark Time Series** [Brown / Box&Jenkins]

- **132 observations**
- **13 periods of monthly data**

Demonstration: Preview of Neural Network Forecasting

- NeuraLab Predict! → „look inside neural forecasting"



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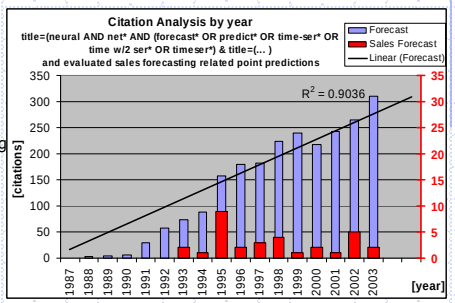
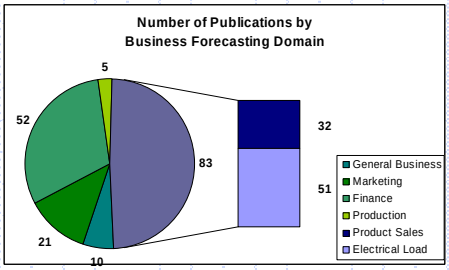
Applications of Neural Nets in diverse Research Fields
→ 2500+ journal publications on NN & Forecasting alone!

- Neurophysiology
  - → simulate & explain brain
- Informatics
  - → eMail & url filtering
  - → VirusScan (Symmantec Norton Antivirus)
  - → Speech Recognition & Optical Character Recog
- Engineering
  - → control applications in plants
  - → automatic target recognition (DARPA)
  - → explosive detection at airports
  - → Mineral Identification (NASA Mars Explorer)
  - → starting & landing of Jumbo Jets (NASA)
- Meteorology / weather
  - → Rainfall prediction
  - → ElNino Effects
- Corporate Business
  - → credit card fraud detection
  - → simulate forecasting methods
- Different Forecasting Domains
  - Electrical Load / Demand
  - Financial Forecasting
    - Currency / Exchange rate
    - stock forecasting etc.
  - Sales forecasting

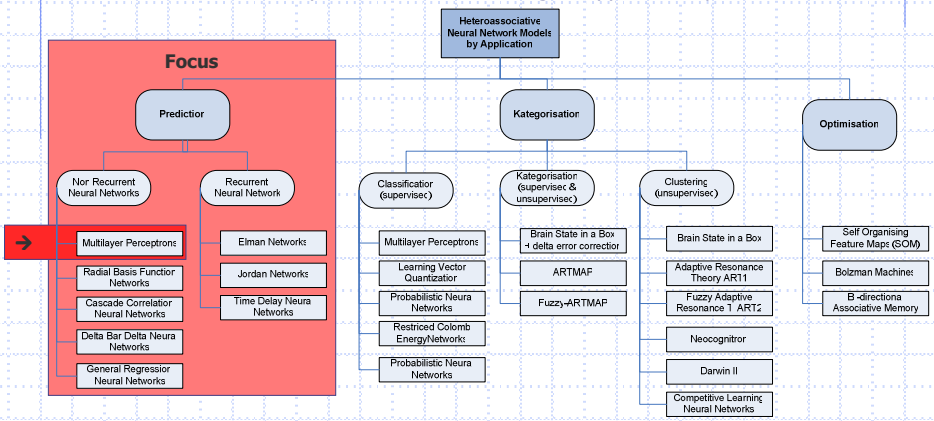
→ not all NN recommendations are useful for your DOMAIN!





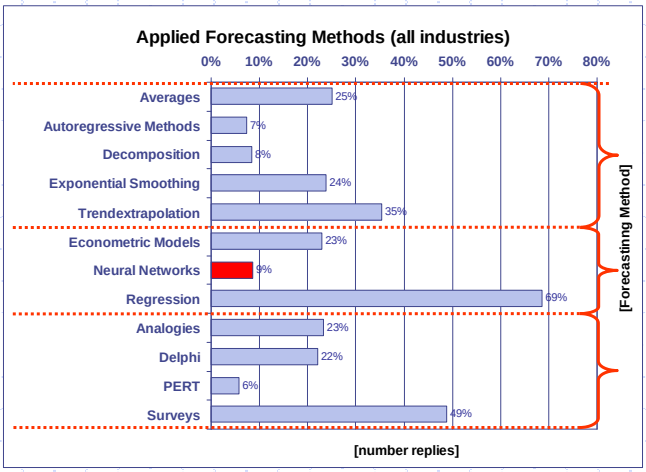
Different model classes of Neural Networks

- Since 1960s a variety of NN were developed for different tasks
  - → Classification ≠ Optimization ≠ Forecasting → Application Specific Models



- Different CLASSES of Neural Networks for Forecasting alone!
  - → Focus only on original Multilayer Perceptrons!

IBF Benchmark– Forecasting Methods used



Time Series methods (objective) → 61%

Causal Methods (objective) → 23%

Judgemental Methods (subjective) → 2x%

→ Survey 5 IBF conferences in 2001
- 240 forecasters, 13 industries

→NN are applied in coroporate Demand Planning / S&OP processes!

[Warning: limited sample size]

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Motivation for using NN ... BIOLOGY!

- Human & other nervous systems (animals, insects → e.g. bats)
  - Ability of various complex functions: perception, motor control, pattern recognition, classification, prediction etc.
  - Speed: e.g. detect & recognize changed face in crowd=100-200ms
  - Efficiency etc.

