Proceedings of the 4th International Conference on Computing Innovation and Applied Physics
DOI: 10.54254/2753-8818/79/2025.20000

Comparison of Manual and Robotic Food Transportation in Small Restaurants

Shuzhi Zhang[1,a,*]

[1]*School of Software Henan University of Science and Technology, Jianxi District, Zhengzhou Road Street, Henan, China*
a. 2023308335@qq.com
**corresponding author*

Abstract: In the catering industry, with the development of science and technology, more and more robots are used in catering services, especially in small restaurants, and meal transportation robots have become the first choice for some operators. This review will compare the cost, efficiency (including speed, reliability, accuracy), and customer experience and satisfaction between food delivery robots and manual transportation. Although the development trend of robotics in the catering industry is improving, there are still many challenges in the future, including the use of robots in complex environments, which requires more resources to be invested in research.

Keywords: Food Transportation, Catering Industry, Robotics, Customer Experience and Satisfaction.

1. Introduction

With the rapid development of technology, especially in the field of artificial intelligence and automation, the application of food transportation robots in small restaurants is gradually emerging [1]. Small restaurants face challenges such as human resource shortages, rising operating costs, and diverse customer needs, and traditional manual service models are difficult to meet peak demand. In this context, food transportation robots have emerged as an effective solution to increase efficiency and improve customer experience. Equipped with advanced navigation and positioning technology, these robots are able to move autonomously around the restaurant, transporting dishes quickly and accurately, and reducing customer wait times. At the same time, with the improvement of customers' requirements for service quality, the consistent service provided by robots is also welcomed.

As consumers demand more from the dining experience, restaurants need to not only serve delicious dishes, but also ensure that customers can enjoy them in a reasonable amount of time. Efficient food transportation can significantly reduce customer wait times and improve overall service speed, which in turn increases customer satisfaction and return rates. In addition, fast food delivery also helps to optimize the restaurant's operational processes, reducing the workload of employees, allowing them to focus more on the quality of the dishes and the individual needs of customers [2]. In a highly competitive F&B market, smaller restaurants that are able to efficiently transport dishes tend to have a good image in the minds of customers, thus attracting more customers. Therefore, improving the efficiency of food transportation is not only related to the smooth daily operation, but also has a direct impact on the profitability and sustainable development of the restaurant [3].

DOI: 10.54254/2753-8818/79/2025.20000

This review will compare the manual and machine transportation methods of dishes in small restaurants, including transportation costs, transportation efficiency and customer experience and satisfaction, and discuss the trend of robotics in the food industry.

2. Manual Food Transportation

In small restaurants, traditional manual transportation of dishes is still the most common form of service. By manually delivering dishes from the kitchen to the customer's table, the waiter not only provides personalized service, but also interacts with the customer during the delivery process to enhance the dining experience. The waiter can adjust the presentation and service of the dishes in a timely manner according to the needs of the customer, answer the customer's questions, and provide recommendations if necessary. This humanized service can effectively improve customer satisfaction and create a warm dining atmosphere.

However, there are some significant drawbacks to traditional manual transportation of dishes. First of all, waiters can face a lot of work pressure during peak hours, resulting in reduced service efficiency and increased customer wait times, which can affect the overall dining experience. In addition, the stability and consistency of manual transportation are low, and the experience and status of the waiter will directly affect the quality and speed of the delivery of dishes. In addition, as labor costs rise, restaurants also need to invest more resources in staff training and management, which increases the complexity of operations to a certain extent. Therefore, while traditional manual transportation has advantages in terms of service quality, it faces challenges in terms of efficiency and cost control.

3. Robotic Food Transportation

The food transportation robot system uses automation technology and robotics technology to achieve efficient transportation of food from the kitchen to the customer's table. These systems often integrate sensors, navigation algorithms, and artificial intelligence to ensure that food is transported safely, quickly, and efficiently. Food transport robots can reduce labor costs, improve service efficiency, and improve the customer experience.

