Vegetable Detection and Automated Bill Generation

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***Abstract*—The Automated Vegetable Detection and Billing System is an intelligent retail solution designed to automate vegetable identification, weight measurement, price calculation, and bill generation using artificial intelligence and embedded system technology. The proposed system uses a camera module to capture images of vegetables and the YOLOv8 object detection algorithm to identify and classify different vegetable categories. A load cell connected to an HX711 amplifier measures the weight of vegetables, while the ESP32 microcontroller coordinates sensor readings and billing operations. Based on the detected vegetable category, measured weight, and predefined price per kilogram, the system calculates the total cost and displays billing details on an LCD or OLED screen. This approach reduces manual effort, minimizes billing errors, and improves checkout efficiency in supermarkets, grocery stores, and vegetable retail shops. The system can be further enhanced with digital payments, automatic receipt generation, and inventory management to support smart retail automation.**

***Index Terms*—Automated Vegetable Detection, YOLOv8, Deep Learning, Computer Vision, ESP32, Load Cell, HX711, Automatic Billing, Smart Retail**

I. Introduction

The rapid development of artificial intelligence, computer vision, and embedded system technologies has created new opportunities for automating routine activities in retail environments. In traditional vegetable shops and supermarkets, identifying vegetables, measuring their weight, calculating prices, and preparing bills are generally performed manually by shopkeepers or billing staff.

These processes require continuous human involvement and may lead to errors in vegetable identification, weight measurement, price calculation, and billing. As customer demand increases, manual billing can also cause delays and reduce the overall efficiency of the checkout process.

To overcome these challenges, the Automated Vegetable Detection and Billing System is proposed as an intelligent solution that combines image processing, machine learning, weight measurement, and automatic billing.

The proposed system uses a camera module to capture images of vegetables placed on a designated platform. The captured images are processed using computer vision techniques, and the YOLOv8 object detection algorithm identifies and classifies vegetables according to visual characteristics such as shape, colour, texture, and appearance.

The detection model is trained using a labelled dataset containing images of different vegetable categories, allowing it to recognize supported vegetables during operation. OpenCV and Python can be used for image processing and model execution.

In addition to vegetable identification, the system incorporates a load cell connected to an HX711 amplifier module to measure the weight of vegetables placed on the weighing platform.

The measured weight is transferred to the ESP32 microcontroller, which coordinates sensor readings and billing operations. The system retrieves the predefined price per kilogram associated with the detected vegetable category and calculates the total cost.

$$\text{Total Price} = \text{Weight (kg)} \times \text{Price per kg} \quad (1)$$

For example, if a customer purchases 2 kg of potatoes at Rs. 30 per kilogram, the system calculates the total price as Rs. 60.

The ESP32 acts as the main embedded controller for sensor interfacing, display management, and communication with the device running the vegetable detection model.

Since a standard ESP32 has limited resources for running a full YOLOv8 model, image processing may be performed on a connected computer or suitable edge-processing device, while the ESP32 manages hardware and billing functions.

The main objective of the system is to simplify vegetable retail operations by reducing manual effort, improving billing speed, and minimizing errors during identification, weighing, and price calculation.

II. Literature Review

The development of automated vegetable detection and billing systems is driven by advancements in artificial intelligence, computer vision, machine learning, and embedded technologies.

Traditional billing methods require manual vegetable identification, weight measurement, price selection, and bill calculation, which can lead to delays and errors.

Automated systems address these challenges by combining image recognition, electronic weighing, and digital billing to improve checkout speed, accuracy, and efficiency.

Conventional vegetable billing depends on manual identification, weighing, and price calculation. Since fresh vegetables generally do not carry barcodes, automated visual identification offers an effective alternative for simplifying retail transactions.

Artificial intelligence enables vegetable recognition through image processing and deep learning. Models analyze visual characteristics such as colour, shape, texture, and size to distinguish different vegetable categories.

YOLOv8 is a deep learning model capable of detecting and classifying objects efficiently. In the proposed system, a camera captures vegetable images, and the trained model identifies the corresponding category.

Electronic load cells measure vegetable weight, while the HX711 module amplifies and converts sensor signals into digital readings. The measured weight and predefined price per kilogram are combined to calculate the total cost.

The ESP32 acts as the central controller for managing sensor readings, billing operations, and communication with the display.

Several research studies have investigated related automated retail technologies.

Sudhakara H. M., Rakshita C. U., and Rashmi K. proposed an IoT-based vegetable vending machine in April 2022. The system uses load cells to measure vegetable quantities and calculate prices. Cloud computing and digital payment facilities support automated transactions.

Kuntal Gorai, S. V. S. C. Santosh, and Skanda S. proposed an automated shopping cart in 2023. The system combines deep learning models, smartphone cameras, and weight sensors for automated product identification and billing. MobileNetV2 and EfficientNetV2 are used to classify products.

