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Application of Real Coded Genetic Algorithm in Inventory Management

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ABSTARCT

For any organization, total inventory cost must be optimum so that inventory will minimize total cost or maximize total profit of the organization. Total inventory cost depends on various factors and parameters such as, replenishment rate, lead time, demand, constraints, planning horizon, perishability, shortages, various types of costs, salvage value etc. Genetic algorithm has wide applications in solving different types of decision-making problems in the field of Operations Research and Engineering. In this paper Inventory model is modified from Lee and Nahmias inventory model (The Newsboy model) and then Real coded Genetic Algorithm is developed and applied as optimization algorithm to find optimum inventory cost. The research is applied on wheat flour inventory of one of the biscuit companies in India. Lead time and demand have been kept fixed as well as varied to get optimum maximum inventory value and order interval so that company can plan their order plan. The result is obtained for different number of generations from 1000 to 4000 with gap of 1000. Demand value for which total cost can be minimum is also obtained. Due to some demerits of binary genetic algorithm, simple and straight forward Real coded genetic algorithm is applied which gives accurate result. Roulette wheel selection, Uniform crossover and random mutation of real coded genetic algorithm is used as natural genetics operator's technique. MATLAB software is used to code real coded genetic algorithm.

Keywords: Total inventory cost, Optimum, Real coded genetic algorithm, The Newsboy model, Generations

1. INTRODUCTION:

Genetic Algorithm has wide applications in solving different types of decision -making problems in the field of Operations Research and Engineering. One of the vital areas of Operations Research is Inventory Management/Control System [1].

Inventory is an idle resource of any kind provided such resource has an economic value. The idle resource generally comprises of a stock of physical goods, commodities or other economic resources which ensure the continuity of production or other business activities by fulfilling the customer's demand or requirement of production. Hence, we can say that inventory acts as a buffer stock between a supplier and a manufacturer or a manufacturer and a customer or a retailer and a customer etc. [1].

The control and maintenance of inventory is a problem common to all organizations in every sector of our economy. The problem of inventory is not only confined to profit making institutions/organizations. Inventories are common to hospitals, manufacturers, wholesalers, retailers, agriculture, universities, and governments (national, state, and local) [1]. Business Organization hold inventory to lessen costs and to improve customer service. The need of the organization to hold inventory is to maintain balance of inventory so that organization can minimize high inventory costs and ensure that inventory is not low which can cause loss of sales of the customers [4].

Genetic algorithm optimizes inventory control strategies which improve customer service, reduces lead time and cost, and fulfill market demand. This ensures that inventory is optimum which further optimizes total inventory cost.

In this project a real coded Genetic Algorithm is applied to periodic review policy of Biscuit manufacturing company, especially for wheat flour inventory management.

2. BASIC TERMINOLOGY IN INVENTORY:

Demand: Demand is defined as the number of units required per period and may be known properly or in terms of probabilistic or to be completely unknown. When demand is known it is called deterministic system and when demand is not known it is possible to ascertain its probability distribution from past record, this type of system is known as probabilistic system and demand as probabilistic demand. In fuzzy system, demand termed as fuzzy demand is represented by uncertain data in non-stochastic sense i.e., by vague/ imprecise data.

Constraints: In an inventory system, there are several limitations due to customers, suppliers, economic behavior of the market and various other factors. These limitations are known as constraints. These constraints may be imposed on several factors like the available space, the amount of inventory held, number of orders, average instantaneous expenditure, amount of investment. The objective of an inventory system is to minimize/maximize the cost/profit functions and ensure smooth functioning of the organization after satisfying these constraints.

Fully / partially Backlogged Shortages: Sales are lost due to incapability to fulfill demand in sales period. Same demand is fulfilled completely later then this situation is known as fully backlogged shortage. On the other hand, if backlogged demand is satisfied gradually after the starting of production it is called partially backlogged shortage.

Lead time: The time gap between the placing of an order and its actual arrival is known as lead time.

2.1 Various Types of Cost:

Review cost (Cr)/order: It is cost of evaluating the current inventory scenario before placing an order. It includes administration and labor cost required for storage.