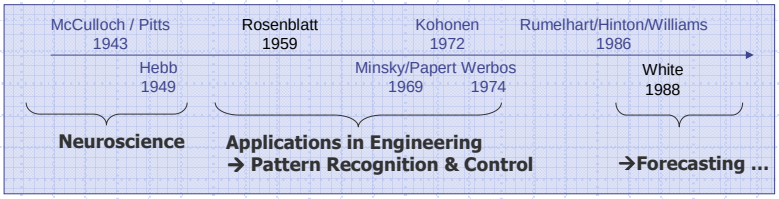
→ brains are the most efficient & complex computer known to date

	Human Brain	Computer (PCs)
Processing Speed	10^{-3}ms (0.25 MHz)	10^{-9}ms (2500 MHz PC)
Neurons/Transistors	10 billion & 10^3 billion conn.	50 million (PC chip)
Weight	1500 gr	kg to tons!
Energy consumptio	10^{-16} Joule	10^{-6} Joule
Computation: Vision	100 steps	billions of steps

→ Comparison: Human = 10.000.000.000 → ant 20.000 neurons

Brief History of Neural Networks

- History
  - Developed in interdisciplinary Research (McCulloch/Pitts1943)
  - Motivation from Functions of natural Neural Networks
    - neurobiological motivation
    - application-oriented motivation



  - Research field of Soft-Computing & Artificial Intelligence
    - Neuroscience, Mathematics, Physics, Statistics, Information Science, Engineering, Business Management
    - different VOCABULARY: statistics versus neurophysiology !!!

Dictionary for Neural Network Terminology

- Due to ist neuro-biological origins, NN use specific terminology

Neural Networks	Statistics
Input Nodes	Independent / lagged Variables
Output Node(s)	Dependent variable(s)
Training	Parameterization
Weights	Parameters
…	…

→ don't be confused: ASK!

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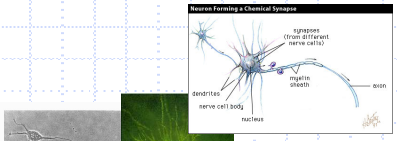
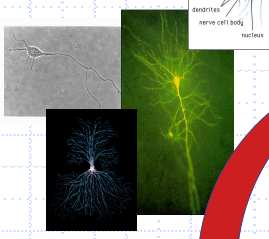
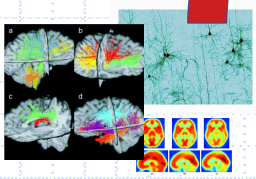
Motivation & Implementation of Neural Networks

- From biological neural networks … to artificial neural networks





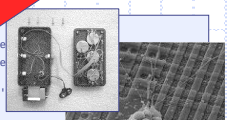


Mathematics as abstract representations of reality

→ use in software simulators, hardware, engineering etc.

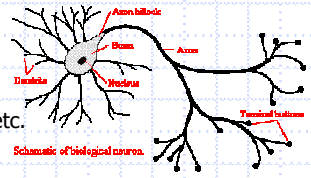
$$o_i = \tanh\left(\sum_j w_{ji} o_j - \theta_i\right)$$

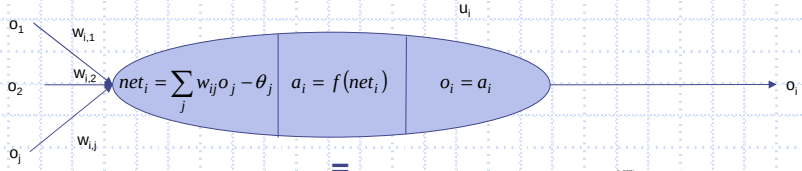
```
neural_net = eval(net_name);
[num_rows, ins] = size(neural_ne
[outs,num_cols] = size(neural_ne
neural_net.numLayers-1});
if (strcmp(neural_net.adaptFcn,'
net_type = 'RBF';
else net_type = 'MLP';
end

fid = fopen(path,'w');
```



Information Processing in Nodes (Neurons)

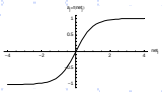
- **Modelling of biological functions in Neurons**
  - 10-100 Billion Neurons with 10000 connections in Brain
  - Input (sensory), Processing (internal) & Output (motoric) Neurons
- **CONCEPT of Information Processing in Neurons**
  - Input Function (Summation of previous signals)
  - Activation Function (nonlinear)
    - binary step function {0;1}
    - sigmoid function: logistic, hyperbolic tangent etc.
  - Output Function (linear / Identity, SoftMax …)





=

$$o_i = \tanh\left(\sum_j w_{ji} o_j - \theta_i\right)$$ with **tanh:**

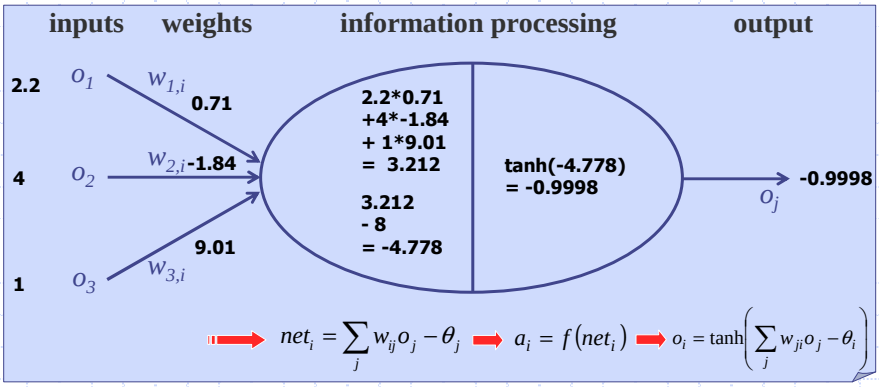


Information Processing: Node Threshold logic

Node Function → THRESHOLD LOGIC

1. weight individual input by connection strength
2. sum weighted inputs
3. add bias term
4. calculate output of node through transfer function [BINARY of SIGMOID!]

