Hot Data for Cold Chain Logistics: Hybrid Artificial Chemical Reaction Optimization Algorithm employing the data to find the most optimal path for Biomedical Cold Chain Logistics.

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Abstract

Cold Chain Logistics refers to managing perishable cold storage products to maintain quality and safety until it reaches the customer. A rise or fall in the temperature during the storage and transportation of the biomedical product can be disastrous. Secure delivery of this chill chain product is only half battle won. But this literature review will focus on the other half, timely distribution using hot transportation data. More than one and a half years ago, the coronavirus (COVID-19) virus was spreading everywhere. After that, it has become more urgent to minimize the total travel distance. This review will compare the efficiency of the Hybrid Artificial Chemical Reaction Optimization Algorithm with other algorithms. HACROA is a metaheuristic optimization approach. Other algorithms currently used for biomedical cold chain logistics are Ant Colony Optimization (ACO) Algorithm, Genetic Algorithm, Cuckoo Search Algorithm, Harmony Search Algorithm, MAX-MIN Ant System (MMAS), and more. These different approaches increase the international and domestic optimization ability, shorten the distribution path and foster the development of the logistics industry.

Keywords: Cold Chain Logistics, algorithm, metaheuristic approach, Vehicle Routing Problem (VRP)

Introduction

Logistics distribution broadly refers to the logistics campaigns of selecting, processing, casing, partitive, and gathering materials within a certain area according to the needs of users and delivering them to the places designated by users on time (Zheng et al., 2020). In this Logistics distribution, transportation plays a very crucial role when it comes to the cold chain. The ultimate goal of any logistic enterprise is high efficiency and low cost in the transportation route. Minimum travel time is a value to logistics and biomedical products' terms of validity. Vaccination is an essential element for the prevention of the disease. The quality and effectiveness of vaccines depend on the immunization supply chain. Some vaccines are sensitive to freezing, few to heat, and others to light (World Health & World Health Organization. Department of, 2015). The Vaccine Vial Monitors (VVM) are used to estimate if a vaccine has been exposed to excessively hot temperatures (Ross et al., 2020). Introduction to new cold chain logistics technologies is required to help the people and protect the environment. The lag and advance of the cold chain policy restrict the development of the industry to a certain extent, and the lag of the cold chain logistics land, traffic, electricity, and other policies make the development of the industry difficult (Yu et al.).

In the past few years, there has been an upgrade in business philosophy. Researchers are also proposing a new framework for Cold Chain Management and Logistics by consuming the Internet of Things (IoT) combined with Cloud Computing, Machine Learning, and Big Data Analytics. Due to the ability of the metaheuristic method to solve problems containing incomplete, imperfect information or limited computational capacity, it has become popular. A metaheuristic is a high-level procedure to find a search algorithm that provides the best solution to large-scale optimization problems. Metaheuristic optimization methods are commonly biology-based, chemistry-based, ethnomusicology-based, sociology-based, and physics-based (Sujaree,2017). Other categories are Swarm-based, Sport-based, Mathematics-based, and hybrid. Some population-based methods utilized are Genetic Algorithm (Golberg) and Particle Swarm Optimization (Eberhart & Kennedy). In this population-based learning, the entire population is taken into consideration and not just individual members. Imperialist Competitive algorithm (Atashpaz-Gargari & Lucas) and Teaching Learning-based Algorithm (Rao et al., 2011), the social algorithm can be applied to get an optimal solution. Biology forms the basis for Ant Colony Optimization (Dorigo, 2004), Cat Swarm optimization (Tsai et al., 2006), Cuckoo Search (Yang & Deb), Monarch Butterfly optimization (Wang et al., 2019), and Whale Optimization Algorithm (Mirjalili & Lewis, 2016). One advantage of metaheuristic algorithms is their ability, via their stochastic properties, to avoid becoming trapped in a local optimum (Akyol & Alatas, 2017). All these algorithms work practically well for certain types of problems. No algorithm has yet been designed which is capable of giving the best outcomes in all scenarios, and for this reason, there is a continuous series of artificial intelligence proposals offered to move closer to this goal (Sujaree, 2020).

