Sigma J Eng Nat Sci, Vol. 43, No. 3, pp. 899–909, June, 2025

Sigma Journal of Engineering and Natural Sciences
Web page info: https://sigma.yildiz.edu.tr
DOI: 10.14744/sigma.2025.00078

Research Article

Evaluation of a robotic restaurant management system with UI design, voice assistant, and machine learning integration

Lalit N. PATIL[1,*], Vikash K. AGRAWAL[1], Kishor K. DHANDE[2], Shrihari D. KHATAVKAR[1], Ganesh D. MANDE[1], Vishvajit S. PATIL[1], Shreyash S. RATNAPARKHI[1]

[1]Department of Automation and Robotics, Dr. D. Y. Patil Institute of Technology, Pimpri, Pune, 411033, India
[2]Department of Mechanical Engineering, Dr. D. Y. Patil Institute of Technology, Pimpri, Pune, 411033, India

ARTICLE INFO

Article history
Received: 13 April 2024
Revised: 13 May 2024
Accepted: 26 June 2024

Keywords:
Data Analysis; ML Algorithm; Sk-Learn; Principal Component Analysis Clustering Algorithms; UI Design

ABSTRACT

There has been a growing interest in robotics system and automation leveraging in the food service industry to enhance efficiency and customer experience. This paper presents the design and implementation of a Robotic Restaurant Management System (RRMS) that incorporates user-friendly UI design, voice assistant capabilities, and machine learning algorithms. The RRMS aims to streamline restaurant operations, optimize resource utilization, and provide personalized services to customers. The system integrates robotic platforms for food preparation and delivery, along with a centralized management interface for administrators and staff. Additionally, a voice assistant interface enables seamless interaction with the system, while machine learning algorithms analyze data to improve decision-making processes and enhance overall performance. This paper discusses the architecture, functionalities, and implementation details of the RRMS, along with potential benefits and challenges associated with its deployment.

Cite this article as: Patil LN, Agrawal VK, Dhande KK, Khatavkar SD, Mande GD, Patil VS, Ratnaparkhi SS. Evaluation of a robotic restaurant management system with UI design, voice assistant, and machine learning integration. Sigma J Eng Nat Sci 2025;43(3):899–909.

INTRODUCTION

The implementation of advanced technologies to improve restaurant management systems has led to a revolutionary change in the food service sector. Traditional manual processes are being replaced by innovative solutions powered by robotics, they can improve the enhanced efficiency, accuracy, and customer satisfaction [1]. Modern digitization has made it possible for creative solutions to be developed that optimize multiple facets of restaurant operations due to the combination of robotics, AI, and ML [2]. The present work focuses on developing a Restaurant Management System to optimize the order management process and elevate the dining experience. The restaurant industry characterized by dynamic consumer preferences and evolving technological landscapes, necessitates innovative solutions to streamline operations and enhance customer experiences [3]. In response to this demand, it is required to develop the Restaurant Management System

***Corresponding author.**
*E-mail address: lalit.patil@dypvp.edu.in

This paper was recommended for publication in revised form by Editor-in-Chief Ahmet Selim Dalkilic

Published by Yıldız Technical University Press, İstanbul, Turkey
Copyright 2021, Yıldız Technical University. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

(RMS), aligning with the contemporary shift toward technology-driven service enhancements. In the present work, a new Robotic Restaurant Management System (RRMS) with advanced algorithms for UI design, customer review analysis, and food order analysis are discussed [4].

The integration of food order analysis, customer review analysis, and UI design within the RRMS represents a paradigm shift in restaurant management practices [5]. Restaurants can improve consumer satisfaction, improve operations, and gain a competitive edge in the continually shifting food service industry by using AI, ML, and robotics [6]. This research paper delves into the design, implementation, and potential impact of these components, elucidating their significance in shaping the future of the industry.

A well-designed user interface (UI) is essential for facilitating seamless interaction between users and the Robotic Restaurant Management System, ensuring usability and efficiency [7]. The Robotic Restaurant Management System has an easy to use interface that is intuitive and customised to satisfy the demands of various user roles, such as consumers, employees, and administrators. Customisable dashboards and Current data provide users with useful data that support performance improvement and well-informed decision-making. User interface (UI) design is crucial for modern systems, particularly in the context of the Robotic Restaurant Management System [8,9]. The UI serves as the bridge between users and the system, ensuring seamless interaction. In a robotic restaurant management system, an intuitive UI enhances user experience, making it easier for staff to manage orders, track inventory, and communicate with robotic systems efficiently[10]. A well-designed UI improves efficiency, reduces errors, and enhances overall system performance. Therefore, UI design is essential for the usability, effectiveness, and success of restaurant operations.

Food order analysis serves as the backbone of efficient restaurant management, influencing menu planning, inventory management, and resource allocation [11]. Traditional methods of order analysis often suffer from inefficiencies and inaccuracies due to manual data processing. ML algorithms to analyse historical order data, extract patterns, and forecast future demand accurately [12]. Restaurants may improve operational efficiency and customer happiness by optimising their menu offerings, pricing strategies, and supply chain management through the use of insights based on data. Food Order Analysis is vital for restaurants to streamline operations and boost revenue [13]. It entails studying order frequency, popular menu items, and modifications to tailor offerings. Analysis of order channels and accuracy is crucial for enhancing efficiency and customer satisfaction. Understanding seasonal trends and customer demographics provides insights for menu planning and targeted marketing strategies. Effective analysis also supports inventory management by predicting ingredient demand. In conclusion, Food Order Analysis is an invaluable tool for restaurants seeking to optimize operations, enhance customer satisfaction, and drive business growth [11].

A restaurant's popularity and performance are strongly affected by its customer's reviews; therefore it is critical for businesses to keep a watch on them and quickly solve any issues raised [14]. The use of automated solutions is required because manual review analysis is difficult and biased [15]. For the analysis machine learning algorithm are used[16]. Restaurants can increase revenue, build customer loyalty, and improve their brand image by solving customer issues and leveraging good feedback. Customer Review Analysis involves examining customer feedback to understand sentiments and identify improvement areas [17]. It includes sentiment analysis, topic modeling, and keyword extraction to gauge customer satisfaction and preferences. Analyzing ratings, review volume, and frequency provides insights into overall customer engagement. Businesses also study their responses to reviews, especially negative ones, to manage customer perceptions effectively. Comparing reviews with competitors helps identify market trends and informs competitive strategies. Customer Review Analysis impacts business decisions, product development, marketing strategies, and customer service improvements. Overall, it is a valuable tool for businesses to enhance customer experience and loyalty [18].

