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Appled Statistics for Business and Method of Forecasting

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ABSTRACT

The intrinsic uncertainties associated with demand forecasting become more acute when it is required to provide invaluable dimensions for the decision-making process. The concept of decision support system (DSS) is very broad and it can take many different forms. In general, we can say that a DSS is a computerized system for assisting decision making. Forecasting models has been recognized as one of the tools used in DSS. The need and relevance of forecasting tools has become a much-discussed issue and this has led to the development of various new tools and methods for forecasting in the last two decades. One traditional tool for forecasting time series data is the Winter's method with three parameters that determine the accuracy of the model. The search for the best parameter value of α, β and γ and their combinations using trial and error method is time consuming. Hence, a good optimization technique is required to select the best parameter value to minimize the fitness function. We employ the unique search of Genetic Algorithm (GA) to generate and search for the best value and due to the nature of GA that is based on random search; the near optimum solution could be improved by the introduction of a more systematic search known as Tabu Search (TS). Our study shows that combining both GA and TS search methods generate a more accurate forecast.

Keywords— decision support system, genetic algorithm, tabu search, forecasting, heuristics.

I. INTRODUCTION

Research on statistical forecasting and decision support system for forecasting has been widely explored in the past decades and its application ranges from the business communities, government agencies and private individuals. Depending on who is making the forecast and the nature of the forecasts and decisions being made, the methods used will vary from extremely crude extrapolations based on past experience to very detailed forecasts for the whole economy (Chaman, L. J (2000). Research into forecasting using heuristic methods has increase for the past few years particularly using method that simulate natural phenomenon such as the gene reproduction. Such a heuristic is known as the Genetic Algorithm (GA). Other methods include the Evolutionary Programming and Evolution Strategies. GA is an algorithm that has the ability to solve NP-hard problems (Glover, Fred, 1993). Another popular search methods are the Neural Networks and Tabu Search (TS).

In building a forecasting system, we need to understand the types of forecasting models that are commonly used for time series data. There are two major types of forecasting models namely the explanatory (also known as causal) model and time series model. Explanatory model assumes that the variable to be forecasted exhibits an explanatory relationship with one or more independent variables. Among the array of exponential smoothing techniques are the Brown's Double Exponential Smoothing, Holt's Two Parameter Exponential Smoothing and Winter's Three Parameter Exponential Smoothing. All the exponential smoothing techniques require that certain parameters be defined and these parameters will determine the unequal weights to be applied to past data. It is suggested that the value of α above 0.30 frequently yielded a reasonably good forecasts but also suggested the use of search method for the best value of α rather than using trial and error method (Webster, A.L, 1998). Searching for the value of α, β and γ and their combinations in Winter's model using trial and error method is costly. We proposed using the unique search of GA to generate the best value these parameters. Nevertheless, due to the nature of GA that based on random search, the near optimum solution could be improved by the introduction of a more systematic search known as Tabu Search (TS). Our study shows that combining both GA and TS search methods generate a better solution.

II. PROBLEM DESCRIPTION

The suitable smoothing constant values of α, β and γ is between 0 and 1. Winter's method requires a large number of possible combinations of the three parameters by just taking 2 decimal places. Conventional searching technique will take a very long time to search for the best value in order to minimize the fitness function. Using GA based on different crossover and mutation probability rate, size of population, type of crossover and the techniques of convergence on the Winter's Method. Results generated using GA is good but it may sometimes just arrive at a near optimal solution. TS are then used with dynamic tabu list to improve the result generated from GA. A DSS for Winter's method of forecasting with an improved parameter estimation using GA and TS.

III. RESEARCH DATA

Three sets of data are used to demonstrate the effectiveness of GA and TS in forecasting using Winter's Method. The data used are secondary data provided by a company producing soft drinks, sales of packed boxes and fish landing data from fishery department. The Tasty Cola Sales consist of 48 month of data (Bowerman and O'Connel, 1987) throughout this paper. This set of data is referred to as Tasty Cola Data. The second data is the sales data from the sales of boxes at Federal Packages Sdn Bhd. The data is from January 1995 until August 1998 (Heah and Zuhaimy, 1999) and this set of data is referred to as Federal Package Data. The third data is the Fish Landing from 1990 to 1998 (Wong and Zuhaimy, 2001). This set of data is referred to as Fish Landing Data. Every sample of data will be divided into two sections. The first section of the data is used as an observation data and the second section is used to measure the accuracy (comparing the actual and the forecast value). For Tasty Cola Data, the first 36-month of data is used to examine and calculate the forecast value. While, the last 12 month of data is used to check the accuracy of the forecast value given by the forecast model. For Federal Package Data, the data from January 1995 until July 1998 is used as an observation to calculate the forecast value and the last month of data (August 1998) is used to compare the accuracy of the forecast value with the actual value, besides comparing the result from Heah and Zuhaimy (1999). For Fish Landing Data, the data from year 1990 to 1998 (108 month of data) is used to examine and calculate the forecast value and the data in year 1999 (12 month of data) is used to compare the accuracy of the forecast value and the actual value. The forecast model that gives the lowest error is considered as the best model.

