Statistical Arbitrage using Artificial Neural Networks

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Outline

Establishing relationship between stock prices

- **'One of the major problems faced in modelling financial market movements is the fact that information comes in from a very large number of sources,...'**
- All news impacts are captured by their influence on the other stocks
- Under the assumption that all company specific news cancel each other out in the long run, we have developed a response relationship amongst the components.

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Should Time Series Econometric be used?

- Time Series Forecasting attempts to model a non linear relationship via a recurrence relation derived from past values. This is unacceptable since such a relationship is not exploitable towards an efficient trading strategy.
- Any non-parametric regression is likely to fail owing to the complexity related to forecasting stock price movement.
- Previous work on Time Series forecasting has failed in development of profitable strategies over long run.
- Mainly as a consequence of close to random-walk behavior of the stock time series, non-parametric techniques have failed and in this paper we have resorted to neural networks.

Advantages of using Neural Networks

- **Non-parametric** data specific regression can be developed here.
- Detecting multi-dimensional **non-linear connections** in data.
- Ability to find patterns and irregularities, and consequently **train** based on data.
- **Recent success of neural networks to stock price prediction.**

Disadvantages of Neural Network

- Currently there does not exist any widely accepted procedure for determining the network architecture in a given application.
- Traditional techniques of statistical inference, such as significance tests cannot be applied to the network model because of the nesting of layers.
- Comprehension of the model if not feasible owing to the nesting and use of complex transfer functions.
- Black-Box : The system basically acts as a black box with little relevance to economic theory.

Outline

Why is the inputs chosen at time 't'

- Why is input chosen at time 't':
  1. Disadvantages of input data at time ¡ t
  2. Disadvantages of oscillators, moving averages and other indicators
- **YAHOO!**
- **UNITECH**

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- **YAHOO!**
  1. Prediction of price of Yahoo![YHOO] based on `intraday data` [1st October '04].
  2. Input vector - Members of HHH (Internet Holdrs). 8 other tech company intraday trade data.
  3. Why this combination - Since only freely available intra-day data.
  4. Data - **Creation of input vectors.**
  5. Total 155052 input data vectors.
- **UNITECH**

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- **UNITECH**
  1. Prediction of price of Unitech from the Contracting and Construction industry.
  2. Input data - Other companies from Contracting and Construction industry in India, with net worth ¿ 2000 Cr. as of Nov 04 2008.[7 companies besides Unitech]
  3. Data - Start of day and end of day data used to derive two price vectors.
  4. Total 640 input vectors.[24th July'07-4th Nov '08].

What is the trading strategy employed?

Analogous to ETF arbitrage

As in ETF arbitrage, our strategy will be to short the 'expensive component' and go long on the 'cheaper stock'. Thus, if estimated price[by ANN] of YHOO is $>$ true price, we will short its constituent components at that point.

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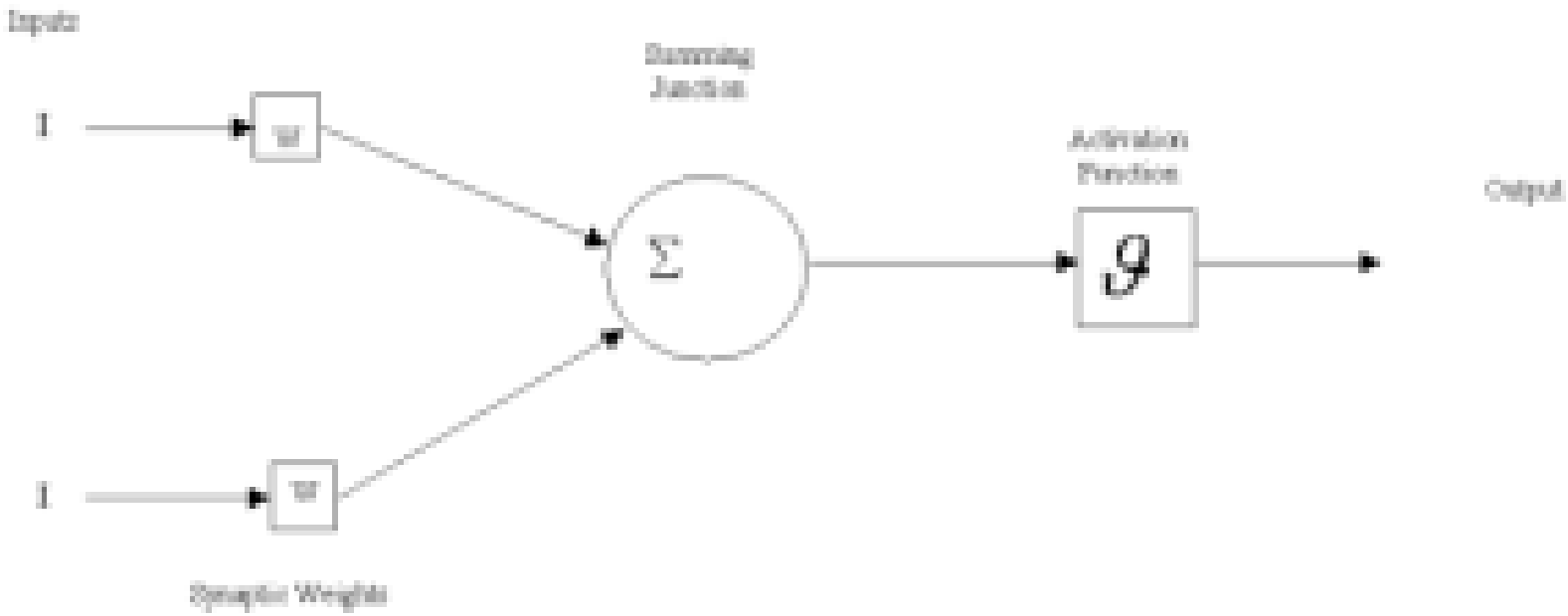
at that point $==$ At every point, we can linearly approximate the constiutents `locally`. Thus, this strategy is a case of *statistical arbitrage*, not pure arbitrage.

