Introduction

This introductory chapter presents a layout of financial time series data, role of data mining techniques for analysis of these data, different aspects of financial time series analysis and an extensive literature review available in this field. In addition it provides the broad outline of the thesis including its objectives and major contributions.

1.1 Financial Time Series Analysis

Analysis of the time varying events of nature has been the focal point of research in various domains such as finance, engineering, weather, medicine, science and so on. A set of continuous observations of any variable recorded at regular time intervals is specified as a time series. The time interval may be of any duration such as hourly, daily, weekly, monthly or yearly. A real-world time series, irrespective of its type and application, often contains various patterns, such as, seasonality, trend and outlier. The whole idea behind this analysis is to foretell future value of a certain variable, from past successive observations.

Owing to the commercial applications and potential significant benefits, financial time series analysis is one of the most popular one. With the era of economic globalization and the facility of digital technology, generation and accumulation of financial data has reached at an unprecedented rate. The rapidly growing volume of data has far exceeded the ability of a human being to analyze them manually. Again financial time series data are more complicated than other statistical data due to the long term trends, cyclical variations, seasonal variations and irregular movements. These are highly influenced by several external factors, such as many highly interrelated economic, political, social and even if the psychological behavior of the investor. The continuous growth of such highly fluctuating and irregular data has put forth the critical need for developing more automated approaches for efficient analysis of such massive financial data to extract meaningful statistics from that. Data mining techniques plays an increasingly major role in approaching these enormously complex and dynamic problems.
1.2 Data Mining for Financial Time Series Analysis

Data mining is an intelligent process of extracting useful information and knowledge out of enormously complex and huge data sets. This process of deciphering hidden patterns from massive data set have emerged from several historically disjoint fields, such as applied statistics, machine learning, artificial intelligence, data engineering, information systems and knowledge discovery. As a whole the objective of this process is to discover meaningful information from large amount of raw data and translate it to an understandable structure for making crucial decisions.

Being a process of exploring useful hidden knowledge, Data mining has carved its own niche in financial time series analysis. It provides pathways for investors to take proactive and knowledge-driven decisions in order to achieve successful gain with less investment risk. Most of the data mining methods and techniques have been applied to different financial applications, enclosing prediction of stock market indices and currency exchange rates, modeling and forecasting future fluctuation of prices to reduce financial risk, prediction of future trading points by development of trading models, investment selection, portfolio optimization, fraud detection, loan assessment bankruptcy prediction, real-estate assessment, and so on [1, 2].

1.3 Scope of Financial Time Series analysis

Gaining high profit is the ultimate goal of an investor participating in financial market. There are so many investment opportunities like trading (i.e. buying and selling) bonds, shares, foreign exchanges and precious metals etc. present in a financial market. Trading in stock market is one of the popular channels of financial investment. Stock market data has been the centre of attraction for most of the financial time series analyses. Investors in the stock Market can maximize their profit by buying or selling their investment at proper time. The key to realize high profits in stock trading is to find out the suitable trading time with the minimum risk of trading. But it is crucial to figure out the benefits and risks before entering into any trading. Traders must presage stock price movements in order to buy at a lower scale and to sell at the higher scale. Again to reduce the risk of the investment, it is necessary to predict the fluctuations of those stock movements. The outspread of the stock market analysis mainly includes:
Forecasting the value of a stock index
Forecasting the measure of fluctuation of stock index value from day to day so that risk of investment can be reduced,
Predicting the movement of stock index
Recognizing the trend of stock index
Predicting trading signals of selling and buying
Efficient portfolio management

1.4 Literature Review

Over the years, many efforts have been made for meaningful analysis of financial time series data by using machine learning, evolutionary computing and statistical techniques. However, it is not feasible to go through each and every work in the limited space of a thesis. Hence, this section briefly highlights some research contributions related to different aspects of stock market analysis using different computationally intelligent techniques.

1.4.1 Survey on Stock Price Prediction

It is well known that stock prices are highly dynamic and volatile in nature. Efficient prediction of such dynamic time series values can be formulated as a function of getting output from the past input, output or both. The models used for stock price prediction barge into two categories. The first group involves models based on statistical theories, e.g. autoregressive moving average (ARMA), autoregressive integrated moving average (ARIMA), autoregressive conditional heteroscedasticity (ARCH), and generalized autoregressive conditional heteroskedasticity (GARCH) models. All these models are based on the assumption of linearity of earlier and present observed values. However the real time financial time series data does not necessarily follow any exact ordering or linearity and hence the statistical approaches do not accomplish the satisfied performance label in stock market index prediction. The second category comprises models based on computational intelligence techniques, like artificial neural network (ANN), Fuzzy set theory, Support Vector Machine (SVM), Rough Set theory etc.