The novelty and purpose of the study lie in its comprehensive evaluation of a cutting-edge system that combines robotic technology with user-friendly interfaces and advanced machine learning capabilities in a restaurant setting. The study aims to assess how this integrated system improves operational efficiency, customer satisfaction, and overall restaurant performance. It seeks to contribute to the existing literature by providing empirical evidence of the benefits and challenges associated with deploying such a system, thereby informing future research and practical implementations in the field of restaurant management and automation.

Literature Review

The development and deployment of a Robotic Restaurant Management System (RRMS) incorporating UI design, voice assistant integration, and machine learning represent a notable advancement in restaurant automation [19]. Some researchers examine the key components and technologies involved in such a system, highlighting their significance and potential impact on the restaurant sector [20]. Robotic Restaurant Management System (RRMS) utilizes robotics and automation to streamline various restaurant operations, including order management, inventory control, and customer service [21]. User Interface (UI) design is crucial for the RRMS, directly influencing user experience. A well-designed UI can improve usability and efficiency, enabling seamless interaction for restaurant staff. Incorporating voice assistants like Amazon Alexa or Google Assistant into the RRMS allows for voice-based interactions, enhancing accessibility and convenience.

Furtheremore, Machine learning algorithms play a key role in the RRMS for tasks such as predicting customer preferences, optimizing inventory management, and enhancing order accuracy. The integration of UI design, voice assistant, and machine learning in the RRMS has the potential to revolutionize the restaurant sector, leading to improved efficiency, cost savings, and increased customer satisfaction. Despite its promise, the RRMS faces challenges such as data privacy, scalability, and integration with existing restaurant infrastructure. Future research could focus on enhancing system intelligence and adaptability through advanced machine learning approaches. In summary, the design and implementation of a Robotic Restaurant Management System with UI design, voice assistant, and machine learning integration offer significant potential for transforming the restaurant industry through improved efficiency, reduced costs, and enhanced customer experiences.

Restaurant technology has undergone a significant transformation, offering a range of innovative solutions to enhance operational efficiency and customer experience. Point-of-sale (POS) systems have evolved to include advanced features like order management and customer analytics, enabling restaurants to streamline transactions and gain valuable insights into their business operations [22]. Online ordering and delivery platforms have also become increasingly popular, allowing restaurants to expand their reach and cater to customers who prefer the convenience of ordering food from home. Tabletop tablets are another emerging technology that enables customers to browse menus, place orders, and pay bills without the need for a waiter, reducing wait times and improving overall efficiency. However, despite these advancements, there are several lacunas or gaps in current restaurant technology that need to be addressed [23]. One major challenge is the integration of multiple technology solutions that are often incompatible, leading to inefficiencies and data silos. Another issue is the high cost associated with implementing and maintaining advanced technology solutions, especially for small and independent restaurants with limited budgets [24]. Additionally, cybersecurity risks have become a concern, as restaurants are increasingly using digital platforms for transactions and customer data storage, making them vulnerable to data breaches and cyber attacks. To overcome these challenges and further enhance restaurant technology, it will be important to focus on improving integration between different solutions, reducing costs, and enhancing cybersecurity measures. Restaurants can also benefit from investing in staff training to ensure that employees are comfortable with new technologies and can use them effectively [25]. Furthermore, ensuring that technology is accessible to all customers, including those with disabilities or older adults who may be less familiar with technology, will be crucial for creating an inclusive dining experience. By addressing these lacunas, restaurant technology can continue to evolve and play a key role in improving the overall dining experience for customers [26].

SYSTEM ARCHITECTURE

The initial phase involved a comprehensive analysis of the requirements, leading to the formulation of a detailed system architecture design. This included the delineation of various modules, such as the navigation system, localization algorithms, user interface components, and the integration of ROS for efficient communication between system modules.

The restaurant management system project is designed to automate various tasks in a restaurant setting using a robotic waiter. The system architecture consists of several interconnected components that work together to achieve this automation. The system architecture of our Restaurant Management System is designed to seamlessly integrate hardware, software, and communication components, providing an efficient and user-friendly solution for automating restaurant operations. Figure 1 shows food ordering system.

The Figure 2 shows how a customer places an order with a restaurant using an online ordering system. The customer selects the items they want to order, enters their payment information, and submits the order. The system then forwards the order to the restaurant's kitchen staff, who prepare the food. Once the food is ready, it is delivered to the customer. The customer pays for the order and receives a receipt

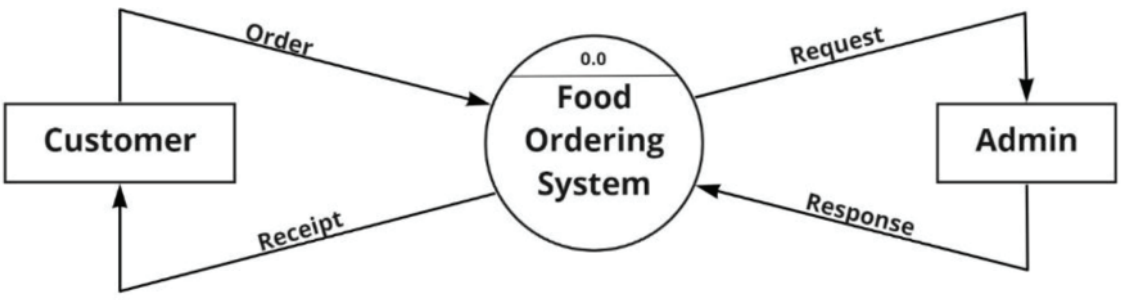

Figure 1. Food ordering system.