Ordering/Set up/Procurement Cost (Co): The ordering or set up cost deals with obtaining commodities through an order from an external supplier or purchasing or manufacturing or setting up a machinery before starting of production.

Holding Cost (Ch): Holding cost is the cost required to hold the inventory until its sale or use.

Shortage cost (Cs): If the demand or consumption of a product exceeds the present available stock then that situation is known as shortage. This is the penalty cost due to the shortage or running out of stock in situation where we cannot fulfill customer orders.

3. ASSUMPTIONS:

Assumptions on constraints:
1) Demand is taken as constant as well as varying.
2) Backorders are allowed.
3) Lead times are known, constant as well as varying.
4) Buffer stock (X) is zero or more than zero.
5) Buffer stock (X) at the end of period can be positive or negative.
6) Capacity of production is constant despite breakdown of the machine.
7) Cost required for production is constant throughout the study.
8) Purchasing cost $<$ shortage cost.

4.PROBLEM AND MODEL FORMULATION:

This research gives optimum number of inventories with optimum order interval for the one of the biscuit companies of India. The EOQ model using Genetic Algorithm to solve economic order quantity by Stockton and Quinn (1993) is deterministic where demand is constant. The drawback of this model is that conditions used in this model is deterministic and predictable [6]. Deterministic model of EOQ cannot be applied when the system is under stochastic condition.

One of the stochastic inventory models is an order-up-to periodic review policy. Unlike continuous review model where order quantity is fixed, order -up-to periodic review policy places an order in every period that will raise inventory to a target level [5].

Order quantity can vary since demand fluctuates period by period which can result in changes in production or capacity plans. The charges required for production and capacity plans can be incurred by the supplier but may be charged to the buyer.

In this paper, after every n interval buyer review situation and orders stock for upcoming period to raise the inventory to target level [3]. It is also possible to make order quantity fixed in review system.

In this research order quantity and lead time has been kept fixed and varied to get the required optimum order interval T and max. inventory Y.

The company need to order only when buffer stock (X) is less than maximum inventory (Y). The quantity order will be Y-X. Otherwise if $X \geq Y$, do not order. Optimal solution for the model is when $X < Y$. [2]

The Total inventory cost model modified from The Newsboy model solved in MATLAB by Real coded Genetic Algorithm is as follows:

Z= Cr+ Co+((1-Ps). *(Ch. *(Y- (D. *T+D.*LT))) + (Ch. *((D. *T+D. *LT). /2)) + (Ps. *((Pb. *Cb) + (Pl. *Cl)). *((D. *T+D. *LT)-Y)))

Here

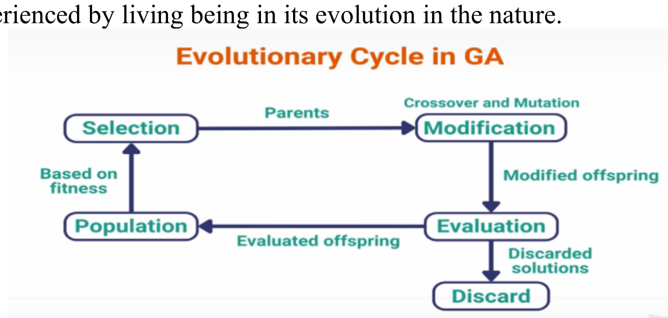
TC= Total inventory cost

Cr= Review cost per review

Co= order cost/order
Ps= Probability of shortage is occurred
Ch= Holding cost/unit/month
Y= Max inventory level
D= Average daily demand
T= Period review
LT= Lead time
Pb= Shortage backordered in percent
Cb= Backorder cost
Pl= percent of shortage is lost
Cl= Unit lost-sale cost

5. MECHANISM OF REAL CODED (CONTINOUS) GENETIC ALGORITHM:

Genetic algorithm is searching algorithm with logic which uses natural genetic operators such as selection, crossover, mutation experienced by living being in its evolution in the nature.