Kishen Vivel Mascarenhas, Nihal C., and Nagarjuna T. introduced an AI-powered autonomous checkout system in May 2024. The system integrates computer vision, machine learning, and weight sensors to support product recognition, automatic billing, and inventory monitoring.

Zaiba Khan, Shivam Rawat, and Satyendra Kumar explored computer vision for automated grading and sorting of fruits and vegetables in July 2025. The study considers colour, shape, size, texture, and visible defects using techniques such as CNNs, YOLO, and MobileNetV2.

Safaina Khan Oishi, Md. Minhazul Islam, and Shakhar Das Rony presented a hybrid YOLOv8-based grocery detection and billing system in April 2026. A custom dataset containing 1,109 images across 27 categories was used to evaluate YOLO models. The study reported YOLOv8s as a suitable balance between detection accuracy and computational efficiency.

The reviewed studies demonstrate the potential of computer vision, deep learning, electronic weighing, and embedded technologies for automating retail billing.

The proposed Vegetable Detection and Automated Billing System combines these technologies to provide an integrated solution for vegetable identification, weight measurement, price calculation, and bill generation.

III. Methodology

The methodology of the Automated Vegetable Detection and Billing System involves integrating computer vision, deep learning, weight measurement, embedded control, and automatic price calculation.

The system identifies vegetables using a camera and YOLOv8, measures their weight using a load cell, and calculates the total cost based on predefined prices.

A. Image Acquisition

A camera module captures images of vegetables placed on the weighing platform. The captured images are transferred to a computer or suitable edge-processing device for analysis.

B. Image Preprocessing

The captured images are processed using Python and OpenCV. Preprocessing operations such as image resizing, normalization, and adjustment of image dimensions are performed to prepare the images for the detection model.

C. Vegetable Detection and Classification

The YOLOv8 object detection model analyzes the processed images and identifies the vegetable category.

A trained model uses visual characteristics such as shape, colour, and texture to classify supported vegetables. The detected vegetable name and confidence score are generated as output.

D. Weight Measurement

The vegetables are placed on a weighing platform connected to a load cell.

The load cell converts the applied load into an electrical signal, while the HX711 amplifier converts the signal into digital readings.

The ESP32 reads the sensor data and calculates the corresponding weight after proper calibration.

E. Price Database Access

After identifying the vegetable, the system retrieves its predefined price per kilogram from a price database or lookup table.

This database can be updated whenever vegetable prices change.

F. Automatic Price Calculation

The system calculates the cost using the measured weight and corresponding price per kilogram.

$$P = W \times R \quad (2)$$

Where P represents the total price, W represents the weight in kilograms, and R represents the price per kilogram.

G. Embedded System Integration

The ESP32 coordinates load cell readings, billing logic, display operations, and communication with the device running the YOLOv8 model.

Since a standard ESP32 generally cannot run the full YOLOv8 model directly, vegetable detection is performed on a connected computer or suitable edge-processing device.

H. Display of Billing Information

The vegetable name, measured weight, price per kilogram, and calculated amount are displayed on an LCD or OLED screen.

This allows customers and shopkeepers to verify billing details before completing the transaction.

I. Multiple-Item Billing

When multiple vegetable items are purchased, the system records each item's name, weight, and price.

The individual amounts are added together to calculate the final bill.

J. Testing and Validation

The complete system is tested using different vegetable categories and known weights.

The detected vegetable names are checked against actual items, load cell readings are compared with reference weights, and calculated prices are verified manually.

Testing under different lighting conditions and repeated trials helps identify limitations and improve system reliability.

IV. Problem Statement

In traditional vegetable shops and supermarkets, vegetable identification, weight measurement, price calculation, and billing are commonly performed manually.

This process requires continuous human involvement and can result in incorrect vegetable identification, inaccurate weight measurement, billing errors, and long checkout queues.

Fresh vegetables generally do not contain barcodes, making conventional barcode-based checkout systems less suitable for automatic identification.

Shopkeepers must manually recognize vegetables, select prices, measure weight, and calculate the payable amount.

These activities become time-consuming when many customers are present.

Therefore, an intelligent automated system is required to identify vegetables using computer vision, measure their weight electronically, calculate prices, and generate billing information with minimal manual intervention.

V. Objectives

The main objective of the Automated Vegetable Detection and Billing System is to develop an intelligent retail solution that simplifies vegetable identification, weighing, and billing.

The major objectives are:

1) To identify and classify different types of vegetables using a camera and the YOLOv8 object detection algorithm.
2) To process captured vegetable images using computer vision techniques.
3) To measure vegetable weight using a load cell connected to an HX711 amplifier.
4) To calculate the total cost based on the detected vegetable category, measured weight, and predefined price per kilogram.
5) To use the ESP32 microcontroller for coordinating sensor readings and display operations.
6) To display the vegetable name, measured weight, price per kilogram, and total amount on an LCD or OLED screen.
7) To reduce manual effort and minimize billing errors.
8) To provide a flexible system that can support digital payments, receipt generation, inventory tracking, and transaction management in the future.