- Customer: The customer is the person who places the order for food. They can do this through a variety of channels, such as a website, mobile app, or phone call
- Admin: The admin is the person who processes the customer's order. They may also be responsible for preparing the food, depending on the size and type of restaurant.
- Food Ordering System: The food ordering system is the software that manages the whole system.
- Browse menu: The customer browses the menu to see what items are available. They can filter the menu by category or search for specific items.
- Add to cart: The customer selects the items they want to order and adds them to their cart. They can also view the contents of their cart and make changes to their order at any time. Proceed to checkout: Once the customer is happy with their order, they can proceed to checkout. This is where they will enter their delivery address and payment information. Confirm order: The customer reviews their order and confirms it. Once the order is confirmed, it will be sent to the restaurant for processing.
- Restaurant prepares order: The restaurant prepares the customer's order. This may involve cooking the food, assembling the order, and packaging it.
- Restaurant delivers order: The restaurant delivers the customer's order to the specified address.
- Customer pays for order: The customer pays for the order upon delivery.
- The user requests a product from the system.
- The system checks to see if the product is in stock.
- If the product is in stock, the system reserves the product for the user.
- The system sends a confirmation to the user.
- The user pays for the product.
- The system ships the product to the user.
- The user receives the product.

Architecture of Admin Interface is shown in figure 3. UI Interface Design The development of the user interface (UI) was a collaborative effort, incorporating principles

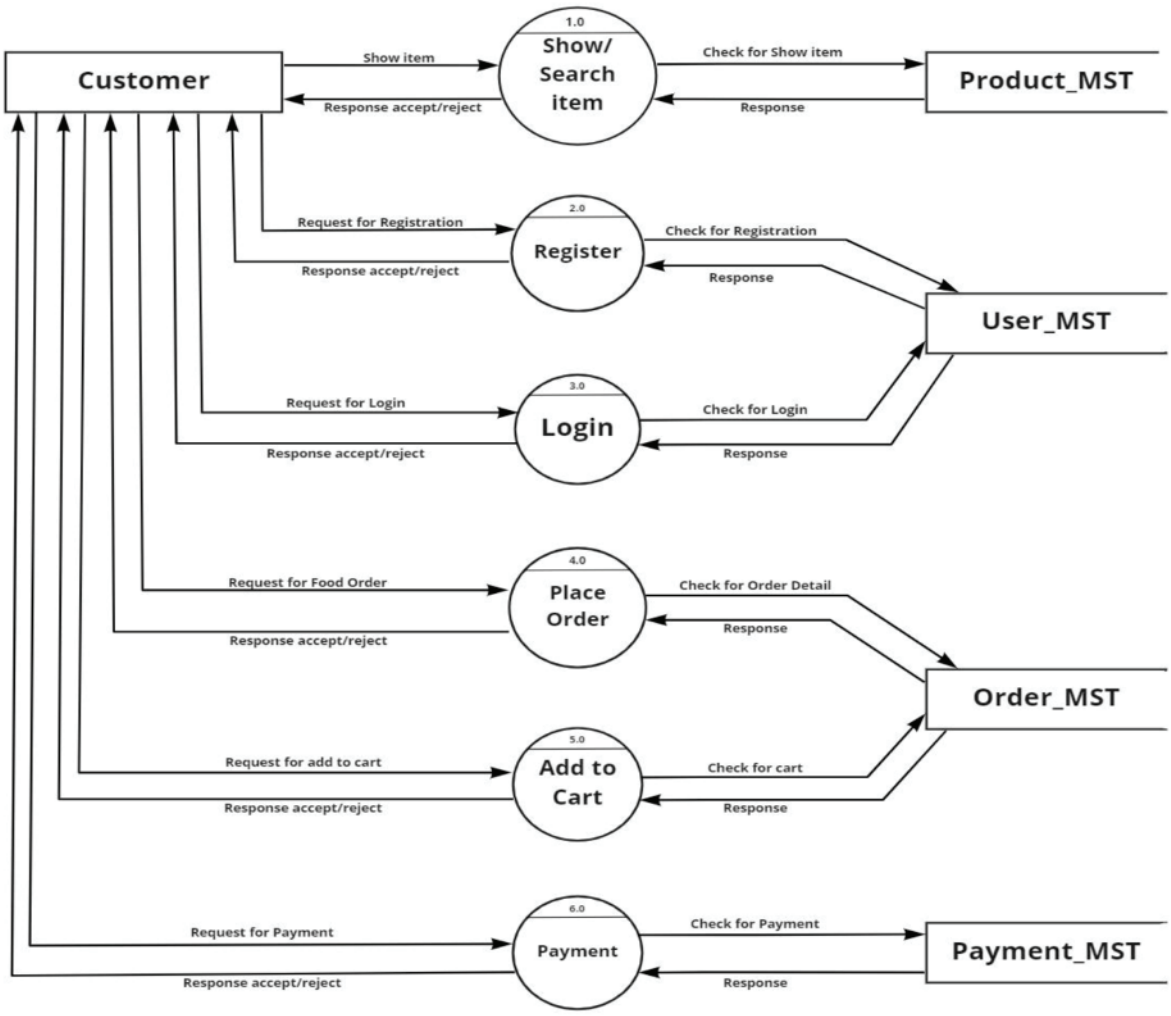

Figure 2. Architecture of customer interface.

