A systematic review on the delivery optimization in food delivery industry

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***Abstract*—The systematic study seeks to offer an in-depth review of many approaches and techniques used to enhance food delivery services. It is crucial to assess the current literature to find best practices and opportunities for development, given the food delivery industry's recent rapid expansion. A thorough analysis of publications from 2010 to 2023 was carried out. The technique used to carry out the controls was then examined, the gaps in the literature were highlighted, and potential research directions were identified. In conclusion, the purpose of this study is to give a review of the literature on the use of route optimization models and to help academics and practitioners understand the performance measures, models, and problem-solving approaches used in delivery industry.**

Keywords—delivery optimization, systematic review, cost reduction, food delivery

I. INTRODUCTION

In Sri Lanka, ordering takeout using mobile applications has grown in popularity over the past few years, especially after the COVID pandemic. By the end of 2023, it is anticipated that the food delivery online sector in Sri Lanka will generate US$624.30 million in sales [17]. Through online ordering, customers might avoid the inconvenience of visiting restaurants while still receiving more meal options and faster service. The majority of those who are employed all around the island can order takeout through internet platforms like Pickme and Uber. Pickme, one of the most used online food ordering sites in Sri Lanka, claims to generate yearly revenues of over 1 billion rupees and to have produced venture capital financing of $3 million USD, the biggest amount among all Sri Lankan businesses [21].

A. Vehicle routing problem (VRP)

Vehicle routing is one of the most significant applications in logistics operations. Many other VRP variants are being researched right now. It appears that researchers have started to focus more on sustainable VPR during the recent 20 years, taking social, environmental, and economic considerations into account [13].

B. Research question

In order to ensure that clients receive food as soon as feasible within the required period with low delivery cost, creating a schedule and route for riders who deliver food is a major challenge that all takeaway delivery platforms must address [11]. Also, finding the quickest route between client locations is another challenge faced by delivery services when trying to deliver the goods in a reasonable amount of time, conserve fuel, and maximize the use of delivery vehicles and workers [19].

The Travelling Salesman Problem (TSP) is the name of the routing issue that is connected to the state of the food delivery business [19]. In TSP the seller departs from their hometown and is obligated to travel to a number of cities precisely once before returning home with the shortest possible distance. Therefore, there is a need to find a model which helps to optimize this route.

The fundamental Vehicle Routing Problem (VRP) is made up of a number of geographically separated clients, each of which needs a certain amount of items delivered or picked up [16]. Developing a set of transportation paths that meet the delivery fee issue while having a low overall cost provides the solution to the problem.

C. Research objective

This paper aims to conduct a thorough analysis of the delivery process optimization for food delivery to reduce delivery costs. As, the research objectives are:

1. Give a thorough study and categorization of the body of existing research on delivery optimization
2. Identify the primary gaps in the collection of data
3. Thus, suggest study paths that would be useful to people in the academic and management worlds

II. METHODOLOGY

A. Overview of the methodology

Before beginning the literature search, the first stage in this strategy is to decide on the research's overall scope. In step 2, studies of high level and significance are sought after using a variety of research databases (including Google Scholar, IEEE Xplore, Elsevier). The chosen articles are reference checked in the last phase to incorporate any other applicable research.

B. *Searching strategy*

The aim of this research is to identify the strategies used in the current market for an effective food delivery which reduces delivery cost and increases customer satisfaction.

The following keywords were used when searching for literature:

1. Food delivery
2. Supply chain
3. Transportation
4. Delivery optimization
5. Delivery route
6. Delivery cost reduction
7. Last mile delivery

21 research papers, published between 2010 - 2023 were considered in this paper. All the papers were written in English and from all geographic regions. Google scholar, Elsevier and IEEE Xplore were used for the searching purpose. The Google scholar database was initially searched electronically using the terms "vehicle routing" and "delivery optimization" to find publications. Figure 1 shows the schematic diagram of the search methodology.

