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AI and ML revolution in last-mile delivery optimization : A bibliometric analysis

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Abstract

Purpose: The integration of AI &ML technologies revolutionized last-mile delivery optimization in retort to the exponential growth in the global e-commerce market. Efficient last-mile logistics have become crucial to meeting consumer demands and operational challenges in the transport industry.

Methodology: This study adopted a systematic literature review (SLR) united with a bibliometric analysis approach to explore and analyze existing literature on AI & ML

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applications in last-mile delivery optimization. By employing targeted keywords - "last mile," "machine learning," and "artificial intelligence" a comprehensive review of academic articles and review papers is conducted. A total of 81 research articles are screened and analyzed using bibliometric techniques, including co-occurrence analysis and co-citation author analysis, to identify key themes and trends.

Findings: The analysis has revealed significant thematic clusters, highlighting spreads in last-mile delivery strategies, digital transformation and the influence of pandemic situations on logistics operations. Co-authorship analysis has unveiled collaborative networks among researchers, emphasizing the contributions of influential authors to the field. The study has also tracked the chronological evolution of publication trends, providing insights into emerging research directions. By identifying critical gaps and emerging research directions, this research has paved the way for advancements in logistics and transportation systems.

The research proposes solutions for last-mile delivery challenges by employing quantitative techniques using AI/ML tools. Four critical gaps are investigated, including comparative studies on vehicle capacity optimization, machine learning approaches for dynamic routing, and AI-based systems for enhancing first-time delivery success rates in the last-mile.

Subject Classification (2020): *68T05, 90B06, 90C35.*

Keywords: *Last-mile delivery, Vehicle routing, Logistics, Optimization, Routing, Transportation.*

1. Introduction

Delivering products from the nearest hub to the customer or the delivery location concerned is called the last-mile delivery process. Efficient last-mile logistics save time and money by optimizing routes and rates and allow businesses to expand their reach more aggressively. In the current decade, AI tools aimed at refining decision making have varied statistical tools and data science are used [1]. Alternative Method for problem solving and conclusion creation is framing over optimization. Research applies tools for the road transport industry to improve logistics last mile [2]. In the rapidly advancing world of e-commerce and supply chain management, optimization of the last mile has arisen as a critical zone of focus [3]. As online shopping continues to surge, businesses are increasingly challenged to fulfill customer orders efficiently, minimizing costs and environmental impact [4]. In this context, integrating AI has shown promising potential to transform last-mile delivery operations. The last-mile delivery phase signifies the last leg of the supply chain, wherein goods are transported from a DC to the end consumer's doorstep [5]. Despite its short geographical distance, last mile delivery accounts for a significant share of the total logistics costs; exceeding 50% [6]. According to industry reports, inefficient last-mile logistics contribute to congestion,

pollution, and increased carbon emissions, posing sustainability challenges for urban environments. With the rising expectations of consumers for reliable delivery services, industries are under vast pressure to optimize last-mile operations [7].

The transport industry has changed and grown recently, evolution of e-commerce and growth in the last 5 years. This paper recommends a solution meant for the problem of delivery for DC with a quantitative technique using AI/ML tools to deal with last-mile operations. For industries, the last-mile directly affects customer satisfaction, competition, cost efficiency, inventory management, and sustainability [8]. The global last-mile delivery market should grow at a CAGR of 20.6 percent between 2022 and 2030, reaching a value of 121.1 billion by 2030. Advancements in AI and ML have introduced promising tools for transforming last-mile delivery operations. From intelligent routing systems and demand prediction to autonomous delivery vehicles and real-time optimization, these technologies are reshaping the way goods are delivered in complex urban environments.

"Last mile" is important for industries to get their products to the end user. Enormous efforts were made by the supply chain team and Operations. Transportation of goods to customer locations with the support of rail, road and airways for quick delivery for generating income [9]. To generate a profitable income industry, take help from operations with technology & new techniques where employment is increased. Experience team molding with new technology to give Impact [10]. The last-mile accounts for over 45-50% of overall shipping costs and in the entire supply chain cost. Benefits for industries are in optimizing costs with excellent delivery to the customer.

