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Embedded System-based Restaurant Automation

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Abstract: The restaurant industry is evolving rapidly, with technology playing a crucial role in enhancing customer satisfaction and operational efficiency. This paper proposes an embedded system-based restaurant automation (ESRA) system to automate key tasks such as order management, table monitoring, inventory control, and customer service. The ESRA system's functionality, components, architecture, and benefits for restaurant operations are outlined in detail. In today's competitive and fast-paced restaurant environment, effective management and service delivery are essential to meet customer expectations. By automating operations, the ESRA system offers a solution that improves efficiency, accuracy, and customer satisfaction compared to traditional manual processes.

Keywords: Arduino, Embedded system, Inventory Control, Restaurant Automation.

1 INTRODUCTION

In today's fast-paced restaurant industry, technology is increasingly relied upon to enhance both operations and customer experiences. Embedded systems, which combine hardware and software to perform specialized tasks, are driving this technological shift. An ESRA solution provides an efficient approach to managing various restaurant operations. An ESRA system optimizes key activities such as ordering, food preparation, inventory management, and customer service. By implementing embedded technologies, restaurants can significantly improve efficiency, reduce errors, and enhance the overall dining experience. A critical aspect of this system is order management, where customers place orders using a digital interface, such as a tablet or smartphone, which are then sent directly to the kitchen for preparation. This eliminates manual order entry, reducing errors and ensuring faster, more accurate processing.

Another vital component is the kitchen display system (KDS), which displays orders in real-time, allowing kitchen staff to prioritize and manage tasks efficiently. The KDS accelerates food preparation, minimizes errors, and ensures that orders are delivered to customers promptly. Inventory management also benefits greatly from embedded systems. Restaurants can track inventory levels in real-time and automatically reorder items when supplies run low, ensuring that popular items remain available, reducing waste, and optimizing stock levels.

Customer service is enhanced through embedded systems as well. Customers can provide feedback via digital interfaces, which management can use to improve service quality. Additionally, personalized recommendations based on previous orders can be offered, further enhancing the dining experience. In traditional restaurant operations, order-taking is often done manually using paper menus, which is time-consuming, prone to errors, and costly due to the need for frequent reprints. Self-service systems like kiosks and digital menus offer a more efficient alternative, reducing errors and speeding up the order process. However, these systems come with high initial costs, potential technical issues, and the need for regular maintenance and staff training.

2 LITERATURE SURVEY

Technological innovations have significantly improved restaurant operations and customer satisfaction. Zhangyuan and Weibing [1] introduced a wireless ordering system utilizing embedded technology to streamline order processing, which helped reduce labor requirements. Cheong et al. [2] further developed a multi-touch e-restaurant management system, enabling customers to interact directly with digital menus and place orders through a centralized database, thus enhancing accuracy and service speed during peak hours.

In addition to operational advancements, inventory management remains a crucial aspect of the food industry. Liang [3] highlighted predictive models for inventory control in food-processing, reducing costs linked to perishable goods. Lasek et al. [4] discussed demand forecasting models essential for revenue management in restaurants, addressing both internal and external sales factors.

Cho et al. [5] explored how restaurants' supply chain dynamics impact their ability to adapt to market changes, noting that information technology adoption strengthens market responsiveness. Building on these advancements, [6] proposes an Android-based automation system for food ordering, where digital menus on individual tables facilitate ordering, improving order accuracy and timing through Bluetooth-connected kitchen systems.

The integration of IoT and AI has also transformed kitchen management. Rezwan et al. [7] introduced an IoT-based inventory system for kitchens that automates stock reordering when levels are low, minimizing disruptions. Additionally, Duong et al. [8] highlighted robotics' role in enhancing food supply chains, while Yang et al. [9] examined the early impacts of COVID-19 on restaurant demand, providing insights into industry resilience amid market volatility. AI-powered chatbots like those presented by Chong et al. [10] can address customer queries and automate order processing, showcasing AI's service potential. Kaur et al. [11] investigated restaurant automation using sensors for real-time customer monitoring and table management, fostering efficient resource allocation. Wang et al. [12] introduced a Cantonese-specific dataset for restaurant-based dialogue systems, enabling more accurate customer interactions within diverse linguistic contexts.

Meanwhile, Gupta et al. [13] developed "Genie," an AI-powered chatbot, that leverages natural language processing to streamline restaurant operations and enhance customer service through quick, accurate responses. Together, these innovations underscore the potential of advanced technologies to drive both operational efficiency and customer satisfaction in the restaurant industry.

3 PROPOSED WORK

The system is designed to automate various restaurant operations, such as order processing, inventory control, and customer service, through the integration of embedded devices like microcontrollers, sensors, and actuators. Customers can place orders using smartphone apps or self-service kiosks, which are transmitted directly to the kitchen, reducing both order errors and wait times. Real-time inventory monitoring minimizes food waste and prevents stockouts. The system sends automated alerts to staff when inventory needs replenishing. The dining experience is enhanced through digital menus, tableside ordering systems, and order status notifications. Customers enjoy faster service and personalized interactions, while embedded electronics simplify the checkout process, supporting credit card and smartphone payments.

