Design and Development of a Prototype of Web Controlled TomatoPlucking Robot using IOT

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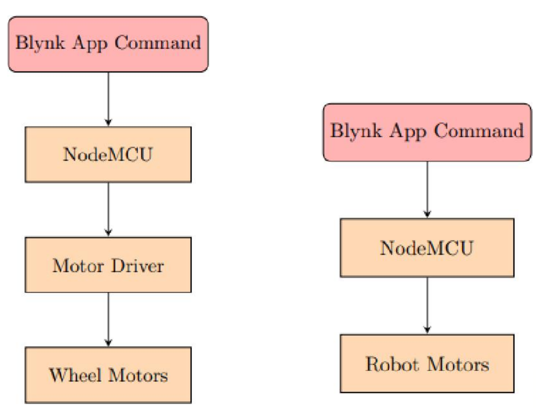
Abstract: *In agriculture, the integration of robotics and Internet of Things (IoT) technologies has revolutionized traditional farming practices, offering efficient solutions for tasks such as harvesting. This paper presents the design and development of a web- controlled Tomato Plucking Robot (TPR) utilizing IoT principles. The TPR consists of a robotic arm mounted on a rover platform, enhancing mobility and reach. A dedicated storage unit within the rover facilitates the collection of harvested tomatoes. The entire system is remotely operated via a web interface, enabling real-time control and monitoring from any location with internet connectivity. Additionally, an ESP32 cam module is integrated to provide live navigation views, aiding in precise maneuvering and tomato detection. This research contributes to the advancement of automated agricultural practices, offering a scalable and adaptable solution for tomato harvesting while showcasing the potential of IoT-enabled robotics in optimizing farm operations.*

Keywords: Agriculture, Tomato, Rover, Robot Arm, Gripper, Servo Motors, DC motors

I. INTRODUCTION

The agricultural landscape is witnessing a technological transformation driven by automation and IoT integration. In this context, the development of robotic systems for harvesting tasks, particularly for crops like tomatoes, has become imperative to address labor shortages and enhance yield consistency. This paper presents the design and implementation of a web-controlled Tomato Plucking Robot (TPR) with IoT capabilities. The TPR comprises a robotic arm mounted on a rover platform, enabling seamless mobility and efficient tomato collection. Leveraging web-based control and an ESP32 cam module for navigation, operators can remotely oversee and command the TPR system, facilitating precise maneuvering and real-time monitoring. By combining robotics, IoT, and web- based control, the proposed TPR system offers a scalable and adaptable solution for modern agriculture. This research contributes tothe discourse on automated agricultural technologies, showcasing the transformative potential of IoT-enabled robotics in revolutionizing farming practices.

II. BLOCK DIAGRAM



III. METHODOLOGY

- Problem Statement and Objectives: Define the problem statement, focusing on the challenges in traditional tomato harvesting methods and the need for automated solutions. Establish the objectives of the research, outlining the goals and outcomes expected from the development of the Tomato Plucking Robot (TPR).
- Literature Review: Conduct a comprehensive review of existing literature on agricultural robotics, IoT applications in farming, and previous efforts in tomato harvesting automation. Identify key technologies, methodologies, and best practices relevant tothe design and implementation of the TPR system.
- System Design: Develop conceptual designs for the TPR system, including rover, robotic arm, and web-based control interface. Develop conceptual designs for the rover, robotic arm, storage unit, and overall system architecture, utilizing tools like Fusion 360 for design visualization.
- Prototyping and Fabrication: Implement the designed components through prototyping and fabrication processes. 3D print the robotic arm components based on the Fusion 360 design, ensuring precision and compatibility. Manufacture the rover using mild steel, following the Fusion 360 design specifications.
- Power Management System: Select appropriate power sources and implement efficient management systems to sustain prolonged operation periods.
- Integration and Testing: Integrate the individual components of the TPR system, including the rover, robotic arm, microcontrollers, sensors, and communication modules. Conduct rigorous testing to verify the functionality and performanceof each subsystem, ensuring seamless integration and compatibility.
- Data Collection and Analysis: Gather data from experimental trials and analyze performance metrics to evaluate TPR effectiveness. Analyze the collected data to evaluate the effectiveness of the TPR system in comparison to traditional harvesting methods.
- Results and Discussion: Present the findings from the experimentation and analysis in a clear and concise manner. Discuss the implications of the results in the context of agricultural automation and IoT-enabled robotics.
- Conclusion: Summarize the key findings and contributions of the research. Reflect on the effectiveness of the TPR system inaddressing the challenges of tomato harvesting automation. Provide insights into future research directions and potential enhancements to the TPR system.
- Documentation and Training Materials: Create detailed documentation covering assembly instructions, operational procedures, and maintenance protocols for users and technicians.

