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Demand Value Identification Using Improved Vector Analysis

Shivnarayan Rajput[1], Prof. P M Chawan[2]

[1] *Department of Computer Engineering, VJTI, Mumbai, Maharashtra, India*
[2] *Professor, Department of Computer Engineering, VJTI, Mumbai, Maharashtra, India*

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Abstract - *Supply chain can be said as a set of distributed entities composed of distributors, retailer's manufacturers, suppliers, and costumers. Supply chain management (SCM) is the supervision of its three flows: the materials flow, the finances flow and the information flow. Indeed, this paper focuses on the information flow, more precisely on sharing information within a one echelon supply chain. Supply chain management (SCM) is an emerging field that has commanded attention from different communities. On the one hand, the optimization of supply chain which is an important issue, it requires a reliable future demand prediction. On the other hand, it has been shown that intelligent systems and machine learning techniques are useful for forecasting in several applied domains. In this paper, we used the Particle Swarm Optimization (PSO) algorithm to optimize the SVR parameters. Furthermore, we will use the Artificial Bee Colony (ABC) algorithm to optimize SVR parameters. Furthermore, we will find the time complexity of SVR- PSO and SVR-ABC for supply chain demand forecasting and compare these two algorithms. The goal of our work is to optimize both inventory and transportation costs by using the concept of SVR-ABC.*

Key Words: Supply Vector Machine(SVM), Supply Vector Regression(SVR), Particle Swarm Optimization(PSO), Artificial Bee colony(ABC), Supply Chain Management.

1.INTRODUCTION

Demand forecasts play an important role in supply chain management. Demand forecasting is predicting future demand for the product. In other words, it means the prediction of probable demand for a product or a service on the basis of the prevailing trends in the present and past events. The future demand for a certain product is the basis for the optimization of supply chain and of replenishment systems. The benefits of the demand forecasts can be grouped around two main concepts: firstly, the reduction storage costs by the optimization of the stock and secondly the optimization of operations with the development of optimal strategies for procurement.

We present here demand forecasting approach with Support vector regression. Then, the supply chain will be proposed with a method to present the probabilistic demand. The recent machine learning technique, SVM which overcomes the drawbacks of neural networks, has been introduced to provide a model with better explanation to present the supply chain demand.

The two types of flows are: products flow (from supplier-retailer to market) and information flow (from market-retailer to supplier).

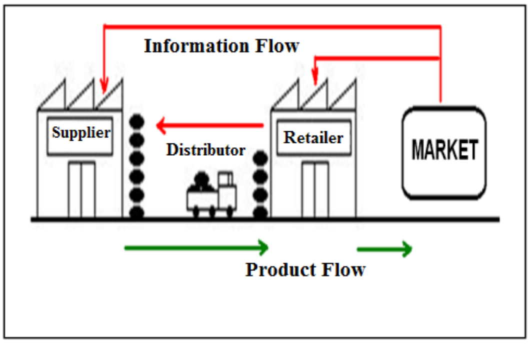

Fig 1. Supply Chain

Following are the advantages of Demand forecasting -

- Helps to Predict the Future
- Learn from The Past
- Reduce Inventory Costs
- Helps Prepare for a Drop-in Sales

1.1 Objectives

A quick response of production systems to changes in consumer demand is not possible. Therefore, demand forecasting is necessary to estimate future consumer demand for a product or service. These demand data serve as the basis of capacity and facility planning and also selection of appropriate inventory levels, capital investments and departmental budgets, material and supplies acquisitions, marketing plans and human resources activities.

The main objectives of any supply chain management(SCM) is to improve the overall organization performance and customer satisfaction by improving the product or service delivery to consumer. Also, other objective of any effective supply chain management (SCM) system is to satisfy the customer demand with very low or minimum costs. In our case, we will be focusing on optimizing inventory costs by using the information flow, more accurately on sharing information within the supply chain.

2. LITERATURE REVIEW

2.1 Support Vector Machine (SVM) -

The support vector machine (SVM) is a latest tool from the artificial intelligence field which use statistical learning theory which has been successfully applied and used in many fields and it recently of increasing interests of researchers: It has been introduced by Vapnik et a1.(1992) and was first applied to pattern recognition (classification) problems, recent research has given extensions to regression problems, including time series forecasting[1].

Issue with SVM is that Parameters of a solved model are difficult to interpret.