➲ RERUN with next input pattern…



$$net_i = \sum_j w_{ij} o_j - \theta_j \Rightarrow a_i = f(net_i) \Rightarrow o_i = \tanh\left(\sum_j w_{ji} o_j - \theta_i\right)$$

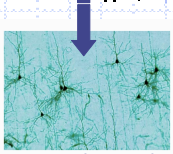
Architecture of Multilayer Perceptrons

- **Architecture of a Multilayer Perceptron**

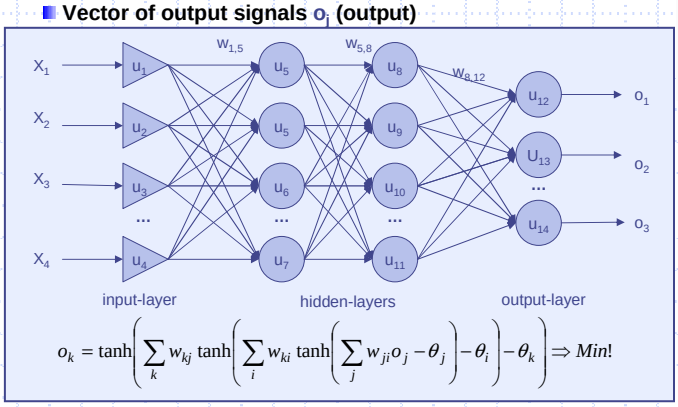
→ Classic form of feed forward neural network!

- **Neurons u_n (units / nodes) ordered in Layers**
- **unidirectional connections with trainable weights $w_{n,n}$**
- **Vector of input signals x_i (input)**
- **Vector of output signals o_i (output)**

Combination of neurons



= neural network



$$o_k = \tanh\left(\sum_k w_{kj} \tanh\left(\sum_i w_{ki} \tanh\left(\sum_j w_{ji} o_j - \theta_j\right) - \theta_i\right) - \theta_k\right) \Rightarrow Min!$$

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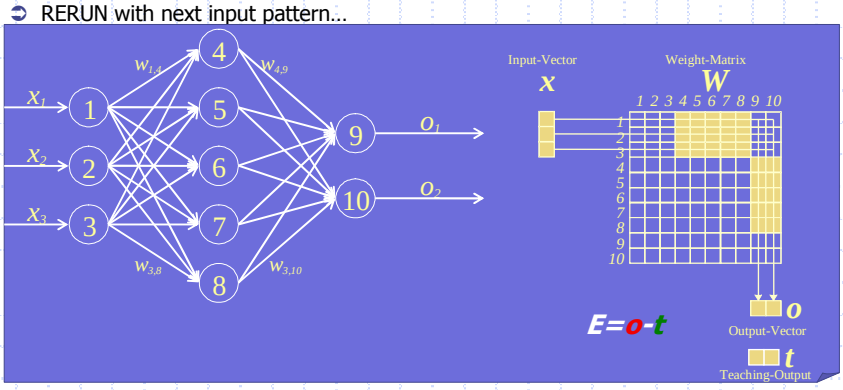
Neural Network Training with Back-Propagation

Training → LEARNING FROM EXAMPLES

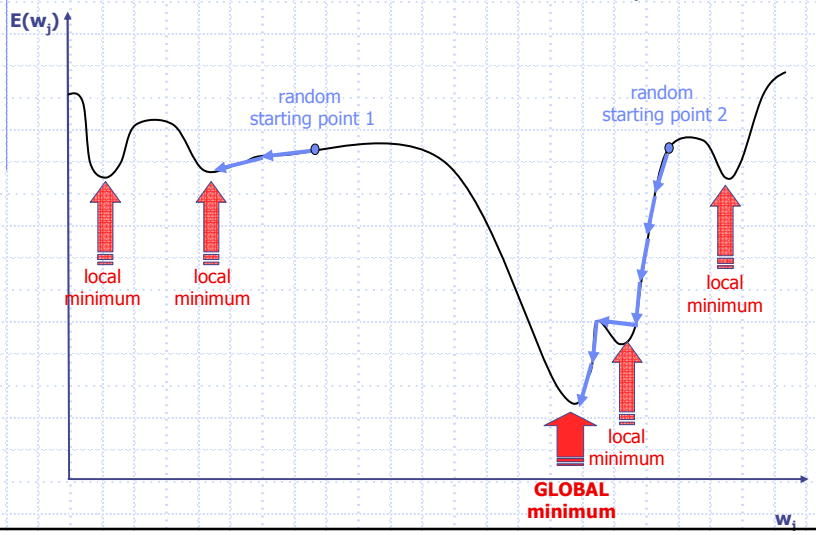
1. Initialize connections with randomized weights (symmetry breaking)
2. Show first Input-Pattern (independent Variables) (demo only for 1 node!)
3. Forward-Propagation of input values unto output layer
4. Calculate error between NN output & actual value (using error / objective function)
5. Backward-Propagation of errors for each weight unto input layer

➲ RERUN with next input pattern…



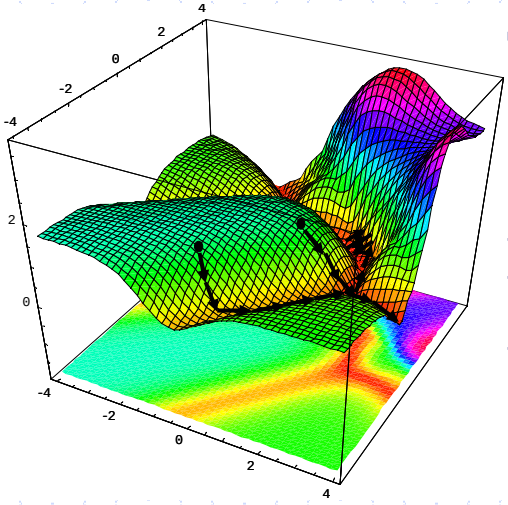
Neural Network Training = Error Minimization

- Minimize Error through changing ONE weight w_j



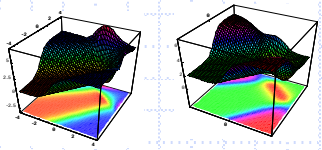
Error Backpropagation = 3D+ Gradient Decent

- Local search on multi-dimensional error surface



- task of finding the deepest valley in mountains
  - local search
  - stepsize fixed
  - follow steepest decent

→local optimum = any valley
→global optimum = deepest valley with lowest error
→varies with error surface