Due to the intrinsic capabilities to identify complex nonlinear relationship present in the time series data based on historical data and to approximate any nonlinear
continuous function to a higher degree of accuracy, the usage of ANN in modeling monetary conditions is amplifying rapidly. An artificial neural network with a suitable chosen architecture is capable to approximate any reasonable function with unpredictable accuracy, in particular time series analysis. The application of neural networks in the field of time series analysis relies on the past recorded data and the network learning steps. The standard steps of neural networks applications include data preprocessing, selection of network, training and validation of the network with out of sample data. The background study points out that among different types of ANNs, i.e. Multi Layer Perception Network (MLP) [3-8], Radial Basis Functional Neural Network (RBFNN) [9, 10], Functional Link Artificial Neural Network (FLANN) [11-13] and Recurrent neural network [14-16] are the most favored neural network tools used for forecasting of financial time series data.

Fuzzy set theory introduced by Zadeh is another popular approach to handle inadequate and imprecise time series under unreliable circumstances. The time series forecasting framework using fuzzy set theory is composed of four steps: deciding and partitioning the universe of discourse, defining the fuzzy sets on the universe of discourse and fuzzifying the time series, constructing fuzzy relationships from the fuzzified time series, and forecasting and defuzzifying the forecasting outputs. The fuzzy rules help these systems in effective mapping of the desired output from given input values. However the manual training and tuning of the parameters of these systems is not always feasible for all the problems. In [17] a Takagi–Sugeno–Kang (TSK) type Fuzzy Rule Based System is presented for stock price prediction. The model has shown a great improvement in forecasting capability compared to other approaches such as multi regression analysis and back propagation neural network by using a linear combination of informative technical indices in its consequent part and estimating the parameters through simulated annealing algorithm. Another fuzzy stock prediction system integrating the stepwise regression analysis for input selection, auto-clustering analysis for initialization of membership function parameters with hybrid evolutionary learning is proposed in [18]. The model is not only capable of automatically initializing and creating the appropriate fuzzy architecture, but it is also able to accurately capture the nonlinear behavior of the daily and weekly stock time-series comparison with other learning methods. In [19] a novel fuzzy time series forecasting model with entropy discretization and a Fast Fourier Transform algorithm has also been proposed for stock
price forecasting. The model uses a Fast Fourier Transform (FFT) algorithm to deal with previously recorded training data for predicting stock prices. The use of FFT precisely improves the forecasting result compared to traditional ARCH, GARCH and other fuzzy time series models.

In past few years Adaptive Neuro Fuzzy Inference system (ANFIS) modeled by incorporating the low level learning and computational power of neural networks with the high level human like thinking and reasoning of fuzzy systems has grown as another popular research topic in financial time series prediction [20–24]. Contrary to the conventional neural network model or fuzzy system, the Neuro Fuzzy Inference system (NFIS) exhibits both their advantages by combining both the rules in the rule base of fuzzy theory to describe the complex relationships between the variables and the learning ability of neural network to adjust the membership functions and rule base. Consequent part is one of the key points in the design of ANFIS structure. The consequent part may be a minimum fuzzy implication as in Mamdani type, may be a linear combination of input variables like Takagi–Sugeno–Kang (TSK)-type or may include nonlinear combination of input variables as in [25-28]. All the fuzzy neural networks (FNN) are again of type feed forward FNN or recurrent FNN. Feed forward fuzzy neural networks being only able to capture the static input output correlation, are not suitable for the solution of dynamic problems. In opposite to feed forward fuzzy neural networks, the feedback topology of recurrent fuzzy neural networks enhances their ability to memorize information and handling the dynamic systems more effectively. Recurrent fuzzy neural network can be designed by containing a set of recurrent path connecting all the fuzzy rules or by containing recursive feedback loops from a given fuzzy rule. Several types of recurrent fuzzy neural networks have been proposed in literature [29-36].