The Smart Restaurant System streamlines the entire ordering process, enabling wireless communication between the customer, waitstaff, chef, and cashier. The system consists of two sections: the transmitter section (customer side) and the receiver section (chef side). Upon entering the restaurant, customers view the menu displayed on an OLED screen at their table. They can select items using a keypad, and the order is processed by an Arduino Uno, which transmits the data serially to the kitchen. The kitchen processes the data using another Arduino Uno. The billing counter can monitor the orders via a 16x2 LCD, allowing for efficient order management and faster food preparation. The cooked food is then delivered directly to the customer. This interaction-based service reduces wait times and optimizes order handling. The key events in the execution are the following.

- **Inputs**: The system receives inputs such as customer orders, selected menu items, payment details, and table status updates.
- **Processing**: Activities include inventory management, order processing, payment handling, and table status updates.
- **Outputs**: The system generates invoices, order confirmations, inventory updates, and status notifications for both waitstaff and kitchen personnel.
- **External Entities**: External entities interacting with the system include the inventory management system, customers, waitstaff, and kitchen personnel.
- **Data Stores**: The system stores information in databases for menus, customers, and inventory.
- **Data Flows**: Information flows between various system components, such as when orders are transmitted to the kitchen, inventory is updated, or payments are processed.

Fig. 1 shows the schematic diagram of different components of the proposed system. Fig. 2 shows the realistic implementation of the scheme. The user who is sitting at the dining table will be given an option to submit his order through the keypad. Fig. 3 shows the OLED screen that displays the items list. This information will be available in the kitchen and at the billing counter.

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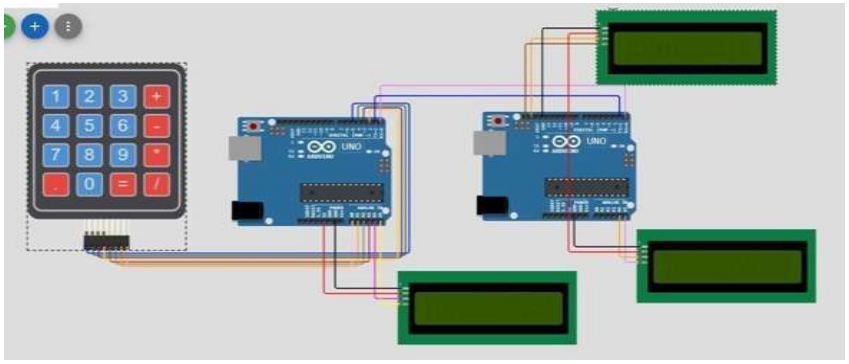

Fig. 1 Schematic Diagram

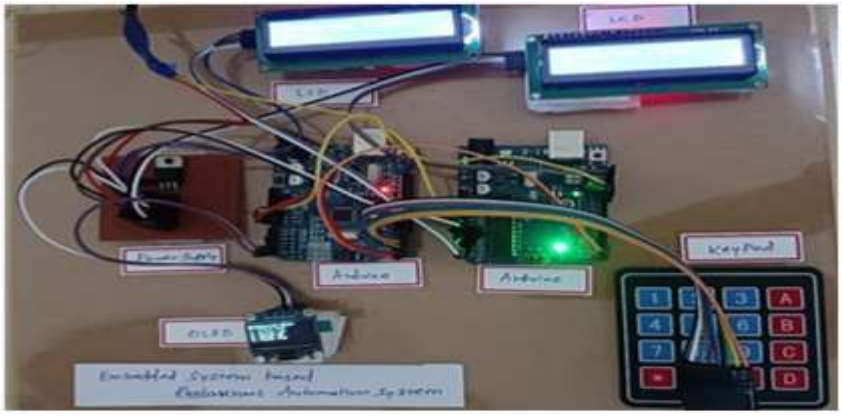

Fig. 2 Practical Implementation of the proposed system

Fig. 3 Menu Card Displayed on Dining Table

The future of embedded systems in restaurant automation looks promising, especially with advancements in AI and IoT. These technologies will enhance customer experiences and operational efficiency. Automation in inventory control, order management, and customer service through systems like Point-of-Sale (POS), Kitchen Display Systems, and inventory management solutions can maximize resource use, improving accuracy and service speed while reducing wait times.

The seamless integration of embedded devices enables real-time communication and data exchange between various operational facets, resulting in better order accuracy and faster service. Self-service kiosks, digital menus, and automated payment processes further enhance customer satisfaction by making the dining experience more convenient and enjoyable. The collection and analysis of data from embedded systems provide valuable insights for decision-making, such as staffing adjustments and menu optimization. Overall, embedded systems-based restaurant automation leads to cost savings, enhanced security, and improved dining experiences, positioning businesses for long-term success in a competitive market.

4 CONCLUSIONS

The implementation of an embedded system-based restaurant automation system marks a significant advancement in restaurant management. This system offers an efficient and cost-effective solution to optimize various operational processes. Developed using the Arduino Uno and programmed via the Arduino IDE, it integrates sensors, actuators, and other hardware components to automate tasks such as inventory management, order processing, and customer service. The system reduces the workload on restaurant staff while improving overall efficiency. Key benefits of this automation include enhanced customer satisfaction, cost reduction, and streamlined operations. By adopting embedded technology, restaurants can modernize their workflows and remain competitive in an evolving industry.

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ETHICS STATEMENT

This study did not involve human or animal subjects and, therefore, did not require ethical approval.

STATEMENT OF CONFLICT OF INTERESTS

The authors declare no conflicts of interest related to this study.

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