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1. Introduction to Neural Networks
2. Application of Neural Networks to Business Forecasting
   a. Neural Networks for Time Series Prediction
   b. Neural Networks for Intervention / Event Time Series Prediction
   c. Neural Networks for Multiple Nonlinear Regression
   d. Comparison of NN to other Forecasting Methods
3. Hands-on exercises in Neural Networks forecasting
4. Tips & Tricks for Improving Neural Networks based forecasts
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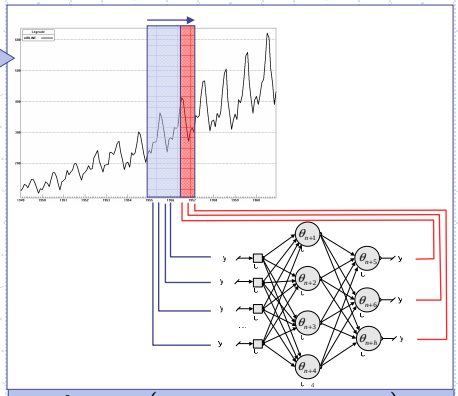
Time Series Prediction with Artificial Neural Networks

- ANN are universal approximators [Hornik/Stichcomb/White92 etc.]
  - Forecasts as application of (nonlinear) function-approximation
  - various architectures for prediction (time-series, causal, combined...)

$$\hat{y}_{t+h} = f(x_t) + \varepsilon_{t+h}$$

y_{t+h} = forecast for $t+h$
$f(\cdot)$ = linear / non-linear function
x_t = vector of observations in t
e_{t+h} = independent error term in $t+h$



$$\hat{y}_{t+1} = f(y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-n-1})$$
Non-linear autoregressive AR(p)-model

- train multilayer perceptrons
  - model "best" architecture → many heuristics!
  - present data & train
  - minimize objective function

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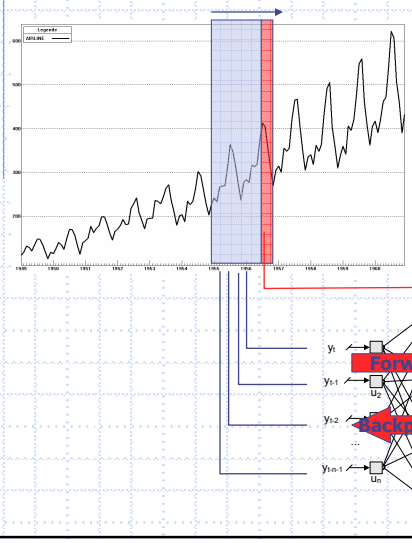
Neural Network Training on Time Series

- Sliding Window Approach of presenting Data



Input
Present new data pattern to Neural Network

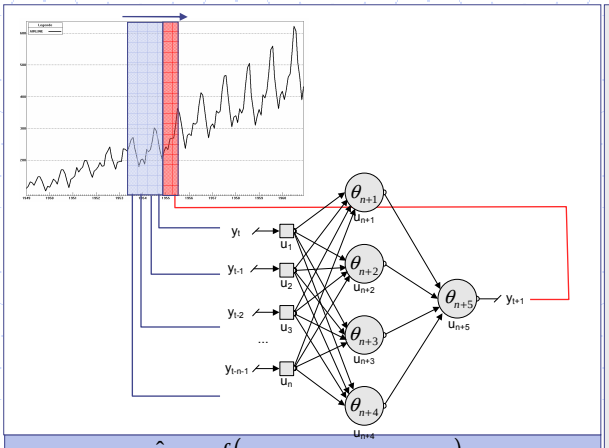
Calculate
Neural Network Output from Input values

Compare
Neural Network Forecast agains <> actual value

Backpropagation
Change weights to reduce output forecast error

New Data Input
Slide window forward to show next pattern

Neural Network Architectures for Forecasting - Single Nonlinear Autoregression



$$\hat{y}_{t+1} = f\left(y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-n-1}\right)$$

$$\hat{y}_{t+1} = \tanh\left(\sum_k w_{kj} \tanh\left(\sum_i w_{ki} \tanh\left(\sum_j w_{ji} y_{t-j} - \theta_j\right) - \theta_i\right) - \theta_k\right)$$

Single nonlinear autoregressive AR(p)-model

→ Interpretation

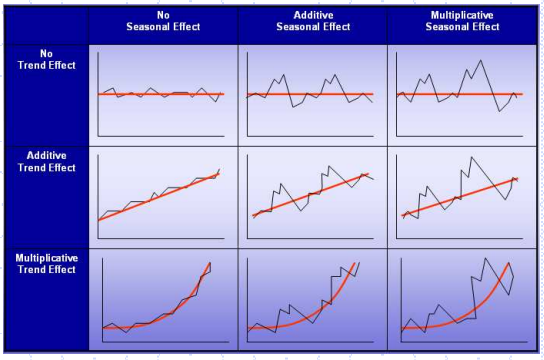
- **Autoregressive modeling AR(p)-approach WITHOUT the moving average terms of errors ≠ nonlinear ARIMA**
- **Similar problems / shortcomings as standard AR-models!**

→ Extensions

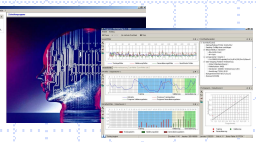
- **multiple output nodes = simultaneous auto-regression models**

Time Series Prediction with Artificial Neural Networks

- Which time series patterns can ANNs learn & extrapolate?
  [Pegels69/Gardner85]



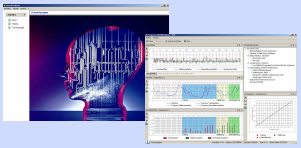
- ... ???



