International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 11 | Nov - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

DIY Smart Vending Machine Using Arduino

[1]Mrs.G.Swathi, [2]R.Vanshika, [3]Ch.Kavya, [4]V.Manasa

[1]Assistant Professor, Department Of ECE, Vignan's Institute of Management and Technology for Women, Ghatkesar, Telangana.

[2,3,4]B.Tech Students, Department Of ECE, Vignan's Institute of Management and Technology for Women, Ghatkesar, Telangana.

ABSTRACT

The project focuses on the designing of the vending machine using Arduino and evaluating its performance. This project presents the design and implementation of an intelligent vending machine that utilizes real-time color detection through a webcam to automate the item dispensing process. The system employs a webcam to capture the color of an object presented in front of the machine (e.g., a colored card or object). Using computer vision techniques and color space analysis, the dominant color is identified and mapped to a specific item stored within the vending machine. Once the color is recognized, a microcontroller-based mechanism is triggered to dispense the corresponding product. This hands-free, intuitive interaction model provides a novel user experience and opens possibilities for accessibility-focused and contactless vending solutions. The system demonstrates practical integration of hardware and software components including a webcam, color recognition algorithm (via OpenCV), and actuators controlled through a microcontroller (such as Arduino). The project highlights applications in smart retail, education, and interactive installations.

Keywords: Colour Detection, Open CV, Webcam-Based Recognition, Item Dispensing Mechanism, Microcontroller Control.

I. INTRODUCTION

Vending Machines are there since very long time, and they have changed much with the time. Vending machines have revolutionized the way goods are distributed in public and commercial spaces by offering convenience, automation, and around-the-clock availability. Traditionally, these machines function through mechanical or digital input methods such as buttons, keypads, or touchscreens. While effective, these conventional interfaces can pose limitations in terms of hygiene, accessibility, and user interaction— especially in contexts where minimizing physical contact is important, such as during pandemics or in sterile environments like hospitals and laboratories.

This project explores a novel approach to vending machine interaction by eliminating the need for direct physical input. The system introduces a smart, color-detection-based vending machine that uses a webcam and computer vision algorithms to identify user intent. Instead of pressing buttons or navigating digital menus, users can interact with the machine simply by presenting a colored object, card, or marker in front of the camera. Once the system detects and processes the color, it maps it to a corresponding product and triggers the dispensing mechanism for that item.

The core functionality of the system is powered by OpenCV, an open-source computer vision library used for real-time color recognition and image processing. The live video feed from the webcam is analyzed to extract the dominant color within a specified detection region. This color is then matched against a predefined set of color-product associations stored within the system's logic. Upon a successful match, a microcontroller—such as an Arduino —controls a servo or stepper motor to release the selected item from the machine.