IV. COMPONENTS AND SPECIFICATIONS

Sr. No.	Components	Specifications
1.	DC Gear Motor	12V, 60RPM
2.	L289N Motor Driver	5V to 35V
3.	Li-ion Battery	12V, 20000mAh
4.	Wheels	100mm Diameter
5.	MG946R Servo Motor	10.5 Kg-Cm (Stall Torque)
6.	SG90 Servo Motor	1.2 Kg-Cm (Stall Torque)
7.	Microcontroller	ESP8266
8.	Camera	ESP32-CAM
9.	Jumper Wires	1mm

V. SYSTEM DEVELOPMENT

5.1 CAD Model of Robotic Arm and Gripper

The robot arm and gripper were meticulously designed in Fusion 360 to optimize functionality for smooth articulation, precise movement, and efficient tomato harvesting automation. 3D printing with PLA material ensured durability and affordability, while careful attention to detail enabled seamless integration and iterative refinement of both components.

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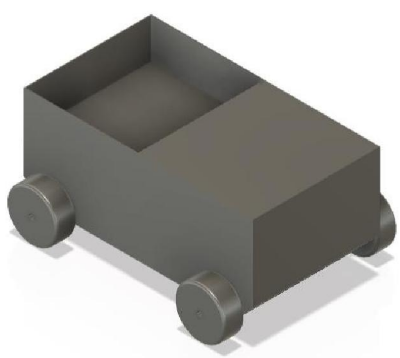
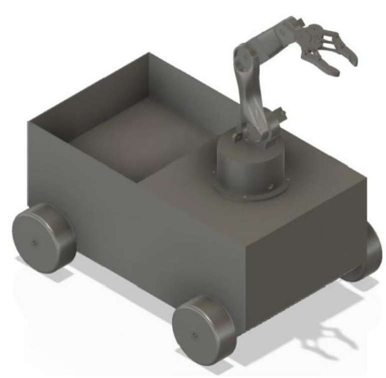
Similarly, the gripper's design focused on precisionand functionality, with every element meticulously detailed to ensure seamless integration with the robotic arm. The Fusion 360 platformfacilitated iterative refinement, resulting in a gripper that enhances the efficiency and accuracy of tomato harvesting operations.

5.2 CAD Model of Rover and Assembly

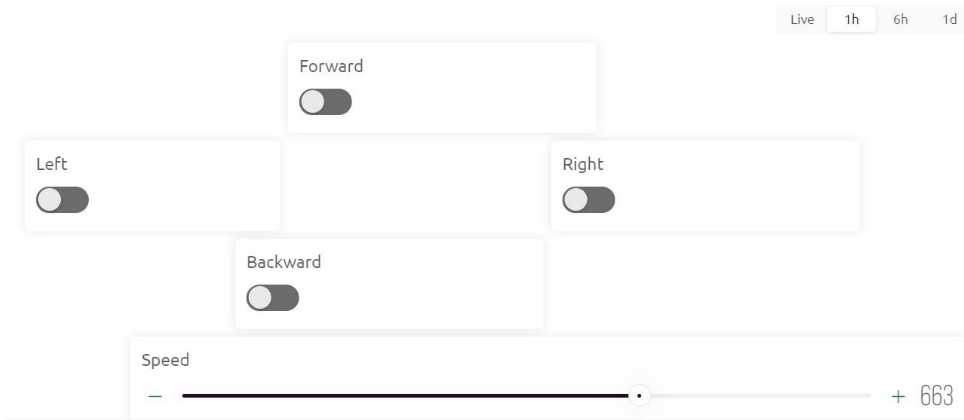
The rover's CAD model, meticulously crafted in Fusion 360, detailed its chassis, wheels, and storage compartment, while its fabricationfrom mild steel ensured durability in agricultural environments. This fusion of CAD precision and steel craftsmanship results in a robust solution for efficient tomato harvesting automation. Similarly, the assembly, designed within Fusion 360, seamlessly integrates the robotic arm onto the rover platform, optimizing stability and precision. Through iterative refinement, Fusion 360 facilitated the creationof a cohesive unit, combining the capabilities of the robotic arm with the mobility of the rover for agricultural automation.





5.3 GUI for Rover

The rover's GUI, developed on the Blynk website, features five intuitive controls for seamless remote operation. Four switches enable easy navigation, allowing for forward, backward, left, and right movements of the rover. Additionally, a cursor control allows operatorsto adjust the rover's speed dynamically. This user-friendly interface enhances operational flexibility and productivity, empowering usersto navigate agricultural fields with precision and efficiency during tomato harvesting tasks.

