ISSN: 2455 - 1597

International Journal of Engineering Research and Generic Science (IJERGS)
Available online at: https://www.ijergs.in

Volume - 11, Issue - 3, May – June - 2025, Page No. 01 - 07

Role of AI and Machine Learning in Predicting Food Delivery Times

[1]Komal Vijay, Assistant Professor, Department of Computer Science, Arya College of Engineering, Jaipur.

[2]Jatin, Research Scholar, Department of Computer Science, Arya College of Engineering, Jaipur

[3]Goutam, Research Scholar, Department of Computer Science, Arya College of Engineering, Jaipur

Abstract

The exponential growth of the food delivery industry has placed a premium on operational efficiency, particularly in the accurate prediction of food delivery times. Traditional estimation methods, based on fixed calculations of distance and preparation time, often fall short in dynamic urban environments where real-time variables such as traffic, weather, and kitchen load significantly impact delivery durations. This paper explores the transformative role of Artificial Intelligence (AI) and Machine Learning (ML) in addressing these challenges. It examines how leading food delivery platforms integrate AI-driven models to analyze historical data, rider behavior, customer profiles, and environmental conditions to deliver precise Estimated Times of Arrival (ETAs). Various ML techniques—including supervised learning, deep neural networks, reinforcement learning, and geospatial modeling—are discussed in the context of their application to route optimization, order dispatching, and demand forecasting. Real-world case studies from companies such as Uber Eats, Zomato, and Domino’s Pizza highlight the effectiveness of AI in reducing delays, improving customer satisfaction, and optimizing delivery logistics. Furthermore, this paper identifies ongoing challenges in data quality, model drift, explainability, and ethical concerns, while proposing future directions for AI-powered automation, personalization, and predictive logistics in food delivery. The findings conclude that AI is not merely a supporting tool but a foundational element in creating the next generation of intelligent, responsive, and efficient food delivery systems.

Keywords: Logistics, Machine Learning, Real-Time, Neural Networks, Uber Eats, Zomato, Dynamic ETA, Food Tech Innovation

Introduction

In the modern era, the rapid evolution of the food delivery industry has significantly changed the way consumers interact with restaurants and food vendors. With the growing reliance on mobile apps and web platforms for ordering food, there has also been a sharp increase in customer expectations. One of the most crucial aspects of a satisfying user experience in this domain is the accuracy of delivery time predictions. Consumers are not just looking for good food; they expect that food to arrive quickly, and more importantly, within the estimated time frame promised by the platform.

Traditional systems often relied on simple, rule-based approaches to predict delivery times—using linear calculations based on distance, average speed, and static preparation times. These models, however, fail to account for the myriad of real-world variables that affect delivery time, such as traffic conditions, weather, roadblocks, order load at the restaurant, rider experience, and peak hours. A misjudgement of even a few minutes can lead to customer dissatisfaction, canceled orders, and negative reviews, thereby impacting the platform's reputation and profitability.

Artificial Intelligence (AI) and Machine Learning (ML) offer a powerful solution to this challenge by leveraging historical and real-time data to build models that can more accurately and dynamically estimate delivery times. These technologies are designed to learn patterns from vast datasets and make intelligent predictions that adapt to changing conditions. By integrating AI/ML into delivery platforms, companies can enhance their accuracy, optimize resources, reduce delivery costs, and most importantly, improve the customer experience. This integration is no longer a luxury but a necessity in today's competitive food delivery ecosystem.

Figure 1:

Machine Learning Techniques in Delivery Time Prediction

AI and Machine Learning systems used in predicting food delivery times rely on a combination of supervised, unsupervised, and reinforcement learning techniques. These methods are designed to extract patterns from large sets of historical and real-time data, which include customer orders, delivery partner behavior, traffic conditions, weather reports, and more.

In supervised learning, algorithms like Linear Regression, Decision Trees, Random Forests, and Gradient Boosting are used to train the model on labeled data—where the input (order details) and output (actual delivery time) are known. These models learn how different features influence the delivery time and apply that knowledge to predict future outcomes. Gradient Boosted Decision Trees (GBDTs), in particular, are widely used because of their ability to handle complex interactions between variables and high predictive accuracy.

For more nuanced and large-scale implementations, Deep Learning models such as Artificial Neural Networks (ANNs) and Recurrent Neural Networks (RNNs) come into play. These models are especially useful when dealing with time-series data or spatial data, where the sequence and location of events matter—like rider GPS movements or changes in order volumes over time.

In reinforcement learning, systems learn through a feedback loop, making real-time decisions and adjusting their behavior based on reward and penalty signals. Platforms like Uber Eats use reinforcement learning to optimize rider assignment and route planning. The model learns from the consequences of each decision and improves its policy over time.