2.2. Support Vector Regression (SVR) -

Support Vector Machine (SVM) is one of a machine learning technique for classification, regression, and other learning tasks. Support Vector Regression is a modified version of Support Vector Machines. Support Vector Regression (SVR), a type of support vector machine that attempts to minimize the generalization error bound so as to achieve generalized performance. Regression means a measure of the relation between the mean value of one variable (e.g. output) and corresponding values of other variables also, is that of finding a function which approximates the mapping from an input domain to the real numbers based on training sample. Support vector regression is the extension of large margin kernel methods that is used for classification to regression analysis. In this paper Support Vector Regression is used to forecast the demand and supply of Product or Resources[2].

2.3 SVR-Particle Swarm Optimization (PSO) -

Malek and Afia (2014) [4] introduced the machine learning technique of time series forecasting Support Vector Regression(SVR) and they used the Particle Swarm Optimization (PSO) algorithm to optimize the SVR parameters. They divided experimental data into the two subsets: the testing data and the training data. The forecasting accuracy here is measured by the mean absolute percentage error(MAPE) on the testing data. This paper takes the retail sales data that is published by the Census Bureau. These data are available on the official website of the bureau. In this paper, SVR-PSO gives better results than SVR-GA for this sample and also SVR-PSO gives better minimum values than the SVR-GA method.
Here, we are going to introduce new SVR parameter i.e. Artificial Bee Colony(ABC), that will give better result than the PSO.

2.4. Artificial Bee Colony -

The Artificial Bee Colony (ABC) algorithm is a imaginary, population-based evolutionary method proposed by Karaboga in the year 2005. This ABC algorithm is simple and flexible when compared to other swarm based algorithms. This method has become very popular and is widely accepted and used, because of its good convergence properties. Artificial Bee Colony (ABC) is a swarm intelligence based algorithms inspired by the intelligent behavior of honey bees. Honey bees use several mechanisms like waggle(jiggle) dance to locate most favorable food sources and to search the new ones. Waggle dance is a way of communication among bees by which the successful foragers(mob) share the information not only about the direction and distance of the food sources but also the amount of nectar available to the other foragers. This information exchange among bees helps them in detecting the optimal food locations. ABC has the advantages of very simple, strong robustness, fast convergence, high flexibility and fewer setting parameters [8].

In ABC three artificial agents are defined named as the employed, the onlooker and the scouts. A bee that is waiting on the dance area for making a decision to choose a best food source is called onlooker and one going to the source of food visited by it before, is named employed bee. The other kind of bee is scout bee that carries out random search and discover new sources [9]. In general, the position of food source is represented as Si = (Si1, Si2, ... ,SiD). Information is shared by the employed bees after scout bees returns to the hive, onlooker bees go to the region of food source that has been explored by employed bees at Si based on probability Pi defined as [8]

$$Pi = \frac{fit_i}{\sum_{k=1}^{FS} fit_i}$$

Where FS is total number of Food Sources. Fitness value is calculated here by using the equation [8]

Where fit_i is the fitness value of the i^{th} solution in the swarm. As seen, the better the solution i, the higher the probability of the i^{th} food source selected.

$$Fit_i = \frac{1}{1 + f(S_i)}$$

Where denotes the objective function considered. The onlooker finds its food source in the region of Si by using the following equation [8].

If a position cannot be improved over a predefined number (called limit) of cycles, then the food source is abandoned. Assume that the abandoned source is S_{new} and then the scout bee discovers a new food source to be replaced with i^{th} as equation below:

$$S_{new} = S_{ij} + r^{*} \left(S_{ij} - S_{kj} \right)$$

Where Snew is the new food source exploited by onlooker and S_{ij} *and* S_{kj} are lower and upper boundaries of the i^{th} dimension respectively, k is the solution in the neighborhood of i, r* is the random number in the range -1 to +1 and j is the dimension of the problem considered.

2.4.1 Algorithm -

ABC model has colony that consists of three groups of bees: onlookers, employed bees and scouts. It is assumed that there is only one artificial employed bee for each food source. In other words, the total number of the employed bees in the colony is equal to the number of food sources around the hive. Employed bees go to their food source and come back to hive and dance on this area. The employed bee whose food source has been abandoned or has no resource becomes a scout and starts to search for finding a new food source. Onlookers watch the dances of employed bees and choose food sources depending on dances. The steps of the algorithm are given below.: [3]

- Initial food sources are produced for all employed bees
- REPEAT
  - Each employed bee goes to a food source which is in her memory and determines a neighbor source, then evaluates its nectar amount and dances in the hive
  - Each onlooker watches the dance of employed bees and chooses one of their sources depending on the dances performed, and then goes to that source. After choosing a neighbor around that, she evaluates its nectar amount.
  - Abandoned food sources are determined and are changed or replaced with the new food sources discovered by scouts.
  - The best food source of all found so far is registered.
- UNTIL (requirements are met)