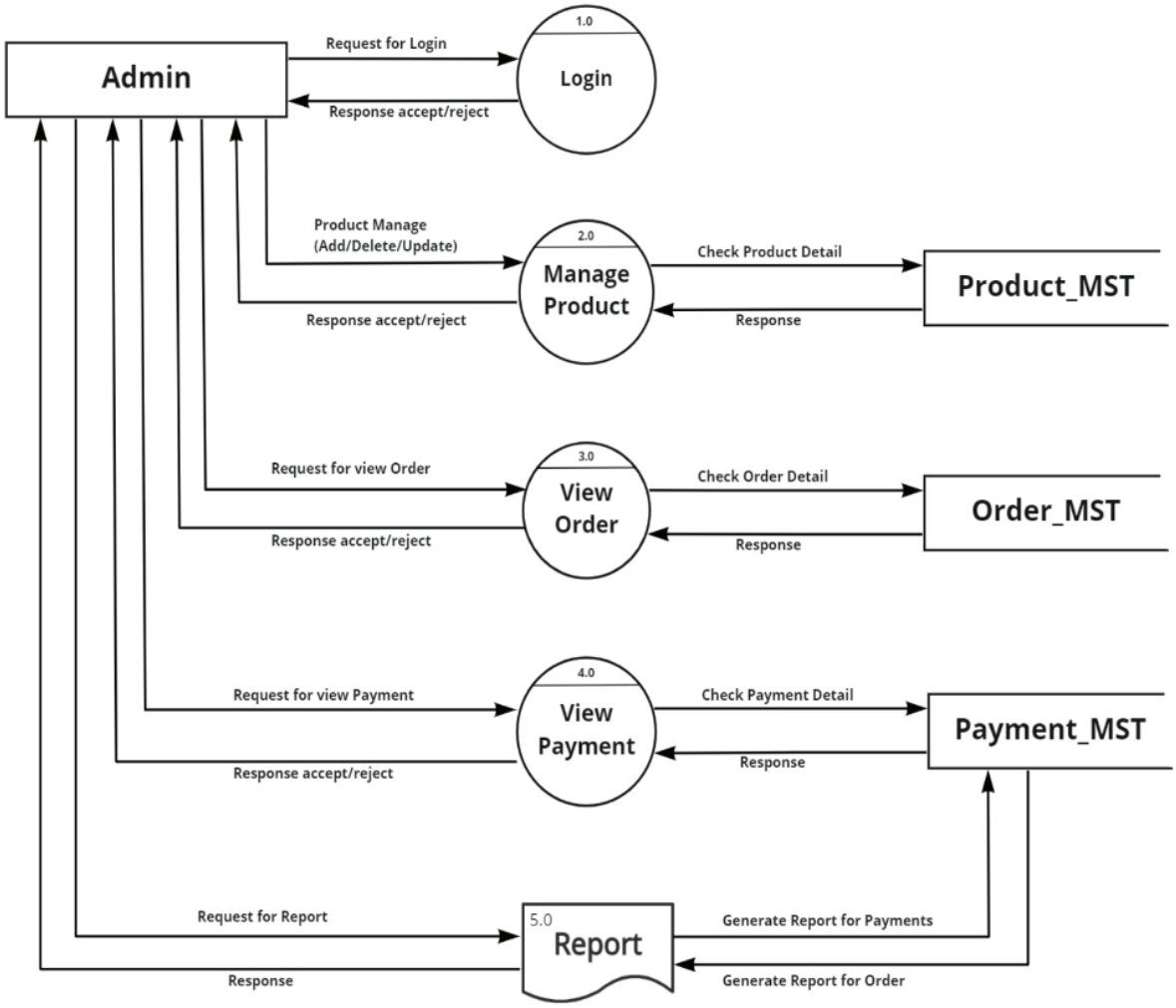

Figure 3. Architecture of admin interface.

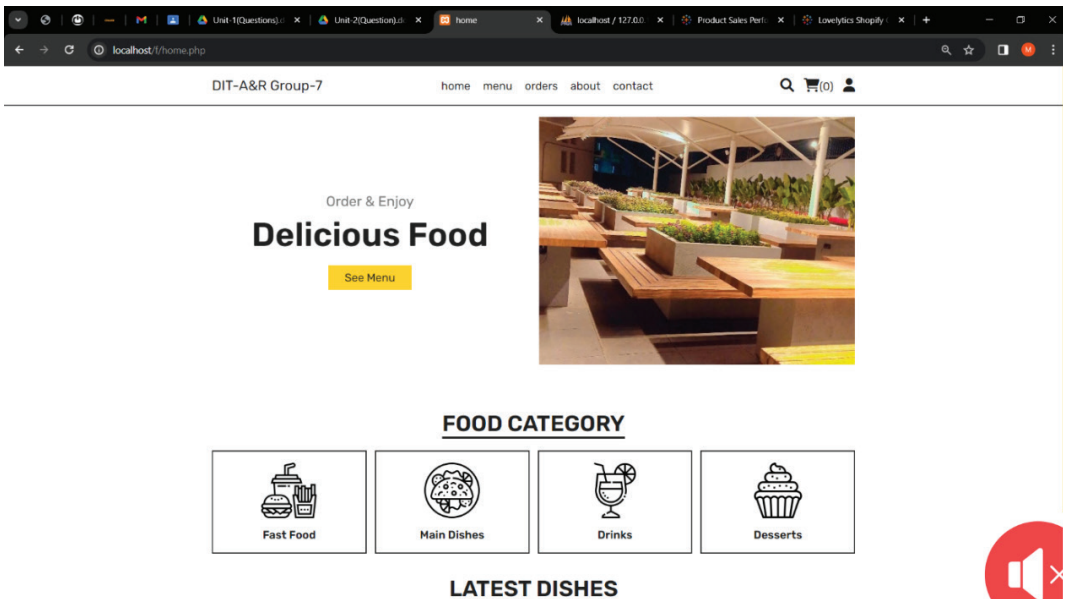

Figure 4. Food ordering system.

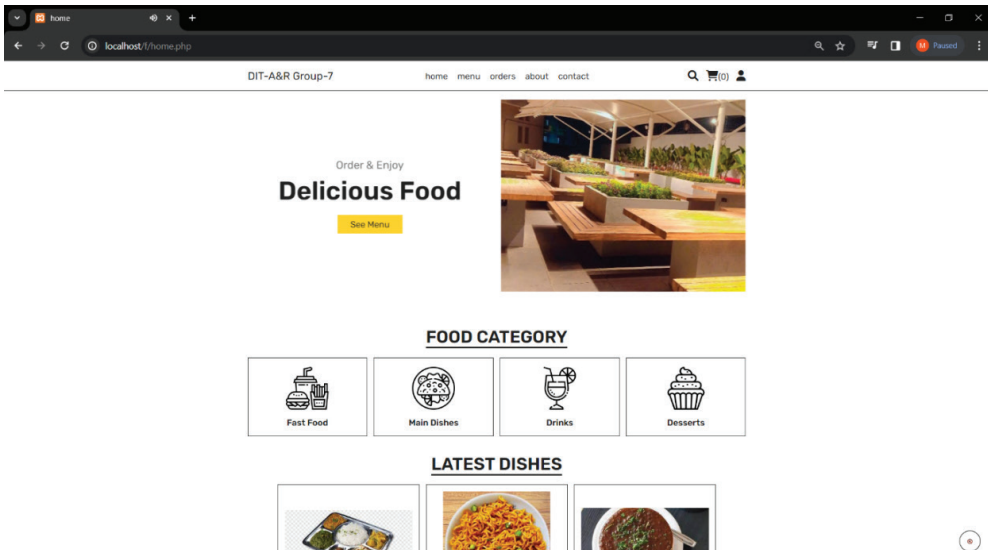

Figure 5. Food category.

