An Implementation of Genetic Algorithm Optimized Fuzzy System on JIT for Waste Reduction of Automobile Spare Parts

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Abstract— JIT is not just a philosophy but an actual process. The core JIT philosophy is to achieve the performance of activities based on immediate need or demand. JIT can be applied not just in the manufacturing area, but it also can be broadly used as a process that is designed to assist companies in operating cost, reduce their energy usage, processing times and material. This paper explores that JIT (Just- in-time) System is used as a process in order to achieve high performance level. A JIT System is an inventory management philosophy aimed at reducing waste and redundant inventory by delivering products, components, or materials just when an organization needs them. In this paper optimized JIT is proposed in order to optimize the wastage in stock preserving for automobile spare parts and to dynamic scheduling of deliveries to reach customer satisfaction level.

Keywords: JIT, Eliminating waste, optimization, waste reduction, customer satisfaction

I. INTRODUCTION

The concept of Just-in-Time (JIT) was pioneered by Toyota in the 1950's and since then has been expanded and modified by companies all over the world. Originally, managers viewed JIT as an inventory reduction technique. This narrow focus centered on small batches of product delivered just in time for downstream consumption. In today's progressive organizations the meaning of JIT embodies a wide variety of concepts and principles [1].

The concept of just-in-time (JIT) manufacturing and ordering helps you keep just enough inventory on hand to meet demand.

To implement a JIT system, you must have accurate sales forecasts. These JIT improvements can only become available with efficient supply chains. There are 3 JIT system principles which are of importance when considering implementation:

- Total quality control: JIT system focuses on improving efficiency of material processes and quality is very important.
- Elimination of waste: JIT system focuses on improving the effectiveness of processes and operations that add value to the materials. Inventory is considered as waste and should be reduced as much as possible.
- People involvement: The company's employees are its most valuable resource. It is essential that everyone understands JIT system and gets involved with making it a success.

Most of manufacturing and management systems are not aware about the methodology and benefits of JIT and even not confident about the successful implementation of these advance production methodology [2]. Some benefits of Implementing JIT System are such as:

- Productivity improvements and greater control between various production stages.
- A reduction in manufacturing cycle times.
- Dramatically improved inventory turnover rates.
- Reduce distribution costs.
- Improved quality of supplier products.
- Reduced number of transportation carriers and suppliers.
- This study focuses on identifying the application and benefits of JIT in warehouse management system.

A wide range of customer are facing the problems in automobile servicing, like late delivery, longer duration maintenance, slower gradation process of accessories and device, unsatisfactory performance of vehicle even after servicing. This work will uncover the problem and issues which are coming as a barrier in smooth and successful implementation of JIT based system. Each vehicle contains approximately 15,000 parts. Because automakers decide to have suppliers take care of producing parts, managers of purchasing department have to figure out how to promote long-term relationships and mutual cooperation with suppliers. Their interactions extend from product development to manufacturing or the other option is to rely on shorter-term contracts and competitive bidding, as well as more in-house development and manufacturing, in an attempt to lower cost [3].

This study focuses on identifying the applied efforts by the automobile servicing companies and ranking is provided for these companies based on the degree of implementation of JIT production system.

II. RELATED WORK

Singh et al. [1] predicted the order lead time in a Just in Time (JIT) manufacturing environment. An attempt has been made to predict the order lead time or delivery time for a restaurant using several features. Different supervised state-of-the-art regression machine learning algorithms were used and their accuracies were compared on the given dataset.

Runkler et al. [2] proposed the application of interval type-2 fuzzy decision making (IT2FDM) to dynamic scheduling of deliveries in a just-in-time logistic process. Delivery decisions are based on order priorities computed from the expected decrease of customer satisfaction for each order.

Yildiz et al. [3] presented an optimization model that extends previous approaches focused on optimizing production plans to the JIT setting. Furthermore, based on real order release information provided to the supplier, two simple adjustment heuristic methods are developed. The performances of these approaches are compared with relying solely on order releases received from the customers. The

simple median-based adjustment heuristic performs the best of all the approaches. Implications of the analysis are also discussed.

Bahija et al. [4] tends to put the light on the interest of combine Electronic Data Interchange (EDI) technology with the JIT system to ensure a better performance in logistics and operational integrating firms of the supply chain. The objective is to demonstrate the impact of EDI on the implementation of a system JIT succeeded in enterprises in order to ensure a cost optimization of production, logistics and storage.