ABC is a population based algorithm in this, the position of a food source represents a possible solution to the optimization problem and the total nectar amount of a food source corresponds to the quality (i.e. fitness) of the associated solution. The number of the employed bees is equal to the number of solutions in the whole population. At the first step, a randomly distributed initial population (food source positions) of bees is generated. After initialization, the population is directed to repeat the cycles of the search processes of the onlooker, employed and scout bees, respectively. An employed bee gives a modification on the source position in her memory and then discovers a new food source position. Provided that the nectar amount of the new one is higher than that of the old or previous source, the bee memorizes the new source position and forgets the old one. Otherwise bee keeps the position of the one in her memory.

After all employed bees complete the search process, they all share the position information of the sources with the onlookers on the dance area in the hive. Each onlooker evaluates the nectar information taken by all employed bees and then chooses a food source depending on the nectar amounts of sources. As in some cases of the employed bee, she produces a modification on the source position in her memory and checks its nectar amount. Condition that its nectar is higher than that of the previous one, the bee memorizes the new position and forgets the old one. The sources abandoned or left are determined and new sources are randomly produced to be replaced with the abandoned or left ones by artificial scouts.

2.4.2 The Artificial Bee Colony Meta-heuristic-

The ABC algorithm works as follows:

- Initialization Phase
  - REPEAT
    - Employed Bees Phase
      - Onlooker Bees Phase
      - Scout Bees Phase
    - Memorize the best solution achieved so far
  - UNTIL(Cycle=Maximum Cycle Number or a Maximum CPU time)

A. Initialization Phase

All the vectors of the population of food sources $\overrightarrow{x_m}$'s, are initialized (m=1...SN , SN: population size) by scout bees and control parameters are set. Since each food source, $\overrightarrow{x_m}$, is a solution vector to the optimization problem, each $\overrightarrow{x_m}$ vector holds n variables, (x_{mi}, i=1...n), which are to be optimized so as to minimize the objective function.

The following definition might be used for initialization purposes (5):

$$x_{mi} = l_i + rand\ (0,1) * (u_i - l_i) \qquad (1)$$

where li and ui are the lower and upper bound of the parameter x_{mi} , respectively.

B. Employed Bees Phase

Employed bees search for new food sources ($\overrightarrow{v_m}$) having more nectar within the neighborhood of the food source ($\overrightarrow{x_m}$) in their memory. Each employed bee x_m generates a new candidate solution v_m in the neighborhood of its present position. They find a neighbor food source and then evaluate its profitability (fitness). For example, they can determine a neighbor food source $\overrightarrow{v_m}$ using the formula given by equation (6):

$$v_{mi} = x_{mi} + \emptyset_{mi} (x_{mi} - x_{ki}) \qquad (2)$$

where $\overrightarrow{x_k}$ is a randomly selected food source, i is a randomly chosen parameter index and $\emptyset_{mi}$ is a random number within the range [−a,a] . After producing the new food source $\overrightarrow{v_m}$, its fitness is calculated and a greedy selection is applied between $\overrightarrow{v_m}$ and $\overrightarrow{x_m}$.

The fitness value of the solution, $fit_m\ (\overrightarrow{x_m})$, might be calculated for minimization problems using the following formula

$$fit_m(\overrightarrow{x_m}) = \begin{cases} \frac{1}{1+f_m\,(\overrightarrow{x_m})} & if\ \ f_m(\overrightarrow{x_m}) \geq 0 \\ 1+abs(f_m\,(\overrightarrow{x_m})) & if\ \ f_m(\overrightarrow{x_m}) < 0 \end{cases} \quad (3)$$

where $f_m\ (\overrightarrow{x_m})$ is the objective function value of solution $\overrightarrow{x_m}$.

C. Onlooker Bees Phase

Unemployed bees consists of two groups of bees i.e, onlooker bees and scouts. Employed bees share their food source information with onlooker bees waiting in the hive and then onlooker bees probabilistically choose their food sources depending on this available information. In ABC, an onlooker bee chooses a food source depending on the probability values calculated using the fitness values provided by employed bees.