In [29] a recurrent self-evolving fuzzy neural network with local feedbacks (RSEFNN-LF) is proposed by locally feeding the firing strength of a fuzzy rule back to itself for dynamic system processing. In [30] a TSK-type recurrent fuzzy network (TRFN) structure is designed by feeding the output of fuzzy firing strength layer back to both the network input and output layers, which helps in memorizing the temporal history of its corresponding fuzzy rule. The internal variable is also combined with external input variables in each rule’s consequence, which shows an increase in network
learning ability. A robust recurrent fuzzy neural network control (RFNNC) system is proposed in [31] to control the position of the mover of a permanent magnet linear synchronous motor drive system. Another kind of recurrent fuzzy neural network (RFNN) has been constructed by inserting feedback connections on the first layer of the network [32]. Back propagation algorithm has been used to train the proposed RFNN. In [33] a recurrent compensatory fuzzy neural network (RCFNN) with an online learning is proposed by including both structure and parameter learning. Addition of a new node for satisfying fuzzy partition is decided through the structure learning algorithm. Moreover, the parameters of the RCFNN are tuned by the gradient descent learning algorithm so as to minimize the output cost function. A nine layer recurrent neuro-fuzzy network using Chebyshev functional expansion is proposed in [34] for identification of a nonlinear system. The nonlinear dynamics of this system is greeted by including a Chebyshev polynomial based functional expansion block in the consequent parts of the fuzzy rules. The antecedent and consequent parameters of the network is tuned by the well known back propagation algorithm. A recurrent RBFN-based self-evolving fuzzy-neural-network (RRSEFNN) is proposed in [35] by integrating the advantages of radial basis functional network, recurrent network with the self-evolving fuzzy-neural-network. Here the consequent part of the proposed model specifies a nonlinear blending of input variables. In [36] an enhanced discriminability recurrent fuzzy neural network (EDRFNN) has been proposed for temporal classification problems. The feedback topology of the proposed EDRFNN is fully connected in order to handle temporal pattern behavior.

Efficient parameter tuning is another important issue in designing a neural network or fuzzy neural network. The traditional Back Propagation (BP) algorithm with gradient descent method is the commonly used learning technique for ANNs and ANFIS models. It is a powerful training technique for networks with a forward structure. Since back propagation algorithm is based on the steepest descent approach of minimizing the error function, it may attain the local minima very quickly and not ever achieve the global solution. Additionally, the performance of BP training highly depends on the initial values of the system parameters. To avoid the common drawbacks of back propagation algorithm such as imprecise learning rate, local minimal and slow rate of convergence and to increase the accuracy, some scholars proposed other improved approaches such as additional momentum method, Recursive Least square
method, self-adaptive learning rate adjustment method, and various search algorithms such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Differential Evolution (DE), Harmony Search (HS) algorithms [37-40], in the training step of the neural network based models to optimize the parameters of the network. A number of hybrid learning techniques have also been developed by researchers for further improvement of the forecasting speed and accuracy. A hybrid learning algorithm using evolutionary PSO and adaptive recursive least-squares (RLS) called RPSO has been developed for efficiently acquiring available parameters value of the RBFNs prediction systems in [10]. In [26] a reinforcement evolutionary learning algorithm (REL) is proposed for both structure and parameter learning of a self-evolving neural fuzzy inference networks (SENFIN). In [27] an integrated functional link interval type-2 fuzzy neural system (FLIT2FNS) optimized using particle swarm evolution technique is proposed for predicting the stock market indices. The hybrid model is developed by using a Takagi–Sugano–Kang (TSK) type fuzzy rule base in the antecedent part and with a FLANN network used in the consequent. Another hybridization of PSO and BP algorithm for training of ANN has been proposed in [41, 42]. Current advancements in evolutionary algorithms have provided strategies favorable to ANFIS models that can find global solution to the problem optimizing the overall structure [43-45]. A fuzzy wavelet neural networks trained using differential evaluation (DE) algorithm is proposed in [46] for prediction of stock prices. A set of TSK fuzzy rules including wavelet function in the consequent part of each rule is the base of construction of the proposed network. In [47] a differential evolution with local information (DELI) algorithm is proposed for TSK-type neuro fuzzy systems (NFSs) optimization. The DELI algorithm helps to increase the population diversity and search capability by applying a modified mutation operation considering a neighborhood relationship for each individual. In [48, 49] a Simulated annealing based parameter optimization method for type1 Takagi-Sugeno fuzzy system (TSK) has been proposed to predict two well known time series data. Simulated annealing has been used to derive an improved configuration of the fuzzy system.