Food transport robots provide consistency and reliability. The most significant benefit is the increased efficiency of the service. Robots are able to quickly and accurately transport food from the kitchen to the customer's table, significantly reducing the time required for manual transport. This efficient service is especially important during peak hours to effectively respond to customer needs and enhance the overall dining experience. Compared to human attendants, robots are less susceptible to emotions and fatigue when performing tasks, and are able to complete transportation tasks accurately and unerotically according to set procedures, thereby reducing the occurrence of human error. This consistency not only improves the quality of service, but also strengthens customer trust in the restaurant.

However, food delivery robots are not without their drawbacks. First of all, the initial investment cost is high, and the purchase and maintenance of robots requires a considerable capital investment, which can be a significant burden for some small restaurants. In addition, bots are highly dependent on technology and may experience glitches or software issues that not only affect the continuity of service, but can also cause customer dissatisfaction and churn. While modern robots are equipped with advanced sensors and navigation systems, they often lack the flexibility of humans when dealing with complex or unexpected situations. For example, in a crowded environment, robots may not be able to effectively avoid obstacles, resulting in reduced service efficiency.

From the article by Eksiri, A., & Kimura, T. (2015), the study conducted a six-month practical evaluation of each robot in five branches of the MK restaurant chain in the Bangkok area of Thailand

DOI: 10.54254/2753-8818/79/2025.20000

from 2009 to 2012 [4]. During this period, the robot provided a total of 14,280 services and attracted the attention of 235,680 customers. The study summarizes the "lessons learned" from this four-year project, which will provide useful references for similar service robot development projects.

4. Comparative Analysis

4.1. Transportation costs

1. Initial investment: Robots typically require a high initial investment, which can range from a few thousand to tens of thousands of dollars, depending on the robot's capabilities and level of technology. Some modifications may be required to the inside of the restaurant to accommodate the operation of the robots, such as setting up dedicated walking routes or charging stations. Waiters need to be recruited, which includes expenses such as job advertisements, interviews, training, etc. Manual transportation also needs to consider long-term costs such as employees' wages, benefits, insurance, etc.

2. Maintenance costs: Robots require regular maintenance, including software updates and hardware checks, which can incur additional costs. In case of failure, professional technical support may be required, which increases maintenance costs. Employees need to be trained regularly to improve service quality and efficiency. Employee turnover can lead to additional recruitment and training costs.

3. Operating costs: Robots need electricity during operation, which can increase the restaurant's electricity bill. Robots may work efficiently during peak hours, but may have lower usage during periods of low foot traffic, resulting in a lower ROI. Employee wages and related benefits are ongoing operating costs, especially in areas with high labor costs. Manual transportation may be more flexible during peak hours, but it can also incur fixed payroll expenses during off-peak hours.

4.2. Efficiency

1. Speed: Food transport robots are usually able to move efficiently in restaurants at a steady speed, without fatigue and emotional disturbances, and can work continuously, especially during peak hours. Since the robot travels along a fixed route, the delays that can be caused by waiters navigating crowded environments are avoided [5]. In contrast, manual transport shows greater flexibility, with attendants able to quickly adjust their speed to suit customer needs or handle emergencies based on on-site conditions, although this may result in fluctuations in the speed of a single shipment.

2. Reliability: Food transport robot provides consistency and stability, and can perform tasks according to preset paths and procedures, thereby reducing the possibility of human error. However, robots can also be affected by technical failures and environmental changes, resulting in shipping delays. In contrast, manual transport is better at responding to unexpected situations, and the waiter is able to quickly respond to the customer's special requests or changes in the environment, showing a higher level of adaptability. However, the reliability of manual transportation is also affected by the status and experience of employees, which can lead to inconsistencies in the quality of service.

3. Accuracy: With the help of sensors and navigation systems, the robot can accurately identify the target location, reduce the risk of delivering the wrong dish, and ensure the accuracy of each shipment [6]. However, manual shipping can make adjustments based on real-time customer feedback to provide more personalized service when processing complex orders, but due to the human factor, waiters can make mistakes in high-pressure environments.