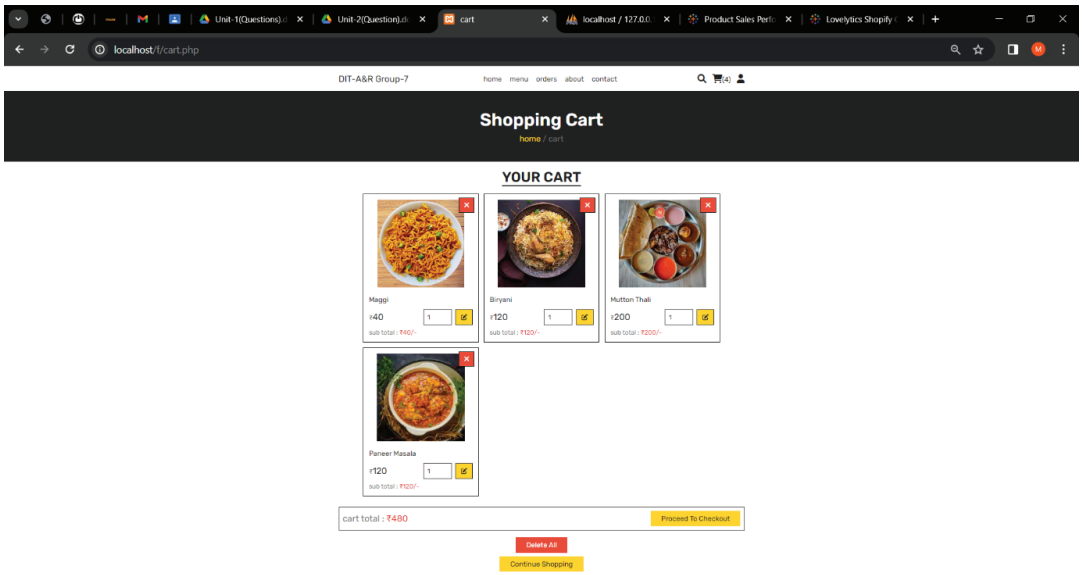

Figure 6. Food cart with numerous dishes.

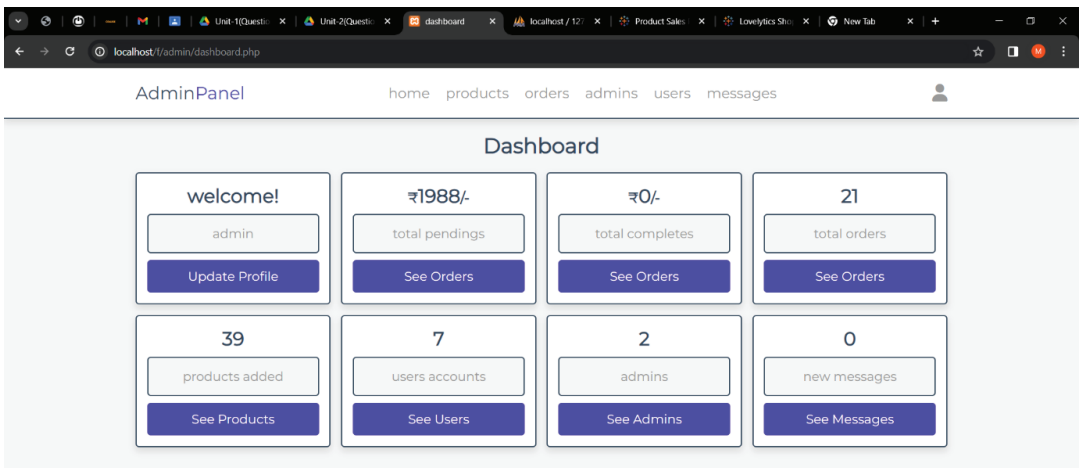

Figure 7. Dashboard design for admin panel.

of user experience (UX) design to ensure a seamless and intuitive dining experience. Focused on creating a user-friendly interface that allowed customers to effortlessly place orders, provide feedback, and interact with the RMS, while simultaneously facilitating effective communication with the administrative and kitchen panels. Food ordering system is shown in figure 4. The food categories are depicted in figure 5. Food Cart with numerous dishes is shown in figure 6. Dashboard design for Admin Panel is shown in figure 7.

RESULTS AND DISCUSSION

The evaluation of the Robotic Restaurant Management System (RRMS) with UI Design, Voice Assistant, and Machine Learning Integration revealed several key findings. Firstly, the integration of robotic technology significantly improved operational efficiency in the restaurant. Tasks such as order taking, food preparation, and serving were automated, leading to reduced wait times for customers and increased table turnover rates. This automation also resulted in more consistent and accurate food preparation, enhancing overall food quality and customer satisfaction. Secondly, the user-friendly interfaces, including touchscreens and voice assistants, were well-received by both customers and staff. Customers found the interfaces easy to use and appreciated the personalized recommendations provided by the system. Staff also reported that the interfaces improved their efficiency and made their job easier. Thirdly, the integration of machine learning algorithms proved to be highly effective in predicting customer orders and providing personalized recommendations. This led to an increase in the average order value as customers were more likely to add recommended items to their order. Additionally, the system was able to optimize inventory levels and reduce waste, leading to cost savings for the restaurant. Overall, the evaluation of the RRMS demonstrated that the integration of robotic technology, user-friendly interfaces, and machine learning algorithms can significantly improve operational efficiency, customer satisfaction, and overall restaurant performance. Future research could focus on further refining the system and exploring its implementation in different restaurant settings to assess its scalability and effectiveness in various contexts.