Binary coded genetic algorithm has some demerits such as requires changing many bits, fixed string length as well as appropriate string length not know prior. Real coded genetic algorithm is simple and straightforward.
This research attempts to apply Real coded genetic algorithm in inventory management problem to optimise total inventory cost
In this research all the operations of natural genetics such as selection, crossover, mutation is applied to the Real coded genetic algorithm.
1) Roulette wheel selection:
The simplest selection scheme is roulette wheel selection, also called stochastic sampling with replacement, originally proposed by Holland (1975). The basic idea is to determine the selection probability for each individual proportional to the fitness value [7].
The procedure used in this research is explained with the help of one example:
Let random solutions for the objective function $f(x) = x1^2 + x2^2$,with constraints: -5≤ $x1$, $x2$ ≤ 5 with their fitness values be:

Solution Number	X1	X2	Fitness Value
1	4.79	-3.33	8.2
2	-3.50	-4.37	3.2
3	-3.17	3.03	1.4
4	-2.93	4.98	1.2
5	-2.82	-1.12	4.2
6	1.17	-0.90	0.3

Wheel is divided into six parts based on fitness values and spined [7]. Solution with better fitness value has more chance of being selected for crossover operation. But this concept is implemented in computer by first finding objective function (zi) value then finding fitness value $\frac{1}{1+Zi}$ and probability $=\frac{\text{Fitness value}}{\sum Fitness\ Value}$. Finally, cumulative probability is found out for
the solution by adding all the previous probabilities. Random number is generated and it is compared with cumulative probabilities from start to end. First parent that has cumulative probability greater than random number is selected for crossover. This is done two times by generating another random number.
Crossover: Two parents are selected for crossover operation by roulette wheel selection.

Parents selected:	X1	X2
P1	-2.82	-1.12
P2	4.79	-3.33

The new offspring's Y1 and Y2 are given by following equation:
Y1= alpha *P1+ (1-alpha) *P2
Y2= alpha* P2 + (1-alpha) *P1, alpha is random number between 0 and 1. Taken as [0.8910 0.1770].
New solutions are obtained as shown below (If same solutions are obtained process is repeated until we get better solution) and checked if they satisfy boundary conditions:

Y crossover	X1	X2
Y1	-2.82	-1.12
Y2	4.79	-3.33

Mutation: We require only one parent in the mutation because we make changes in the gene of the solution. Gene here is the decision variable of the solution. One parent is selected at random from the population. Then one of the decision variables is selected as random as X1.

Parent selected for mutation operation	
X1	X2
1.17	-0.90

The mutated solution is given by Y (1) =P6 (X1) + [sigma * randn (size (1)]
sigma = 0.1 (user defined parameter). Here we take X1 decision variable of sixth solution and adding it to user defined parameter multiply by random number of equal to the size of 1st decision variable X1. After mutation operation we get below solution:

Parent selected for mutation operation	
X1	X2
1.23	-0.90

Again, it is checked if it satisfies boundary condition i.e., constraints of the decision variables.
From all the above solutions i.e., random solution generated, crossover and mutation solutions best 6 solutions are obtained and the fitness value is calculated. This calculation is for one generation. We calculate such solutions for number of generations to get optimum result.

6.CONCLUSIONS:

In this research Inventory is optimized. The work is carried out in four stages.
1) The results of total cost are obtained by keeping demand and lead time fixed.
2) The Demand fixed and lead time vary.
3) Demand varies and lead time fixed.
4) Demand and lead time vary.
The Genetic Algorithm is applied to different number of generations varying from 1000 to 4000 and optimum result is obtained in MATLAB. Roulette wheel selection and Uniform crossover is and random mutation is used. The mutation and crossover rate are kept as 0.2 and 0.7. Number of crossover and mutations is 4 and 2 respectively. The population size is taken as 10.
Since research is applied to perishable product of biscuit company i.e., Wheat as the inventory. T (order interval) and Y (Maximum inventory level) are decision variables. The value of inventory is kept between 2000 to 25000 bags of wheat flour and order interval as minimum 1 day and maximum 30 days since wheat is perishable item.