DOI: 10.54254/2753-8818/79/2025.20000

4.3. Customer experience and satisfaction

Dish transport robots can significantly reduce customer waiting times. Dish transport robots can significantly reduce customer waiting times. Research shows that fast service response is one of the key factors in improving customer satisfaction [7]. The robots are able to operate continuously during peak hours, reducing the bottleneck of manual service and improving overall service efficiency. This efficiency gain is often directly reflected in customer satisfaction surveys, where customers are more likely to give high ratings.

However, the literature by Huang, M. H., & Rust, R. T. (2021) shows that the success of bot services is closely related to customer acceptance [8]. Customer attitudes toward robotic service are influenced by a variety of factors, including their familiarity with technology and expectations of service quality. Some customers may feel uncomfortable with bot service, especially if personalized service is required. Therefore, when introducing robots, restaurants should fully consider the diverse needs of customers and ensure that robots are combined with human services to provide a more comprehensive dining experience.

The performance of the robot in the service also needs to maintain a high level of stability and accuracy. The literature shows that the stability of service quality has a significant impact on customer satisfaction [9]. If the robot makes mistakes or delays during shipping, it can lead to customer dissatisfaction, which in turn affects the overall experience. As a result, restaurants need to regularly maintain and update their robots to ensure their efficient operation.

From the literature by Pande, S., & Gupta, K. P. (2023),the data collected through the survey yielded 419 usable customer responses that were used to empirically test the proposed model using structural equation modeling (SEM) [10]. The results of the study show that customers go through a three-stage process, including a primary evaluation phase, a secondary evaluation phase, and an outcome phase, to determine whether they are comfortable with using service robots in restaurants. The results also showed that customer gender and preference had a significant moderating effect.

El-Said, O., & Al Hajri, S. (2022) used a sample of customers dining at robot-serviced restaurants in Muscat [11]. This study explores the factors influencing experience satisfaction and experience prolongation. The results show that perceived usefulness, service speed and experience novelty have a direct impact on experience satisfaction, while perceived enjoyment and experience satisfaction have a direct impact on experience lengthening.

The comparative analysis based on transportation costs, efficiency, and customer experience and satisfaction are summarized in Table 1. It summarizes key points from the comparative analysis across different aspects of robot-based and manual transportation in restaurants.

Table 1: Comparative analysis of robot-based and manual transportation in restaurants.

	Category	Robots	Manual (Waiters)
Transportation Costs	Initial Investment	High upfront cost ($1,000s to $10,000s), requires modifications (routes, charging stations).	Recruitment, training costs, ongoing wages, benefits, and insurance.
	Maintenance Costs	Regular software updates, hardware checks, and technical support.	Regular employee training, additional costs due to turnover.
	Operating Costs	Electricity costs, efficient in peak hours, lower ROI during off-peak.	Fixed payroll, flexible in peak hours, but ongoing wage expenses in off-peak.

DOI: 10.54254/2753-8818/79/2025.20000

Table 1: (continued)

Efficiency	Speed	Steady, consistent speed, avoids delays in crowded spaces.	Flexible speed based on needs, but variable in crowded or emergency situations.
	Reliability	Consistent performance, but vulnerable to technical failures.	Adaptable, but service depends on employee status and experience.
	Accuracy	High accuracy due to sensors, fewer delivery mistakes.	Can adjust to real-time feedback, but more prone to errors under pressure.
Customer Experience	Customer Satisfaction	Reduces wait times, improves efficiency during peak hours, boosting satisfaction.	Personalized service, but potential bottlenecks during busy periods.
	Customer Acceptance	Varies based on familiarity with tech; some may prefer human service.	Generally preferred for personalized interaction.
	Service Stability	Requires regular maintenance to avoid errors; crucial for customer satisfaction.	Service quality can vary but adaptable to errors, offering human responsiveness.
	Study Findings	Customer acceptance involves stages and varies by gender and preference	Positive influence on perceived usefulness, service speed, and novelty

5. Technological Trends and Challenges in Food Service Robots

5.1. Advances in robotics

In recent years, the combination of artificial intelligence and machine learning has enabled robots to learn and adapt more autonomously, so that they can more effectively understand and respond to human instructions and improve the interactive experience. The rise of collaborative robots (cobots) has enabled these devices to safely work with human workers, especially in manufacturing, logistics, and healthcare, demonstrating flexibility and ease of use, allowing small businesses to benefit from robotics as well [12].