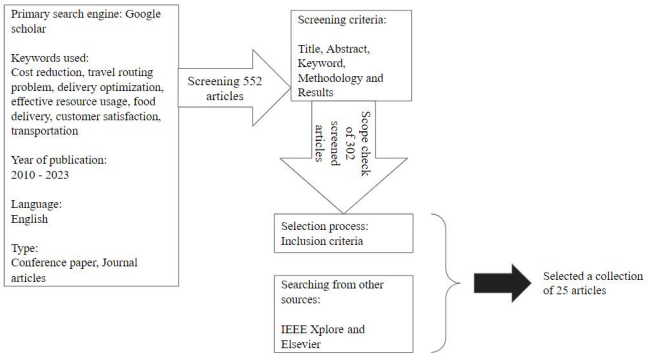

Figure 1: Search Methodology

C. *Inclusion criteria*

The study has focused on the optimization of food delivery services and operation. Therefore, the papers related to food delivery, vehicle route scheduling, routing optimizing and transportation have focused on this review. All the simulation studies, experimental studies, case studies and observational studies were considered. Data, including study aims, methodology, and major findings, were taken from the chosen papers.

D. *Reviewing the papers*

Four categories were created from the screening method's output. First, the application situations, performance indicators, model properties, and solution techniques of these 21 publications were thoroughly examined. This categorization system was employed to assist narrow the emphasis on the Vehicle Routing Problem applications and the relevant aspects of the problem. Then, the strategies used in the optimizing delivery were reviewed, and the research difficulties connected with various optimization methodologies were noted. Finally, this study made recommendations for more research on the delivery optimization.

III. RESULTS

A. *Descriptive analysis*

Over the past few decades, food delivery has become a serious pattern. On the other hand, there is extensive literature on optimizing delivery routes that is growing. Figure 2 illustrates how there is a growing interest in the online food delivery investigations.

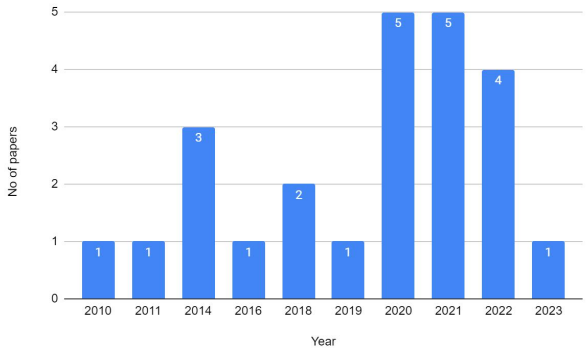

Figure 2: Research distribution o delivery on food delivery optimization based on publication year

Most studies were released in 2020 and 2021. There were many different classifications for the optimization technique used to solve the food delivery optimization: heuristic, SPIDER DESIGNER software, non-linear multi objective optimization model, generic algorithm, FDNET, SYMBIT and historical data analysis.

Minimizing travel costs has been a major concern in many papers [11], [27], [20], [22], [5] and [18]. Some researchers have conducted a study to solve rider scheduling time [11], [16], [23], [3], [6], [8] and [5].

TABLE I. SUMMARY ON USED TECHNIQUES IN PAST PAPERS

Reference	Technique used	Major concern
[1]	Synchronized model for Belgian Inland Transport	This helped to reduce inefficient movement of vehicle
[3]	Used FDNET (A deep learning based deep network)	This helped to estimate the time and route of delivery
[5]	A measurement function on food safety	Considered food safety loss and economic cost. Also, it helped in optimizing transportation routing
[6]	Integrated linear programming model	Considered periodic vehicle routing problem
[8]	Heuristic algorithm	Reducing delivery time and improving customer satisfaction
[9]	Historical data analysis	Optimize delivery and predict customer habit
[11]	ALNS heuristic algorithm	Minimize total cost and rider scheduling time
[16]	SPIDER DESIGNER software	Saves travel distance and vehicle usage
[15]	ALNS heuristic algorithm	Manage workload and vehicle capacity
[27]	Non-linear multi objective optimization model	Minimize operational cost and workload balancing
[23]	Hierarchical agglomerative clustering and generic algorithm	Maximize customer satisfaction