Najm A. Najmet. al. [5] investigated two issues. The first is to determine the impact of TQM dimensions of a medical care system (quality system, quality leadership, medical and sanitary staff, relationship with patient, relationships with suppliers, and continuous improvement) on the hospital competitive advantage (innovation, competitive benchmarking) in sample Jordanian hospitals. The second is to explore the moderating effect of two basic organizational characteristics: the size and the age of a hospital, on the relationship between TQM dimensions and competitive advantage.

Sunil Kumar et. al. [6] stated that - In the era of cut throat competitive market, Indian industries are under tremendous pressure to continuously reduce the cost and improve product quality. The main objective of this research paper is to provide a road map for investigating the opportunities to reduce cost and improve productivity and quality in the existing production system through the application of Lean-Kaizen concept using value stream mapping (VSM) tool at shop for of an Indian Small-Scale Enterprise (SSE).

III. METHODOLOGY

The main goal of this paper is to proposed optimized JIT system for supply chain management which reduce the wastage of spare parts in stock [7][8]. Along with optimization, this paper is focused to gain insights into the importance of the different predictor variables and their influence on forecast accuracy. So, algorithm needs to reduce the risks associated with decision-making, which can be done by anticipating the future more clearly to reduce the cost of wastage and enhancing customer satisfaction level in a system via optimum prediction.

In this just–in–time spare parts logistic process customers are placing orders. The goal is to deliver maximum order on time, not later because this will cause delays in the supply chain, and not earlier because this will lead to additional costs for intermediate storage of components. Figure 1 shows the overall architecture for prediction/forecast the demand or warehouse sales. The proposed work is designed for forecasting the sales/demand using ensemble support vector machine.

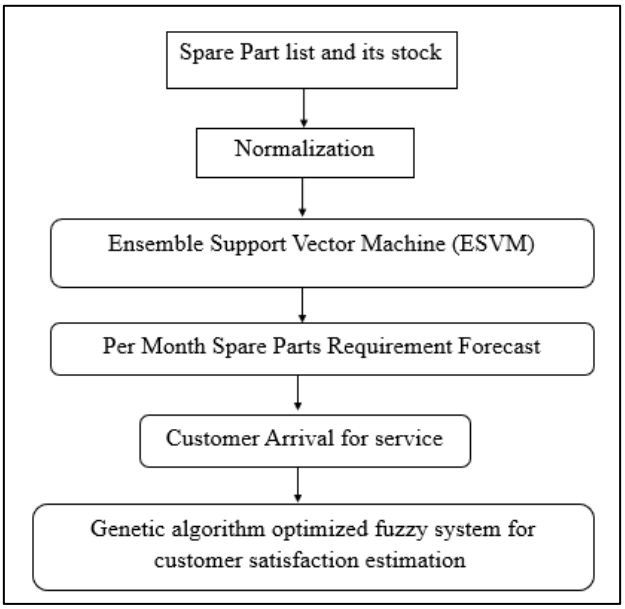

Fig. 1: Flowchart of Proposed Methodology

In this work simulation, the number n ∈ {0, 1, . . .} of incoming customer' s order every month can be randomly drawn from user input. Here, 20 spare part list is considered for servicing purposed of 7 different automobile companies. There would be random number of customer's order that can be delivered. So, it is required to forecast spare part stock for next month and evaluation of randomly arrived customer such that maximum number of customers can be serviced.

A. Spare Part list and its stock collection

This Dataset is for Servicing monthly data from January, 2017 to March, 2018. Total Number of Data is 4396. This dataset contains Monthly requirement of spare parts having seven automobile company data with 20 spare part lists.

B. Normalization of dataset

In this step, normalization of data is performed. In this step, missing data are selected and replaced with zero value. This is done because for further calculation missing data will show error.

C. Ensemble Support Vector Machine

In this work, an ensemble of support vector machine is proposed which combines the features of support vector machine and ensemble classification machine learning approach for prediction of future requirement of the spare parts. Figure 2 shows a general architecture of the proposed SVM ensemble. During the training phase, each individual SVM is trained independently by its own replicated training data set via a bootstrap method.

The SVM has two drawbacks. First, since it is originally a model for the binary-class classification, we should use a combination of SVMs for the multi-class classification. Methods for combining SVMs for the multi-class classification is also there but the performance does not seem to improve as much as in the binary classification. Second, since learning of the SVM is a very time consuming for a large scale of data, we should use some approximate algorithms.