The current cold chain network is similar to the Vehicle Routing Problem (VRP). VRP was first proposed by Dantzig and Ramser (Dantzig & Ramser, 1959). In logistics distribution, the objective of VRP is to arrange several vehicles for a lot of customers from the distribution center and return to the common distribution center without exceeding the capacity of each vehicle at a minimum cost (Bo & Li,2016). Numerous variants of VRP have been studied to address the wide range of situations in the real world (Kachitvichyanukul et al., 2015). It includes RP with Simultaneous Delivery and Pick-up (VRPSDP), Vehicle Routing Problem with Time Windows (VRPTW), Capacitated Vehicle Routing Problem (CVRP), Site-dependent Vehicle Routing Problem (SDVRP), and Open Vehicle Routing Problem (OVRP). Harmony Search Algorithm is a Music-Based algorithm that can be used to resolve the standard VRPs but has not yet been applied to solve dynamic VRPs (Chen et al., 2017).

Hybrid Artificial Chemical Reaction Optimization Algorithm is one method to solve the problem. It is a seven-step approach that includes synthesis, decomposition of single displacement, combustion, redox, reversible souble, and displacement (Sujaree & Samattapapong, 2021). All the reaction is carried out after the tabu list processes the paths. Tabu Search (Glover, 1986) and Nearest Neighbor Search availed for the initial procedure and final procedure when the biomedical product is delivered to Contracting Units for Primary Care (CUP). In tabu search, the person needs to keep track not only of local information (like the current value of the objective function) but also of information related to the exploration process (Hertz et al.). The memory structure in tabu search (TS) is an essential feature used to describe the visited solution. In the process, if a particular spot is already visited it is marked as forbidden (tabu). It removes the duplicate routes. Whereas the nearest neighbor searches for an optimization problem, it finds a point that minimizes the objective function. The HACROA process terminates once they meet the criteria. Experimental results obtained from Hybrid Central Force Optimization (HCFO), Max-Min Ant System (MMAS), Artificial Chemical Reaction Optimization Algorithm (ACROA), and Hybrid Artificial Chemical Reaction Optimization Algorithm (HACROA) are compared (Sujaree & Samattapapong, 2021). The procedure is carried out ten times using a random technique. The result is displayed in Table 1.

Table 1: *The following table presents the calculation time and total distance for different algorithms which are used for comparison.*

No of Times	MMAS (22.77 sec)	HACROA (23.48 sec)	ACNSO (22.12 sec)	HCFO (24.65 sec)
1	3848	3832	3826	3848
2	3867	3849	3804	3854
3	3898	3854	3838	3867
4	3826	3872	3792	3838
5	3881	3826	3832	3848
6	3838	3804	3792	3872
7	3854	3816	3854	3804
8	3826	3898	3826	3898
9	3906	3792	3838	3804
10	3854	3814	3804	3826

(Sujaree, 2020)

Conclusion

The hybrid algorithm used, minimizes the total distance between different stations within the cold chain network. HACROA algorithm can be used for the delivery of Covid-19 freight and organs. The algorithm is implemented with the help of reactions, tabu search, and nearest neighbor search. The search methods aid in improving the overall efficiency of the algorithm. From the comparison, it was observed that the objective function derived from HACROA and ACNSO could achieve a distance of 3826 km but, the computation time of *the HACROA Algorithm* is less. Whereas the processing time of ACNSO is less in the same scenario. HACROA Algorithm must be preferred above ACNSO Algorithm because Carbon Nanotube Algorithm would require Nanotechnology which will increase performance costs. The performance of both algorithms depends on the setting of the parameters. Many other limitations come into the picture during cold chain delivery. For instance, some CUPs have sufficient stock while others

Along with optimizing the algorithms, Supply Chain Thinking ought to be for the overall improvement of biomedical cold chain logistics. There should be communication between logistics enterprises supplying the biomedical product and the Hospital/Contracting Unit for Primary Care regarding patients' health conditions before making the final decision of delivering the end product. The future variants of all the existing algorithms or the new algorithm developed for cold chain transportation should include parameters like percentage of viability left after transit, medical urgency, availability of the stock in the CUPs, and maximum preservation time allowed for the vaccine or organs. Adding an electronic traceability system will improve the supply chain. The hot data collected by the traceability systems can be monitored and employed for performing real-time data analysis that, in the end, aid in making better decisions. Finally, there must be some alarm tools elided/linked to the refrigerator/cold storage to notify if there is a system failure or breakout during the transit. Simultaneously, the predictive model software can be installed on the storage unit to assist decision-making during a malfunction.

