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FARM TO TABLE: AUTOMATING FRUIT YIELD AND SALES USING ESP-32CAM AND TELEGRAM BOT

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Abstract: This paper presents a solution to improve fruit yield monitoring and sales in agriculture by combining the ESP32CAM module with Telegram bot technology. The system uses the ESP32CAM to capture real-time images of fruit, which are then analysed with machine learning algorithms for accurate counting and quality assessment. The images are uploaded to a cloud server, where advanced analytics estimate the yield and predict the best harvest times. This approach helps farmers make better decisions about when to harvest and manage their inventory.

The Telegram bot acts as an easy-to-use interface for farmers and customers, allowing smooth communication and realtime updates on inventory, sales, and yield information. Farmers can use the bot to manage their stock, get notifications about fruit quality and quantity, and directly sell to consumers, removing intermediaries and improving profitability.

By automating the processes of monitoring yield, assessing quality, and handling sales, this system cuts down on manual work, boosts efficiency, and creates a direct link between farmers and customers. Using machine learning, realtime communication, and cloud-based analytics, the system offers a modern and scalable solution to problems in agriculture, paving the way for future advances in precision farming and direct sales to consumers.

Keywords: Road safety, Fruit yield monitoring, ESP32CAM module, Telegram bot, Machine learning algorithms, Image processing, Real-time data, Cloud-based server, Yield estimation, Sales management, Agriculture technology, Precision farming, Scalable solution.

INTRODUCTION

Agriculture is crucial for food production and economies, especially in rural areas. As the global population grows, farmers are under pressure to boost productivity while saving resources. To meet this challenge, technology, particularly automation and data-driven solutions, is being adopted in agriculture. Innovations like IoT devices, machine learning, and cloud-based analytics are helping farmers make better decisions and improve their operations.

Traditional methods of monitoring fruit yields and managing sales are timeconsuming, prone to errors, and rely heavily on manual tasks like counting and visual inspections. Farmers often depend on intermediaries to assess yields and sell produce, which can lead to inefficiencies such as missed harvests, overstocking, or pricing problems. To address these issues, many farmers are turning to automation technologies, particularly IoT-enabled devices, to streamline farm operations and improve efficiency.

One such technology is the ESP32-CAM, a microcontroller with a built-in camera that captures high-resolution images of crops. These images can be analysed using machine learning algorithms to count fruits, assess quality, and predict ripeness, helping farmers monitor their yields more accurately without manual effort. The data can also be sent to cloud servers for further analysis, providing valuable insights on the best harvest times and yield estimates.

Another innovative application is the use of Telegram bots in agriculture. By connecting the ESP32-CAM to a Telegram bot, farmers can get real-time updates on crop conditions, inventory, and sales. The bot also acts as an interactive sales assistant, helping farmers manage orders and communicate directly with consumers, which reduces reliance on intermediaries and boosts profitability.

The benefits of this approach are clear: automation reduces manual labor and helps farmers make faster, data-driven decisions about harvest timing, inventory, and sales. Real-time insights lead to more accurate yield predictions and better

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stock management. Additionally, the Telegram sales platform gives farmers a direct link to consumers, improving market access and pricing.

This review paper explores how the ESP32CAM, machine learning, and Telegram bot technology are coming together to improve agriculture. It highlights their potential to boost farm efficiency, profitability, and sustainability, paving the way for the future of smart, automated farming.

PROBLEM STATEMENT

The agricultural sector faces challenges in yield monitoring, quality assessment, and sales management, with traditional methods being labour-intensive, error-prone, and inefficient. Farmers also rely on intermediaries for sales, which reduces profitability. This paper proposes using the ESP32-CAM module, machine learning, and a Telegram bot to automate fruit yield monitoring, improve quality assessment, and enable direct sales, ultimately increasing efficiency, reducing manual labour, and boosting farmers' profitability.

PROPOSED METHOD

The proposed system automates fruit yield monitoring, quality assessment, and sales management by integrating the ESP32CAM module, machine learning, and a Telegram bot. The ESP32-CAM captures high-resolution images of fruits, which are then processed with machine learning algorithms to count and assess their quality, providing accurate yield estimates and realtime quality checks. The data is sent to a cloud platform for further analysis, predicting yield volumes, harvest times, and fruit quality. The system also uses a

Telegram bot to send farmers updates on crop status, inventory, and sales, allowing them to manage orders, interact with customers, and make informed decisions. This setup reduces manual labor, eliminates intermediaries, and improves profitability by streamlining the entire process from monitoring to sales.