Using the approximate algorithms can reduce the computation time, but degrade the classification performance. To overcome the above drawbacks, we propose to use the SVM ensemble. We expect that the SVM ensemble can improve the classification performance greatly than using a single SVM by the following fact. Each individual SVM has been trained independently from the randomly chosen training samples and the correctly classi6ed area in the space of data samples of each SVM becomes limited to a certain area. We can imagine that a combination of several SVMs will expand the correctly classi6ed area incrementally. This implies the improvement of classification performance by using the SVM ensemble. Likewise, we also expect that the SVM ensemble will improve the classification performance in case of the multi-class classification.

The SVM has been known to show a good generalization performance and is easy to learn exact parameters for the global optimum [2]. Because of these advantages, their ensemble may not be considered as a method for improving the classification performance greatly. However, since the practical SVM has been implemented using the approximated algorithms in order to reduce the computation complexity of time and space, a single SVM may not learn exact parameters for the global optimum. Sometimes, the support vectors obtained from the learning is not sufficient to classify all unknown test examples completely. So, we cannot guarantee that a single SVM always provides the global optimal classification performance over all test examples.

To overcome this limitation, we propose to use an ensemble of support vector machines. Similar arguments mentioned above about the general ensemble of classi6ers can also be applied to the ensemble of support vector machines. Fig. 2 shows a general architecture of the proposed SVM ensemble. During the training phase, each individual SVM is trained independently by its own replicated training data set via a bootstrap method.

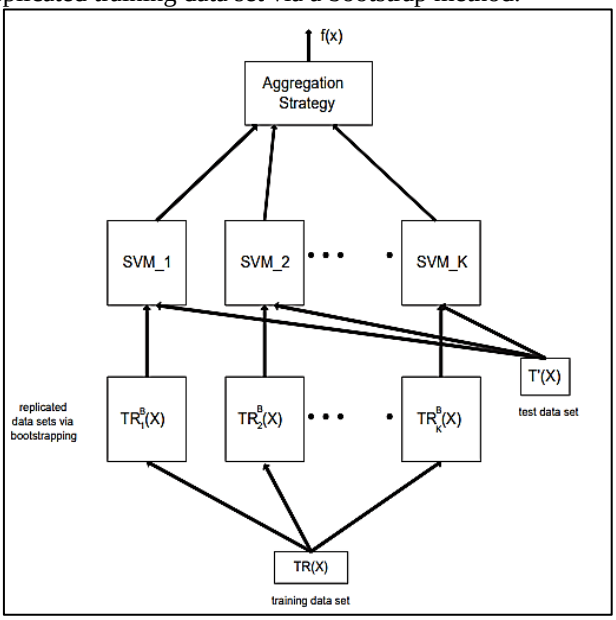

Fig. 2: Architecture of the Ensemble SVM

Many methods for constructing an ensemble of classi6ers have been developed. The most important thing in constructing the SVM ensemble is that each individual SVM becomes different with another SVM as much as possible. This requirement can be met by using different training sets for different SVMs. Some methods for selecting the training samples are bagging, boosting, randomization, stacking and bagging. Among them, we put focus on the representative methods such as bagging.

Bagging First, we explain a bagging technique to construct the SVM ensemble. In bagging, several SVMs are trained independently via a bootstrap method and then they are aggregated via an appropriate combination technique. Usually, we have a single training set TR = $\{(x_i; y_i)|i = 1; 2,\ldots\ldots\ldots\ldots,l\}$. But we need K training samples sets to construct the SVM ensemble with K independent SVMs. From the statistical fact, we need to make the training sample sets different as much as possible in order to obtain higher improvement of the aggregation result. Each example x_i in the given training set TR may appear repeated times or not at all in any particular replicate training data set. Each replicate training set will be used to train a certain SVM.

D. Per Month Spare Parts Requirement Forecast

An ensemble of support vector machine is used to predict the requirement of the spare parts month wise as well as company wise.

E. Genetic algorithm optimized fuzzy system for customer satisfaction estimation

Genetic algorithm optimized fuzzy system is proposed which estimate the customer satisfaction. In this algorithm customer priority is determined on the basis of their arrival, their requirements, user frequency and profit earned from requirement.