IV. DECISION SUPPORT SYSTEM FOR FORECASTING

Forecasting is the estimation of the value of avariable at some future point in time. A forecasting exercise is usually carried out in order to provide an aid for future decision-making and planning in area of interest. In our market today, we have a variety of decision tools in making an analysis especially in area of forecasting. The applications of these forecasting tools include in the Production planning and control - forecasting the demand for a product enables us to control the stock of raw materials and finished goods, plan the production schedule, utilities control and so on; The Investment policy - forecasting financial and market information such as interest rates, exchange rates, share prices, the price of gold, energy demand and supply, etc (Zuhaimy Ismail and M.H. Ahmad, Mac, 2000). This is an area in which no one has yet developed a reliable forecasting technique; In the Economic policy - forecasting economic information such as the growth in the economy, unemployment, the inflation rate, etc is vital both to government and business in planning for the future.

Many of the above applications are common in many industries and organizations. Each organization has its own administrative or operational structure. Different set of organizational structure requires different level of forecasting practices. The growing importance of the forecasting function within companies or organizations is reflected in an increased level of commitment in term of money, hiring of operational researchers and statisticians (Bowerman, B. L and O'Connell, R. T. (1997). To support the goal, A DSS has been developed specially designed for forecasting using the Winter's method with the used of GA and TS to improve the forecast accuracy. The DSS for forecasting is a standalone forecasting system that can be used as a useful tool for decision planning.

V. FORECASTING MODEL AND PARAMETER ESTIMATION

For Winter's method, it is hard to guess the best value of α, β and γ in order to minimize the MSE and MAPE value. By searching one by one the value of α, β and γ or use the trial and error method, it times consuming. Here, Genetic Algorithm technique is used to search for the best value of α, β and γ. Genetic Algorithm is known as the best heuristic searching technique, but to select the best characteristic in Genetic Algorithm in order to produce a good solution is still a question. As mentioned earlier, the characteristics to be examined are:

- The crossover and mutation probability rate;
- Size of population;
- Type of crossover; and
- Convergence technique.

These characteristics are given in the Genetic Algorithm Properties Windows. The simulation is done using a different characteristic according to the Genetic Algorithm Properties Windows. Demonstration of one of the characteristics is given as:

- Crossover rate; 90% or 0.90.
- Mutation rate; 10% or 0.1.
- Size of population; 300.
- Type of crossover; Single point crossover.
- Convergence; number of iteration: 500.
- Forecast Accuracy; Mean Square Error, MSE

Changes in the characteristics of GA will generate different results. GA in this cases are used in the parameter estimation rather than using it a toll for forecasting. This paper demonstrates the use of GA in improving parameter estimation accuracy thus produce an improved forecast values. Tabu Search (TS) is used to refine the search value found by using GA. Here the value generated using GA is used an initial solution for TS. The main characteristic of TS search is the definition of Tabu List, which signifies the name of the search. In TS, the size of the list may be set to follow the static rules or dynamic rules. The indicated value such as 7 only suggestive and values between 7 and 400 appears to work well for a variety of problem classes. In this study, the Neighbourhood Size used is one and the Tabu List Size is dynamic, which range from 7 till 400. Once the TS algorithm have reached the local minimum, it will search for the second best solution from the neighbourhood that is not already in the Tabu List and the process will continue until it satisfy the stopping criteria. In this case the stopping criteria is the number of iteration (can be set to any number; 0 - 500). Using the Tabu List Size equal to 100 and neighbourhood size equal to one, the best value found does improve the result from Genetic Algorithm.