Other notable techniques include clustering algorithms to group similar delivery zones, Natural Language Processing (NLP) for analyzing customer instructions, and graph-based models to understand city logistics. Together, these ML tools form the backbone of predictive engines that can provide accurate and adaptive delivery time estimates in real-time.

Data Sources and Features Used

The success of AI and ML in predicting food delivery times largely depends on the quality and variety of data sources feeding into the system. A comprehensive prediction model considers a wide range of both static and dynamic features that influence the outcome.

One of the primary data sources is historical order data, which includes time of order placement, preparation duration, delivery route, and actual delivery time. This dataset forms the ground truth for training supervised models. It helps the algorithm understand patterns such as which restaurants consistently take longer or which areas are harder to navigate during rush hours.

Geolocation data from delivery riders' GPS systems provides real-time tracking and routing information. It enables the system to account for the rider's current position, average speed, route selection, and traffic delays. Similarly, traffic APIs (like Google Maps or Mapbox) offer live congestion data, which can be integrated into the model for more accurate route-based time estimates.

Weather data is another essential variable. Rain, fog, or extreme heat can significantly affect delivery speed. By incorporating weather forecasts, the model can preemptively adjust ETAs.

Restaurant data, including current kitchen load, menu complexity, staff availability, and order queue, also plays a crucial role. Some platforms integrate with POS (Point of Sale) systems to access real-time updates on food prep status.

Lastly, customer data—such as location type (apartment, gated society, office), past behavior (frequent order cancellations or special instructions), and feedback—can also be factored in to personalize predictions further.

Together, these diverse datasets enable the machine learning model to operate like a dynamic, context-aware system that adapts to minute-by-minute changes in the environment.

Benefits of AI-Based Delivery Time Prediction

The incorporation of AI and ML into food delivery platforms brings a multitude of benefits, both for businesses and end-users. One of the most obvious advantages is the improved accuracy of estimated time of arrival (ETA), which directly correlates with increased customer satisfaction. When users receive their orders within or ahead of the promised time, their trust in the platform grows, leading to higher retention and repeat orders.

From a business operations perspective, precise delivery predictions enable better resource allocation. Companies can optimize how delivery partners are distributed across geographic zones, ensuring that high-demand areas are well-staffed, especially during peak hours. This efficiency not only saves time but also reduces fuel costs and wear on vehicles or bikes.

Accurate predictions also contribute to reduced order cancellations and fewer customer complaints. If users are informed of realistic delivery times upfront—and those times are consistently met—they're less likely to abandon the order midway. It also gives restaurants clearer timelines to prepare food, reducing kitchen bottlenecks.

Moreover, AI can facilitate real-time route optimization. By analyzing ongoing traffic and rider data, the system can reroute deliveries instantly, choosing the fastest path and avoiding congested roads or areas with accidents. This dynamic adjustment ensures better punctuality and saves time.

In the long term, platforms can leverage AI-based predictions for strategic planning. They can forecast delivery times for upcoming festivals, weather changes, or marketing campaigns and scale resources accordingly. AI can even assist in predictive hiring, where additional delivery partners are temporarily onboarded based on demand forecasts.

Overall, integrating AI into delivery prediction systems fosters a smarter, more agile, and customer-focused ecosystem, giving platforms a competitive edge in the crowded food delivery market.

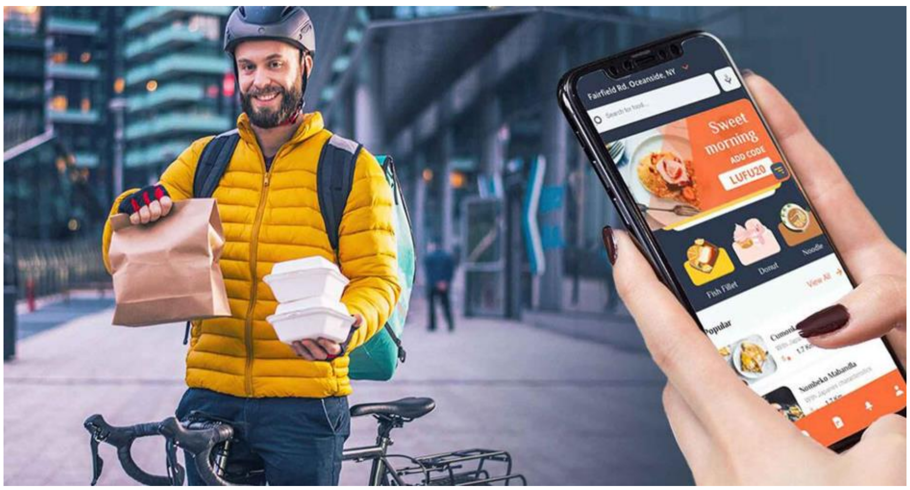

Figure 2

Challenges in AI-Driven Delivery Time Prediction

While AI and machine learning offer tremendous benefits in predicting food delivery times, there are several significant challenges that developers and companies must address for optimal performance and scalability.