F. Algorithm

N= number of customer's order
for 1:n do
get f(priority_cust) from GOFL (genetic-optimized fuzzy logic)
for month ← 1, . . . , 12 do
append additional orders
deliver max orders by priority, f(priority_cust)
end
end
store number of just–in–time deliveries
store average customer satisfaction

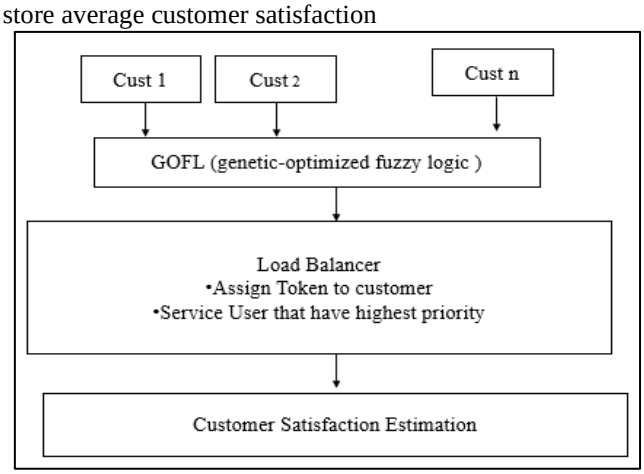

Fig. 3: Flowchart for Estimating Customer Satisfaction

IV. RESULT ANALYSIS

The dataset used here is taken from [7]. In this paper, 4 companies are studied which contains details of 20 spare parts for 4 companies i.e. Toyota, Nissan, Renault and Ford. The data contains information about month, company, spare parts, monthly ordered spare parts, scrap and unused spare parts. Along with these companies, market was analysed from spare part dealers and data was extended with three more companies specially focused on Maruti. Details of spare parts details are discussed as in Table I.

1	AC Servicing
2	Air Filter
3	Battery - Diesel
4	Battery - Petrol
5	Brake Disc
6	Brake Hose
7	Clutch Replacement
8	Front Brake Pads
9	Front Bumper
10	Front Fog Light
11	Front Shock Absorber
12	Front Windshield
13	Fuel Filter - Diesel
14	Fuel Filter - Petrol
15	Headlight Assembly
16	Rear Brake Shoe
17	Rear Shock Absorber
18	Spark Plug
19	Tail Light Assembly
20	Wiper Blades

Table 1: Spare part list in Dataset

The MATLAB platform is used to implement proposed model for the functional approximation optimized JIT for automobile servicing. Input for the demand forecasting model are:

- Stock record of spare parts for automobile companies.
- Number of customer arrival of servicing

The output of the model corresponds to the expected demand monthly of spare parts as well as customer satisfaction level.

A. Spare Part Requirement Forecasting Month Wise

In this section, spare part requirement month wise is forecasted using proposed methodology. Table II represents the result analysis. The table illustrates the difference between actual spare part needed and forecasted spare parts. The difference rate shows that proposed model is efficiently gives accurate result which can be used for future demand and reduction of customer waiting time. Similarly, table III represents the forecasting result according to company wise.

Month	Spare Part Needed	Forecasted Spare parts	Difference	Difference Rate
Jan	7519	7514	5	0.07%
Feb	7588	7588	0	0.00%
March	7733	7727	6	0.08%
April	7636	7630	6	0.08%
May	7418	7414	4	0.05%
June	7128	7146	18	0.25%
July	7771	7762	9	0.12%
Aug	7605	7615	10	0.13%
Sept	7712	7707	5	0.06%
Oct	7231	7227	4	0.06%
Nov	7701	7719	18	0.23%
Dec	8258	8268	10	0.12%

Table 2: Spare Part Requirement Forecasting Month Wise

Company	Spare Part Needed	Forecasted Spare parts	Difference	Error Rate
Maruti	12461	12472	11	0.09%
Ford	12913	12929	16	0.12%
Hyundai	13225	13227	2	0.02%
Nissan	13165	13172	7	0.05%
Renault	13268	13259	9	0.07%
Volkswagen	12918	12905	13	0.10%
Toyota	13350	13353	3	0.02%

Table 3: Spare Part Requirement Forecasting Company Wise

B. Waste Reduction Month Wise

In this section, according to forecasting result of spare part requirement month wise made helpful for waste reduction, figure 4-10. In figure 11, average annual waste reduction percentage is estimated using proposed methodology. From this result highest waste reduction was achieved in Maruti as its demand in market is high. So, due to proposed technique, there is no requirement of keeping stock of spare parts in bulk.