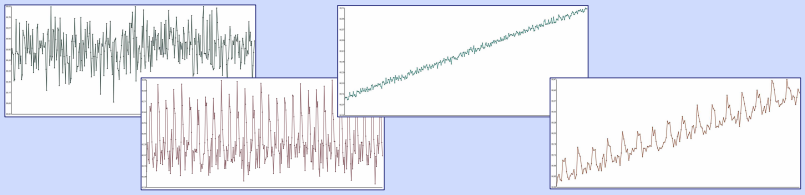
→ Simulation of Neural Network prediction of Artificial Time Series

Time Series Demonstration – Artificial Time Series

- Simualtion of NN in Business Forecasting with NeuroPredictor

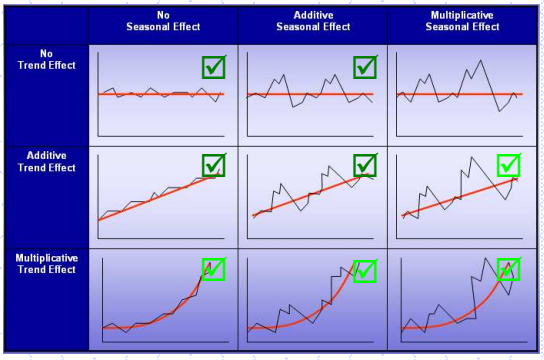


- Experiment: Prediction of Artificial Time Series (gaussian noise)
  - Stationary Time Series
  - Seasonal Time Series
  - linear Trend Time Series
  - Trend with additive Seasonality Time Series



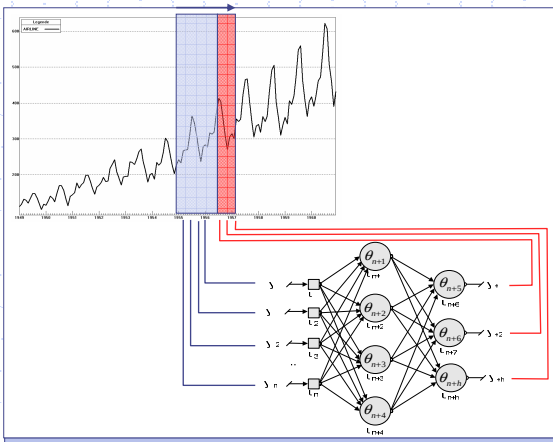
Time Series Prediction with Artificial Neural Networks

- Which time series patterns can ANNs learn & extrapolate?
  [Pegels69/Gardner85]



→ **Neural Networks can forecast ALL mayor time series patterns**
  - → NO time series dependent preprocessing / integration necessary
  - → NO time series dependent MODEL SELECTION required!!!
  - → **SINGLE MODEL APPROACH FEASIBLE!**

Neural Network Architectures for Forecasting - Single Nonlinear Autoregression – Multiple Step Ahead



$$\hat{y}_{t+1}, \hat{y}_{t+2}, \ldots, \hat{y}_{t+n} = f\left(y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-n-1}\right)$$

Single nonlinear autoregressive AR(p)-model

→ Interpretation

- **As single Autoregressive modeling AR(p)**

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   b. Neural Networks for Intervention / Event Time Series Prediction
   c. Neural Networks for Multiple Nonlinear Regression
   d. Comparison of NN to other Forecasting Methods
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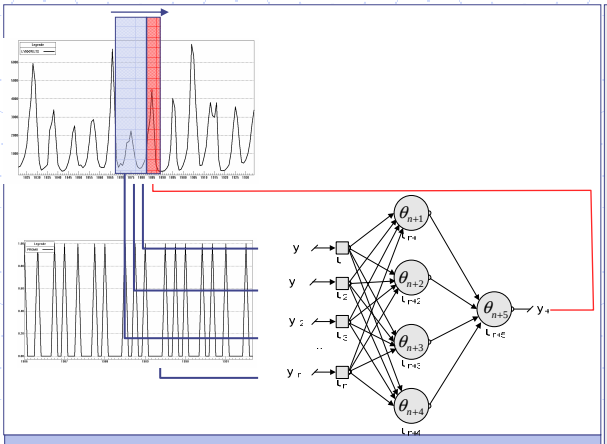
4. Tips & Tricks for Improving Neural Networks based forecasts
5. Questions & Answers and Discussion

Neural Network Architectures for Forecasting - Nonlinear Autoregression Intervention Model



$$\hat{y}_{t+1}, \hat{y}_{t+2}, \ldots, \hat{y}_{t+n} = f\left(y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-n-1}\right)$$

Single nonlinear autoregressive AR(p)-model

→ Interpretation

- As single Autoregressive modeling AR(p)
- Additional Event term to explain external events

→ Extensions

- multiple output nodes = simultaneous multiple regression

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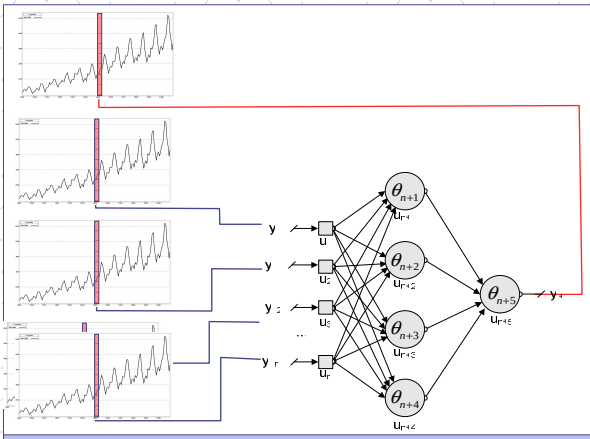
Neural Network Architectures for Forecasting - Multiple nonlinear Multiple Regression



$$\hat{y} = f(x_1, x_2, x_3, ..., x_n)$$

$$\hat{y} = x_1 w_{1j} + x_{2t} w_{2j} + x_{3t} w_{3j} + ... + x_n w_{nj} - \theta_j$$

Nonlinear Regression Model

→ Interpretation

- **Similar to linear Multiple Regression Modeling**

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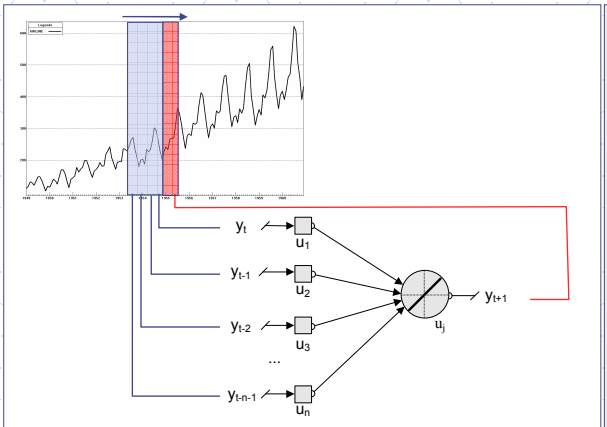
Neural Network Architectures for Forecasting - Linear Autoregression



$$\hat{y}_{t+1} = f(y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-n-1})$$

$$\hat{y}_{t+1} = y_t w_{tj} + y_{t-1} w_{t-1\,j} + y_{t-2} w_{t-2\,j} + \ldots + y_{t-n-1} w_{t-n-1\,j} - \theta_j$$

linear autoregressive AR(p)-model

→ Interpretation

- weights represent autoregressive terms
- Same problems / shortcomings as standard AR-models!