One of the foremost challenges is data quality and consistency. Machine learning models are only as effective as the data they're trained on. Inaccurate timestamps, missing delivery logs, or inconsistent location data can skew model training, leading to poor predictions. In real-world settings, factors such as network failures, GPS inaccuracies, or delayed updates can introduce noise into the data pipeline.

Another critical issue is model drift. As customer behavior, restaurant operating procedures, city infrastructure, and delivery partner habits evolve, the conditions that once shaped accurate predictions may no longer apply. A model trained six months ago may no longer represent the current dynamics. This necessitates continuous model retraining, validation, and versioning, which can be both resource- and time-intensive.

Additionally, explainability of predictions poses a problem, especially in platforms using deep learning. While a neural network may predict an ETA accurately, it may not be able to justify its reasoning in human-understandable terms. This lack of transparency can become problematic in customer support scenarios where users question late deliveries.

Edge cases are another concern. Sudden events such as unplanned road closures, traffic accidents, extreme weather, or political rallies can disrupt delivery routes and cause abrupt delays. These anomalies are difficult to predict unless the system integrates multiple real-time data streams and uses anomaly detection mechanisms.

Lastly, ensuring fairness and ethics in AI decision-making is essential. Algorithms that unknowingly prioritize certain regions or delay assignments to lower-rated delivery partners can cause unintended bias. Companies must build checks to ensure fairness in partner allocation, especially in densely populated or underserved areas.

Real-World Applications and Case Studies

Several leading food delivery platforms globally have adopted AI and ML to improve their delivery time predictions, showcasing the real-world applicability and value of these technologies.

Uber Eats, one of the pioneers in this space, utilizes a sophisticated ML-based system that considers over 100 variables to estimate the delivery time of each order. Their model uses rider telemetry data, restaurant preparation speed, traffic patterns, and real-time order surge data. The system not only predicts ETA but also dispatches the most suitable delivery partner for the job. Uber's algorithm even learns the behavioral patterns of individual restaurants, improving accuracy over time.

Zomato, an Indian food delivery giant, uses machine learning to assign delivery partners to orders based on a combination of location, speed, ratings, and predicted kitchen readiness. Their backend system can dynamically update ETAs as new variables are introduced—such as an unexpected rainstorm or a rider's change in direction. They also use forecasting models to predict demand surges before festivals or peak meal times, allowing proactive allocation of riders.

DoorDash in the United States integrates AI to determine not just the ETA but also the "dasher efficiency". Their model predicts how long a specific delivery partner will take based on previous trips, which improves the allocation process and customer satisfaction. The platform also accounts for parking availability, elevator wait times, and time spent waiting at restaurants.

Domino's Pizza uses a proprietary AI platform called DRU (Domino's Robotic Unit) to track order status from preparation to delivery. It combines internal kitchen operations with external GPS-based delivery analytics, which has significantly improved their "30-minute delivery" promise in many regions.

These case studies demonstrate that AI is not a future concept in food delivery it is already a critical infrastructure component driving innovation, competitiveness, and efficiency across the industry.

Conclusion and Future Scope

In conclusion, the application of Artificial Intelligence and Machine Learning in predicting food delivery times is revolutionizing the logistics of online food services. By intelligently processing a variety of data inputs—ranging from GPS locations and traffic data to kitchen workload and weather conditions—AI-powered systems can deliver highly accurate, real-time delivery estimates that enhance user experience and streamline operations.

The integration of these technologies has moved from being a competitive edge to an operational necessity. As food delivery markets grow, customer expectations for transparency, speed, and reliability will only increase. Platforms that effectively leverage AI will enjoy higher customer retention, more efficient delivery cycles, and better scalability during peak demand.

However, despite these advances, challenges remain. Data quality, algorithm transparency, and model adaptability are ongoing areas of concern. Companies must invest in continual model retraining, real-time monitoring, and ethical AI practices to ensure fairness and effectiveness. Additionally, the need for explainable AI will become more significant as users and regulators demand more clarity into how algorithmic decisions are made.

Looking forward, the future of AI in this space appears promising. Innovations like predictive dispatching, hyper-local weather integration, computer vision in kitchens for live order tracking, and AI-powered demand forecasting will become mainstream. Autonomous delivery bots and drones, once fully integrated, will depend heavily on ML models for route planning and traffic navigation. Moreover, personalized ETA prediction—based on a user's past location access times, preferences, or building-specific delays—may emerge as a new standard in the food delivery experience.