Fig. 4: Maruti Spare Parts Wastage Reduction

Fig. 5: Ford Spare Parts Wastage Reduction

Fig. 6: Hyundai Spare Parts Wastage Reduction

Fig. 7: Nissan Spare Parts Wastage Reduction

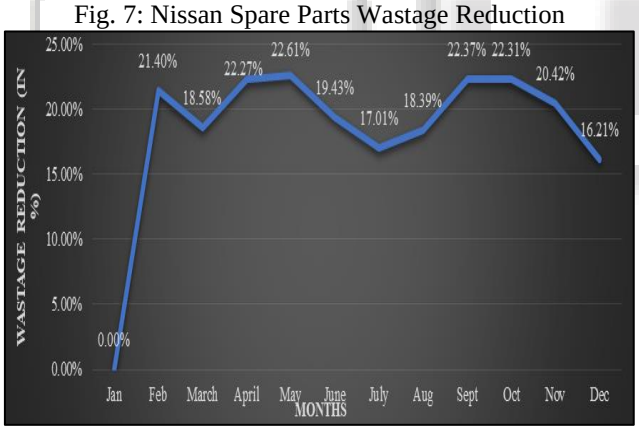

Fig. 8: Renault Spare Parts Wastage Reduction

Fig. 9: Toyota Spare Parts Wastage Reduction

Fig. 10: Volkswagen Spare Parts Wastage Reduction

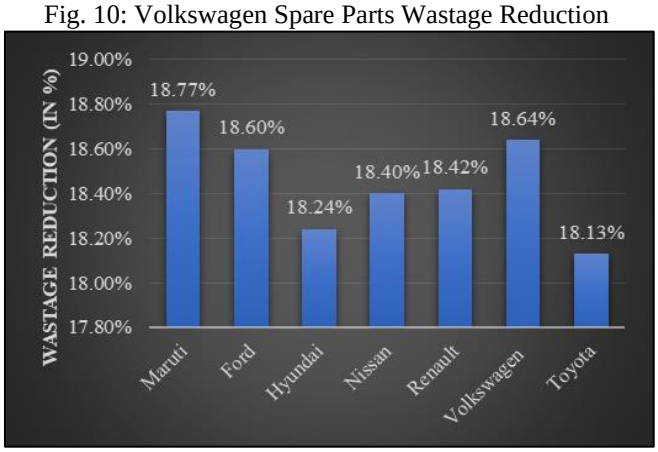

Fig. 11: Annual Average Wastage Reduction Company Wise

C. *Average Customer Satisfaction*

In this section, average customer satisfaction level was estimated according to proposed methodology and discussed in table IV and figure 12. A comparative result analysis for average customer satisfaction level according to some existing techniques are shown in figure 13.

Automobile Company	Average Customer Satisfaction (in %)
Maruti	81.62
Ford	81.95
Hyundai	81.28
Nissan	90.82
Renault	87.93
Volkswagen	91.71
Toyota	74.73

Table 3: Average Customer Satisfaction Company Wise

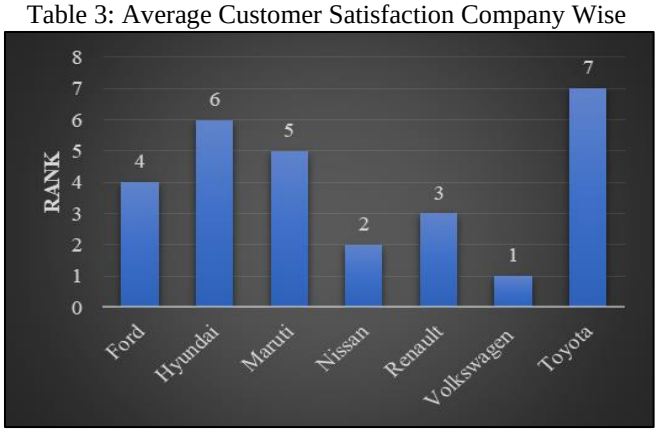

Fig. 12: Rank of Automobile Companies on the basis of Customer Satisfaction Level

Fig. 13: Comparative Average Customer Satisfaction

V. CONCLUSION

In this paper the problem of dynamic scheduling of automobile servicing is considered in a just–in–time process based genetic optimized fuzzy model for estimation of customer satisfaction. In this methodology, customer satisfaction model is used to compute the expected decrease of customer satisfaction for each order and used these to prioritize the orders to be delivered. A broader perspective for customer's demand plan can be achieved by producing a range of forecasts that you can re-calculate frequently to reflect market conditions, changing assumptions, and probabilities. To successfully estimate demand, the current and future marketing plans.

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