From the literature by Garcia, E., Jimenez, M. A., De Santos, P. G., & Armada, M. (2007) ,the new trend of robot research is called service robots, because their overall goal is to make robots closer to the social needs of human beings, and to better and more reasonably meet human requirements and goals, and the resulting medical robots, rehabilitation robots, underwater robots, field robots, construction robots and humanoid robots and other service robots provide great convenience for human beings, from the traditional motion control of industrial robots to modern intelligent control technology and social learning paradigms [13].The development of robotics is becoming more and more biomimetic and intelligent

Advances in artificial intelligence and machine learning have significantly improved robots' ability to learn and adapt to their environment, enabling them to make more accurate decisions in complex operating environments. For example, Kumar et al. (2022) pointed out that the application of deep learning algorithms has led to a significant improvement in the performance of robots in visual

DOI: 10.54254/2753-8818/79/2025.20000

recognition and path planning, thereby enhancing the naturalness and efficiency of human-computer interaction [14].

Advances in autonomous navigation and mobility technology cannot be ignored either. Research has shown that advanced sensors and algorithms enable service robots and drones to navigate autonomously in complex environments. The study by Trulls et al. (2021) highlights that the application of these technologies is not limited to the industrial field, but also extends to emerging fields such as intelligent distribution and environmental monitoring, driving the widespread application of robotics [15].

In addition, there is a growing discussion about sustainable development. More and more literature is focusing on how to achieve sustainability goals by designing environmentally friendly robots and optimizing energy consumption. According to Walker et al. (2017), the advancement of environmentally friendly robotics not only responds to the global call for environmental protection, but also points the way for the future development of robotics [16].

5.2. Challenges

1. Integration with traditional system: First of all, although the rapid development of technology provides many opportunities for food service robots, it also brings challenges of technology integration. According to Garcia-Haro et al. (2020), existing robotic systems often need to interface seamlessly with traditional food and beverage management systems, which requires significant investment and improvements in software and hardware [17]. In addition, rapid iteration of technology can also lead to equipment becoming obsolete quickly, increasing the financial burden on enterprises.

2. Food Safety: Stringent food safety and hygiene standards also pose challenges to food service robots Chen et al. (2021) highlighted that despite the ability of robots to reduce human contact, their cleaning and disinfection remains a key issue [18]. How to ensure that the robot maintains a high standard of hygiene during operation is an important topic for future development.

3. Cost: Economic viability is also a challenge that cannot be ignored. Despite the efficiency gains made by robotics, the high initial investment and maintenance costs can be prohibitive for many small and medium-sized F&B businesses. According to the research of Akhund et al. (2020), how to reduce the cost and improve the cost performance of robotics in order to achieve sustainable development is an urgent problem to be solved in the future [19].

6. Conclusion

Both manual and robotic food transportation methods offer unique advantages and disadvantages. While manual transportation provides personalized service, it faces challenges related to efficiency and cost in a rapidly evolving technological landscape. As robotics technology advances, food transportation robots are poised to play a larger role in small restaurant operations, improving efficiency and customer satisfaction. Future research should prioritize sustainable development, affordability, and user experience to ensure the successful integration of robotics in the food service industry.

