Article

Blood bank supply chain inventory model for blood collection sites and hospital using genetic algorithm

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Abstract

Optimal blood management is one of the key tasks in managing a blood bank supply chain. Optimal methods of blood supply management are aimed at reducing costs in the blood bank supply chain through effective blood supply management so that members of monitoring committees are not affected by excess or shortage. In this article, we proposed an efficient approach that uses a genetic algorithm for optimal inventory management. This article presented a method based on a genetic algorithm for optimizing stocks in managing a blood bank supply chain. In particular, we focused on identifying the most likely stocks and levels of interaction needed to optimize blood supply in the blood bank supply chain in order to minimize the total cost of the blood bank supply chain.

Keywords supply chain; inventory; blood collection sites; hospital of blood bank; genetic algorithm.

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1 Introduction

Blood inventory control is used to indicate how much reserves are available at any one time and how to track them. This applies to all items used to produce a product or service, from raw materials to finished products. It covers blood inventories at every stage of the manufacturing process, from purchase to delivery, through the use and reorganization of inventory. Thanks to effective monitoring of the Blood Inventory, the organization / sector / Sites for blood collection can have the right amount of stock at the right time and place. This ensures that capital is not unduly connected and protects production in the event of problems in the blood supply chain. Blood inventory control is a technique for keeping inventory at a desired level. The goal of all bearing models is to minimize storage costs. Due to the changing model, the air conditioning designer decided to revise the old blood model in order to improve work efficiency and reduce storage costs in order to reach a global hospital for its air conditioning system.

Blood supplies are conducted along the entire supply chain of the Blood Bank in the form of raw materials, work in progress and finished products. Shares in the Blood Bank supply chain exist because of the gap between supply and demand. This disagreement is directed to blood collection sites, where it is cost-effective to produce large quantities that are then stored for future sales. A mismatch is also expected in a retail store, where stocks are kept in anticipation of future demand. Blood inventory is the main source of costs in the Blood Bank supply chain and has a large impact on responsiveness. The important role played by the Blood Inventory in the Blood Bank supply chain is: (1) an increase in demand that can be satisfied if the product is ready and available at the request of the customer. (2) Reduce costs by taking advantage of the scale effect on blood collection and distribution sites. (3) Maintain a competitive hospital strategy. When a hospital's competitive strategy requires a high level of response, a business can reach that level of response by placing large levels of blood supplies near Pansent. Conversely, blood collection sites can also use their blood inventory to increase efficiency by reducing blood supply through centralized storage. So far, the discussion has been limited to GA, which concerned the optimization of one parameter. Optimization criteria are represented by suitability functions and lead to an acceptable solution. A typical optimization task with one goal is TSP. The only optimization criterion is the cost of the tour performed by the seller, and these costs should be minimized. However, in practice, we often encounter problems that require the simultaneous optimization of several criteria. For example, when designing a VLSI scheme, the critical parameters are the chip's energy consumption time, fault tolerance, etc. I want. The problem is compounded when optimization criteria conflict. For example, attempting to design a low-power VLSI circuit may adversely affect fault tolerance. These problems are called multipurpose optimization (MOO). Multipurpose optimization is the process of systematically and simultaneously optimizing the set of objective functions. Many objective problems usually have conflicting goals that prevent the simultaneous optimization of each goal. Since GAs are aggregate-based optimization processes, they are usually suitable for solving OOM problems. However, traditional GAs must be adapted to these problems. This is achieved through the use of special fitness functions and the use of methods to promote various solutions. The rest of this section presents the characteristics of a multipurpose GA.