→ Extensions

- multiple output nodes = simultaneous auto-regression models
- Non-linearity through different activation function in output node

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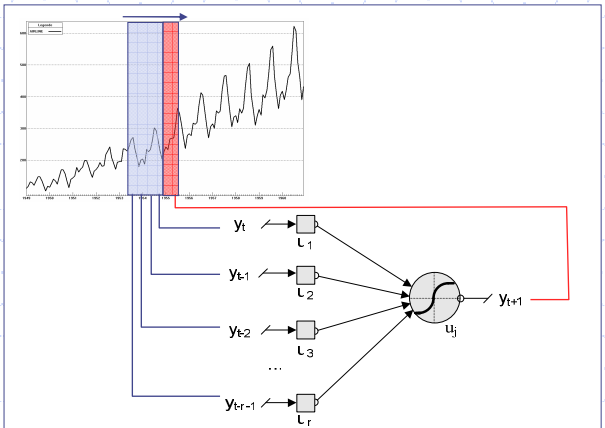
Neural Network Architectures for Forecasting - Nonlinear Autoregression (similar to Logistic Regression)



$$\hat{y}_{t+1} = f(y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-n-1})$$

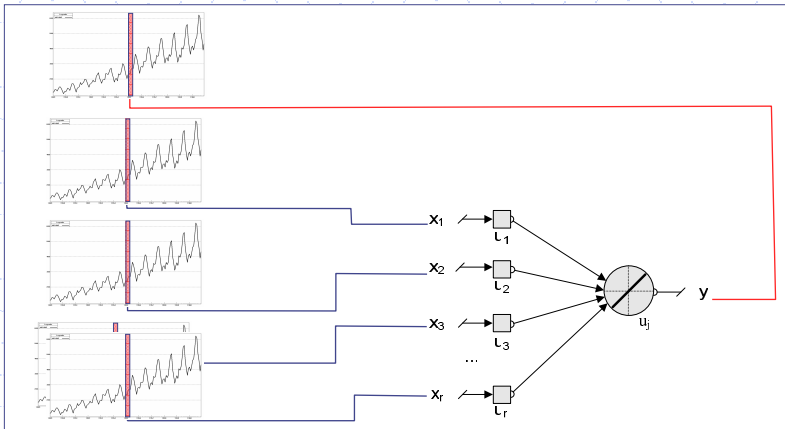
$$\hat{y}_{t+1} = \tanh\left(\sum_{i=t}^{t-n-1} y_i w_{ij} - \theta_j\right)$$

non-linear autoregressive AR(p)-model

→ Extensions

- additional layers with nonlinear nodes
- linear activation function in output layer

Neural Network Architectures for Forecasting - Linear Multiple Regression



$$\hat{y} = f(x_1, x_2, x_3, ..., x_n)$$

$$\hat{y} = x_1 w_{1j} + x_{2t} w_{2j} + x_{3t} w_{3j} + ... + x_n w_{nj} - \theta_j$$

Linear Regression Model

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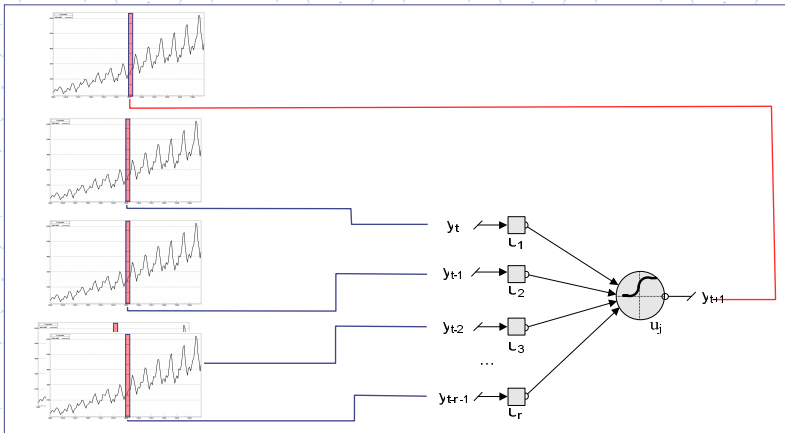
Neural Network Architectures for Forecasting - Non-Linear Multiple Regression



$$\hat{y}_{t+1} = f(y_t, y_{t-1}, y_{t-2}, ..., y_{t-n-1})$$

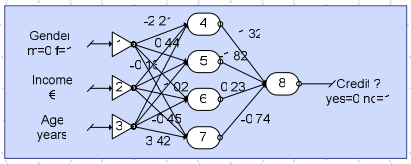
$$\hat{y}_{t+1} = \log\left(\sum_{i=t}^{t-n-1} y_i w_{ij} - \theta_j\right)$$