SYSTEM ARCHITECTURE

The proposed system for automated fruit yield monitoring, quality assessment, and direct sales is organized into four main layers: the Edge Layer, which uses the ESP32-CAM module to capture images; the Data Processing Layer, where data is analysed on a cloud server using machine learning; the Communication Layer, which involves a Telegram bot for real-time updates; and the User Interface Layer, where farmers and customers interact with the system.

- The Edge Layer uses the ESP32CAM module, deployed on the farm to capture high-resolution images of fruits. It performs initial image processing, detecting and counting fruits, and assessing their quality, such as ripeness or damage, using simple machine learning models. This helps reduce data transmission by processing basic information locally before sending it to the cloud.
- The Data Processing Layer uses a cloud server to receive the images and apply advanced machine learning algorithms, like Convolutional Neural Networks (CNNs), for tasks such as fruit classification, yield estimation, and ripeness analysis.
- The Communication Layer connects the system to the farmer through a Telegram bot, which provides real-time updates on yield estimates, inventory levels, and harvest readiness. The bot also helps manage customer orders and sales.
- The User Interface Layer enables interaction between the farmer and the customer through the Telegram bot. It allows the farmer to manage inventory, track sales, and receive notifications about orders and stock levels.

This architecture is designed to be scalable, modular, and efficient, allowing for seamless automation of fruit yield monitoring and sales management. It provides real-time insights, helping farmers make informed decisions, while also enabling direct engagement between farmers and consumers. This structure ensures that as farming operations grow, the system can easily adapt, much like a toolkit where new tools can be added without disrupting the overall function. By streamlining processes and improving accessibility, the system enhances both productivity and profitability.

IMPLEMENTATION

The proposed system combines the ESP32CAM module, machine learning, cloud analytics, and a Telegram bot to automate fruit yield monitoring, quality assessment, and direct sales management. It integrates real-time image

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processing, data-driven decision-making, and direct-to-consumer sales, offering farmers a seamless solution for managing their crops and sales efficiently.

The ESP32-CAM module is placed in the field or orchard to capture high-resolution images of the fruits. It performs basic preprocessing locally, such as detecting and counting fruits and conducting initial quality checks using simple machine learning models. This reduces data transfer and speeds up processing. The captured data, including fruit type, quantity, and quality score, is then securely sent to a cloud server for further analysis.

In the cloud data processing layer, advanced deep learning models are used for detailed fruit classification and ripeness detection. The platform also integrates environmental data like temperature and humidity, along with historical yield information, to provide predictive analytics. These models help farmers optimize harvest timing, predict yields, and manage inventory, generating actionable insights for better decision-making, such as pricing strategies and harvest windows.

The Telegram bot acts as the user interface for both farmers and customers, offering real-time notifications about crop status, yield estimates, and sales updates. Farmers can use the bot to manage inventory, set harvest schedules, and receive recommendations. It also supports direct sales, allowing customers to place orders and make payments through Telegram, which helps farmers bypass intermediaries and increase profitability.

This system combines edge processing with the ESP32-CAM and cloud-based analytics, offering scalability and efficiency. It helps reduce labor costs, improve decision-making, and enable direct consumer engagement, making the agricultural process more streamlined, profitable, and data-driven for farmers.

CONCLUSION

The proposed system for automated fruit yield monitoring, quality assessment, and direct sales management presents an innovative solution for contemporary agriculture. By utilizing the ESP32-CAM module, artificial intelligence (AI), cloudbased analytics, and a Telegram bot, farmers can effortlessly track the development of their crops, forecast harvest volumes, and fine-tune harvest schedules. The direct-to-consumer sales platform boosts profitability by eliminating intermediaries, ensuring that farmers receive a greater share of the revenue. This data-driven approach not only minimizes labour and operational expenses but also equips farmers with timely, actionable insights to make more informed decisions. In turn, this fosters more efficient, ecofriendly farming practices while strengthening the relationship between farmers and consumers.

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