Reference	Technique used	Major concern
[1]	Synchronized model for Belgian Inland Transport	This helped to reduce inefficient movement of vehicle
[14]	Heuristics and meta-heuristics algorithms	Determine the optimal delivery routes from the retailer to a specific customer
[2]	ALNS meta-heuristics algorithm	Reducing food waste by introducing a vehicle routing procedures
[10]	Data analysis by using GPS, RouteLigiX & MODTRANStools	Mapping a food distribution system and identifying the opportunities for a coordinated optimized system
[4]	Heuristic algorithm	Optimizing operation planning on medium and short term

B. Major findings on the papers

[11] outlines a two-stage methodology for enhancing riders in immediate food delivery. It breaks down time into smaller sub-time units and the town into smaller sub-regions. In order to reduce the number of riders throughout each period, the initial stage uses a dial-a-delivery rider model. The second step takes timetables and imbalances in transportation capacity into account. For the first stage, an ALNS heuristic is created and Gurobi 9.1 is used to solve the problem. According to the study, introducing a new approach lowers demand for riders for delivery and results in cost savings of 4200 CNY. The suggested approach can enhance scheduling and maximize the total number of riders across every sub region.

[26] solves a scheduling issue with vehicles that occurs in the cold food delivery industry's cold chain operations. This research suggests a remedy for the vehicle routing problem in the distribution of multi product frozen foods. The generated model considers damage cost of cargo which delivers food, transportation cost, Cost for refrigeration and customer penalty cost. A generic algorithm, which is a heuristic algorithm, has been used in the study. By the results, it has shown that, in general, the suggested model can offer distribution industries a viable and reasonable truck scheduling solution along with reducing expenses and maintaining food, enhancing quality and customer happiness.

A model has been developed for balancing the workload among several staff and reducing operating costs throughout a number of time periods by [27]. For the task distribution issue facing the food delivery sector, the research has put out a multi-objective optimization model that takes human factors into account. The study suggests a multi-objective optimization methodology that takes human aspects into account while allocating food delivery orders. It illustrates how employee performance variance greatly affects total delivery performance and quantifies the effects of learning and deterioration on individual performance. At a minor increase in operating costs, the approach increases task distribution across staff. The welfare of employees and corporate social responsibility are benefited by this research's advancement of theoretical understanding on staff planning as well as management in service-oriented sectors. The study uses linear representations for simplicity, but could use different formats for accurate mathematical expressions. Parameter settings are based on personal experience and observation, and the study assumes learning effect is achieved in one period.

[12] has sought to give O2O systems a methodical approach for optimizing order allocation and routing. This paper explores various driver sources in an O2O on-demand system, including in-house, full-time, and part-time drivers. The paper has separated the issue into the assignment model and the routing model. Then solved it using a rolling horizon algorithm. It has been discovered that raising the percentage of delays for part-time crowd sourced drivers can increase earnings and on-time delivery rates. It's because part-time drivers can adjust to changes in order volume.

A framework called FooDNet was developed by [25] to reduce delivery cost and improve delivery efficiency. To overcome the aforementioned challenges, a two-stage approach is suggested, consisting of the ALNS algorithm and a construction algorithm.

[3] has considered the last mile delivery problem. In order to get an effective delivery routing, a SPO framework which combines machine learning techniques has been developed.The combined order allocation and routing issue associated with last-mile delivery service is solved using effective mini-batching optimization and heuristic methods.

[16] has considered vehicle routing problems. The study covers route optimization for delivering meals to senior citizens. To generate optimized routes, the study employs a commercial routing application called SPIDER Designer. Results indicate considerable vehicle and distance savings of up to 50%.

Using a three-stage architecture consisting of order arrangement, splitting, and routing, [15] investigates food delivery scheduling in O2O fast logistics solutions. While a revolutionary order splitting technique covers long-distance requests based on transfer stations, the DBSCAN algorithm boosts efficiency. The ALNS heuristic algorithm and mixed-integer programming paradigm are used to create real-world orders for instant delivery networks. The algorithm swiftly converges, effectively extending the delivery ranges of couriers. Also the paper suggests their future goals as creating a spatial-temporal clustering method for order combination and a dynamic meal delivery routing system with stringent requirements like vehicle capacity and courier workload balancing.

