Chapter 1

Introduction
INTRODUCTION

1.1 Background

Financial forecasting is the process of estimating future business performance in terms of sales, costs, earnings. Corporations use financial forecasting to do financial planning, which includes an assessment of their future financial needs. Forecasting of financial data is also important for production planning, human resource planning and optimal utilization of available funds to access the health condition of bank and for efficient investment of available resources etc. It is also used by outsiders to value companies and their securities. The various financial parameters which need forecasting are stock indices, exchange rate, interest rate, net asset value etc. Earlier the research carried out in financial forecasting to predict the future financial values, the statistical forecasting models and the conventional derivative based least mean square (LMS) type algorithms [1] for the parameter estimation were used. But the available practical financial data are dynamic, nonlinear, uncorrelated and combination of above characteristics. The conventional LMS and recursive least square (RLS) [2] techniques work well but when the data are of correlated or nonlinear type, the existing forward-backward LMS [3] and the RLS algorithms very often lead to non optimal solution due to premature convergence of weights to local minima [4]. This is a major drawback of the use of existing derivative based techniques. To alleviate this shortcoming, this thesis suggests the use of derivative free optimization techniques in place of conventional techniques for designing efficient adaptive models for prediction of financial data. In recent past, population based optimization techniques have been reported which fall under the category of evolutionary computing [5] or computational intelligence [6] which include genetic algorithm (GA) and its variants [7], differential evolution (DE) [8] and swarm intelligence based algorithms such as particle swarm optimization (PSO) [9], bacterial foraging optimization (BFO) [10] and cat swarm optimization (CSO) [11]. These techniques are suitably employed to obtain efficient iterative learning algorithms for developing adaptive forecasting models. Development of financial forecasting models essentially consists of two components. The first component is an adaptive network which may be linear or nonlinear in nature. Use of a nonlinear network is preferable when nonlinear, uncorrelated and continuous time series data are used. The linear network used in the thesis is adaptive auto regressive moving
average (ARMA) [12]. Under nonlinear category low complexity single layer function link artificial neural network (FLANN) [13], multilayer artificial neural network (MLANN) [14] and radial basis function neural network (RBFNN) [15] have been employed to develop efficient forecasting models.

The second component is the training or learning algorithm used to train the parameters of the model. As stated earlier the structures used are trained by various evolutionary computing techniques such as the genetic algorithm (GA), differential evolution (DE) and swarm intelligence based algorithms such as particle swarm optimization (PSO), bacteria foraging optimization (BFO) and cat swarm optimization (CSO). Depending upon the complexity and nature of the financial data, proper adaptive structure for the model, corresponding evolutionary and swarm intelligence based learning rule is selected so that the combination yields the best possible performance in forecasting future values. This requires the knowledge of prior experience and suitable features of the data. One of the objectives of the present investigation is to choose models with appropriate combination of structure and algorithm so that it provides best possible forecasting values. The bio-inspired optimization tools are applied to the forecasting models for training the parameters. To obtain the optimized parameters of the model, suitable evolutionary and swarm intelligence based techniques have been introduced to effectively optimize the cost function of the models. In the proposed development of adaptive models, the mean square error at the output is considered as the cost function. The cost function is to be minimized by using bio-inspired techniques to accomplish the parameter estimation. Despite of these two components, judicious selection of features is also important to enhance the efficiency of the forecasting models.

In many practical situations, the available past financial data is highly corrupted by outliers and may be as high as 10%. Under such constraints the training of the models gets severely affected if the squared error is used as the cost function for minimization and also the conventional cost function is not robust against outliers [16]. In statistics few cost functions have been defined which are robust in nature and are not affected by outliers. These are (i) Wilcoxon norm, (ii) $\sigma (1 - \exp (-e^2 / 2\sigma))$ and (iii) $\log (1 + e^2 / 2)$, where $\sigma$ is a parameter to be adjusted during training and $e^2$ is mean square error. In this thesis robust financial data prediction scheme is proposed by minimization of the Wilcoxon norm along with a low complexity artificial neural network namely Wilcoxon FLANN. Wilcoxon
FLANN is able to predict the days’ and months’ ahead future values of exchange rates and also the outlier has been maximized up to 50% to test the robustness.

