© FEB 2026 | IRE Journals | Volume 9 Issue 8 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV9I8-1714526

AI Enabled Smart Modular Cutting System with Intelligent Control for Vegetables

J. KARTHIKEYAN[1], R. HARIHARAN[2], S. SAKTHI DEVA[3], A. MUZAMIL[4]
[1]*Assistant Professor, UG Scholar, Department of Electrical and Electronics Engineering, Kongunadu College of Engineering and Technology (Autonomous), Thottiam, Tiruchirappalli (Dt), Tamilnadu, India.*
[2, 3, 4]*UG Scholar, Department of Electrical and Electronics Engineering, Kongunadu College of Engineering and Technology (Autonomous), Thottiam, Tiruchirappalli (Dt), Tamilnadu, India.*

Abstract- The AI-enabled smart modular cutting system provides an automated and safe solution for vegetable cutting. Unlike manual cutting, which takes more time and effort and may cause uneven sizes or safety risks, this system ensures consistent and efficient results. It uses an STM32 microcontroller connected to a mobile app for wireless control. AI-based methods identify the vegetable, and the required cutting size is selected through a smartphone. Based on the input, the system performs slicing, chopping, or dicing automatically. The modular blade design offers flexibility, improves hygiene, reduces human contact, and enhances safety for homes and small food units.

Index Terms - Smart modular cutting, Wireless control, STM32 microcontroller, Modular blade structure, small food processing units.

I. INTRODUCTION

In the modern era, automation and artificial intelligence (AI) play a significant role in improving efficiency, safety, and productivity across various sectors, including food processing. Traditional vegetable cutting methods are time-consuming, labor-intensive, and often result in uneven cutting sizes. Manual handling of sharp blades also increases the risk of injuries and reduces overall hygiene standards, particularly in restaurants, catering services, and small food processing units where large quantities of vegetables must be prepared daily.

To challenges, the AI Enabled Smart Modular Cutting System with Intelligent Control for Vegetables is proposed. This system integrates AI-based vegetable identification with an intelligent microcontroller-based control unit to automate cutting operations such as slicing, chopping, and dicing.

The machine allows users to select the desired cutting type and size through a smartphone application connected wirelessly to the controller.

A modular blade mechanism is incorporated to provide flexibility for different vegetables and customizable cutting dimensions. The intelligent control system ensures precise operation, reduces human intervention, and enhances safety by minimizing direct contact with sharp components. Additionally, the automated process improves consistency, reduces processing time, and maintains better hygiene standards. This system is designed to be suitable for homes, restaurants, and small-scale food industries, offering a smart, efficient, and user-friendly solution for modern vegetable processing needs.

II. LITERATURE REVIEW

Yildirim, *et al.* described that design, analysis, and prototyping of a squirrel-cage induction motor for industrial vegetable cutting machines. Key parameters such as power, voltage, phases, and efficiency were considered. FEA analysis and experimental validation confirm that the motor meets performance requirements for efficient and reliable operation.

Liang *et al.* presented a design an automated vegetable harvesting system for soilless cultivation to reduce labor and improve efficiency. SolidWorks and MATLAB were used for mechanism design and kinematic analysis. An optimized cutting method minimizes tool damage and improves durability, enabling a complete automated harvesting process.

Yu-qiu *et al.* reviewed presents the design of a splice-type vegetable grafting machine with an automated feeding system for scion and rootstock. A pneumatic mechanism and stepper motor ensure precise motion control, managed by an 89C51 microcontroller. Testing confirms programmed operation with a productivity of 450 grafted plants per hour.

Ramnath *et al.* presents an automated vegetable cutting machine designed to reduce time and manual effort in hotels and catering services. A high-speed motor drives interchangeable blades to cut vegetables into desired shapes. The system is portable, low-cost, efficient, and does not require skilled operation.

Pawar *et al.* development of a fruit and vegetable slicing machine designed to improve efficiency and uniformity in food preparation. The system uses a motor-driven cutting mechanism with interchangeable blades to achieve consistent slicing. The machine is compact, cost-effective, easy to operate, and suitable for homes, restaurants, and small-scale food processing units.

Singhal *et al*. proposes a smart vegetable cutter integrated with cleaning, peeling, and cutting functions in a single system. Controlled through an Android application and IoT technology, the machine reduces manpower, saves time, and improves hygiene. It addresses health concerns related to pesticides while offering an efficient, automated solution for modern lifestyles.

Juliusa *et al.* focuses on the development and performance evaluation of a motorized vegetable and fodder slicer. The machine was designed to improve cutting efficiency, reduce labor, and ensure uniform slicing. Response Surface Methodology (RSM) was applied to optimize operating parameters and evaluate performance, confirming improved productivity and reliable operation under various working conditions.