Despite the progress made in last-mile delivery optimization, several gaps and limitations persist, underscoring the need for further research. Challenges lie in the dynamic nature of urban environments, characterized by fluctuating traffic conditions, varying customer favorites, and growing delivery demands [11]. Traditional optimization techniques often struggle to accommodate such uncertainties, leading to suboptimal solutions and increased operational costs. Existing research focuses on operational efficiency metrics such as cost minimization and delivery time optimization, overlooking other important considerations such as environmental sustainability [12]. As sustainability becomes a progressively prominent concern for industries and policymakers alike, there is a growing need to develop holistic delivery optimization frameworks that balance economic efficiency with environmental responsibility [13]. This study aims to

address gaps through leveraging AI-driven optimization techniques to advance the sustainability and productivity of last–mile operations through bibliometric analysis. This methodology uses statistical tools to study patterns in written works, recommending a sound basis aimed at exploring the distribution and then response of scholarly information. This paper aims to synthesize existing knowledge through a systematic literature review supported by a bibliometric analysis. Examining the structure and evolution of scholarly work in this domain, we highlight key research themes, influential authors, and emerging trends. This approach not only merges the current state of AI & ML applications in last-mile logistics but also identifies critical research gaps and opportunities for future exploration.

2. Literature Review

We identified relevant literature through searching and selected academic articles/ review papers and published with keyword "last mile" "machine learning" "artificial intelligence" 'machine learning in last mile in ecommerce', artificial intelligence in last mile and machine learning in last mile. From the searched articles, extracted eligible information and brought out findings also future scope. Presented in Fig 1–is the number of papers screened and excluded at each stage of the selection process - SLR - Systematic Literature Review. Identification of literature with keywords brought out the literature selection from earlier studies of researchers such as literature reviews and research articles. Our search strings are keyword "last mile" "machine learning" "artificial intelligence" 'machine learning in last mile in ecommerce', artificial intelligence in last mile and machine learning in last mile.

To ensure comprehensiveness, academic databases were used– Scopus, IEEE, ScienceDirect, Taylor and Francis and Business source from web. Articles were obtained using the above keywords - published papers. Total of 5569 articles screened in Springer (n = 5135), IEEE (n= 46), ScienceDirect(n=66), Taylor & Francis (n=322). After disregarding duplicates, articles allied with the research framework but fitting into further disciplines without artificial intelligence, last-mile and ecommerce were discarded due those outside of the scope. The screening process yields 276 research articles. The foregoing eligibility process led to 81 articles. The work cited in 81 papers was also systematically examined.

The first journal article on this topic was published in 2016. Relevant literature matured after 2019. In the years 2021-2023, there was a high

(72%) number of articles published. Thus, it is revealed that research on Last mile delivery using AI & ML, although still at an emerging stage but reflects a growing trend.

3. Research Methodology

This study examines the progress in AI & ML, focusing particularly on their role in optimizing the last-mile. Performed a bibliometric analysis, a frequently employed technique for visually representing the conceptual ground of a particular research field [14]. The study conducted a Systematic Literature Review (SLR) to gather relevant literature, search for keywords and choose relevant articles [15]. The study employed bibliometric techniques to inspect the literature, revealing crucial findings about the temporal trends of noteworthy publications, renowned articles, and vital research. By applying these approaches, the study seeks to highlight how AI and ML are transforming management practices, while offering a systematic overview of developments in the field.

4. Findings

As seen in Figure 2, the publication of articles related to applications of AI and ML in last mile delivery increases exponentially.

