NurseryKart - A Smart Plant Nursery Assistant Robot

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Abstract

Automation and robot technologies are also being used to increase efficiency in agricultural and retail industries. This paper proposes a smart robot assistant called "NurseryKart" for automating tasks in plant nurseries. The system utilizes embedded technologies, sensors, and IoT concepts for providing interactive assistance to customers. The robot is equipped with navigation capabilities for moving through nursery aisles and identifying plant species using QR codes. The robot also displays plant information such as the plant's name, price, and care instructions using an LCD interface. Additionally, the system facilitates contactless billing using UPI-based QR code generation for digital payments. The system architecture is based on an ESP32 microcontroller, ultrasonic sensors, motor drivers, and QR code scanning modules for providing autonomous navigation and interaction capabilities. The proposed system is an example of the implementation of robot and automation technologies in agricultural industries and is also a starting point for further developments such as AI-powered plant care suggestions and cloud-based nursery management.

***Keywords*: Robotics, Smart Nursery, IoT, QR Code Identification, Autonomous Robot

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1. Introduction

Technology and automation are transforming industries such as agriculture and retail by improving efficiency and customer experience. In plant nurseries, traditional methods rely heavily on manual assistance for plant identification, guidance, and billing, which can be time-consuming and less efficient. To overcome these limitations, this paper presents **NurseryKart**, a smart robotic assistant designed to automate nursery operations and enhance user interaction.

The system integrates embedded systems, IoT, and robotics to provide real-time assistance to customers. The robot can navigate nursery aisles autonomously, identify plants using QR codes, and display information such as name, price, and care instructions through an LCD interface and audio output. It uses an ESP32 microcontroller for processing and ultrasonic sensors for obstacle detection, ensuring safe operation in dynamic environments.

Additionally, NurseryKart includes a contactless billing system using UPI-based QR codes, enabling convenient and hygienic transactions. The system's modular design also allows future enhancements such as AI-based recommendations and cloud connectivity. Overall, NurseryKart offers a practical solution for transforming traditional nurseries into smart and efficient systems.

2. Literature Review

The integration of robotics, IoT, and automation has significantly improved efficiency in agricultural and retail environments. This section reviews key studies related to autonomous navigation, plant identification, embedded systems, and smart retail automation.

Ramesh and Kumar [1] discussed IoT-based smart agriculture systems, highlighting the role of connected sensors in real-time monitoring and decision-making. Their work emphasizes how IoT improves efficiency and reduces manual effort in agricultural practices.

Jain and Patel [2] focused on the design of autonomous mobile robots for agricultural applications. The study demonstrated the use of sensors and microcontrollers for navigation and obstacle avoidance, providing a foundation for robotic movement in dynamic environments.

Sharma et al. [3] explored IoT-enabled plant monitoring systems, which utilize sensors to track environmental conditions and plant health. Their research shows the importance of real-time data collection in improving agricultural productivity.

et al. [4] presented autonomous robots for plant monitoring in smart greenhouses. Their system integrates sensors and embedded systems to perform continuous monitoring and automation, reducing human intervention.

Patel and Kumar [5] proposed IoT-based plant care systems using wireless sensor networks. The study highlights the role of automation in improving plant maintenance and ensuring efficient resource utilization.

Nair et al. [6] developed a mobile robotic assistant for plant nurseries, focusing on customer interaction and plant identification. Their work demonstrates how robotics can enhance user experience and reduce manual workload in nursery environments.

Chen et al [7] introduced machine learning techniques for plant disease detection, showing how AI can improve plant health analysis and decision-making in smart agriculture systems.

In summary, existing research highlights the growing use of robotics, IoT, and automation in agriculture and retail. However, many systems focus on individual functionalities such as monitoring, navigation, or plant care. There is a need for an integrated system that combines customer assistance, plant identification, and automated billing, which is addressed by the proposed NurseryKart system.

3. Objectives

The primary objective of the NurseryKart system is to design and develop an intelligent mobile robotic assistant that enhances operational efficiency in plant nurseries. The system aims to provide real-time plant information and guidance to customers, thereby reducing dependency on manual assistance and improving the overall user experience. In addition, the project focuses on automating the billing process through contactless UPI-based payment methods, ensuring faster, secure, and hygienic transactions.