1.4.2 Survey on Volatility Prediction

Expected Market return is highly influenced by predictable stock market volatility. The necessity of volatility prediction paves a way for development of large number of time
series models for financial data with changing variance over time. GARCH family models play a key role among them. Bollerslev (1986) introduced the Generalized ARCH (GARCH) model, which combines the ARCH and autoregressive moving average (ARMA) models. The GARCH model reflects the non-linear dependence of the conditional variance of the time series, estimating jointly a conditional mean and conditional variance equation [50, 51]. Despite the success of GARCH model, it fails to capture the asymmetric volatility, since for stock prices volatility is greatly affected by negative shocks to returns rather than positive shocks. The GARCH model does not identify the transference of volatility that caused by input of positive or negative information. Hence, the model is not suitable for asymmetric market environment. Further the GARCH volatility forecasting models are segregated broadly into distribution (GARCH-N, GARCH-t, GARCH-HT and GARCH-SGT) and asymmetry-type (GJR-GARCH and EGARCH) models and extensive studies to predict S&P-100 stock index volatility are presented in references [52-55] using both category of models. The conclusion of this study indicated that the asymmetry –type GARCH models outperformed the volatility forecasts using the error distribution types. The results of traditional time series models are based on some strict statistical assumptions about data distributions that make them unsuited to address the forecasting problem of financial datasets [56]. Also due to their complexity, application of nonlinear models is squeezing in current scenario, with a demand for developing more flexible models.

To improve the predictive power of the financial time series model numerous computational intelligence based models like Artificial Neural Network, fuzzy inference system, Support Vector Machine, Relevance Vector Machine hybridized with the financial time series models have been proposed in literature [57-70]. A back propagation neural network for forecasting TXO price under different volatility models, including historical volatility, implied volatility, deterministic volatility function, GARCH and GM-GARCH models is proposed in [57]. Two hybrid models based on EGARCH and Artificial Neural Networks to forecast the volatility of S&P 500 index are given in [59]. Here the output of an EGARCH model is fed as input to a neural network. Another hybrid NN-EGARCH model representing the benefits of the neural network forecasting merged with time series analysis are discussed in [60-61].
Again to overcome drawback of neural network models and to tackle the uncertainties that exist in accurately forecasting of stock market volatility several fuzzy time series models have evolved, which has shown outstanding improvements in stock market volatility prediction, outperforming the traditional time series models, neural network and other hybrid models. An adaptive fuzzy GARCH model comprising a functional type1 fuzzy inference system with a GARCH model has been proposed in [62]. The model parameters are estimated by application of a genetic algorithm. Another evolving fuzzy-GARCH model for modeling and forecasting fluctuation of stock prices was proposed in [63]. The model helps to deal with the time-varying volatility and volatility clustering by combining the features of both evolving fuzzy systems and the GARCH model. A new state space form of robust Kalman filter based on Fuzzy-GARCH has been proposed in [64]. The Fuzzy-GARCH model has been used to analyze clustering properties and robust Kalman filter has been used to deal with the problem of irregular behavior. State space joining of the parameters of membership functions and GARCH models make this problem highly nonlinear and complicated. The particle swarm optimization (PSO) technique has been used to estimate parameters of the membership functions and GARCH models. In [65] a Fuzzy GJR-GARCH model considers the principles of time-varying volatility, leverage effects and volatility clustering, and uses a differential evolution (DE) algorithm for the estimation of GJR-GARCH parameters. The experimental result clearly reveals that the proposed method offers notable improvements in forecasting accuracy comparison to GARCH-type models and other Fuzzy-GARCH model reported in the literature.

Adaptive Neuro Fuzzy system (ANFIS) is another popular hybrid models used in volatility forecasting [66]. The ANFIS models provide the advantage of combining the rules in the rule base of fuzzy theory to describe the complex relationships between the variables and the learning ability of neural network "to adjust the membership functions and rule base. A novel GA-weighted ANFIS model in combining the AR method, multi stock volatility causality and GA weighted rule with the ANFIS model has been used to forecast volatility of Taiwan stock market [67]. A recurrent hybrid SVM-GARCH model is used to forecast (multi-periodically) volatility of Asian (emerging) stock markets, BSE SENSEX and NIKKEI225 in [68]. An effective wavelet kernel combining the wavelet theory with SVM to construct for volatility prediction is presented in [69].
1.4.3 Survey on Stock trading