The goal of [23] is to improve food delivery routes for clients who have time-sensitive clients. It suggests a two-stage approach utilizing GA and HAC to enhance quick services for orders with high volume. While the GA optimizes routes according to customer time satisfaction, the HAC algorithm combines orders depending on pickup location. This strategy increases customer happiness and delivery effectiveness.

[14] has discovered that for the best route schedules, greedy allocation is insufficient. The results of this study can help developers choose the best algorithm for their usage, allowing for the creation of complex inventory and route management system.

A bi-objective solution approach is suggested in [2], to minimize food quality losses throughout store-based e-grocery delivery. It takes into account a variety of fresh food products, temperature ranges, and pickup locations. The findings demonstrate that combined routing as well as store

assignment decisions may both reduce travel length and improving the food quality.

The goal of [4] is to create a model for mathematical programming that will optimize food departure timings and fleet size for the combined distribution of various temperature-range meals. The findings imply that in order to maximize profit, carriers should choose departure times for food that is served at several temperatures based on the relationship between supply and demand.

IV. CONCLUSION

In summary, this systematic review provides a wealth of information on food delivery optimization, illuminating the various tactics and tools used to raise productivity, cost effectiveness, and client satisfaction in the food delivery sector. Route optimization, last mile delivery problem, customer satisfaction and technological integration are crucial for expediting food delivery services, as seen by the data given in this research.

The majority of delivery optimization issues involve minimizing the overall expense of the distribution goal function. In contrast, only a small number of papers are utilized to study issues like maximizing the quality of the supplied items, lowering the overall cost of environmental effect, as well as minimizing the damage of the products. This study suggests that future research should concentrate on creating optimization for unique purposes as well.

REFERENCES

[1] B. Kin, T. Ambra, S. Verlinde, and C. Macharis, "Tackling Fragmented Last Mile Deliveries to Nanostores by Utilizing Spare Transportation Capacity—A Simulation Study," Sustainability, vol. 10, no. 3, p. 653, Mar. 2018

[2] C. Fikar and K. Braekers, "Bi-objective optimization of e-grocery deliveries considering food qualities losses," Computers & Industrial Engineering, vol. 163, p. 107848, Jan. 2022.

[3] C. Ga, "A Deep Learning Method for Route and Time Prediction in Food Delivery Service," Aug. 2021

[4] C. Hsu and W. Chen, "Optimizing fleet size and delivery scheduling for multi-temperature food distribution," Applied Mathematical Modelling, vol. 38, no. 3, pp. 1077-1091, Feb. 2014.

[5] Chen, Gui, Ding, Na, and Zhou, "Optimization of Transportation Routing Problem for Fresh Food by Improved Ant Colony Algorithm Based on Tabu Search," *Sustainability*, vol. 11, no. 23, p. 6584, Nov. 2019

[6] D. J. Nair, H. Grzybowska, D. Rey, and V. Dixit, "Food Rescue and Delivery," Transportation Research Record: Journal of the Transportation Research Board, vol. 2548, no. 1, pp. 81–89, Jan. 2016

[7] D. M. Utama, S. K. Dewi, A. Wahid, and I. Santoso, "The vehicle routing problem for perishable goods: A systematic review," Cogent Engineering, vol. 7, no. 1, p. 1816148, Jan. 2020

[8] E. Xing and B. Cai, "Delivery Route Optimization Based on Deep Reinforcement Learning," IEEE Xplore, Oct. 01, 2020

[9] F. Fu and W. Zhou, "The Application of Order Scheduling Algorithm for Food Delivery Logistics Based on Historical Data," Journal of Physics: Conference Series, vol. 2074, no. 1, p. 012081, Nov. 2021

[10] G. Gebresenbet, I. Nordmark, T. Bosona, and D. Ljungberg, "Potential for optimised food deliveries in and around Uppsala city, Sweden," Journal of Transport Geography, vol. 19, no. 6, pp. 1456-1464, Nov. 2011.