2 Related Works

A lot of works have been done on present topic. Nagurney et al. (2012) presented a supply chain network operations management of a blood banking system with cost and risk minimization. Ahumada and Villalobos (2009) reviewed the application of planning models in the agri-food supply chain. Cetin and Sarul (2009) discussed a blood bank location model. Cohen and Pierskalla (1979) presented a target inventory levels for a hospital blood bank or a decentralized regional blood banking system. Prastacos (1984) overviewed theory and method of blood inventory management. Rytila and Spens (2006) proposed a simulation to increase efficiency in blood supply chains. Sivakumar et al. (2008) presented a multi-phase composite analytical model for integrated allocation-routing problem. Yadav and Swami (2018) proposed a integrated supply chain model for deteriorating items with linear stock dependent demand under imprecise and inflationary environment. Yadav and Swami (2018) discussed a partial backlogging production-inventory lot-size model with time-varying holding cost and Weibull deterioration. Yadav et al. (2018) presented a supply chain inventory model for decaying items with two ware-house and partial ordering under inflation. Yadav et al. (2018) proposed an inventory model for deteriorating items with two warehouses and variable holding cost. Yadav et al. (2018) presented an inventory of electronic components model for deteriorating items with warehousing using genetic algorithm. Yadav et al. (2018) analyzed green supply chain inventory management for warehouse with environmental collaboration and sustainability performance using genetic algorithm. Yadav and Kumar (2017) presented a electronic components supply chain management for warehouse with environmental collaboration and neural networks. Yadav et al. (2017) analyzed the effect of inflation on a two-warehouse inventory model for deteriorating items with time varying demand and shortages. Yadav et al. (2017) proposed an inflationary inventory model for deteriorating items under two storage systems. Yadav et al. (2017) proposed a fuzzy based two-warehouse inventory model for non instantaneous deteriorating items with conditionally permissible delay in payment. Yadav (2017) analyzed the supply chain management in inventory optimization for warehouse with logistics using genetic algorithm. Yadav et al. (2017) proposed a supply chain inventory model for two warehouses with soft computing optimization. Yadav et al. (2016) presented a multi objective optimization for electronic component inventory model & deteriorating items with two-warehouse using genetic algorithm. Yadav (2017) analyzed supply chain inventory model with two-warehouses and economic load dispatch problem using genetic algorithm. Yadav et al. (2018) discussed a particle swarm optimization for inventory of auto industry model for two warehouses with deteriorating items. Yadav et al. (2018) analyzed a hybrid technique of genetic algorithm for inventory of auto industry model for deteriorating items with two warehouses. Yadav et al. (2018) discussed a supply chain management of pharmaceutical for deteriorating items using genetic algorithm. Yadav et al. (2018) analyzed a particle swarm optimization of inventory model with two-warehouses. Yadav et al. (2018) presented a supply chain management of chemical industry for deteriorating items with warehouse using genetic algorithm. Yadav (2017) analyzed seven stages supply chain management in electronic component inventory optimization for warehouse with economic load dispatch using GA and PSO. Yadav et al. (2017) given a multi-objective genetic algorithm optimization in inventory model for deteriorating items with shortages using supply chain management. Yadav et al. (2017) analyzed a supply chain management in inventory optimization for deteriorating items with genetic algorithm. Yadav et al. (2017) analyzed the supply chain management in inventory