Validation

It was developed a recommender system that suggests menu items tailored to individual user preferences, considering their past orders and current food trends. This system can utilize algorithms such as Collaborative Filtering or Content-Based Filtering. Developed and trained ML model consist of using different machine learning algorithms such as clustering for the customers' reviews and ratings for the food items. Machine learning model for optimizing

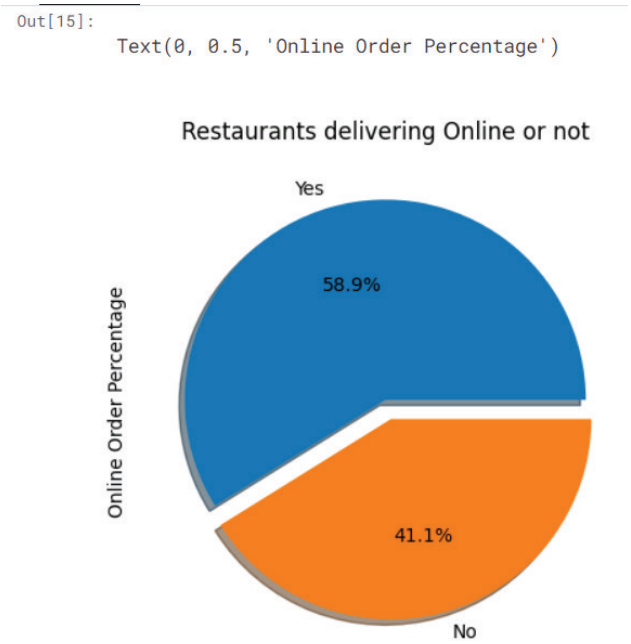

Figure 8. Order delivery status analysis.

the robot performance and efficient service were trained by using the data collected from admin panel as shown in figure 7. Furthermore, robot get skilled performs work with lesser delay in customer services. Data analysis in our research involves processing and interpreting the data collected from various sources within the restaurant management system. This includes customer orders, inventory levels and sales data. ML algorithms were used to analyse historical order data, extract patterns, and forecast future demand accurately. For example, analysing customer order patterns can help in predicting demand, optimizing inventory levels and improving menu offerings. By promptly addressing customer concerns and capitalizing on positive feedback, restaurants can enhance their brand image, foster customer loyalty and drive revenue growth. Data analysis can also help to identify popular menu items, predict demand for certain dishes and optimize inventory levels to reduce waste. By using data analysis, we can make informed decisions to improve the efficiency and profitability of our restaurant.

Any notable trends or patterns observed in the data for customer engagement in online and offline mode as shown in figure 8.

Insights into factors that may influence user ratings, such as price or type of cuisine, food and based on customer service are shown in figure 9. The date wise data was considered for processing as shown in figure 10.

Figure 11 shows Correlation between foods ordering dataset with different aspects. The cuisines or foods with the highest and lowest average ratings.

In [26]:
```
import matplotlib
matplotlib.rcParams['figure.figsize']=(12,6)
sns.barplot(x= 'Aggregate rating', y='Rating Count', data= rating);
```

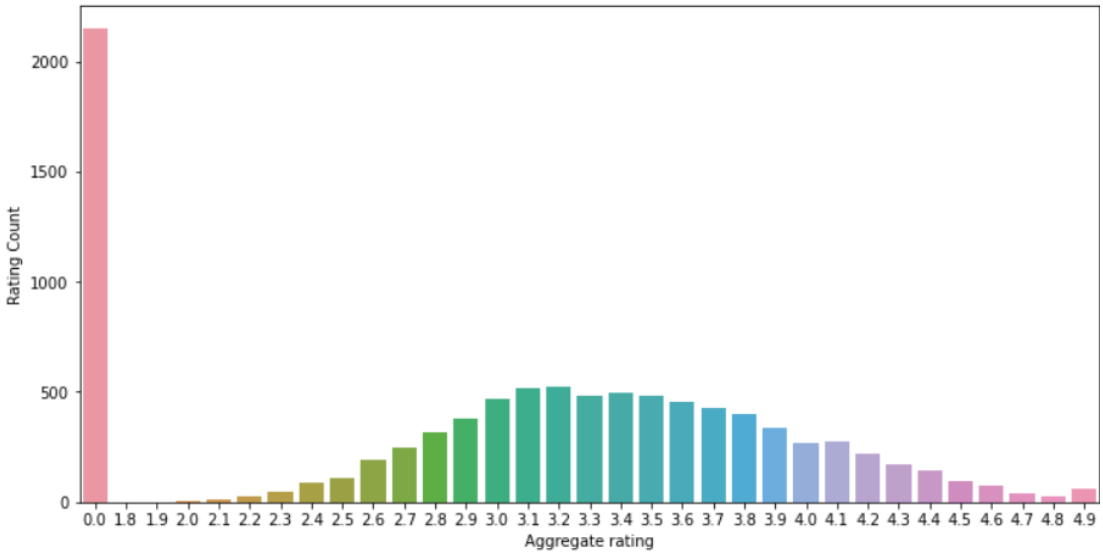

Figure 9. Aggregate rating variation.