VI. RESULTS AND DISCUSSIONS

The Decision Support System has been developed specifically as an interactive system for solving Winter's method of forecasting. The aim of this system is to search for the smoothing parameter (α, β and γ) within the range 0 to 1 using Genetic Algorithm (and Tabu Search). The results are output in the form of Graph that show the actual value and the forecast value using the estimated parameters found earlier. This software is written using Borland Delphi 5 Enterprise. The software is divided into two parts, first is the integration of GA into Winter's method and second is the TS as a refinement from GA search result. It consists of several Windows. The Main Windows, Genetic Algorithm Properties Windows, Genetic Algorithm Search Graph Windows, Forecast Graph, Tabu Search Graph Search Windows and Tabu Search Properties Windows.

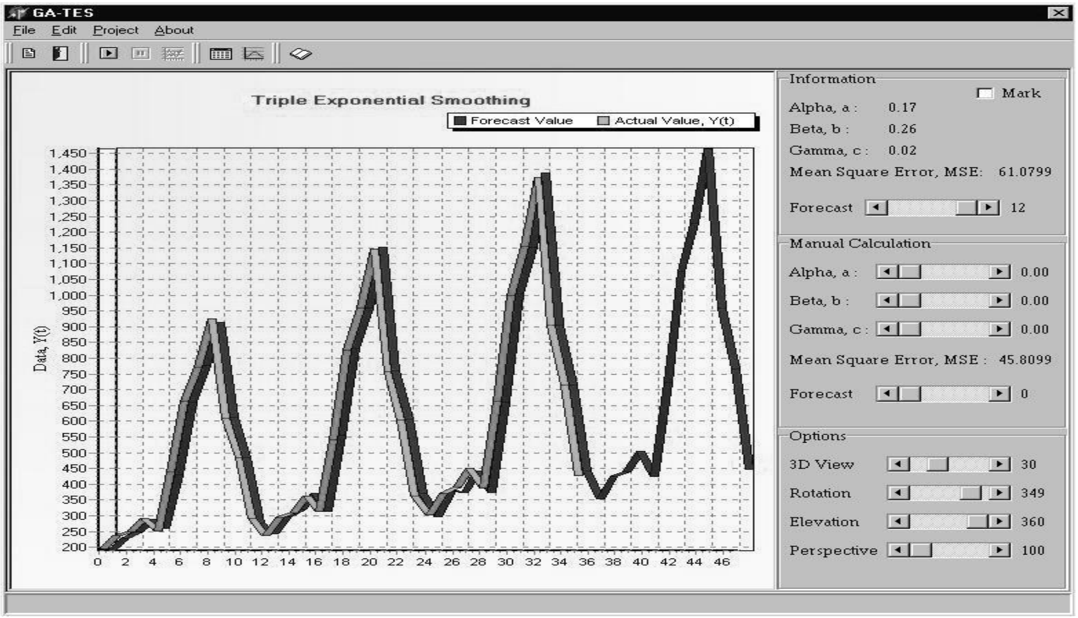
GA is known as the best heuristic searching technique, but one has to select the best characteristic of GA in order to produce a good solution and this is still a huge problem. As mentioned earlier, the characteristic of those going to be examined include the crossover and mutation probability rate; size of population; type of crossover and convergence technique. These characteristics are given in the Genetic Algorithm Properties Windows. The simulation is done using a different characteristic according to the Genetic Algorithm Properties Windows. Not all of the windows will be shown in this paper. Table - 1 shows the MSE using the characteristics of GA in 10 Runs. The properties of GA selected enable the model to generate the desired results. The properties are the crossover rate at 90% or 0.90; the mutation rate is at 10% or 0.1; the size of population is 300; the type of crossover as Single point crossover; the convergence - number of iteration equals to 500 and forecast accuracy using Mean Square Error, MSE.

Table-1. Genetic Algorithm Simulation in 10 runs applied to Tasty Cola Data.

No. of Run	*Α*	*Β*	*γ*	**MSE**
1	0.19	0.21	0.01	59.337263
2	0.21	0.16	0.01	59.380873
3	0.18	0.00	0.01	59.633042
4	0.22	0.20	0.01	60.175348
5	0.23	0.00	0.01	58.787060
6	0.19	0.18	0.01	59.323921
7	0.24	0.14	0.01	59.912237
8	0.18	0.22	0.01	59.366667
9	0.27	0.01	0.01	59.707686
10	0.23	0.01	0.01	58.787060

The Forecast Graph is used to display the forecast value as shown in Figure-1. This graph display the actual value and the forecast value using α, β and γ generated using GA search procedure. This graph is shown automatically when the test of convergence has been reached. On the right hand side of the Forecast Graph, is the Information, Manual Calculation and Option group. On the Information group, it displays the value of α, β, γ and the error value found (MSE or MAPE). The scrollbar next to the Forecast label allow the user to choose the number of forecast period.