optimization for deteriorating items with genetic algorithm and particle swarm optimization. Yadav et al. (2017) presented a multi-objective particle swarm optimization and genetic algorithm in inventory model for deteriorating items with shortages using supply chain management. Yadav et al. (2017) proposed a soft computing optimization of two warehouse inventory model with genetic algorithm. Yadav et al. (2017) analyzed a multi-objective genetic algorithm involving green supply chain management. Yadav et al. (2017) presented a multi-objective particle swarm optimization algorithm involving green supply chain inventory management. Yadav et al. (2017) given a green supply chain management for warehouse with particle swarm optimization algorithm. Yadav et al. (2017) analyzed the seven stages supply chain management in electronic component inventory optimization for warehouse with economic load dispatch using genetic algorithm. Yadav et al. (2017) discussed the six stages supply chain management in inventory optimization for warehouse with artificial bee colony algorithm using genetic algorithm. Yadav et al. (2016) analyzed electronic component inventory optimization in six stages supply chain management for warehouse with ABC using genetic algorithm and PSO. Yadav et al. (2016) analyzed a two-warehouse inventory model for deteriorating items with variable holding cost, time-dependent demand and shortages. Yadav et al. (2016) discussed a two warehouse inventory model with ramp type demand and partial backordering for Weibull distribution deterioration. Yadav et al. (2016) proposed a two-storage model for deteriorating items with holding cost under inflation and genetic algorithms. Singh et al. (2016) analyzed a two-warehouse model for deteriorating items with holding cost under particle swarm optimization. Singh et al. (2016) presented a two-warehouse model for deteriorating items with holding cost under inflation and soft computing techniques. Sharma et al. (2016) giveb an optimal ordering policy for non-instantaneous deteriorating items with conditionally permissible delay in payment under two storage management. Yadav et al. (2016) analyzed genetic algorithm and particle swarm optimization for warehouse with supply chain management in inventory control. Swami et al. (2015) analyzed the inventory policies for deteriorating item with stock dependent demand and variable holding costs under permissible delay in payment. Swami et al. (2015) presented an inventory model for decaying items with multivariate demand and variable holding cost under the facility of trade-credit. Swami et al. (2015) discussed an inventory model with price sensitive demand, variable holding cost and trade-credit under inflation. Gupta et al. (2015) proposed a binary multi-objective genetic algorithm and PSO involving supply chain inventory optimization with shortages and inflation. Yadav et al. (2015) analyzed a soft computing optimization based two ware-house inventory model for deteriorating items with shortages using genetic algorithm. Gupta et al. (2015) discussed a fuzzy-genetic algorithm based inventory model for shortages and inflation under hybrid and PSO. Yadav et al. (2015) presented a two warehouse inventory model for deteriorating items with shortages under genetic algorithm and PSO. Taygi et al. (2015) analyzed an inventory model with partial backordering, Weibull distribution deterioration under two level of storage. Yadav and Swami (2014) presented a two-warehouse inventory model for deteriorating items with ramp-type demand rate and inflation. Yadav and Swami (2013) discussed the effect of permissible delay on two-warehouse inventory model for deteriorating items with shortages. Yadav and Swami (2013) analyzed a two-warehouse inventory model for decaying items with exponential demand and variable holding cost. Yadav and Swami (2013) presented a partial backlogging two-warehouse inventory models for decaying items with inflation.