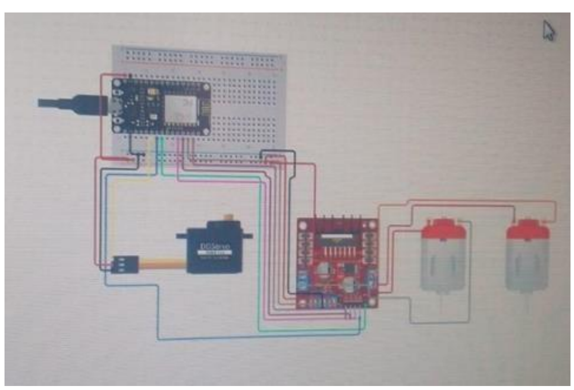


5.4 GUI for Robot Arm

The GUI for the robot arm, crafted on the Blynk website, incorporates five intuitive controls for seamless remote operation. Each controlcorresponds to a specific joint of the robotic arm, enabling precise manipulation during tomato harvesting tasks. Operators can adjust the waist, shoulder, elbow, and wrist movements individually, allowing for fine-tuning of the arm's position and orientation. Additionally, a dedicated control operates the gripper mechanism, facilitating efficient tomato plucking. This user-friendly interface enhances operational control and productivity, empowering users to execute delicate maneuvers with ease and accuracy.

VI. CIRCUIT DIAGRAM

At the core of the Tomato Plucking Robot (TPR) lies a meticulously designed circuit configuration, orchestrating seamless coordination and control over its multifaceted functionalities. Central to this setup are the 12V DC gear motors, intricately linked to a motor driver module for regulating speed and direction under the guidance of the ESP8266 microcontroller. The circuit also integrates servo motors for delicate manipulation tasks; SG90 servos enable granular control over arm articulation, while MG996R servos ensure robust power delivery for operation. This intricate web of connections ensures the TPR's seamless functionality, poised to revolutionize tomato harvesting with engineering excellence.



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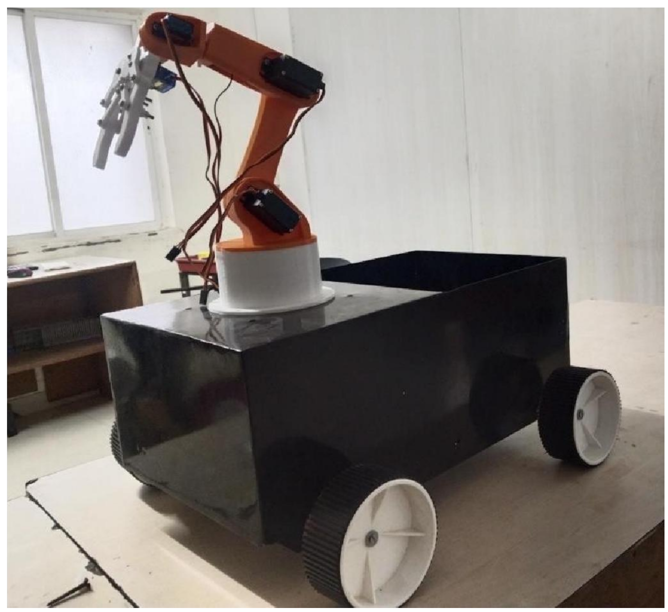
VII. RESULTS

The culmination of our efforts has yielded the successful design and development of a web-controlled Tomato Plucking Robot (TPR)leveraging IoT technology. Through meticulous planning, design, and implementation, we have achieved a robust and efficient systemcapable of automating tomato harvesting tasks with precision and reliability. The integration of web-based control mechanisms has empowered operators to remotely oversee and command the TPR's operations from any location with internet connectivity, enhancingflexibility and operational efficiency.

Furthermore, we are pleased to showcase the tangible outcome of our endeavor through the inclusion of a comprehensive photo documentation of the complete fabrication and development process of the robot. This visual representation not only underscores thecomplexity and sophistication of the TPR system but also serves as a testament to our dedication and ingenuity in realizing this innovative solution for agricultural automation.

Overall, the successful realization of the web-controlled TPR marks a significant milestone in our research and development journey.It not only demonstrates the potential of IoT-enabled robotics in optimizing agricultural practices but also lays the groundwork for future advancements and applications in this domain.



VIII. CONCLUSION

In conclusion, the development of the web-controlled Tomato Plucking Robot (TPR) represents a significant achievement in the realmof agricultural automation. Through the integration of IoT technologies and robotics, we have created a versatile and efficient solution for addressing the challenges of tomato harvesting. The TPR's ability to remotely pluck tomatoes with precision and reliability showcases the transformative potential of automation in enhancing agricultural productivity and sustainability.

Our research journey has been marked by innovation, collaboration, and perseverance, culminating in the successful realization of a functional TPR system. The comprehensive integration of web-based control mechanisms, coupled with robust hardware design, underscores our commitment to delivering practical and effective solutions for real-world challenges in agriculture.

Looking ahead, the TPR stands poised to revolutionize traditional farming practices, offering farmers a scalable and adaptable tool for optimizing harvesting operations. As we continue to refine and iterate upon the TPR's design and functionality, we remain committed to advancing the frontiers of agricultural automation and contributing to the ongoing evolution of sustainable farming practices.

In essence, the TPR represents not only a technological achievement but also a testament to our dedication to harnessing innovation forthe betterment of agricultural communities worldwide

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