Outline

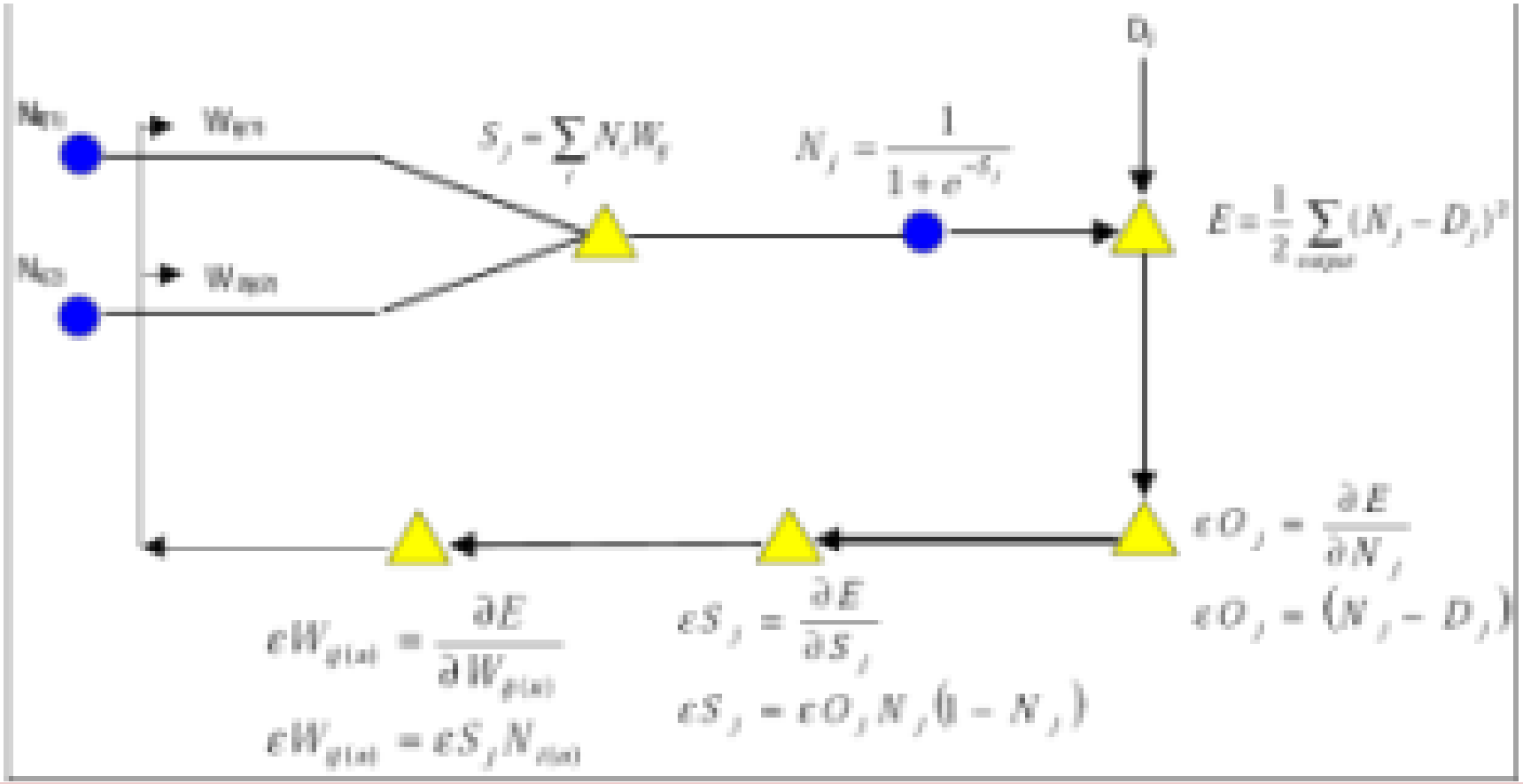
Neuron


Inputs
I
I
w
w
Summing Junction
Σ
Activation Function
g
Output
Synaptic Weights

Neural Network basics

- A neural network has different *input nodes*, which are assigned different weights. *Transfer function* and *activation functions*, along with hidden nodes help compute the output at the *output node*.