1) The result obtained for different generations by keeping demand and lead time constant as 5000 bags and 6 days respectively is shown below:

Total number of generations (iterations):	T (order interval) Days	Y (maximum inventory) Bags	Total Cost (Rs)	Remarks
1000	12	16,959	39,40,884	Optimal cost
2000	23	9,864	48,89,072	Cost increases
3000	4	14,246	47,90,493	Cost increases
4000	8	14,820	48,60,225	Cost increases

2) Lead time is varied between [1, 8], [6 ,13], [3, 10] days demand is kept fix as 5000 bags of wheat flour. Optimum result is given below each for iterations 1000 to 4000 for varied lead times:

Optimal number of generations (iterations):	T (order interval) Days	Y (Maximum inventory) Bags	Total Cost (Rs)	Lead time (Days)	Lead Time varied interval	Remarks
4000	18	11,399	11,05,009	6 days	[1,8]	Optimal Cost
1000	27	6,272	51,03,744	12 days	[6,13]	Cost increases
1000	9	22,765	1,51,83,613	9 days	[12,19]	Cost increases

3) Lead time is kept fix as 6 days and demand are varied between [2000, 5000], [5000, 8000], [8000,11000] bags.

Optimal number of generations (iterations):	T (order interval) Days	Y (maximum inventory) bags	Total Cost (Rs)	Demand bags	Demand varied	Remarks
1000	26	20,534	1,00,924	2,653	[2000,5000]	Optimal cost
2000	16	23,050	57,07,421	5,182	[5000,8000]	Cost increases
1000	2	17,390	1,28,05,383	9,956	[8000,11000]	Cost increases

4) Varying lead time and demand:

Optimal number of generations	T days	Y Bags	Total Cost (Rs)	Demand bags	LT	LT varied	Demand varied	Remarks
1000	14	20,245	94,489	4383	4	[1,8]	[2000, 5000]	Optimal Cost
1000	26	21,602	80,00,144	5814	9	[6,13]	[5000, 8000]	Cost increases
4000	23	16,247	3,05,61,094	10,729	13	[12,19]	[8000, 11000]	Cost increases

Result shows that for fixed lead time and demand value of 6 days and 5000 bags of wheat flour respectively, the best cost obtained is for 1000 generations with maximum inventory (Y) of 16,959 bags and order interval (T) of 12 days with value 39,40,884 Rs.
Again, for fixed value of demand of 5000 and varying lead time from [1,8] we get best cost of 11,05,009 Rs. for lead time of 6 days having inventory holding value of 11,399 bags.
For varied demand of [2000,5000] keeping fixed lead time of 6 days and inventory value of 20,534 we get optimal cost of 1,00,924 for demand value of 2653 bags. Which states that when demand is lower than 5000, total inventory cost is less. By varying both lead time and demand we get optimum value of cost as 94,489 Rs. for lead time 4 days, demand 4383 with maximum inventory value of 20,245 and order interval of 14 days. Further it shows that average Inventory value of 20,400 is optimal to get minimum cost, with lead time between 4 to 6 days and when demand is between 2653 and 4383.
This help company to plan their order plan so that total inventory cost will be minimum and company can gain maximum profit.

7. REFERENCES:

[1]. Pintu Pal Asoke Kumar Bhunia, Genetic Algorithm and its applications in Inventory Control, LAP LAMBERT Academic Publications
[2]. Dania, W.A.P., Application of Genetic Algorithms in Inventory Management, DAAAM International Scientific Book 2010.
[3]. S. Narmadha,Dr. V. Selladurai, G.Sathish , Multi product Inventory Optimisation Using Uniform Crossover Genetic Algoorithm , (IJCSIS) Internatuonal Journal of Computer Science and Information Security, Vol. 7 , No.1,2010.
[4]. Sunil Chopra, Peter Meindl, Supply Chain Management -stratergy planning and operation,fifth edition.
[5]. Chi Chiang, A periodic review replenishment model with a refined delivery scenario, Int. J. Production Economics 118 (2009) 253–259.

[6]. David John Stockton, Liam Quinn, Identifying Economic Order Quantities Using Genetic Algorithms, International Journal of Operations, and production Management
[7]. Mayank Dadge, Dr. H. T. Jadhav, Optimisation using Genetic Algorithm in MATLAB, Source: Internet.