An adaptive differential evolution (DE) based ARMA forecasting model has also been developed to overcome the limitation of statistical models which were employed for financial forecasting. Since derivative based algorithms have been used to train the parameters of statistical models, hence its parameters have a tendency to fall into local minima.

An attempt has also been made to develop models for long range prediction of financial data. To achieve this, a recurrent radial basis functional neural network has been introduced.

In recent years evolutionary computing based multi-objective optimization has played an important role in the field of financial forecasting, in which the aim is to optimize more than one objective like the structure of the model as well as its error. In this thesis, one of the multi-objective algorithms has been introduced to reduce the complexity of the forecasting model as well as to achieve efficient computation and accurate future values.

1.2 Motivation

In summary the main motivations of the research work carried out in the present thesis are listed below.

(i) To design and develop robust forecasting models, that has the potential to predict financial value with high degree of precision in presence of outliers in the training data.

(ii) To develop adaptive forecasting models using bio-inspired optimization tools such as GA, PSO, DE, CSO and BFO to efficiently adjust the weights of the model so that the squared error cost function is iteratively and efficiently minimized.

(iii) To develop adaptive models for long range forecasting of the financial values.

(iv) Multi-objective formulation of financial forecasting problem and providing efficient adaptive structure as well as best possible MSE during training phase.
1.3 Major contributions of the thesis

The following few contributions have been made in the thesis:

A robust exchange rate forecasting model employing Wilcoxon norm based low complexity functional link artificial neural network has been developed. Its performance has been evaluated in presence of outliers in the training samples and accurate prediction performance has been demonstrated.

An adaptive ARMA model using differential evolution based training scheme has been developed to effectively predict the exchange rates. This new feed forward feed backward approach has been shown to predict more accurate exchange rates compared to other evolutionary computing based forecasting models.

A recurrent radial basis function neural network (RRBF) has been developed for long range forecasting of net asset value (NAV). This new approach demonstrates improved performance compared to other competitive methods.

The stock market prediction problem has been formulated as a two objective problem and has been effectively solved using NSGA-II. Both the structure and accuracy of prediction of the model have been simultaneously optimized to provide a set of optimal solutions.

1.4 Chapter wise contribution

The research work carried out in this thesis is embodied in seven Chapters as detailed below.

1. Introduction
2. Outline of various adaptive structures and learning algorithms employed for adaptive model development.
4. Hybrid adaptive model for exchange rate prediction using ARMA structure and DE based training scheme.
5. Development and performance evaluation of recurrent RBF model for long range prediction of net asset values.


7. Conclusion and scope for future work.

Out of the proposed seven Chapters, the research contribution is contained in Chapters 3 to 6.

A brief outline of chapter wise contribution is presented in sequel. Chapter 1 is to deal with introduction. It comprises of motivation of the proposed research work followed by problem statement, literature survey and outline of various chapters embodied in the thesis.

Chapter 2 provides brief description on model architecture such as multilayer artificial neural network (MLANN), radial basis function neural network (RBFNN) and functional link artificial neural network (FLANN). It also deals with evolutionary computing algorithms such as genetic algorithm (GA), differential evolution (DE), swarm intelligence based algorithms such as particle swarm optimization (PSO), bacteria foraging optimization (BFO) and cat swarm optimization (CSO) algorithm which are used for developing learning schemes of various adaptive models.