In [26]:
```
# user's ordered from each cusines
plt.figure(figsize=(16, 6))
dataset["cusine_id"].value_counts().plot.bar()
```

Out[26]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f81b2ffd278>
```

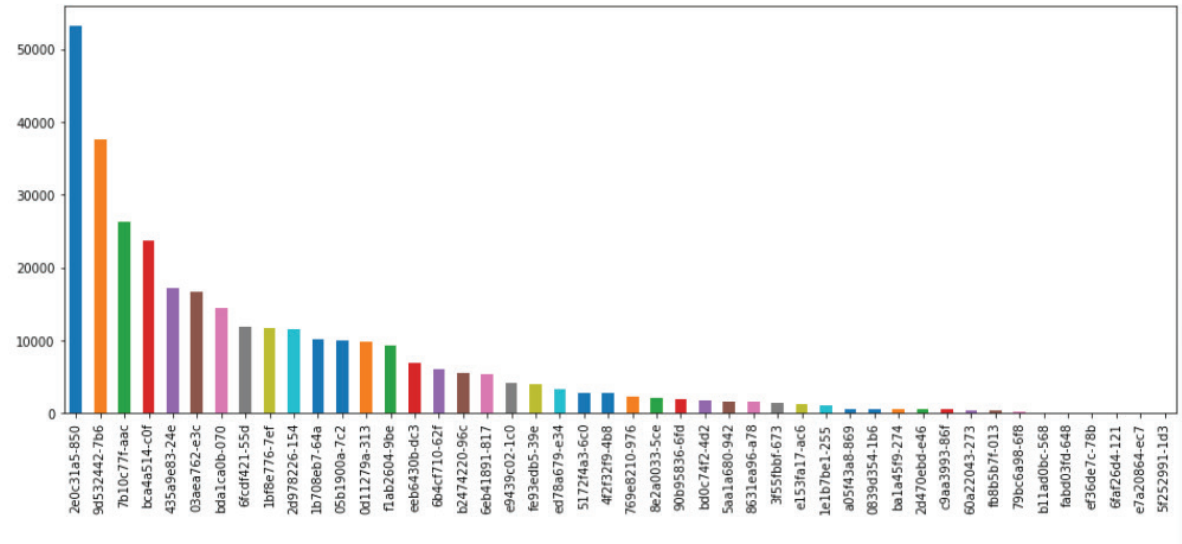

Figure 10. Dataset Analysis with orders and food quantity.

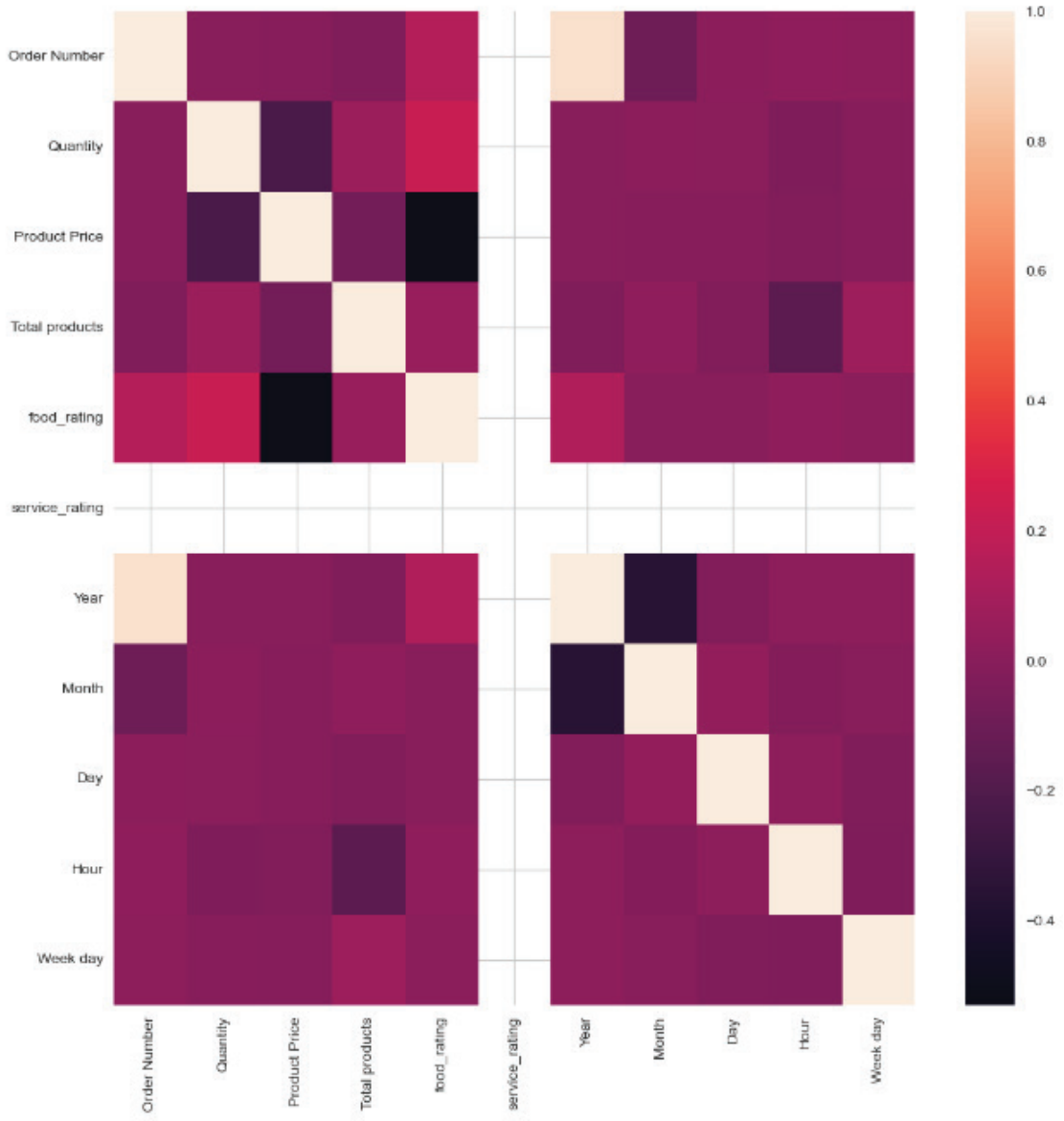

Figure 11. Correlation between foods ordering dataset with different aspects.

CONCLUSION

The evaluation of the Robotic Restaurant Management System (RRMS) with UI Design, Voice Assistant, and Machine Learning Integration demonstrates the significant potential of this integrated system to enhance operational efficiency, customer satisfaction, and overall restaurant performance. The study found that the automation of tasks such as order taking and food preparation led to reduced wait times and increased table turnover rates, while user-friendly interfaces improved the customer experience. Additionally, the integration of machine learning algorithms enabled the system to predict customer orders and provide personalized recommendations, leading to an increase in the average order value and cost savings through optimized inventory management. Overall, the findings suggest that the RRMS has the potential to revolutionize the restaurant industry by improving efficiency and customer service. Further research could explore the long-term effects of implementing such a system and its scalability to different restaurant settings. Followings are the concluding remarks from the present study.

- It was developed a recommendation system using customer reviews and ratings for personalized food suggestions.
- Machine learning algorithms were used for a personalized dining experience, enhancing satisfaction.
- A regression model for predicting restaurant sales, aiding in demand forecasting were successfully used.

- Clustering algorithms for improved recommendation accuracy and discovering new menu offerings were implemented successfully.
- Finally, It was demonstrated the transformative potential of technology in the restaurant industry.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

[1] Abbas Z, Abbas S, Mazhar A. Automatic cafe management system using waiter robot. In: 2019 2nd International Conference on Communication, Computing and Digital Systems (C-CODE). IEEE; 2019:211–214. [CrossRef]

[2] Deng B, Li S, Zhang B, Wang F, Li D, Lin H. IoT intelligent restaurant system design. In: Proceedings of the 3rd International Conference on Computer Science and Application Engineering. 2019:1–7. [CrossRef]

[3] Noone BM, Coulter RC. Applying modern robotics technologies to demand prediction and production management in the quick-service restaurant sector. Cornell Hosp Q 2012;53:122–133. [CrossRef]

[4] Pieskä S, Liuska M, Jauhiainen J, Auno A, Oy D. Intelligent restaurant system Smartmenu. In: 2013 IEEE 4th International Conference on Cognitive Infocommunications (CogInfoCom). IEEE; 2013:625–630. [CrossRef]

[5] Mishra N, Goyal D, Sharma AD. Automation in restaurants: Ordering to robots in restaurant via smart ordering system. Int J Converg Technol Manag 2018;4:1–4.

[6] Qasim MA, Abrar F, Ahmad S, Usman M. AI-based smart robot for restaurant serving applications. In: AI and IoT for Sustainable Development in Emerging Countries: Challenges and Opportunities. Cham: Springer International Publishing; 2022:107–123. [CrossRef]