3 Inventory Optimization Analysis Using GA

Inventory requires a lot of control over the blood inventory. This is the basic requirement by which any type of blood inventory control can be effective. For this, we use K-Means clustering as an aid. In practice, the blood bank supply chain has a length n, that is, it has n participants in the blood bank supply chain, for example: a factory, distribution centers, suppliers, retailers, etc. shown in Fig. 1. Our sample blood bank supply chain includes blood collection sites, a blood bank hospital 1 and a blood bank hospital 2.

Fig. 1 Three member Blood Bank supply chain.

In the illustrated supply chain of the blood bank blood collection sites make up a large warehouse where supplies are made in accordance with the requirements of hospital of blood bank 1. Then hospital of blood bank 1 will be responsible for hospital of blood bank 2. As mentioned above, our approach is to predict the optimal inventory using previous records, so using a planned inventory does not lead to excessive inventory and reduced resources. Therefore, we can say that our approach ultimately indicates the amount of inventory that will be stored in the three members of the blood bank supply chain, the plant, the blood bank hospital 1 and the blood bank hospital 2.

4 Genetic Algorithm Model in Blood Bank Supply Chain Inventory Control

Here we show the steps to optimize the analysis. Initially, overstocks and stocks of different suppliers in the blood bank supply chain are represented by zero or non-zero values. Zero means that the contributor does not need to monitor the Blood Inventory, while non-zero data requires control of the Blood Inventory. Nonzero data indicates inventory and bottleneck. The surplus amount is expressed in a positive value, and the deficit amount is in a negative value. The first process is clustering, which combines either higher or lower stocks, and stocks that are neither excessive nor insufficient. This is done simply by grouping zero and non-zero values. For this, we use the Economic Dispatch algorithm. After performing the process of distribution of the economic burden using a genetic algorithm, the work begins with a genetic algorithm, which is the core of our work. To distribute the economic load using a genetic algorithm instead of generating a random population of random chromosomes, a random chromosome is generated at each iteration point for a subsequent operation. The goal is to find the optimal solution to achieve the lowest fuel costs under certain conditions of equality and inequality. A problem can be expressed as a function consisting of a cost function and a constraint. In this paper, the equality constraint reflects the actual energy balance, and the inequality constraint reflects the limit of real energy production.

Mathematically, the wording can be given as follows.

Minimize

$$F = \sum_{i=1}^{N} F_i P_i \qquad (1)$$

GA step by step procedure for ELD problem

1. Generate the initial population of generating abilities randomly.
2. Calculate the total cost of generating capacity production taking into account the constraints in the equation but.

a. Power balance limits are set as follows.

$$\sum_{i=1}^{N} P_i - P_D = 0$$

where P_D is the total real power demand in MW

b. The limits of generating capacity are set as follows.

$P_i^{min} \leq P_i \leq P_i^{max}$ for i =1, 2,…………..N

1. Calculate the ΔP error when performing a power balance limit.
2. The goal is to minimize cost and ΔP. Thus, the fitness function is developed on the basis of these two parameters.

   Fitness =A [(1−%cost)] + B [(1−%Error)]

   Where A, B (>0): weighting coefficients

   $\text{Error} = \sum_{i=1}^{N} P_i - P_D$

   $\%\text{Cost}=\frac{\text{Stringcost} - \text{Mincost}}{\text{Maxcost} - \text{Mincost}}$

   $\%\text{Error}=\frac{\text{StringError} - \text{MinError}}{\text{MaxError} - \text{MinError}}$

   Line Cost = Line Generation Cost

   Minimum cost = minimum value of the objective function among the population.

   Maximum cost = maximum value of the objective function in the population.

   String error = String’s error in meeting the power balance constraint.

Min error = the minimum constraint error within the population.

Max error = the maximum constraint error within the population.

The total production cost and the error has to be minimized which leads to the maximization of fitness function.

A Chromosome

A randomly generated initial chromosome is created by keeping stocks at the lower and upper limits for all participants in the blood supply chain, plants, and distribution centers. As we know, the chromosome consists of genes that determine the length of the chromosomes. The inventory of each member of the chromosome is called the chromosome gene. A randomly generated initial chromosome is created by keeping stocks at the lower and upper limits for all participants in the blood supply chain, plants, and distribution centers. As we know, the chromosome consists of genes that determine the length of the chromosomes. The inventory of each member of the chromosome is called the chromosome gene (Fig. 2).

Chromosome 1

900	800	750

Chromosome 2

900	750	700

Fig. 2 Random specimen created for genetic operation.

These types of chromosomes are produced for genetic surgery. Initially, only two chromosomes are generated, and one random chromosome value is generated from the next generation. The resulting chromosomes are then used to determine the number of entries in the database contents using the select count () function. The function indicates the number of occurrences / repetitions of the corresponding inventory for ten items that will continue to be used in the format function.

B Selection

The selection operation is the first genetic operation responsible for selecting the most appropriate chromosome for the subsequent genetic operation. This is achieved by providing a rating based on the form calculated for each of the predominant chromosomes. Based on this classification, the best chromosomes are selected for the subsequent procedure.