In essence, AI and ML are not just enhancing delivery time predictions—they are shaping the future architecture of the food delivery industry itself.

References

1. Kumar, I., Rawat, J., Mohd, N., & Husain, S. (2021). Opportunities of artificial intelligence and machine learning in the food industry. Journal of Food Quality, 2021(1), 4535567.
2. Yalçinkaya, E., & Hızıroğlu, O. A. (2024). A comparative analysis of machine learning models for time prediction in food delivery operations. Artificial Intelligence Theory and Applications, 4(1), 43-56.
3. Kumar, V., & Mishra, A. (2024, March). Efficient Food Delivery Management: Predicting Delivery Times for Improved Customer Experience. In 2024 2nd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA) (pp. 1-4). IEEE.
4. Kumar, V., & Mishra, A. (2024, March). Efficient Food Delivery Management: Predicting Delivery Times for Improved Customer Experience. In 2024 2nd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA) (pp. 1-4). IEEE.
5. Gao, C., Zhang, F., Wu, G., Hu, Q., Ru, Q., Hao, J., ... & Sun, Z. (2021, August). A deep learning method for route and time prediction in food delivery service. In Proceedings of the 27th ACM SIGKDD Conference on Knowledge Discovery & Data Mining (pp. 2879-2889).
6. Gao, C., Zhang, F., Wu, G., Hu, Q., Ru, Q., Hao, J., ... & Sun, Z. (2021, August). A deep learning method for route and time prediction in food delivery service. In Proceedings of the 27th ACM SIGKDD Conference on Knowledge Discovery & Data Mining (pp. 2879-2889).
7. Yaiprasert, C., & Hidayanto, A. N. (2023). AI-driven ensemble three machine learning to enhance digital marketing strategies in the food delivery business. Intelligent Systems with Applications, 18, 200235.

8. Yaiprasert, C., & Hidayanto, A. N. (2023). AI-driven ensemble three machine learning to enhance digital marketing strategies in the food delivery business. Intelligent Systems with Applications, 18, 200235.
9. Garg, A., Ayaan, M., Parekh, S., & Udandarao, V. (2025). Food Delivery Time Prediction in Indian Cities Using Machine Learning Models. arXiv preprint arXiv:2503.15177.
10. Gao, C., Zhang, F., Zhou, Y., Feng, R., Ru, Q., Bian, K., ... & Sun, Z. (2022, August). Applying deep learning based probabilistic forecasting to food preparation time for on-demand delivery service. In Proceedings of the 28th ACM SIGKDD conference on knowledge discovery and data mining (pp. 2924-2934).
11. Gao, C., Zhang, F., Zhou, Y., Feng, R., Ru, Q., Bian, K., ... & Sun, Z. (2022, August). Applying deep learning based probabilistic forecasting to food preparation time for on-demand delivery service. In Proceedings of the 28th ACM SIGKDD conference on knowledge discovery and data mining (pp. 2924-2934).
12. Rabaa'i, A. A., Zhu, X., Jayaraman, J. D., Nguyen, T. D., & Jha, P. P. (2022). The use of machine learning to predict the main factors that influence the continuous usage of mobile food delivery apps. Model Assisted Statistics and Applications, 17(4), 247-258.
13. Khan, R. (2022). Artificial intelligence and machine learning in food industries: A study. J Food Chem Nanotechnol, 7(3), 60-67.
14. Adak, A., Pradhan, B., Shukla, N., & Alamri, A. (2022). Unboxing deep learning model of food delivery service reviews using explainable artificial intelligence (XAI) technique. Foods, 11(14), 2019.
15. Adak, A. (2022). Analyzing Customer Reviews on Food Delivery Services Using Deep Learning and Explainable Artificial Intelligence (XAI). University of Technology Sydney (Australia).
16. Cieplak, T., Maj, M., & SZyMańSki, Z. Optimizing delivery time with an intelligent forecasting model: leveraging ai and machine learning for efficient logistics.
17. Anitha, E., Prasath, M. N., Sanjai, L., Shiny, J. A., & Varsini, P. (2023). Effective Food Demand Forecasting Using Machine Learning Algorithms. 2023 IEEE Engineering Informatics, 1-7.
18. Ghosh, T. (2025). Combating the Bullwhip Effect in Rival Online Food Delivery Platforms Using Deep Learning. arXiv preprint arXiv:2503.22753.
19. Ghosh, T. (2025). Combating the Bullwhip Effect in Rival Online Food Delivery Platforms Using Deep Learning. arXiv preprint arXiv:2503.22753.