References

[1] *Berezina, K., Ciftci, O., & Cobanoglu, C. (2019). Robots, artificial intelligence, and service automation in restaurants. In Robots, artificial intelligence, and service automation in travel, tourism and hospitality (pp. 185-219). Emerald Publishing Limited.*

[2] *Christ-Brendemühl, S. (2022). Bridging the gap: An interview study on frontline employee responses to restaurant technology. International Journal of Hospitality Management, 102, 103183.*

[3] *Davis, B., Lockwood, A., Pantelidis, I. S., & Alcott, P. (2018). Food and beverage management. Routledge.*

DOI: 10.54254/2753-8818/79/2025.20000

[4] *Eksiri, A., & Kimura, T. (2015). Restaurant service robots development in Thailand and their real environment evaluation. Journal of Robotics and Mechatronics, 27(1), 91-102.*

[5] *Fang, J., Qin, S., & Zhou, H. (2022, September). Research on the Obstacle Avoidance System of Restaurant Delivery Robot. In 2022 International Conference on Artificial Intelligence and Computer Information Technology (AICIT) (pp. 1-5). IEEE.*

[6] *Sun, Y., Guan, L., Chang, Z., Li, C., & Gao, Y. (2019). Design of a low-cost indoor navigation system for food delivery robot based on multi-sensor information fusion. Sensors, 19(22), 4980.*

[7] *Kwortnik Jr, R. J., & Thompson, G. M. (2009). Unifying service marketing and operations with service experience management. Journal of service research, 11(4), 389-406.*

[8] *Huang, M. H., & Rust, R. T. (2021). A strategic framework for artificial intelligence in marketing. Journal of the Academy of Marketing Science, 49, 30-50.*

[9] *Zeithaml, V. A., Berry, L. L., & Parasuraman, A. (1996). The behavioral consequences of service quality. Journal of marketing, 60(2), 31-46.*

[10] *Pande, S., & Gupta, K. P. (2023). Indian customers' acceptance of service robots in restaurant services. Behaviour & Information Technology, 42(12), 1946-1967.*

[11] *El-Said, O., & Al Hajri, S. (2022). Are customers happy with robot service? Investigating satisfaction with robot service restaurants during the COVID-19 pandemic. Heliyon, 8(3).*

[12] *Colgate, J. E., Wannasuphoprasit, W., & Peshkin, M. A. (1996, November). Cobots: Robots for collaboration with human operators. In ASME international mechanical engineering congress and exposition (Vol. 15281, pp. 433-439). American Society of Mechanical Engineers.*

[13] *Garcia, E., Jimenez, M. A., De Santos, P. G., & Armada, M. (2007). The evolution of robotics research. IEEE Robotics & Automation Magazine, 14(1), 90-103.*

[14] *Aggarwal, K., Singh, S. K., Chopra, M., Kumar, S., & Colace, F. (2022). Deep learning in robotics for strengthening industry 4.0.: opportunities, challenges and future directions. Robotics and AI for Cybersecurity and Critical Infrastructure in Smart Cities, 1-19.*

[15] *Trulls, E., Corominas Murtra, A., Pérez-Ibarz, J., Ferrer, G., Vasquez, D., Mirats-Tur, J. M., & Sanfeliu, A. (2011). Autonomous navigation for mobile service robots in urban pedestrian environments. Journal of Field Robotics, 28(3), 329-354.*

[16] *Walker, S., Rueben, J., Volkenburg, T. V., Hemleben, S., Grimm, C., Simonsen, J., & Mengüç, Y. (2017). Using an environmentally benign and degradable elastomer in soft robotics. International Journal of Intelligent Robotics and Applications, 1, 124-142.*

[17] *Garcia-Haro, J. M., Oña, E. D., Hernandez-Vicen, J., Martinez, S., & Balaguer, C. (2020). Service robots in catering applications: A review and future challenges. Electronics, 10(1), 47.*

[18] *Chen, T. C., & Yu, S. Y. (2021). The review of food safety inspection system based on artificial intelligence, image processing, and robotic. Food Science and Technology, 42, e35421.*

[19] *Akhund, T. M. N. U., Siddik, M. A. B., Hossain, M. R., Rahman, M. M., Newaz, N. T., & Saifuzzaman, M. (2020, June). IoT Waiter Bot: a low cost IoT based multi functioned robot for restaurants. In 2020 8th international conference on reliability, infocom technologies and optimization (Trends and Future Directions)(ICRITO) (pp. 1174-1178). IEEE.*