III. DESCRIPTION OF EXISTING SYSTEM

At present, most vegetable cutting operations are carried out manually using knives or basic mechanical cutters. In households, restaurants, and small food processing units, manual cutting is common due to its low initial cost and simplicity. However, this method requires significant physical effort and time, especially when handling large quantities of vegetables. It also leads to inconsistent cutting sizes and increased safety risks due to direct handling of sharp blades.

Some motorized vegetable cutting machines are available in the market. These machines use fixed blade mechanisms powered by electric motors to perform slicing or chopping operations. Although they improve speed and reduce manual effort, most of them lack intelligent control features. Users must manually change blades and cannot adjust cutting parameters precisely through digital control. Additionally, existing systems do not include AI-based vegetable identification or smart automation features.

Most commercial machines are expensive and designed mainly for large-scale industries, making them unsuitable for small restaurants or home use. They also require regular supervision and may not provide modular flexibility for different cutting styles in a single compact unit. Therefore, there is a need for a smarter, safer, and more flexible vegetable cutting system with intelligent control and automation capabilities.

Fig.1: Common market-available manual vegetable choppers and slicers including multi-blade cutters, dicing grids, slicing plates, peeling tools, and container-based chopping systems used in homes and small kitchen environments.

Most existing manual and semi-automatic vegetable cutters are difficult to clean properly, especially in blade and joint areas. Food particles may accumulate inside the mechanism, leading to hygiene issues and bacterial growth. Regular maintenance is required, and improper cleaning can affect performance and food safety standards.

Existing systems do not provide real-time monitoring, feedback control, or programmable operation. There is no smart sensing mechanism to

DOI: https://doi.org/10.64388/IREV9I8-1714526

detect vegetable type, cutting load, or blade condition. As a result, the machines cannot optimize cutting performance automatically, leading to energy wastage and reduced efficiency

IV. CHALLENGES IN EXISTING SYSTEM

Existing vegetable cutting systems, whether manual or motorized, face several limitations that reduce efficiency, safety, and flexibility. Manual cutting requires significant physical effort and consumes more time, especially in restaurants and food processing units where large quantities of vegetables must be prepared. It also results in inconsistent cutting sizes, affecting presentation and cooking quality.

Motorized cutters improve speed but still lack intelligent control. Most machines operate with fixed blade configurations and do not allow easy customization of cutting size or type without manual blade replacement. This reduces operational flexibility. Additionally, these systems do not include AI-based vegetable identification, making it necessary for users to manually select and adjust settings.

Safety is another major concern. Direct contact with sharp blades during operation or cleaning increases the risk of injuries. Many existing systems also lack proper protective mechanisms and automated shutoff features. Hygiene and maintenance issues further complicate usage, as food particles accumulate in hard-to-reach areas. Moreover, most commercial machines are expensive and not affordable for small-scale users.

Therefore, there is a need for an intelligent, automated, safe, and cost-effective vegetable cutting solution.

V. BLOCK DIAGRAM

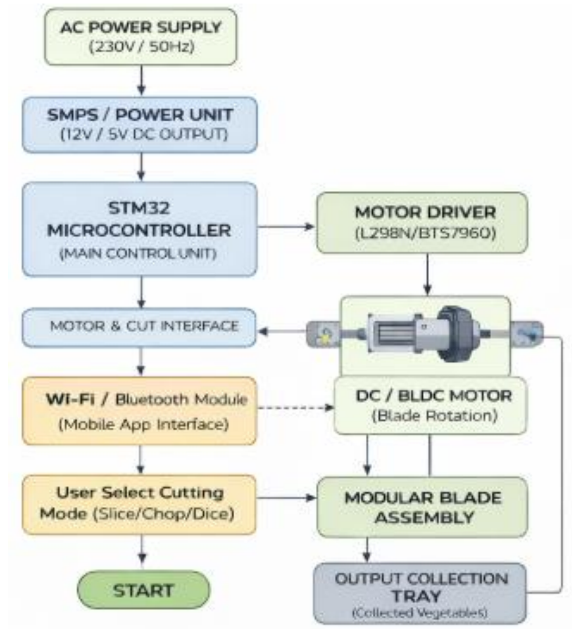

Fig.2: Block Diagram of the Proposed System

VI. FLOW CHART

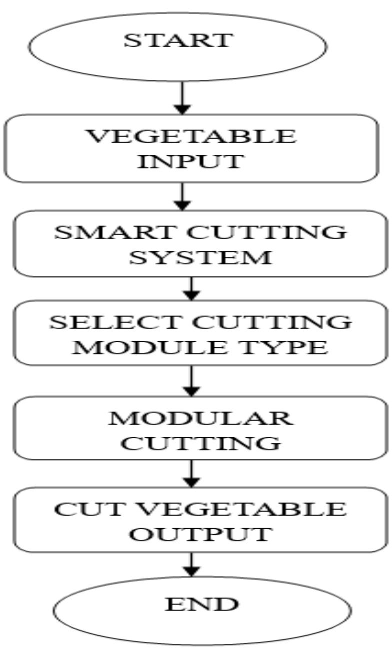

Fig.3: Flow Chart of the Proposed System

VII. HARDWARE IMPLEMENTATION

a. Motor Driver Module: Controls the DC motor or stepper motor for blade rotation and movement.