Word Count: 1467 words

References

Akyol, S., & Alatas, B. (2017). Plant intelligence based metaheuristic optimization algorithms. *Artificial Intelligence Review*, *47*(4), 417-462.

Atashpaz-Gargari, E., & Lucas, C. (2007). Imperialist competitive algorithm: an algorithm for optimization inspired by imperialistic competition.

Bo, X., & Li, H. (2016). Solving Vehicle Routing Problem in the Logistics Distribution Based on Immune Genetic Algorithm.

Chen, S., Chen, R., & Gao, J. (2017). A modified harmony search algorithm for solving the dynamic vehicle routing problem with time windows. *Scientific Programming*, *2017*.

Dantzig, G. B., & Ramser, J. H. (1959). The truck dispatching problem. *Management science*, *6*(1), 80-91.

Dorigo, M. (2004). Stu tzle T. Ant colony optimization. *Bradford Company, Scituate*.

Eberhart, R., & Kennedy, J. (1995). Particle swarm optimization.

Glover, F. (1986). Future paths for integer programming and links to artificial intelligence. *Computers & operations research*, *13*(5), 533-549.

Golberg, D. Genetic Algorithm in Search, Optimization, and Machine Learning, addison. In: Wesley Publishing Company.

Hertz, A., Taillard, E., & De Werra, D. (1995). A tutorial on tabu search.

Kachitvichyanukul, V., Sombuntham, P., & Kunnapapdeelert, S. (2015). Two solution representations for solving multi-depot vehicle routing problems with multiple pickup and delivery requests via PSO. *Computers & Industrial Engineering*, *89*, 125-136.

Mirjalili, S., & Lewis, A. (2016). The whale optimization algorithm. *Advances in engineering software*, *95*, 51-67.

Rao, R. V., Savsani, V. J., & Vakharia, D. P. (2011). Teaching–learning-based optimization: a novel method for constrained mechanical design optimization problems. *Computer-Aided Design*, *43*(3), 303-315.

Ross, J. C., Saidu, Y., Nzuobontane, DVikings, M. Z., & Embrey, S. R. (2020). Application of the remaining vaccine vial monitor life calculation to field temperature monitoring data to improve visibility into cold chain equipment performance. *Vaccine*, *38*(48), 7683-7687. https://doi.org/https://doi.org/10.1016/j.vaccine.2020.09.078

Sujaree, K. (2020). Artificial Carbon Nanotube Synthesis Optimization to Address the Vaccine Cold Chain Network Problem. *International Journal of Modeling and Optimization*, *10*(1), 32-40.

Sujaree, K., & Samattapapong, N. (2021). A Hybrid Chemical Based Metaheuristic Approach for a Vaccine Cold Chain Network. *Operations and Supply Chain Management: An International Journal*, *14*(3), 351-359.

Tsai, P. W., Chu, S. C., & Pan, J. S. (2006). Cat swarm optimization. PRICAI Trends in Artificial Intelligence. In: Springer.

Wang, G.-G., Deb, S., & Cui, Z. (2019). Monarch butterfly optimization. *Neural computing and applications*, *31*(7), 1995-2014.

World Health, O., & World Health Organization. Department of, I. (2015). *Immunization in practice: a practical guide for health staff*. World Health Organization.

Yang, X.-S., & Deb, S. (2009). Cuckoo search via Lévy flights.

Yu, Z., Liu, Y., Wang, Q., Sun, L., & Sun, S. (2021). Research on Food Safety and Security of Cold Chain Logistics.

Zheng, K., Zhang, Z., & Song, B. (2020). E-commerce logistics distribution mode in big-data context: A case analysis of JD. COM. *Industrial Marketing Management*, *86*, 154-162.