Though most of the financial time series analysis involve prediction of stock price or its fluctuation, but trading the stock market is another popular research area. Gaining profit or loss from stock trading ultimately depends on analysis of future movement of highly fluctuating and irregular stock price values. In literature a number of models combining technical analysis with computationally intelligent techniques are available for prediction of stock price index movements [71-73] and for stock trading [74-82]. In [74] a new trading framework enhancing the performance of reinforcement learning based trading systems is proposed to help investors for making appropriate trading decisions relative to daily stock trading so as to maximize their profit in the dynamic stock market. In [76] a new model using Piecewise Linear Representations (PLR) and Artificial Neural Networks (ANNs) is proposed to capture the trading signals by analyzing the nonlinear relationships exists between historical stock closing price and its technical indexes. The trained ANN model is applied to predict the future trading signals on a daily basis. Secondly, a trading decision is triggered by developing a dynamic threshold decision system. Another forecasting model integrating the case based dynamic window (CBDW) and the neural network is applied in [77] to foretell the correct turning points in stock trading, so as to boost the investing revenue. In [78] a method using together the well known k-NN classifier with technical indicators, stop loss, stop gain and RSI filters is proposed to investigate the feasibility of using an intelligent trading system in real market conditions. Another effective trading signal detection system using Piecewise Linear Representations (PLR) and Artificial Neural Networks (ANNs) is proposed in [79]. The trading decision in the model is further triggered by a dynamic threshold bound which helps to gain significant profit amount during trading. In [80] a trading system based on fundamental or chartist analysis is developed for improvement of the investment techniques. The main idea of the system is to generate trading points based on a financial indicator namely, relative strength index which is further calculated by a feed forward neural network. Another intelligent trading system using technical analysis, the Artificial Bee Colony Algorithm (ABC), a selection of past values, nearest neighbor classification (k-NN) and its variation, the Adaptive Classification and Nearest Neighbor is discussed in [81]. In [82] a high-order fuzzy time series model based on entropy-based partitioning and adaptive expectation
model has shown its superiority compared to other conventional fuzzy time series models in generating decision rules as investment references for stock investors.

1.5 Objective of the Thesis

Analysis of future behavior of the financial time series data especially stock market data, as one of the core tasks of data mining is the focal point of this thesis. As is known, it is hard to forecast the future behavior of the financial time series data with respect to its fabulous rapid variation and complicated non-linear dimensionality. However, the benefits fascinated in accurate prediction have encouraged researchers for developing newer and advanced tools and models.

In this research it is proposed to devise new methods in three different areas of financial time series analysis such as, stock index price prediction, volatility prediction and stock trading decision point prediction following stock index movement classification. Primarily the research is focused on estimation of future stock price index in different prediction horizon using a low complexity neural network model along with different learning schemes. Further the work is extended in modeling recurrent Neuro-fuzzy system so that the efficient prediction of dynamic time series values can be formulated as a function of getting output from the past input, output or both. As expected market return is highly related to predictable stock market volatility, so next integrated time series and Neuro-fuzzy models have been devised to measure the fluctuation in financial security price around its expected value that helps in reducing the investing risk in stocks. Lastly for improving the investment decision of when and how many stocks to sell or buy, depending on results of prediction system, a trend analysis has been outlined using an efficient time frequency approach. The parameters of the developed models have been optimized using new globally optimized evolutionary techniques and then the performance of the models is evaluated using few error metrics. To realize a suitable model in a particular field, a comparative method has been adopted by considering other efficient models used in literature. The goal is to improve the accuracy of the analysis by developing more robust dynamic models in different applications of financial data mining.

In brief, the main objectives are:
• To perform an exhaustive study on the use of different low complexity neural network models with different learning algorithms for stock price prediction.

• To devise new hybrid learning algorithm using evolutionary techniques and extreme learning machines for low complexity neural network for financial time series prediction.

• To explore new recurrent Neuro-fuzzy model for stock price index prediction.

• To focus on volatility Prediction using integrated time series and Neuro-fuzzy models.

• To find out an innovative model for trading point prediction following stock price index movement classification.