The probability value p_m with which $\overrightarrow{x_m}$ is chosen by an onlooker bee can be calculated by using the expression given in equation (8) :

$$p_m = \frac{fit_m\,(\overrightarrow{x_m})}{\sum_{m=1}^{SN} fit_m(\overrightarrow{x_m})} \quad (4)$$

After a food source $\overrightarrow{x_m}$ for an onlooker bee is probabilistically chosen, a neighborhood source $\overrightarrow{v_m}$ is determined by using equation (2), and its fitness value is computed. As in the employed bees phase, a greedy selection is applied between $\overrightarrow{v_m}$ and $\overrightarrow{x_m}$. Hence, more onlookers are recruited to richer sources and positive feedback behavior appears.

D. Scout Bees Phase

The unemployed bees who chooses their food sources randomly are called scouts. Employed bees whose solutions or source cannot be improved through a predetermined number of trials, specified by the user of the ABC algorithm and called it "limit" or "abandonment criteria" herein, become scouts and their solutions or source are abandoned. Then, the converted scouts start to search for the new solutions, randomly. For instance, if solution $\overrightarrow{x_m}$ has been abandoned, the new solution that is discovered by the scout who was the employed bee of $\overrightarrow{x_m}$ can be defined by (1). Hence those sources which are poor initially or have been made poor by over exploitation are abandoned and negative feedback behavior arises to balance the positive feedback.

Detailed Pseudocode of the ABC Algorithm

1. Initialize the population of solutions x_{mi}.
2. Evaluate the population.
3. cycle=1.
4. Repeat.
5. Produce new solutions (food source positions) v_{mi} in the neighborhood of x_{mi} for the employed bees using the formula,

$$v_{mi} = x_{mi} + \emptyset_{mi}\,(x_{mi} - x_{ki})$$

(k is a solution in the neighborhood of i, Φ is a random number in the range [-1,1]) and evaluate them.

6. Apply the greedy selection process between x_{mi} and v_{mi}.
7. Calculate the probability values p_m for the solutions xi by means of their fitness values using the equation (1),

$$p_m = \frac{fit_m\,(\overrightarrow{x_m})}{\sum_{m=1}^{SN} fit_m\,(\overrightarrow{x_m})}$$

In order to calculate the fitness values of solutions we employed the following equation (eq. 2):

$$fit_m(\overrightarrow{x_m}) = \begin{cases} \frac{1}{1+\ f_m\,(\overrightarrow{x_m})} & if\ \ f_m(\overrightarrow{x_m}) \geq 0 \\ 1+abs(f_m\,(\overrightarrow{x_m})) & if\ \ f_m(\overrightarrow{x_m}) < 0 \end{cases} \quad (2)$$

Normalize p_m values into [0,1].

8. Produce the new solutions (new positions) v_{mi} for the onlookers from the solutions x_{mi}, selected depending on p_m, and evaluate them.
9. Apply the greedy selection process for the onlookers between x_{mi} and v_{mi}.
10. Determine the abandoned solution (source), if exists, and replace it with a new randomly produced solution x_{mi} for the scout using the equation (3)

$$x_{mi} = l_i + rand\ (0,1) * (u_i - l_i) \quad (3)$$

11. Memorize the best food source position (solution) achieved so far.
12. cycle=cycle+1.
13. until cycle= Maximum Cycle Number (MCN).

2.5. ABC algorithm Summary

- ABC is inspired by the foraging behavior of honeybees,
- Also, it is a global optimization algorithm,
- It has been initially proposed for numerical optimization (e.g.: Karaboga, 2005), but can be also used for combinatorial optimization problems (eg: Pan et al, 2010),
- This algorithm employs only three control parameters (population size, maximum cycle number and limit) that are to be predetermined by the user,

3. CONCLUSIONS

The management of supply chain involves everything from raw materials procurement, production, development and logistics as well as the coordination of these activities ensured by information systems using statistics. "SCM is the units organizational throughout a supply chain and coordinating the products, information and financial flows in order to satisfy customer demands" .

In this paper, we have introduced the machine learning technique of time series forecasting Support Vector Regression (SVR). There are no fixed methods to choose the free parameters of an SVR model. Here we use the Artificial Bee Colony (ABC) algorithm to optimize the SVR parameters. Artificial Bee Colony (ABC) algorithm which is inspired from the behavior of honey bees swarm or group is presented. ABC is a stochastic population-based evolutionary algorithm for problem solving. ABC selects best free parameters for SVR to avoid over-fitting and local minima problems and improve the prediction accuracy. Our goal is to compare the experimental results of the proposed model SVR-ABC and the existing model SVR-PSO using the time parameter.

4. FUTURE WORK

In future, the same algorithm can be reapplied using different Optimizing Algorithm to optimize and reduce the time to predict the demand from the large database.

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