VI. Existing System and Proposed System

A. Existing System

In the existing vegetable billing system, shopkeepers manually identify vegetables and place them on weighing scales.

The measured weight is used to calculate the cost based on the vegetable's price per kilogram.

This process depends heavily on human involvement and may lead to incorrect product selection, calculation errors, and delays during busy shopping hours.

The absence of automated visual identification makes it difficult to streamline billing operations.

B. Proposed System

The proposed Automated Vegetable Detection and Billing System integrates computer vision, electronic weighing, and embedded system technology.

A camera captures the vegetable image and transfers it to the image-processing device.

The YOLOv8 model identifies the vegetable category using its trained dataset.

A load cell connected to an HX711 module measures the weight of the vegetable.

The ESP32 receives sensor readings and coordinates billing operations.

The system retrieves the corresponding price per kilogram and calculates the total amount automatically.

The vegetable name, weight, unit price, and total cost are displayed on an LCD or OLED screen.

The proposed system aims to reduce manual effort, improve billing consistency, and increase checkout efficiency.

VII. System Flow

The Automated Vegetable Detection and Billing System follows a systematic process that combines image recognition, weight measurement, and automatic billing.

The major steps are described below.

A. Vegetable Placement

The customer or shopkeeper places a vegetable on the weighing platform.

B. Image Capture

A camera module captures an image of the vegetable placed on the platform.

C. Vegetable Identification

The captured image is processed using OpenCV and the trained YOLOv8 model.

The system identifies the vegetable category and produces a detection result.

D. Weight Measurement

The load cell measures the vegetable weight, and the HX711 module converts the sensor signal into digital data.

The ESP32 reads the weight information.

E. Price Retrieval

The system retrieves the predefined price per kilogram for the detected vegetable from a database or lookup table.

F. Bill Calculation

The measured weight is multiplied by the corresponding price per kilogram to calculate the total amount.

G. Billing Display

The detected vegetable name, measured weight, unit price, and total cost are displayed on the LCD or OLED screen.

H. Final Bill Generation

For multiple vegetable items, the individual amounts are added together to calculate the final bill.

VIII. Technologies Used

The proposed system integrates hardware and software technologies for automated vegetable detection and billing.

A. Python

Python is used for implementing image processing, machine learning, and vegetable detection operations.

B. YOLOv8

YOLOv8 is a deep learning object detection algorithm used to identify and classify different vegetable categories from captured images.

C. OpenCV

OpenCV is used for image acquisition, resizing, preprocessing, and handling camera images before detection.

D. ESP32 Microcontroller

The ESP32 acts as the embedded controller for sensor interfacing, weight data processing, communication, and display management.

E. Load Cell

The load cell is used to measure the weight of vegetables placed on the weighing platform.

F. HX711 Amplifier

The HX711 module amplifies the load cell signal and converts it into digital readings for the ESP32.

G. Camera Module

The camera captures vegetable images that are processed by the YOLOv8 detection model.

H. LCD or OLED Display

The display presents the vegetable name, measured weight, price per kilogram, and total billing amount.

I. Price Database

A database or lookup table stores vegetable categories and their corresponding prices per kilogram.

The stored prices can be updated according to market requirements.

IX. Results

The proposed Automated Vegetable Detection and Billing System provides an approach to automating vegetable identification, weight measurement, and price calculation.

The YOLOv8 object detection model identifies and classifies supported vegetables from camera images, while the load cell connected to the HX711 module measures their weight.

The ESP32 coordinates sensor readings and billing operations.

The system calculates the total cost using the predefined price per kilogram.

Billing details including vegetable name, weight, unit price, and total amount are displayed on an LCD or OLED screen.

The proposed system can reduce manual intervention, minimize calculation errors, and improve checkout efficiency in vegetable shops and supermarkets.

Actual detection accuracy, weight measurement error, and processing speed must be evaluated through hardware testing and experimental trials.

X. Conclusion

The Automated Vegetable Detection and Billing System integrates artificial intelligence, computer vision, and embedded system technology to simplify vegetable retail billing operations.

By combining YOLOv8-based vegetable recognition with load cell-based weight measurement and automatic price calculation, the system offers a convenient alternative to traditional manual billing methods.

The ESP32 manages sensor interfacing and display operations, while a connected computer or suitable edge-processing device executes the vegetable detection model.

The system is designed to improve billing speed, reduce human errors, and provide clear billing information to customers and shopkeepers.

With further improvements in detection accuracy, sensor calibration, and system integration, the system can be enhanced with digital payments, receipt generation, inventory management, and cloud-based transaction records.

These improvements can make the proposed system a promising solution for smart retail applications.

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