[7] Liyanage V, Ekanayake A, Premasiri H, Munasinghe P, Thelijjagoda S. Foody – smart restaurant management and ordering system. In: 2018 IEEE Region 10 Humanitarian Technology Conference (R10-HTC). IEEE; 2018:1–6. [CrossRef]

[8] Poonguzhali R. Wheeled robotic system for restaurants. Int J Trends Eng Technol 2018;32:12–15.

[9] Srivastava H, Kaushal A, Kumar H, Tripathi A. A design and development of baggage sorting robotic system at the airport. Evergreen 2022;9:86–92. [CrossRef]

[10] Bankar A, Suresh SS. Intelligent restaurant – menu ordering system. IOSR J VLSI Signal Process 2015;5:47–53.

[11] Berrueta LA, Alonso-Salces RM, Héberger K. Supervised pattern recognition in food analysis. J Chromatogr A 2007;1158:196–214. [CrossRef]

[12] Ricci F, Volpe G, Micheli L, Palleschi G. A review on novel developments and applications of immunosensors in food analysis. Anal Chim Acta 2007;605:111–129. [CrossRef]

[13] Williams H, Wikström F. Environmental impact of packaging and food losses in a life cycle perspective: A comparative analysis of five food items. J Clean Prod 2011;19:43–48. [CrossRef]

[14] Gräbner D, Zanker M, Fliedl G, Fuchs M. Classification of customer reviews based on sentiment analysis. In: Information and Communication Technologies in Tourism 2012. Vienna: Springer; 2012:460–470. [CrossRef]

[15] Kumar KS, Desai J, Majumdar J. Opinion mining and sentiment analysis on online customer review. In: 2016 IEEE International Conference on Computational Intelligence and Computing Research. IEEE; 2016:1–4. [CrossRef]

[16] Shoja BM, Tabrizi N. Customer reviews analysis with deep neural networks for e-commerce recommender systems. IEEE Access 2019;7:119121–119130. [CrossRef]

[17] Geetha M, Singha P, Sinha S. Relationship between customer sentiment and online customer ratings for hotels – an empirical analysis. Tour Manag 2017;61:43–54. [CrossRef]

[18] Zhang X, Kim HS. Customer experience and satisfaction of Disneyland hotel through big data analysis of online customer reviews. Sustainability 2021;13:12699. [CrossRef]

[19] Kocaman EM, Türkmen BM. The effects of use of restaurant management systems perceived by the personnel according to their demographic characteristics. In: Handbook of Research on Smart Management for Digital Transformation. IGI Global Scientific Publishing; 2022:256–274. [CrossRef]

[20] Lee C, Hallak R, Sardeshmukh SR. Creativity and innovation in the restaurant sector: Supply-side processes and barriers to implementation. Tour Manag Perspect 2019;31:54–62. [CrossRef]

[21] Cobanoglu C, Dogan S, Berezina K, Collins G, Nanu L, Shahtakhtinskaya K, et al. Hospitality and tourism information technology. Univ South Fla M3 Cent Publ 2021;17:2.

[22] Chen RX, Cheung C, Law R. A review of the literature on culture in hotel management research: What is the future? Int J Hosp Manag 2012;31:52–65. [CrossRef]

[23] Deery M, Jago LK. Hotel management style: A study of employee perceptions and preferences. Int J Hosp Manag 2001;20:325–338. [CrossRef]

[24] Murphy J, Forrest EJ, Wotring CE, Brymer RA. Hotel management and marketing on the Internet: An analysis of sites and features. Cornell Hotel Restaur Adm Q 1996;37:7–82. [CrossRef]

[25] Chung KY. Hotel management curriculum reform based on required competencies of hotel employees and career success in the hotel industry. Tour Manag 2000;21:473–487. [CrossRef]

[26] Jeffrey D, Barden RR, Buckley PJ, Hubbard NJ. What makes for a successful hotel? Insights on hotel management following 15 years of hotel occupancy analysis in England. Serv Ind J 2002;22:73–88. [CrossRef]