1.6 Contribution of the Thesis

In this thesis data mining and artificial intelligence techniques are used to build prediction and classification models to address three important aspects of financial time series analysis such as, stock price prediction, modeling and forecasting volatility and stock trading following stock price index movement classification. In the first part of the work a low complexity Functional link Artificial Neural Network followed by its recurrent structure and a new Self Evolving Recurrent Neuro-Fuzzy Inference System have been proposed for prediction of stock indices with different prediction horizon. Further in the research of volatility prediction, two innovative fuzzy time series models are introduced for accurate forecasting and modeling of financial data with changing variance over time. Finally the thesis represents the framework for stock price index movement classification followed by stock trading decision prediction using extreme learning machines. The hybrid intelligent models developed in this research can produce accurate and effective information in order to facilitate economic activities.

The major contributions of this thesis are described as follows:

2. A Self Evolving Recurrent Neuro Fuzzy Inference System (SERNFIS) optimized through a Modified Differential Harmony Search (MDHS) technique for efficient stock price prediction.

3. An Evolutionary Hybrid Fuzzy Computationally Efficient Exponential GARCH (FCE-EGARCH) Model for volatility prediction.

4. A Differential Harmony Search (DHS) based Hybrid Interval Type2 Fuzzy EGARCH (IT2F-CE-EGARCH) Model for stock market volatility prediction.

5. Stock trading following stock price index movement classification using extreme learning machines.

1.7 Organization of the Thesis

This thesis has been organized into 7 chapters. Chapter 1 provides a general outline of financial time series analysis and highlights relevant reviews on different computational intelligent techniques used to study the future behavior of the financial time series data. The objective and contribution of the thesis is also identified and stated in this chapter.

Chapter 2 elaborates a hybrid learning framework called Self Adaptive Differential Harmony Search Based Optimized Extreme Learning Machine (SADHS-OELM) for two Single Layer Feed forward Networks to address the problem of short term and long term prediction of financial time series data like stock price and its volatility. Computational experiments illustrating the effectiveness of the new learning framework is provided by modeling and forecasting the one day a head closing price and volatility of few benchmark stock indexes in comparison with some other evolutionary and traditional learning schemes.

Chapter 3 discusses the mechanism of a new Self Evolving Recurrent Neuro Fuzzy Inference System (SERNFIS) in details for efficient prediction of highly dynamic stock market indices over varying time frames. A modified differential harmony search (MDHS) technique is also suggested for parameter estimation of the model. The improved predictability of the model is validated by performing a comparative study with other existing neuro fuzzy models and functional link neural over three benchmark financial data sets.
Chapter 4 is related to the modeling and forecasting of stock market volatility. An innovative Fuzzy computationally efficient EGARCH model is discussed in details how to enhance the ability of time series model in forecasting return volatility by integrating it with reasoning of fuzzy inference system and functional expansion, learning component of a neural network. Further to improve the prediction accuracy, the Differential Evolution (DE) algorithm with the ZADE approach is used for parameter adaptation of the fuzzy time series model. The model performance is validated by comparing the results with some traditional GARCH family models, fuzzy time series models and other soft computing techniques on the basis of three error metrics and Hansen’s Superior Predictive Ability test.

Chapter 5 presents an extension of the fuzzy computationally efficient EGARCH model by applying interval type-2 fuzzy sets in antecedent part of the model. The proposed model is denoted as IT2F-CE-EGARCH. The model performance is observed with two membership functions i.e. Gaussian with fixed mean, uncertain variance and Gaussian with fixed variance and uncertain mean. Again a Differential Harmony Search (DHS) algorithm is applied to estimate the parameters of the proposed methodology. Computational experiments illustrating the effectiveness of the IT2F-CE-EGARCH model are provided by modeling and forecasting the volatility of BSE SENSEX and CNX NIFTY indexes in comparison with type-1 fuzzy CE-EGARCH model and IT2F-EGARCH model.

Chapter 6 deals with stock price index movement classification and stock trading decision prediction using Extreme learning machines. Initially a classification model using the computationally efficient functional link artificial neural network (CEFLANN) with ELM learning approach is proposed for classifying the stock price index movements as up and down movements. Two other familiar networks like Chebyshev FLANN (CHFLANN) and Radial Basis Function (RBF) Networks are also used for comparative study. Further the work is extended for generating the stock trading decisions and the model performance is compared with other computationally intelligent techniques like support vector machine (SVM), Naive Bayesian model, K nearest neighbor model (KNN) and decision tree (DT) model.

Chapter 7 draws the conclusion and provides some suggestions for the future scope of the study.