b. DC Motor / BLDC Motor (12V / 24V): Drives the cutting blade mechanism for slicing, chopping, and dicing.

c. Power Supply Unit (SMPS 12V/24V): Converts AC mains supply to required DC voltage for controller and motors.

d. Relay Module (5V/12V): Used for switching high-power motor circuits safely.

e. Stepper Motor: Used for precise movement of feeding mechanism or modular blade positioning.

f. Outer Body Enclosure (Food-Grade Stainless Steel – SS304): Acts as the main structural frame of the machine. Provides durability, corrosion resistance, hygiene, and protection for internal electronic and mechanical components.

g. Modular Blade Assembly: Designed for high sharpness, durability, and uniform cutting performance.

VIII. WORKING OF PROPOSED SYSTEM

The working of the proposed AI Enabled Smart Modular Cutting System with Intelligent Control for Vegetables is based on AI-based identification and microcontroller-controlled cutting automation. When the system is powered ON, the regulated DC supply energizes the STM32 microcontroller, motor driver circuits, sensors, and communication module. The controller initializes all peripherals and establishes wireless communication with the mobile application.

When vegetables are placed inside the feeding hopper, the AI camera module captures the image and processes it using a trained recognition algorithm. The identified vegetable type is sent to the microcontroller. The user selects the required cutting mode (slicing, chopping, or dicing) through the smartphone interface. The controller compares the selected input with predefined control parameters stored in the program memory.

Based on the selected mode, the controller activates the corresponding motor driver and modular blade mechanism. The DC/BLDC motor rotates the blade assembly, while the stepper motor precisely controls the feeding movement of the vegetable towards the cutting chamber. Limit switches and proximity sensors ensure proper positioning and safe operation.

During operation, current sensors monitor motor load to prevent overload conditions. The cut vegetables are collected in the output tray through gravity flow. Once the operation is complete or if any abnormal condition is detected, the controller automatically stops the motor, ensuring safety and efficient performance.

IX. OPERATION OF PROPOSED SYSTEM

The operation of the proposed AI Enabled Smart Modular Cutting System follows a controlled sequence from vegetable detection to automated cutting output. Initially, when the system is connected to the AC mains supply, the SMPS power unit converts the input supply into regulated DC voltages required for the control and motor sections. The 5V/3.3V DC line powers the STM32 microcontroller, sensors, AI camera module, and communication interface, while the 12V/24V DC line supplies power to the motor driver and cutting motor.

After initialization, the controller establishes wireless communication with the mobile application. When vegetables are placed inside the feeding hopper, the AI camera captures and processes the image to identify the vegetable type. The recognized data is sent to the controller, and the user selects the desired cutting mode—such as slicing, chopping, or dicing—through the smartphone interface.

Based on the selected mode, the controller sends control signals to the motor driver circuit. The blade motor rotates at a predefined speed, and the stepper motor regulates the feeding mechanism to ensure uniform cutting. Sensors such as limit switches and current sensors continuously monitor position and load conditions for safe operation.

The cut vegetables are discharged through the output tray by gravity. Once the cutting cycle is completed or if an abnormal condition is detected, the controller automatically stops the motor, ensuring safe, precise, and energy-efficient system performance.

© FEB 2026 | IRE Journals | Volume 9 Issue 8 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV9I8-1714526

X. RESULTS AND DISCUSSIONS

The developed AI Enabled Smart Modular Cutting System demonstrated stable and efficient performance in automated vegetable cutting operations. The integration of AI-based vegetable identification and microcontroller-controlled blade mechanism provided accurate and consistent cutting results. The STM32 controller successfully coordinated sensing, motor control, and wireless communication functions without delay or instability.

Fig.4: Stainless steel modular cutting machine with four vegetable inputs and separate output trays for processed vegetables.

The AI camera module accurately identified different vegetables under normal lighting conditions, and the selected cutting mode was executed precisely through the mobile application interface. The motor driver and blade assembly operated smoothly, producing uniform slicing, chopping, and dicing outputs. The stepper motor-controlled feeding mechanism ensured consistent cutting thickness and minimized wastage.