Furthermore, the system integrates advanced technologies such as embedded systems, IoT, and robotics to enable autonomous navigation, plant identification, and interactive customer support. The use of an ESP32 microcontroller, along with sensors for obstacle detection, ensures safe and efficient robot operation in dynamic environments. Another key objective is to promote smart and sustainable nursery management by reducing manual workload, improving productivity, and enabling technology-driven solutions. The project also lays a foundation for future enhancements such as cloud integration, AI-based recommendations, and scalable smart agriculture applications.

4. Methodology

The proposed NurseryKart system is an intelligent robotic solution designed to automate and enhance operations in plant nurseries by integrating embedded systems, Internet of Things (IoT), and robotics. The system is developed to perform multiple functions such as autonomous navigation, plant identification, customer interaction, and contactless billing within a single platform. This integration enables the system to address key challenges in traditional nursery management, including manual dependency, lack of real-time information access, and inefficient billing processes.

The architecture of the system consists of interconnected hardware and software modules that work together to ensure efficient operation. The ESP32 microcontroller acts as the core processing unit, coordinating sensor inputs, controlling actuators, and managing communication between different components. The robot operates in a dynamic environment where it continuously senses its surroundings, processes real-time data, and responds accordingly. By combining automation with user interaction features, the system minimizes manual effort and improves the overall efficiency of nursery operations.

In addition, the system enhances customer experience by providing instant access to plant-related information through QR code scanning and display interfaces. The inclusion of a web-based platform allows nursery owners to manage plant data efficiently, ensuring that information remains accurate and up to date. The contactless payment feature further improves usability by enabling fast and secure transactions. Overall, the system demonstrates a practical implementation of smart technologies in agricultural retail, offering a scalable and user-friendly solution for modern nursery management.

5. System Design

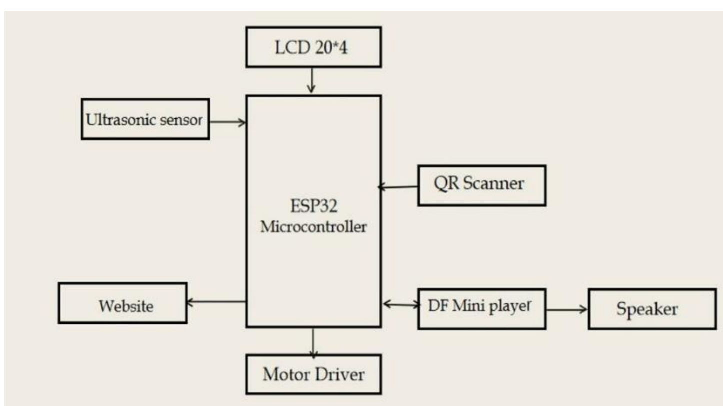

Figure 1: System Design of NurseryKart

5.1 Hardware Layer

The hardware layer forms the physical foundation of the NurseryKart system. It includes components such as the ESP32 microcontroller, ultrasonic sensors, QR code scanner module, DC motors, motor drivers, LCD display, and power supply unit.

- The **ESP32 microcontroller** serves as the main controller, managing all system operations and communication between components.

- **Ultrasonic sensors** are used for obstacle detection, allowing the robot to navigate safely in dynamic environments.
- The **QR code scanner** is responsible for both navigation and plant identification by reading QR codes placed along pathways and on plants.
- **DC motors and motor drivers** enable movement and direction control of the robot.
- The **LCD display** provides plant details, billing information, and user interaction output.

This layer ensures accurate execution of real-time tasks such as movement, sensing, and display.

5.2 Software and Control Layer

The software layer is responsible for data processing, system control, and user interaction. The ESP32 microcontroller processes inputs from sensors and QR code modules, executes navigation logic, and controls output devices such as motors and the LCD display. It ensures real-time decision-making for smooth and efficient robot operation.

In addition to onboard control, the system includes a web-based interface designed for the nursery owner. This website enables the owner to manage plant-related data, including plant names, prices, and care instructions. The data stored in the system is linked with QR codes, allowing the robot to retrieve and display accurate information when a plant is scanned.

The website also provides functionalities such as updating product details, monitoring available items, and managing digital records, making it easier for the owner to maintain the nursery database. This reduces manual effort and ensures that customers always receive up-to-date information.

Furthermore, the system supports UPI-based QR code generation for billing, allowing customers to complete transactions through their mobile devices. The integration of a web interface with embedded control enhances the overall system by enabling both customer interaction and administrative control.