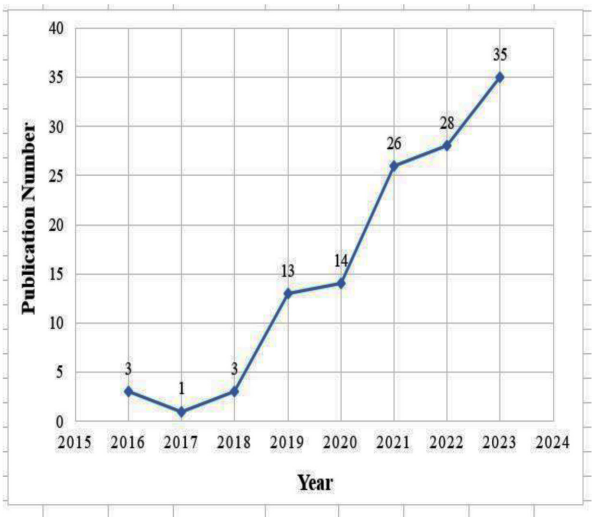

Figure 2

Articles Published per year. (Authors' own depiction)

The VOSviewer software - As inputs; a list of papers, its algorithm completes; word mining of the keywords included by the authors and inevitably assigned by the indexing database with a process called "co-occurrence". The study analyzed author keywords, setting a minimum occurrence of four. Of the 153 keywords, only nine satisfied this requirement. The resulting words were last-mile delivery, last mile delivery vehicle routing, city logistics, digital transformation, logistics, optimization, routing, and transportation with machine learning. Create a keyword network and computers for each keyword, its total link strength.

The last-mile delivery and last mile delivery, which were just added with a hyphen symbol. With these two keywords, their link strengths equal to 51 and 29, this is probably because of the presence of the most articles and reviews being worked on these keywords.

5. Thematic Framework of AI and ML research in last mile delivery.

The co-occurrence of keywords is represented in Figure 3 153 keywords.

Cluster 1- Advancing Last Mile Delivery, Demand Management, Vehicle Routing and Prediction

"This cluster, shown in red and made up of 12 elements, looks at how AI & ML are closely connected to last-mile delivery, demand management, vehicle routing and prediction."

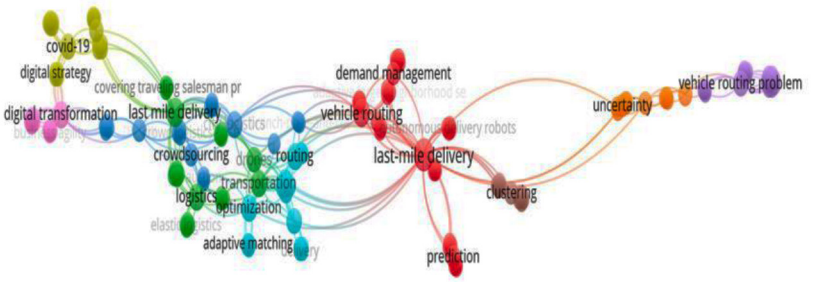

Figure 3

Co-occurrence of 153 keywords (Author's own depiction)

Cluster 2-Revolutionizing Last-mile Delivery, Transportation and Logistics.

The cluster of nine green-colored workings, highlighting the reputation of Last mile delivery, transportation and logistics in both AI & ML with a specific emphasis taking place in last-mile delivery.

Cluster 3- last mile delivery, crowdsourcing and logistics

Cluster with nine blue-colored elements connected with the last-mile delivery, including crowdsourcing and logistics.

Cluster 4-Routing, Transportation, Optimization and Adaptive Matching

Cluster with six elements related to Routing, Transportation, Optimization and Adaptive Matching, highlighted in light blue. These innovative leadership approaches have a substantial impact on AI & ML research in last-mile delivery.

Cluster 5- Digital Strategy and COVID-19

Cluster with six items marked in yellow. Digital Strategy and COVID-19 for last mile delivery.

Cluster 6- Vehicle, Routing and Problems

This cluster with five items in purple, with last-mile delivery. It includes Vehicle, Routing and Problem. It focuses on vehicles and finding the best route and identifying the problems.

Cluster 7- Vehicle Routing and Problems

This cluster with five items in orange, with last-mile delivery; focused on uncertainty.

Cluster 8- Digital Transformation

This cluster with three items in rose, with last-mile delivery; focused on digital transformation.

