# Financial Trading Systems Using Artificial Neural Networks

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## INTRODUCTION

Soft computing represents that area of computing adapted from the physical sciences. Artificial intelligence techniques within this realm attempt to solve problems by applying physical laws and processes. This style of computing is particularly tolerant of imprecision and uncertainty, making the approach attractive to those researching within "noisy" realms, where the signal-to-noise ratio is quite low. Soft computing is normally accepted to include the three key areas of fuzzy logic, artificial neural networks, and probabilistic reasoning (which include genetic algorithms, chaos theory, etc.).

The arena of investment trading is one such field where there is an abundance of noisy data. It is in this area that traditional computing typically gives way to soft computing as the rigid conditions applied by traditional computing cannot be met. This is particularly evident where the same sets of input conditions may appear to invoke different outcomes, or there is an abundance of missing or poor quality data.

Artificial neural networks (henceforth ANNs) are a particularly promising branch on the tree of soft computing, as they possess the ability to determine non-linear relationships, and are particularly adept at dealing with noisy datasets.

From an investment point of view, ANNs are particularly attractive as they offer the possibility of achieving higher investment returns for two distinct reasons. Firstly, with the advent of cheaper computing power, many mathematical techniques have come to be in common use, effectively minimizing any advantage they had introduced (see Samuel & Malakkal, 1990). Secondly, in order to attempt to address the first issue, many techniques have become more complex. There is a real risk that the signal-to-noise ratio associated with such techniques may be becoming lower, particularly in the area of pattern recognition, as discussed by Blakey (2002).

Investment and financial trading is normally divided into two major disciplines: fundamental analysis and technical analysis. Articles concerned with applying ANNs to these two disciplines are reviewed.

## BACKGROUND

There are a number of approaches within the literatures, which deal with applying ANN techniques to investment and trading. Although there appears to be no formal segmentation of these different approaches, this review classifies the literature into the topics proposed by Tan (2001), and augments these classifications with one more category, namely, hybrid. These categories of ANN, then, are:

- **Time series:** Forecasting future data points using historical data sets. Research reviewed in this area generally attempts to predict the future values of some time series. Possible time series include Base time series data (e.g., closing prices), or time series derived from base data, (e.g., indicators--frequently used in technical analysis).
- **Pattern recognition and classification:** Attempts to classify observations into categories, generally by learning patterns in the data. Research reviewed in this area involved the detection of patterns, and segregation of base data into "winner" and "loser" categories as well as in financial distress and bankruptcy prediction.
- **Optimization:** Involves solving problems where patterns in the data are not known, often non-polynomial (NP)-complete problems. Research reviewed in this area covered the optimal selection of parameters, and determining the optimal point at which to enter transactions.
- **Hybrid:** This category was used to distinguish research, which attempted to exploit the synergy effect by combining more than one of the previous styles.

There appears to be a wide acceptance of the benefit of the synergy effect, whereby the whole is seen as being greater than the sum of the individual parts.

Further, the bias in this style of research toward technical analysis techniques is also evident from the table, with one-third of the research pursuing the area of pattern recognition and classification. Technical analysis particularly lends itself to this style of research, as a large focus of technical analysis concerns the detection of patterns in data, and the examination of the behavior of market participants when these patterns are manifest.

## USING NEURAL NETWORKS TO DEVELOP TRADING SYSTEMS

This section briefly considers the characteristics of each of the four main categories previously described. The selected articles were chosen as they are either representative of current research directions, represent an important change in direction for this style of research, or represent a novel approach.

### Research into Time Series Prediction

The area of time series predictions is normally focused on attempting to predict the future values of a time series in one of two primary ways, either:

- Predicting future values of a series from the past values of that same series
- Predicting future values of a series using data from different series

Typically, current research in this area focuses on predicting returns, or some variable thought to correlate with returns (e.g., earnings). Some researchers focus on attempting to predict future direction of a series (e.g., increasing from last known value, decreasing from last known value, no change). Research of this nature is essentially a classification problem, and is discussed in that section.

The following articles were selected and reviewed as they are representative of the current research in Time Series Prediction (Austin et al., 1997; Chan & Foo, 1995; Falas et al., 1994; Hobbs & Bourbakis, 1995; Quah & Srinivasan, 2000, Wang et al., 2003; Yao & Poh, 1995). The articles reviewed consider both fundamental and technical data. For example, Falas et al. (1994) used ANNs to attempt to predict future earnings based on reported accounting variables. They found no significant benefit using ANNs compared to the logit model and concluded that the accounting variables chosen were not appropriate earnings predictors. This conclusion represents one of the major problems encountered when working with ANNs, namely, their non-existent explanatory capability. It is not unusual to find conclusions of this type when reviewing ANN research with non-correlation often being reported as wrongly chosen input variables. Quah et al. (2000) use mainly accounting variables to predict excess returns (with limited success). Chan et al. (1995) use ANNs to predict future time series values of stock prices, and use these "future" values to compute a variety of technical indicators. The ANN produced showed particularly promising results, the authors conclude that the networks ability to predict allows the trader to enter a trade a day or two before it is signalled by regular technical indicators, and that this accounts for the substantially increased profit potential of the network.

In many ways, these two primary prediction methodologies relate quite closely to technical analysis strategies. For example, the use (and projection) of a moving average over a series of stock prices could be regarded as predicting future values of a series (the moving average) from past values of the same series. Indicators in technical analysis are often composed of a number of constituent data items, like price, volume, open-interest, etc. These indicators are commonly used to give indications of future direction of price.

### Research into Pattern Recognition and Classification

Pattern recognition techniques and classification techniques have been grouped together, as their goal is normally not to predict future values of a time series, but to predict future direction of a time series. For example, the primary goal of chartists (a style of technical analyst) is to attempt to predict trend turning points by studying chart price action, looking for certain patterns. Chartists have noticed that these patterns tend to re-occur, and are reasonably reliable indicators of the future direction of price trends. There are a great deal of these chart patterns, and different analysts attach different weightings to the predictive power of any given pattern. Also, these patterns normally need to be confirmed by values from another time series (such as volume) to be considered "reliable." For more detail on this area, the reader is encouraged to refer to Pring (1999). Non-pattern matching techniques, which also attempt to predict future direction of a time series are also classification problems. Quite often, in addition to predicting future direction of a time series, classification research attempts to classify stocks into two main groups, namely "winners" and "losers" as in bankruptcy and financial distress predictions.

The following articles were selected and reviewed as they are representative of the current research in pattern recognition and classification (Baba & Handa, 1995; Baba et al., 2004; Baba & Nomura, 2005; Baba et al., 2001; Baek & Cho, 2000; Enke & Thawornwong, 2005; Fu et al., 2001; Kamijo & Tanigawa, 1990; Michalak & Lipinski, 2005; Mizuno et al., 1998; Skabar & Cloete, 2001; Suh & LaBarre, 1995; Tan & Quek, 2005). As previously described, the research can generally be classified as "winner" and "loser" detection or pattern matching. The work of Tan et al. (2005), and later, Tan and Dihardjo uses the concept of "winner" and "loser" classification, as does Longo et al. (1995) and Skabar et al. (2001). Specifically, Skabar et al. (2001) do not predict "winners" and "losers," but predict two disparate categories,

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