Nonlinear Multiple (Logistic) Regression Model

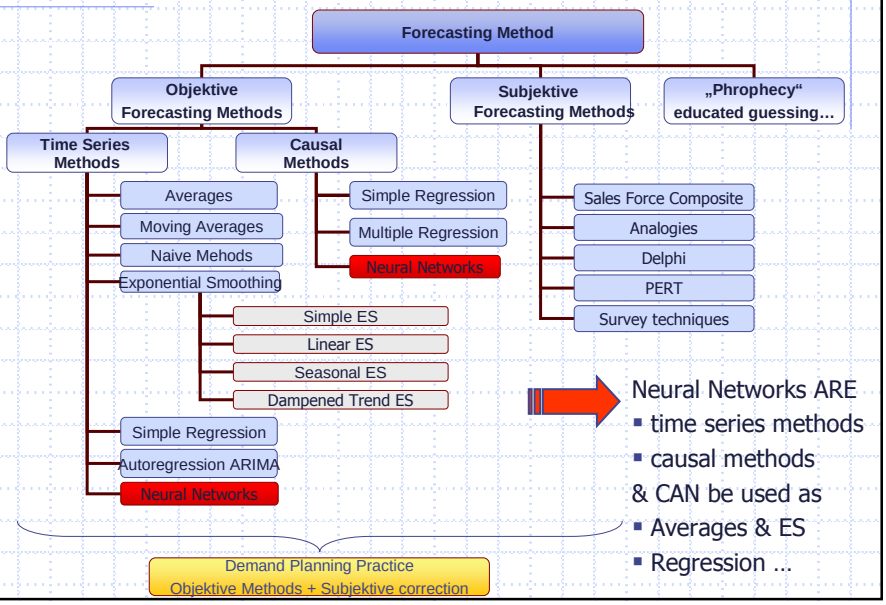
Modelling Flexibility in Neural Networks

- Flexibility on Input Variables → flexible coding
  - binary scale [0;1]; [-1,1]
  - nominal / ordinal scale (0,1,2,…,10 → binary coded [0001,0010,…]
  - metric sclae (0.235; …)
- Flexibility on Output Variables
  - binary → prediction of single class membership
  - nominal / ordinal → prediction of multiple class memberships
  - metric → regression (point predictions) OR probability of class membership!
- Number of Input Variables
  - …
- Number of Output Variables
  - …

→ One SINGLE network architecture → MANY applications



Classification of Neural Networks as Method



Neural Networks ARE
- time series methods
- causal methods

& CAN be used as
- Averages & ES
- Regression …

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Business Forecasting with Artificial Neural Networks

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   b. Experiment B: Time Series Intervention Modelling
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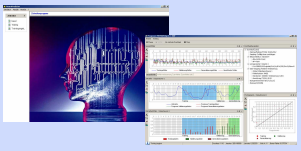
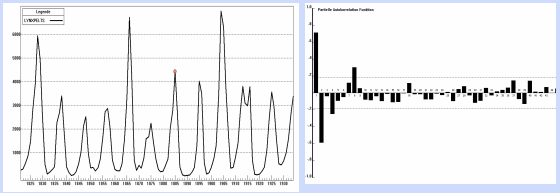
Time Series Demonstration A - Lynx Trappings

- Simualtion of NN in Business Forecasting with NeuroPredictor



- Experiment: Lynx Trappings at the McKenzie River
  - 3 layered NN: (12-8-1) 12 Input units - 8 hidden units – 1 output unit
  - Different lag structures: t, t-1, …, t-11 (past 12 observations
  - t+1 forecast → single step ahead forecast

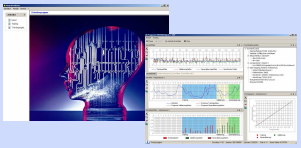


→ **Benchmark Time Series**
[Andrews / Hertzberg]

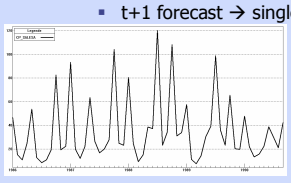
- **114 observations**
- **Periodicity? 8 years?**

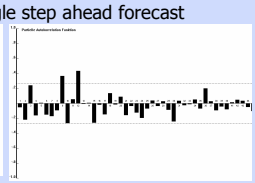
Time Series Demonstration B – Event Model

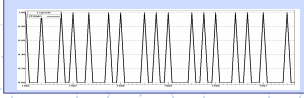
- Simualtion of NN in Business Forecasting with NeuroPredictor



- Experiment: Mouthwash Sales
  - 3 layered NN: (12-8-1) 12 Input units - 8 hidden units – 1 output unit
  - 12 input lags t, t-1, …, t-11 (past 12 observations) → time series prediction
  - t+1 forecast → single step ahead forecast







→ **Spurious Autocorrelations from Marketing Events**
- **Advertisement with small Lift**
- **Price-reductions with high Lift**

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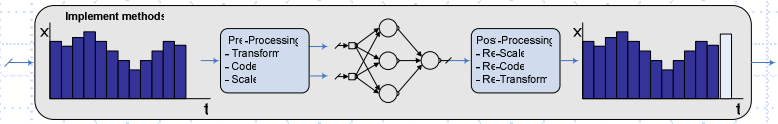
Decisions in Neural Network Modelling

NN Modelling Process

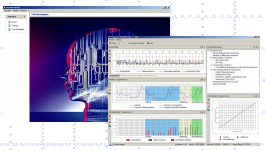
- Data Pre-processing
  - Scaling
  - Normalizing to [0;1] or [-1;1]
- Modelling of NN architecture
  - Number of INPUT nodes
  - Number of HIDDEN nodes
  - Number of HIDDEN LAYERS
  - Number of OUTPUT nodes
  - Information processing in Nodes (Act. Functions)
  - Interonnection of Nodes
- Training
  - Initializing of weights (how often?)
  - Training method (backprop, higher order …)
  - Training parameters
  - Evaluation of best model (early stopping)
- Application of Neural Network Model
- Evaluation
  - Evaluation criteria & selected dataset

manual
Decisions recquire
Expert-Knowledge



Tip & Tricks in Data Pre-Processing

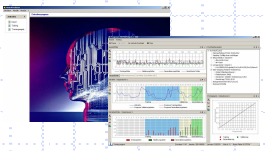
- Do's and Don'ts
  - Outlier correction? YES!
  - De-Seasonalisation? NO!
  - De-Trending / Integration? NO / depends / preprocessing!
  - Normalisation? Not necessarily → correct outliers!
  - Scaling Intervals [0;1] or [-1;1]? Both OK!
  - Apply headroom in Scaling? YES!
  - Interaction between scaling & preprocessing? limited
  - …



→ **Simulation Experiments**

Outlier correction in Neural Network Forecasts?