[11] G. Xue, Z. Wang, and G. Wang, "Optimization of Rider Scheduling for a Food Delivery Service in O2O Business," Journal of Advanced Transportation, vol. 2021, pp. 1–15, May 2021

[12] H. Dai, J. Tao, H. Jiang, and W. Chen, "O2O on-demand delivery optimization with mixed driver forces," IFAC-PapersOnLine, vol. 52, no. 13, pp. 391–396, 2019

[13] H. Dündar, M. Ömürgönülşen, and M. Soysal, "A review on sustainable urban vehicle routing," Journal of Cleaner Production, vol. 285, p. 125444, Feb. 2021

[14] K. Veer Tiwari and S. Kumar Sharma, "An optimization model for vehicle routing problem in last-mile delivery," Expert systems with Application, vol. 222, pp. 1-15, Jul. 2023.

[15] L. Jiu-lin, S. Yang, W. Pan, Z. Xu, and B. Wei, "Meal delivery routing optimization with order allocation strategy based on transfer stations for instant logistics services," Iet Intelligent Transport Systems, vol. 16, no. 8, pp. 1108–1126, May 2022

[16] O. Bräysy, P. Nakari, W. Dullaert, and P. Neittaanmäki, "An optimization approach for communal home meal delivery service: A case study," Journal of Computational and Applied Mathematics, vol. 232, no. 1, pp. 46–53, Oct. 2009

[17] "Online Food Delivery - Sri Lanka | Statista Market Forecast," Statista. https://www.statista.com/outlook/dmo/online-food-delivery/sri-lanka

[18] P. Siddhartha and D. Goda, "Simulation and Optimization Framework for On-Demand Grocery Delivery," 2021 Winter Simulation Conference (WSC), pp. 1–12, 2021.

[19] R. Deddy Hasiholan Tobing, "A food ordering system with delivery routing optimization using global positioning system (GPS) technology and google maps," INTERNETWORKING INDONESIA JOURNAL , vol. 8, no. 1, pp. 17–21, Jan. 2016.

[20] Randhawa, A. Birari, and A. Joshi, "Optimization of Home Delivery Process Using Shortest Path and Fixed Time Method to Reduce Cost and Investment," The IUP Journal of Supply Chain Management, vol. 11, no. 4, Dec. 2014

[21] "Sri Lanka's PickMe to continue growth with acquisitions | EconomyNext," EconomyNext, Aug. 03, 2019. https://economynext.com/sri-lankas-pickme-to-continue-growth-with-acquisitions-14981/

[22] S. Paul, S. Rathee, J. Matthew, and K. M. Adusumilli, "An Optimization Framework for On-Demand Meal Delivery System," 2020 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Dec. 2020

[23] W. Wang and L. Jiang, "Two-Stage Solution for Meal Delivery Routing Optimization on Time-Sensitive Customer Satisfaction," Journal of Advanced Transportation, vol. 2022, p. e9711074, Jul. 2022

[24] X. Lu, X. Guo, J. Zhang, X. Li, L. Li, and S. Jones, "Reducing traffic violations in the online food delivery industry—A case study in Xi'an City, China," Frontiers in Public Health, vol. 10, Oct. 2022

[25] Y. Liu, “FooDNet: Toward an Optimized Food Delivery Network Based on Spatial Crowdsourcing,” IEEE Transactions on Mobile Computing, vol. 18, no. 6, pp. 1288–1301, Jun. 2019

[26] Y. Zhang and X. D. Chen, “An Optimization Model for the Vehicle Routing Problem in Multi-product Frozen Food Delivery,” Journal of Applied Research and Technology, vol. 12, no. 2, pp. 239–250, Apr. 2014

[27] Z. Lou, W. Jie, and S. Zhang, “Multi-Objective Optimization for Order Assignment in Food Delivery Industry with Human Factor Considerations,” Sustainability, vol. 12, no. 19, p. 7955, Sep. 2020