6. Discussion

The integration of AI &ML techniques in optimizing last-mile delivery represents a significant leap in logistics and transportation. This paper presents a comprehensive analysis facilitated by the VOSviewer software, combining bibliometric and thematic

Using the VOS viewer software, our analysis delves into bibliometric trends and thematic patterns, unveiling the pivotal role of AI and ML in last-mile delivery optimization. Co-occurrence analysis identifies dominant themes such as last-mile delivery, vehicle routing, and digital transformation, underscoring their scholarly significance. Clustering of

keywords reveals distinct thematic clusters, encompassing areas from demand management to digital strategies and the impact of external factors like COVID-19.

Co-authorship analysis provides collaborative networks among researchers, highlighting influential authors shaping discourse and theory development. Visualization of co-authorship networks aids in understanding collaborative dynamics and expertise distribution within the research community, emphasizing the importance of interdisciplinary collaboration in advancing last-mile optimization.

While there is a strong network of academic collaboration in certain regions, there is still room for broader international partnerships. This is relevant in a field where challenges and logistics infrastructures can vary significantly by geography and urban environment.

Another important takeaway is the chronological progression of research themes. Earlier studies largely focused on static routing and cost reduction, while more recent research has expanded to include adaptive logistics.

6.1 *Academic Implications*

The growing complexity of last-mile logistics demands a new generation of researchers and practitioners who are fluent not only in traditional supply chain models but also in digital and AI-powered solutions. This study adds to the academic conversation by offering a structured overview of how AI and ML are being used to solve real-world delivery challenges. By combining bibliometric tools with thematic analysis, using tools like VOS viewer software enables a comprehensive examination of research trends and author relationships. Insights from co-occurrence analysis underscore the significance of key themes in current literature. Co-authorship analysis reveals collaborative networks. We offer a useful roadmap for scholars seeking to explore under research areas like regional delivery optimization, sustainability and the human-technology interface in logistics. Our approach shows how advanced data techniques can make sense of vast literature and identify growing research trends in a highly dynamic field.

6.2 *Practical Implications*

For industry stakeholders, our findings offer clear, actionable insights. The integration of AI & ML technologies–such as smart route algorithms, delivery drones and real-time tracking-can pointedly decrease costs, boost

efficiency and progress customer satisfaction. This is especially relevant in markets like where urban density and unique challenges - zero-emission vehicles, can significantly reduce carbon footprint while optimizing delivery routes amidst economic pressures from high fuel rates. Businesses can benefit from investing in adaptive analytics and automation. Collaboration between the public and private sectors will be essential to scale sustainable delivery models and diminish environmental impact, particularly in the wake of rising fuel costs and carbon emission concerns.

6.3 *Limitations of this study*

The effectiveness of bibliometric and thematic analyzes depends deeply on the quality and accessibility of data. Incomplete or inaccurate datasets may lead to biased results and hinder the identification of comprehensive insights.

While this study offers a broad overview of literature, there are some inherent limitations. The findings depend heavily on the quality and scope of data; for example, some relevant studies may not have been included because of database access restrictions or keyword mismatches. Also, bibliometric analysis, while powerful, primarily captures quantitative trends and may miss nuanced, qualitative shifts in literature. The interpretations drawn from co-authorship and citation patterns are subject to the researcher's perspective and may vary slightly under different analytical lenses.

Findings derived from bibliometric and thematic analyzes may not universally apply across all contexts or industries. Factors such as regional variations, industry-specific nuances, and growing technological landscapes could limit the generalizability of results.

Addressing these limitations requires an ongoing refinement of methodologies, improved data quality assurance measures, and careful consideration of contextual factors to ensure the robustness and applicability of findings in advancing last-mile delivery optimization.

7. Conclusions

This study provides a comprehensive overview of how AI &ML are transforming last-mile delivery systems. By analyzing a curated set of 81 academic publications through bibliometric and thematic methods, we identified key research trends, influential scholars, and thematic gaps in the field. The insights drawn from keyword co-occurrence and author

collaboration patterns reveal not only the topics on which the academic community is focusing but also where attention is still lacking—such as localized solutions, sustainable delivery models and real-time optimization.