- Initially the weights and the activation constant are chosen at random. Thus, the value of the output does not match with experimental data.
- *Training the data* : The weights are systematically changed until a best–fit description of the output is obtained as a function of the inputs.

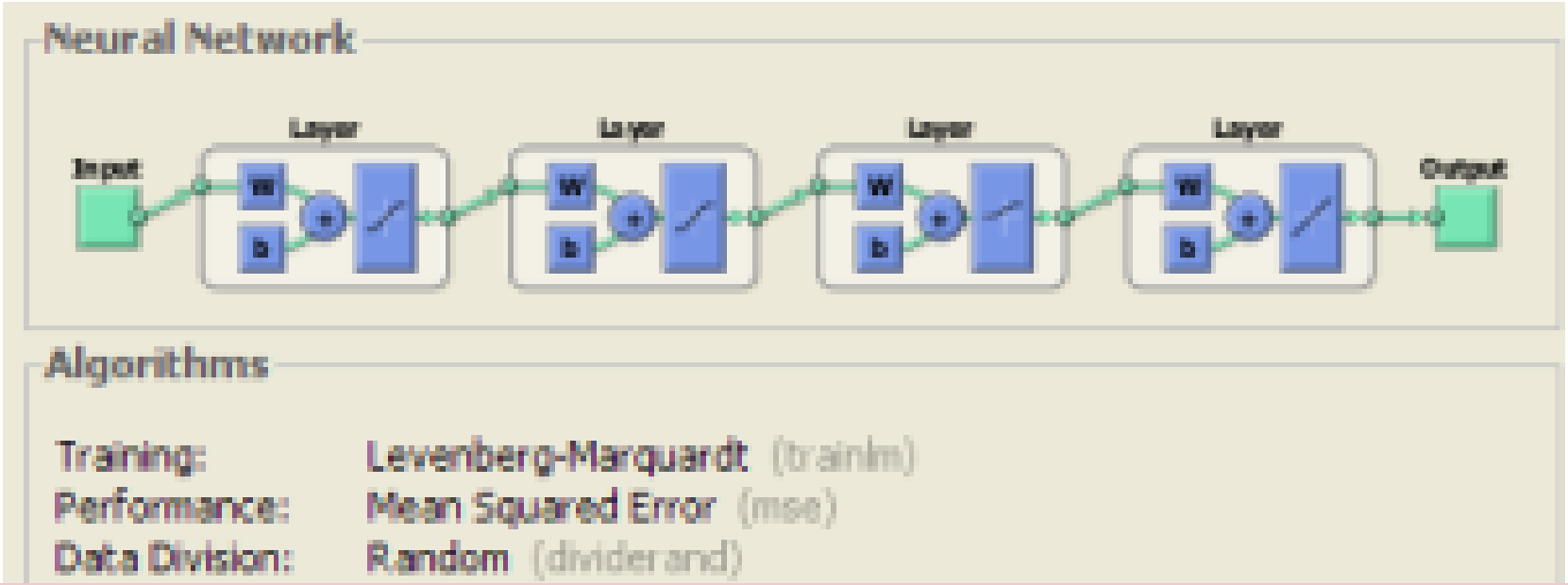
Backpropogation



Yahoo! Back Propogation Neural Network

Three hidden layers:

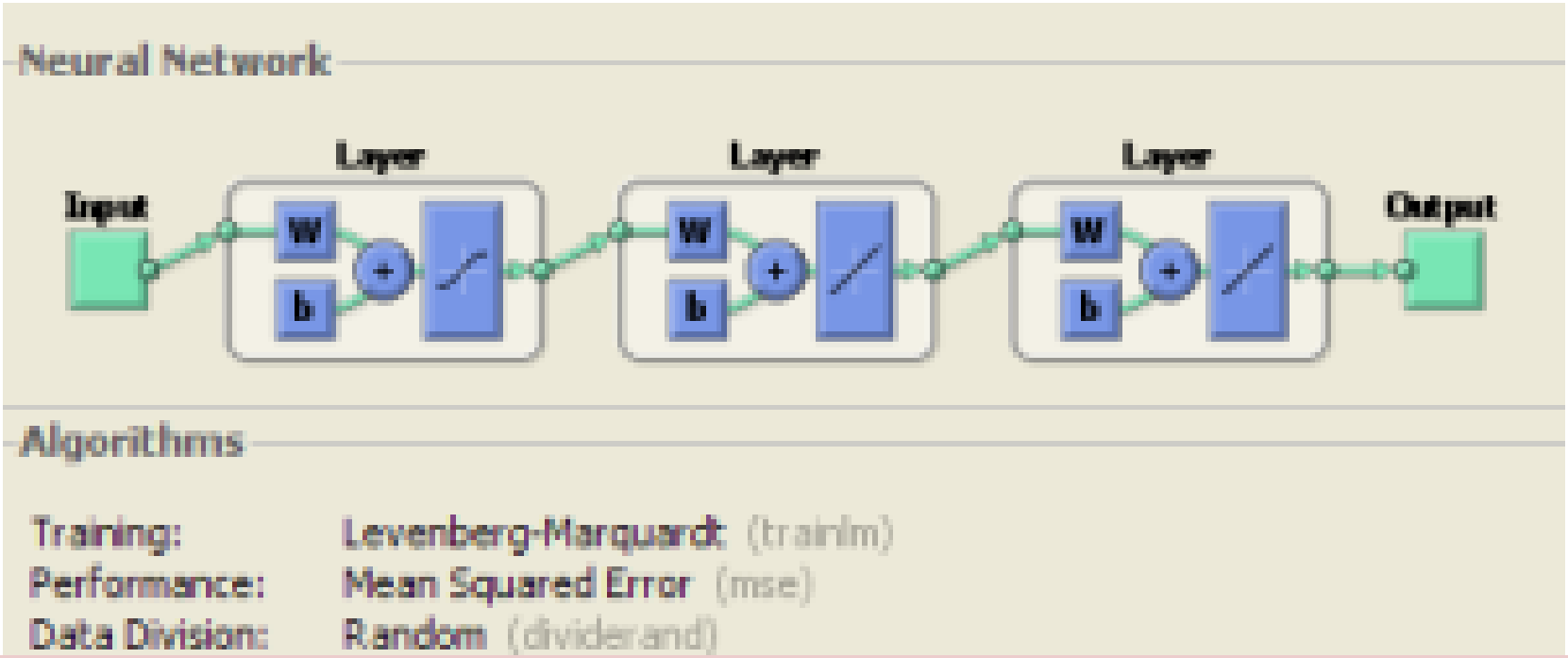
1. First: Neurons = 7, Transfer Function = tansig
2. Second: Neurons = 5, Transfer Function = tansig
3. Third: Neurons = 5, Transfer Function = logsig



Unitech Back Propogation Neural Network

Three hidden layers:

1. First: Neurons = 7, Transfer Function = tansig
2. Second: Neurons = 5, Transfer Function = purelin.



Software used to model Neural Network

- **MATLAB Neural Network Toolbox**, which has extensive capability in terms of creating and training different types of networks is the software likely to be used for the purpose.
- Entire code alongwith data set will be available online at http://home.iitk.ac.in/řamnik/eco311.html

Outline

Application of Neural Networks to Intra-day data of Yahoo!

- Very good fit to testing data. Over R = 0.98
- Even to testing data, the data was fit very nicely. There wasn't much divergence from true value (< 1 %)
- Feasible to trade on intra-day data.
- Yahoo data was not very volatile in nature.
- *Follows our hypothesis of convergence to ANN specified relationship*.
- Large number of vectors to learn from.

Application of Neural Networks to volatile end of day data.

- Very good fit to testing data. Over R = 98
- Over 200% divergence from true value. On inspection of Unitech prices, very volatile data.
- Drops of over 50% noticed in a day. ANN are unable to capture price movements accurately.
- *Does not satisfy our hypothesis of convergence to ANN specified relationship*
- Infeasible to trade with ANN on choppy end of day data. Maximum drawdown exceeds 200
- Very few data vectors to learn from.

Conclusion

- If *properly trained and in non-choppy data*, ANN are a powerful tool in estimation of fair price of a stock.
- Under the realistic assumption of convergence to ANN established relationship, we can deploy an statistically arbitrage strategy.
- In choppy, or highly volatile markets, ANN's can yield inaccurate results.
- A relationship linking the impact of macro-economic factors/news on a stock X with others in the sector would be established.

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Thank you

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