In Chapter-3, the development of robust forecasting models for exchange rate prediction has been dealt. It focuses on exchange rate prediction for future days’ and months’ ahead in presence of outliers in the training set. Two robust forecasting models namely Wilcoxon artificial neural network (WANN) and Wilcoxon functional link artificial neural network (WFLANN) have been introduced for efficient prediction. The learning algorithms required to train the weights of these models are derived by minimizing a robust norm called Wilcoxon norm. These models offer robust exchange rate predictions in the sense that the training of weight parameters of these models are not influenced by outliers present in the training samples. When the training samples are contaminated with outliers the convergence as well as the prediction performance of squared error based FLANN and MLANN models drastically deteriorates and when dense outliers are present the convergence performance practically fails. However the Wilcoxon norm based WANN and WFLANN prediction models show consistent performance during training and testing.
phases in presence of low and high density outliers in the data. As the percentage of outliers in the training samples increases, correspondingly the prediction potentiality of both the robust models decreases. Both the WANN and WFLANN models show identical performance for all conditions but the later model involves very low computational complexity.

**Chapter-4** deals with forecasting of currency exchange rates using an adaptive ARMA model with differential evolution based training. The statistical based prediction model gives little less prediction performance compared to soft computing based model. To alleviate the limitations of the conventional methods, a simple but hybrid (combination of an adaptive autoregressive moving average (ARMA) architecture and differential evolution(DE) based training of its feed forward and feed-back parameters) prediction model has been introduced. To compare the performance of the developed model, other four competitive methods such as ARMA-PSO, ARMA-CSO, ARMA-BFO and ARMA-FBLMS have also been proposed. The ARMA prediction model essentially consists of feed-forward and feed-back linear combiners. The feed-forward section acts as moving average (MA) whereas the feedback one functions as an autoregressive (AR) model. The feed forward and feedback coefficients need proper training using appropriate learning algorithm. Simulation results for test data for rupee and pound indicate that the DE based predictors offer more accurate exchange rates compared to that of other three models. To achieve improved prediction accuracy of Japanese yen exchange rate dataset alternative traditional features need to be extracted from the time series and then applied to the model. In terms of all three measures, the DE-ARMA shows a superior performance compared to other three models. Another comparison of the computational time required for the training of various models shows that the proposed DE based ARMA takes the least time for training followed by the ARMA-PSO, the ARMA-BFO and finally the ARMA-CSO one.

**Chapter-5** focuses on long range prediction of net asset values using recurrent radial basis function neural network. Nowadays, investment is one of the most important economical activities in modern life. Mutual funds have become one of the major channels for investors. The growth of mutual funds is booming rapidly, due to its professional management of capital, stable profitability and low risk. The mutual funds have come a long way since its inception in 1964 and is growing further as a tool of investment. It is one of the reasons behind the popularity of late maturity of Indian capital market. Indian market
has also drawn the attention of global investors. The retail investors are depending on mutual funds to take care of their investments due to the imminent risk in the equity market and low return from fixed income instruments. It is necessary for the mutual fund investors to evaluate the future performance of the various schemes before deciding on investments. Therefore, the prediction of the net asset value (NAV) of mutual funds is very important for investors and fund managers. A new soft computing model based on recurrent radial basis function neural network (RRBFNN) has been developed and employed for prediction of net asset value of HDFC Top200(G), ICICI Top100(G), Birla Sunlife(G) for 1, 3, 7, 15 and 30 days ahead. The performance of these models has been compared with four other existing forecasting models. It is demonstrated that the RRBFNN model exhibits improved performance as compared to other forecasting models.

Chapter-6 deals with the development of RBF prediction model using and non-dominated sorting multi-objective genetic algorithm-II (NSGA-II) for various stock market forecasting. The proposed technique optimizes two mutually conflicting objectives simultaneously.

These are:

I. The structure (number of centers in the hidden layer) of the model.

II. The mean square error (MSE) of the model.

The best compromised non-dominated solution based model is determined from the optimal pareto front using fuzzy set theory. The prediction performance in terms of four metrics is evaluated for prediction of different stock indices at different days’ ahead. The results of various simulation based experiments using real life data demonstrate that the MORBF models developed in this chapter show superior prediction performance in terms of four performance measures compared to its single objective counterpart.

The overall conclusion of the total investigation is listed in Chapter 7. This Chapter also contains the details of further research work that can be carried out in the same or related field.

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