The control logic ensures proper synchronization between hardware components and the web-based system, allowing seamless communication and efficient operation of the entire NurseryKart platform.

A brief synopsis of the work's most intriguing findings should be included in the conclusion. Additionally, you can include details about how research is conducted under a funded program, acknowledgements of companies or individuals involved in the research, and the Research Ethics Committee's approval for any experiments involving human subjects.

5.3 Operational Workflow

The working of the NurseryKart system is carried out through a sequence of well-defined steps to ensure smooth and efficient operation:

1. **System Initialization:** Upon powering on, all components including sensors, display, and controller are initialized and calibrated for operation.
2. **Autonomous Navigation:** The robot moves through nursery aisles using programmed logic and sensor inputs, avoiding obstacles in real time.
3. **QR Code-Based Identification:** The robot scans QR codes placed on plants to retrieve relevant information from the system database.

4. **Customer Interaction:** Retrieved data such as plant name, price, and care instructions are displayed on the LCD, allowing users to interact with the system.
5. **Product Selection and Billing:** Customers can select desired plants, after which the system generates a UPI-based QR code for payment.
6. **Payment Processing:** The customer completes the transaction using a mobile device, ensuring a contactless and secure payment process.
7. **Continuous Monitoring:** The system continuously monitors sensor data and user inputs to maintain smooth and uninterrupted operation.

6. Conclusion

The **NurseryKart system** presents an effective solution for automating plant nursery operations by integrating robotics, embedded systems, and IoT technologies. The developed system successfully demonstrates autonomous navigation, QR code-based plant identification, real-time customer interaction, and contactless billing through UPI-based payment methods. By reducing dependency on manual assistance, the system improves operational efficiency and enhances the overall customer experience.

The implementation of an ESP32 microcontroller along with sensors ensures reliable performance in dynamic environments, while the LCD interface and audio output provide clear and accessible information to users. Additionally, the inclusion of a web-based platform for the nursery owner enables efficient management of plant data, ensuring that information remains accurate and up to date.

Overall, the proposed system highlights the potential of combining automation and smart technologies in agricultural retail. It offers a scalable and user-friendly approach to modernizing traditional nursery practices. Future enhancements may include the integration of artificial intelligence for plant recommendations, cloud-based data management, and advanced navigation techniques, further improving system capabilities and usability.

7. Result & Discussion

The results of the NurseryKart system demonstrate the successful implementation of an intelligent robotic assistant for plant nursery automation. The system effectively integrates embedded hardware, a web-based management platform, and real-time interaction modules to provide a seamless user experience. During testing, the hardware components such as the ESP32 microcontroller, ultrasonic sensors, QR code scanner, DC motors, motor drivers, and LCD display were successfully integrated and operated in coordination.

The ESP32 functioned as the central controller, managing communication between all modules and ensuring smooth execution of tasks. The robot was able to navigate through nursery paths while avoiding obstacles using ultrasonic sensors, demonstrating reliable performance in dynamic environments.

The QR code-based identification system worked efficiently, allowing the robot to scan plant tags and instantly retrieve relevant information such as plant name, price, and care instructions. This information was accurately displayed on the LCD screen, enabling customers to access details without manual assistance. The response time of the system was minimal, ensuring real-time interaction and improved user experience.

The contactless billing feature using UPI-based QR code generation was successfully implemented. Customers were able to complete transactions quickly using their mobile devices, reducing waiting time and eliminating the need for manual billing. This feature enhances convenience and ensures hygienic transactions, which is especially important in modern retail environments.

The web-based platform developed for the nursery owner proved to be effective in managing plant data. The system allowed the owner to update product details, maintain records, and ensure that the information linked to QR codes remained accurate. This integration between the website and the robotic system improved overall efficiency and reduced manual data handling.

Overall, the system demonstrated stable performance with minimal delays in navigation, data retrieval, and user interaction. The integration of hardware and software components ensured consistent operation and reliable results. The proposed system successfully achieves its objective of improving efficiency, enhancing customer interaction, and introducing automation into traditional nursery environments.

However, certain limitations were observed, such as dependency on proper QR code placement and limited intelligence in decision-making. These can be addressed in future work by incorporating AI-based recommendation systems, advanced navigation algorithms, and cloud-based data management.

8. References

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