Sensor-based monitoring improved operational safety. Limit switches ensured proper positioning, while the current sensor effectively prevented motor overload. The modular blade structure allowed quick replacement and flexible cutting operations without affecting system stability.

The power supply unit delivered regulated DC output, supporting uninterrupted system performance. Compared to conventional manual and fixed-blade machines, the proposed system reduced human effort, improved hygiene, and enhanced safety by minimizing direct blade contact.

Overall, the coordinated performance of AI detection, intelligent control, motor actuation, and modular blade mechanism validates the system's suitability for smart kitchen and small-scale food processing applications. Further improvements in AI accuracy and enclosure design can enhance practical deployment efficiency.

XI. CONCLUSION

An AI Enabled Smart Modular Cutting System with Intelligent Control for Vegetables has been successfully designed and implemented to automate vegetable processing operations. The system replaces conventional manual cutting methods with an AI-based identification and microcontroller-controlled cutting mechanism. The STM32 controller, integrated with image recognition and wireless mobile control, enables intelligent selection and execution of slicing, chopping, and dicing operations.

The modular blade mechanism provides flexibility for handling different vegetables and customizable cutting sizes, while motor driver circuits ensure precise and stable blade operation. Sensor-based monitoring enhances operational safety by preventing overload and improper positioning. The regulated power supply system supports uninterrupted and reliable performance.

The developed system demonstrates improved efficiency, consistent cutting quality, enhanced hygiene, and reduced human intervention compared to traditional methods. Its compact and smart design makes it suitable for homes, restaurants, and small-scale food processing units. Further improvements in AI accuracy, mechanical optimization, and large-scale testing can enhance system performance and support wider practical implementation in smart kitchen automation applications.

REFERENCES

[1] A. Yildirim, H. Nory and A. Yildiz, "Design, Analysis, and Prototyping of Induction Motor for Vegetable Cutting Machine," *2025 2nd International Conference on Circuits, Power and Intelligent Systems (CCPIS)*, Bhubaneswar, India, 2025, pp. 1-5, doi: 10.1109/CCPIS65231.2025.11234153.

[2] Y. Liang and G. Gao, "Design and Analysis of Automatic Vegetable Harvesting Machine," *2019 2nd World Conference on Mechanical Engineering and Intelligent Manufacturing (WCMEIM)*, Shanghai, China, 2019, pp. 287-290, doi: 10.1109/WCMEIM48965.2019.00062.

[3] S. Yu-qiu, X. Ming-jin, D. Hong-yu, Z. Xiu-fang and H. Yan-qing, "Process control system for scion and rootstock feeding of vegetable grafting machine," *Proceedings of 2011 International Conference on Electronic & Mechanical Engineering and Information Technology*, Harbin, China, 2011, pp. 3509-3512, doi: 10.1109/EMEIT.2011.6023781.

[4] B. V. Ramnath, S. Krishnaraj, R. S. Kumar, B. Jeyasurya, A. M. Jasar and N. Prasanna, "Automation of Vegetable Cutting Machine," *2024 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)*, Chennai, India, 2024, pp. 1-5, doi: 10.1109/ICPECTS62210.2024.10780416.

[5] Pawar K. R., Ukey P. D., Bhosale P. D., Ghorpade K. B., Jadhav R. B., Patil A. A. 2020. Development of Fruit and Vegetable Slicing Machine. International Research Journal of Engineering and Technology. 07(03): 1399-1404.

[6] S. Singhal, D. Mangal, R. Kumar, B. Sharma and I. B. Dhaou, "Smart vegetable cutter for Smart Home," *2023 1st International Conference on Advanced Innovations in Smart Cities (ICAISC)*, Jeddah, Saudi Arabia, 2023, pp.1-6,doi: 10.1109/ICAISC56366.2023.10085675.

[7] Julius E. U. and Kingsley O. 2020. Development and performance evaluation of a motorized vegetables and fodder slicer using response surface methodology. Global Journal of Engineering and Technology Advances. 04(03): 001-011.

[8] Alias T., Eldhose M., Krishnan N., Harikrishnan V.K. 2019. Design and Fabrication of Peeling and Cutting Machine. International Journal of Applied Engineering Research ISSN 0973-4562, 14(14).

[9] Hoque M. A. and Saha K.K. 2017. Design and development of a manual potato cum sweet potato slicer; J. Sci. Technol. Environ. Inform. 05(02): 395-401.

[10] Aji I. S., Vakaa J. K., Madu M. J., Suleiman Z. B. and Yakda S. B. 2018. Development of A Small Scale Okro Slicing Machine. Arid Zone Journal of Engineering, Technology and Environment. 14(1): 54-60.