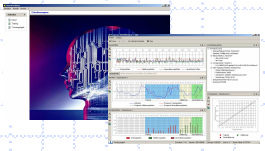
- Neural networks are often characterized as
  - Fault tolerant and robust
  - Showing graceful degradation regarding errors
  - → Fault tolerance = outlier resistance in time series prediction?



→ **Simulation Experiments**

Tip & Tricks in Architecture Modelling

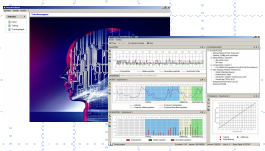
- Do's and Don'ts
  - Number of input nodes? DEPENDS! → use linear AC/PAC to start!
  - Number of hidden nodes? DEPENDS! → evaluate each time (few)
  - Number of output nodes? DEPENDS on application!
  - fully or sparsely connected networks? ???
  - shortcut connections? ???
  - activation functions → logistic or hyperbolic tangent? TanH !!!
  - activation function in the output layer? TanH or Identity!
  - ...



→ **Simulation Experiments**

Tip & Tricks in Network Training & Selection

- Do's and Don'ts
  - Selection of Model with lowest Validation error? NOT VALID!
  - Model & forecasting competition? Always multiple origin etc.!
  - ...
  - Selection of Training Algorithm? Backprop OK, DBD OK ...
  - Parameterisation of Training Algorithm? DEPENDS on dataset!
  - Use of early stopping? YES – carefull with stopping criteria!
  - ...



→ **Simulation Experiments**

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Software Simulators for Neural Networks

Commercial Software by Price

- High End
  - Neural Works Professional
  - SPSS Clementine
  - SAS Enterprise Miner
- Midprice
  - Alyuda NeuroSolutions
  - NeuroShell Predictor
  - NeuroSolutions
  - NeuralPower
  - PredictorPro
- Research
  - Mathlab Library
  - R-package
  - NeuroLab
- ...

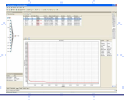
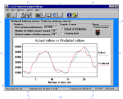
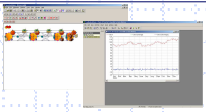
Public Domain Software

- Research oriented
  - SNNS
  - JNNS JavaSNNS
  - JOONE
  - ...

→ **FREE** CD-ROM for evaluation
- Data from Experiments
  - M3-competition
  - airline-data
  - lynx-data
  - beer-data
- Software Simulators

→ **Consider Tashman/Hoover Tables on forecasting Software for more details**

Neural Networks Software - Times Series friendly!

Alyuda Inc.	ALYUDA NEUROSIGNAL XL, ALYUDA FORECASTER XL, ALYUDA NEUROINTELLIGENCE, ALYUDA FORECASTER, Tradecision	
Ward Systems  "Let your systems learn the wisdom of age and experience"	AITrilogy: NeuroShell Predictor, NeuroShell Classifier, GeneHunter NeuroShell 2, NeuroShell Trader, Pro,DayTrader	
Attrasoft Inc.	Predictor Predictor PRO	
Promised Land PROMISED LAND TECHNOLOGIES, INC.	Braincell	
Neural Planner Inc.	Easy NN Easy NN Plus	
NeuroDimension	NeuroSolutions Cosunsultant Neurosolutions for Excel NeuroSolutions for Mathlab Trading Solutions	

Neural networks Software – General Applications

Neuralware Inc	Neural Works Professional II Plus	
SPSS	SPSS Clementine DataMining Suite	
SAS	SAS Enterprise Miner	
...	...	

Further Information

- **Literature & websites**
  - NN Forecasting website www.neural-forecasting.com or www.bis-lab.com
  - Google web-resources, SAS NN newsgroup FAQ ftp://ftp.sas.com/pub/neural/FAQ.html
  - BUY A BOOK!!! Only one? Get: Reeds & Marks 'Neural Smithing'

- **Journals**
  - Forecasting … rather than technical Neural Networks literature!
    - JBF – Journal of Business Forecasting
    - IJF – International Journal of Forecasting
    - JoF – Journal of Forecasting

- **Contact to Practitioners & Researchers**
  - Associations
    - IEEE NNS – IEEE Neural Network Society
    - INNS & ENNS – International & European Neural Network Society
  - Conferences
    - Neural Nets: IJCNN, ICANN & ICONIP by associations (search google …)
    - Forecasting: IBF & ISF conferences!
  - Newsgroups news.comp.ai.nn
  - Call Experts you know … me ;-)

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4. Tips & Tricks for Improving Neural Networks based forecasts

a. Questions & Answers and Discussion
   a. Advantages & Disadvantages of Neural Networks
   b. Discussion

Advantages ... versus Disadvantages!

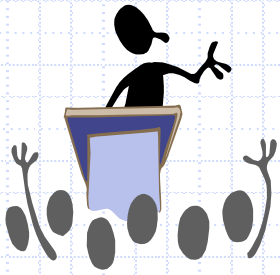
Advantages

- ANN can forecast any time series pattern (t+1!)
  - without preprocessing
  - no model selection needed!
- ANN offer many degrees of freedom in modeling
  - Freedom in forecasting with one single model
  - Complete Model Repository
    - linear models
    - nonlinear models
    - Autoregression models
    - single & multiple regres.
    - Multiple step ahead
    - ...

Disadvantages

- ANN can forecast any time series pattern (t+1!)
  - without preprocessing
  - no model selection needed!
- ANN offer many degrees of freedom in modeling
  - Experience essential!
  - Research not consistent
- explanation & interpretation of ANN weights IMPOSSIBLE (nonlinear combination!)
  - impact of events not directly deductible

Questions, Answers & Comments?



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Summary
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- ANN offer many degrees of freedom in modeling
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  - Research not consistent

What we can offer you:
- NN research projects with complimentary support!
- Support through MBA master thesis in mutual projects

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