C Fitness

Formatting functions ensure that evolution proceeds to optimization by calculating the form value for each person in the population. A fitness score assesses each person’s performance in a population.

$$U(i) = \log\left(1 - \frac{M_P}{M_q}\right) \quad i= 1,2,3,4,5,6,7LL, n$$

where M_P is the number of counts that occurs throughout the period; M_q is the total number of inventory values obtained after clustering; n is the total number of chromosomes for which the fitness function is calculated.

A fitness function is performed for each chromosome, and the chromosomes are sorted according to the result of the fitness function. Subsequently, the chromosomes of the genetic operation are crossed and mutated.

D Crossover

In this study, the intersection operation uses the intersection operator of one point. The first two chromosomes in the marriage pool are selected for the operation of crossing. The intersection operation performed for the sample case is shown in Fig. 3.

Before Crossover

900	800	750

975	750	700

After Crossover

900	800	750

975	750	700

Fig. 3 Chromosome representation.

The genes on the right side of the intersection point in both chromosomes are exchanged, and a crossing operation takes place. After the operation, two new chromosomes are obtained.

E Mutation

Newly acquired chromosomes during a crossing operation are forced to mutate. A mutation creates a new chromosome (Fig. 4).

Before Mutation

975	750	700

After Mutation

975	750	700

Fig. 4 Chromosomes subjected to operation.

This is done by randomly generating two points and then exchanging between both genes.

The mutation operation produces new chromosomes that are not like the chromosomes originally produced. After receiving a new chromosome, another random chromosome number is generated. Then again, the process repeats over a series of iterations, while both chromosomes exposed to the process are determined by the result of the fitness function. Each number of iterations gives a better chromosome, and this is considered the best solution for controlling blood counts. If the number of iterations increases, then the resulting solution is very close to the exact solution. The greater number of iterations will result in the ideal optimal solution. At some point, using the help genetic algorithm, which will be the best stock, may occur in the predictions of the members of the blood supply chain from past records, and, consequently, losses due to the preservation of excess reserves and deficit can be reduced in the next few days. ,

5 Experimental Results

Optimization of control blood inventory in blood supply chain management using genetic algorithms is analyzed using MATLAB. Inventory levels for three different participants in the blood bank supply chain, blood collection sites, blood bank hospital 1 and blood bank hospital 2 are created using the MATLAB script. This generated data set is used to evaluate the performance of a genetic algorithm. Some examples of the data sets used in the implementation are listed in Table 1. Table 1 lists about 28 records that are assumed to be records for the past period.

Table 1 Experiment results.

S.No.	Blood Collection Sites	Hospital of blood bank 1	Hospital of blood bank 2
1	-10	15	19
2	20	25	-29
3	30	35	39
4	-40	-45	49
5	44	46	-51
6	46	48	52
7	47	-49	53
8	-55	56	59
9	57	58	-61
10	-60	62	66
11	65	66	-68
12	69	-70	72
13	-70	74	78
14	71	75	-79
15	76	-79	82

Two initial chromosomes are generated at the beginning of the genetic algorithm "-56 - 82 29" and "-15 248-759". These original chromosomes are subject to interbreeding and mutation of genetic operators. The chromosome obtained in this way after the cross is applied and mutated is "54 - 75 28". With our iteration value of "10", the resulting chromosome moved to the best chromosome after each iteration analysis. At the end of the hundredth iteration, the best chromosome "-59 -39 29" is obtained. Comparing the results obtained using the genetic algorithm with previous records; we can estimate that control over this resulting chromosome is sufficient to reduce losses due to excess stock or lack of stock. This proves that the analysis provides an inventory that allows you to better predict the optimization of stocks in managing the blood supply chain.

6 Conclusions

Blood inventory management is an integral part of blood bank supply chain management. We discussed a process based on genetic algorithms for optimizing blood inventory in managing a blood bank supply chain. We also focus on how to determine the most likely reserves and the lack of reserves in the blood supply chain to minimize the total cost of the blood supply chain. We apply our methods to the model. The proposed method was implemented and its performance received a MATLAB rating**.**

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