This paper contributes a structured framework for understanding the field and delivers actionable understandings for both academia and industry. By spotlighting under-explored areas and merging key contributions, we aim to support ongoing innovation in last-mile logistics, ensuring delivery systems are not only efficient and scalable but also responsive to the growing demands of a digitized and sustainability-conscious world.

References

[1] G. Vicario and S. Coleman, "A review of data science in business and industry and a future view," *Appl Stochastic Models Bus Indus,* vol. 36, no. 1, pp. 6-18 (2020).

[2] E. Gutierrez-Franco, C. Mejia-Argueta, and L. Rabelo, "Data-driven methodology to support long-lasting logistics and decision making for urban last-mile operations," *Sustainability,* vol. 13, no. 11, pp. 6230 (2021).

[3] S. Sorooshian, A. Abbaspour, and A. Jahan, "A system view to the risks of COVID-19 vaccination projects," *Applied System Innovation,* vol. 5, no. 1, pp. 20 (2022).

[4] N. Duman, O. Ergun, and M. Behroozi, "Shared Last Mile Delivery. Reengineering the Sharing Economy: Design," *Policy, and Regulation,* vol. 210 (2023).

[5] R. K. Singh, S. Modgil, and A. Shore, "Building artificial intelligence enabled resilient supply chain: a multi-method approach," *J. Enterp. Inf. Manage.,* vol. 37, no. 2, pp. 414-436 (2024).

[6] V. Silva, A. Amaral, and T. Fontes, "Sustainable urban last-mile logistics: A systematic literature review," *Sustainability,* vol. 15, no. 3, pp. 2285 (2023).

[7] M. Abdollahi, X. Yang, M. I. Nasri, and M. Fairbank, "Demand management in time-slotted last-mile delivery via dynamic routing with forecast orders," *Eur J Oper Res,* vol. 309, no. 2, pp. 704-718 (2023).

[8] A. Abouelrous, L. Bliek, and Y. Zhang, "Digital twin applications in urban logistics: an overview," *Urban, Planning and Transport Research,* vol. 11, no. 1, pp. 2216768 (2023).

[9] V. Belvedere, E. M. Martinelli, and A. Tunisini, "Getting the most from E-commerce in the context of omnichannel strategies," *Italian Journal of Marketing,* vol. 2021, no. 4, pp. 331-349 (2021).

[10] J. Bernal, J. W. Escobar, J. C. Paz, R. Linfati, and G. Gatica, "A probabilistic granular tabu search for the distance constrained capacitated vehicle routing problem," *International Journal of Industrial and Systems Engineering,* vol. 29, no. 4, pp. 453-477 (2018).

[11] N. Boysen, S. Fedtke, and S. Schwerdfeger, "Last-mile delivery concepts: a survey from an operational research perspective," *OR Spectrum,* vol. 43, no. 1, pp. 1-58 (2021).

[12] G. Bray and D. Cebon, "Selection of vehicle size and extent of multidrop deliveries for autonomous goods vehicles: An assessment of potential for change," *Transportation Research Part E: Logistics and Transportation Review,* vol. 164, pp. 102806 (2022).

[13] T. L. Broekhuizen, O. Emrich, M. J. Gijsenberg, M. Broekhuis, B. Donkers, and L. M. Sloot, "Digital platform openness: Drivers, dimensions and outcomes," *Journal of Business Research,* vol. 122, pp. 902-914 (2021).

[14] A. M. Caunhye and D. Alem, "Practicable robust stochastic optimization under divergence measures with an application to equitable humanitarian response planning," *OR Spectrum,* vol. 45, no. 3, pp. 759-806 (2023).

[15] Z. T. Butarbutar, P. W. Handayani, R. R. Suryono, and W. S. Wibowo, "Systematic literature review of Critical success factors on enterprise resource planning post implementation," *Cogent business & management,* vol. 10, no. 3, pp. 2264001 (2023).

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