Figure-1. ACF-Forecast Graph.

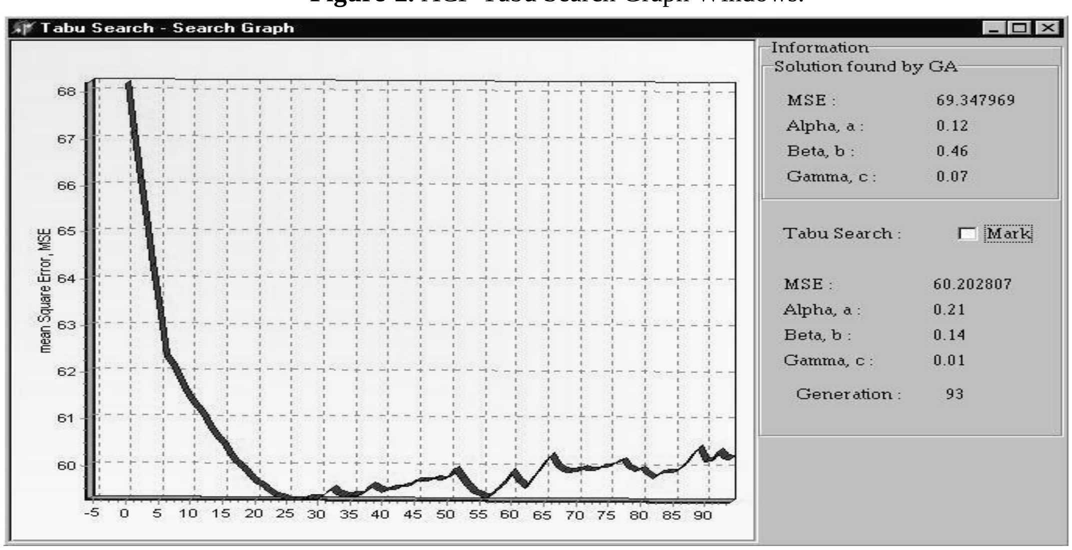


On the Manual Calculation group, it lets the user to choose the value of MSE or MAPE manually by selecting the value of α, β and γ using a scrollbar respectively to the Alpha: α, Beta: β and Gamma: γ label. These facilities allow the user to compare the value of α, β and γ found using the GA search procedure. Lastly, the Option group allows the user to change the view of the graph. The utilities are the 3D view, Rotation, Elevation and Perspective.

This windows is use to display the MSE or MAPE value found during the search. The graph is show in Figure-2. The Tabu Search Graph consists of two major groups, the Solution found by Genetic Algorithm and Search Information.

In Solution found by GA (Genetic Algorithm) group, it shows the solution found earlier using Genetic Algorithm search. This value is then used as an initial value for Tabu Search procedure. The Search Information display the MSE or MAPE value, Alpha: α, Beta: β, Gamma: γ and the generation (number of iteration). The MSE or MAPE, α, β and γ shown is the value in the recent generation. Mark is used to display the value on the graph.

Figure-2. ACF-Tabu Search Graph Windows.



The Tabu Search properties Windows consist of Neighbourhood Size, Tabu List Size and Number of Iteration. For neighbourhood size it allows the user to specify the number of neighbours. A larger number of neighbourhoods would lead to a slower processing time (a more time required to calculate the MSE or MAPE.). As for Tabu List Size, user can specify the size of interest. Tabu List is used to prevent going back to the point visited earlier. Lastly, in Convergence it allows the user to choose the number of iteration for the Tabu search procedure.

VII. CONCLUSION

This paper presents the estimation of smoothing parameters α, β and γ ranges from 0 to 1 by taking two decimal places. When using Winter's Method for forecasting it involved the estimation of three parameters and the search is rather long. With Genetic Algorithm blind search, the algorithm takes into account every related component that was assigned to. Winter's Method, is a forecasting technique that uses three smoothing constants where their value ranges from 0 to 1. This study successfully demonstrate the use of GA search technique to search for the best value of α, β and γ in order to minimize the error function. Due to the random nature of GA search, it may only reach the near optimal solution. Tabu Search was introduced by taking the final solution of GA as the initial solution. Results from this study shows that TS in many cases improve the forecast result and this proved that GA methodology with the help of TS does work in improving forecast.

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