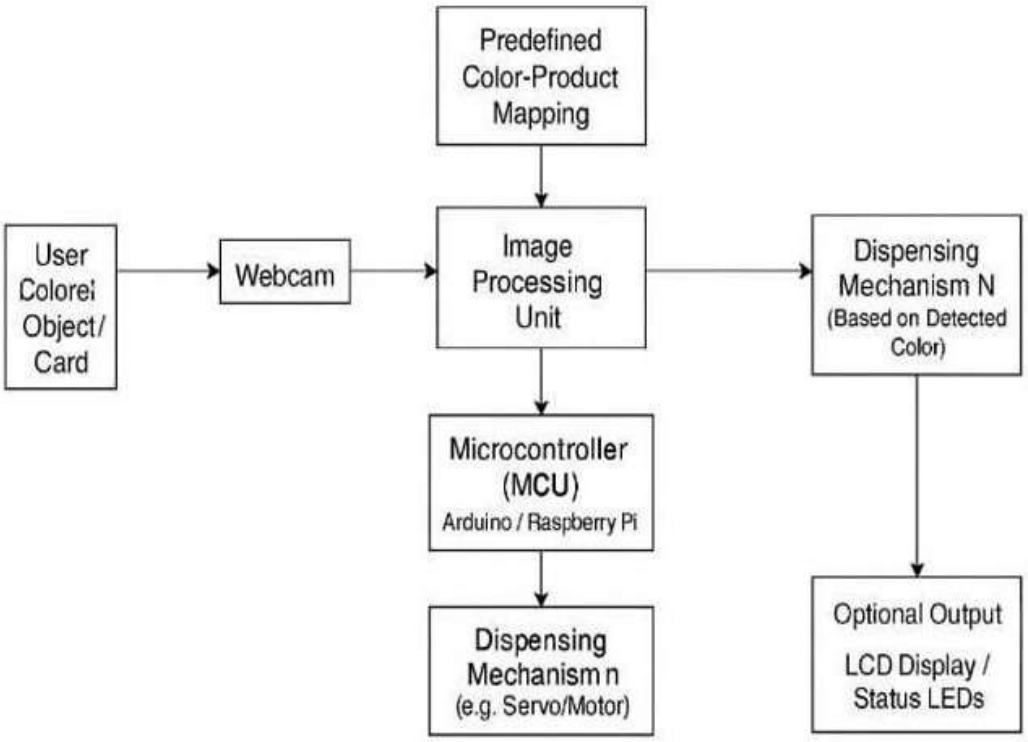


FIG 1: BLOCK DIAGRAM

II. LITERATURE REVIEW

1. TITLE: SMART WATER ATM

ABSTARCT: Access to clean and safe drinking water remains a significant challenge in many parts of the world. The Smart Water ATM system addresses this issue by providing a technologically advanced, automated solution for the distribution of purified drinking water in a controlled, efficient, and user-friendly manner. Unlike traditional water supply methods, this system allows users to access water through digital means, such as prepaid cards, QR codes, or mobile applications, ensuring both fair usage and accountability.The Smart Water ATM integrates multiple technologies, including microcontrollers (e.g., Arduino or Raspberry Pi), flow sensors, solenoid valves, and RFID or QR code scanners. The machine dispenses water only after successful user authentication and deducts the corresponding amount from the user's balance. Additionally, it features real-time monitoring of water quality parameters (such as TDS and pH), automated logging, and IoT- based connectivity for remote management and maintenance alerts.This system not only promotes sustainable water usage and transparency but also ensures equitable access in rural and urban areas alike. It is particularly beneficial in locations with unreliable water distribution infrastructure or where manual supervision is impractical. Through this project, we aim to demonstrate how embedded systems and smart technologies can be leveraged to tackle essential public utility challenges in an innovative and scalable manner.

2. TITLE: RFID-BASED WATER DISPENSER

ABSTRACT: The RFID-Based Water Dispenser is an intelligent and automated solution designed to manage and regulate the distribution of drinking water using Radio Frequency Identification (RFID) technology. The system operates by issuing RFID cards to users, each linked to a unique ID and associated water usage quota or balance. When a user scans their card at the dispenser, the system authenticates the ID, checks the available balance, and dispenses a predefined quantity of water accordingly. This ensures controlled and accountable water distribution, minimizing wastage and preventing misuse. The system is built using a microcontroller (such as Arduino or Raspberry Pi), an RFID reader module, flow sensors, solenoid valves, and a display interface to show real-time status or remaining balance. Optional integration with IoT platforms allows for cloud-based monitoring, remote data logging, and automated refilling alerts.This solution is particularly effective in environments where water conservation and equitable access are critical—such as schools, hostels, rural communities, and public facilities. It promotes responsible water usage by encouraging users to manage their consumption efficiently while enabling administrators to track and monitor usage data in real-

time.By combining RFID technology with embedded systems and automation, the project demonstrates a practical and scalable approach to sustainable water management.

III. SYSTEM ARCHITECTURE AND COMPONENTS

1. System Overview:

The vending machine operates by continuously analyzing the live video feed from a webcam to detect specific colors presented by the user (e.g., through colored cards or objects). Upon detecting a valid and predefined color, the system maps it to a corresponding product and activates a motorized mechanism to dispense the selected item.

2. Core Components:

A. Webcam (Input Device):

- Captures real-time video feed from the user.
- Positioned at the front of the machine to provide a clear field of view.

B. Computer Vision and Color Detection (Software Logic):

- Implemented using OpenCV in Python.
- Analyzes a specific region of interest (ROI) in each frame.
- Detects the dominant color using HSV (Hue, Saturation, Value) color space filtering.

C. Microcontroller or Embedded System:

- Typically an Arduino or Raspberry Pi is used.
- Acts as the bridge between the software (color detection system) and the hardware (dispensing mechanism).
- Receives commands from the computer vision program to actuate motors.

D. Dispensing Mechanism:

- Uses servo motors, DC motors, or stepper motors to control item release.
- Each motor is linked to a specific compartment or product slot.

E. Power Supply:

- Provides sufficient voltage and current for both computational units and electromechanical components.
- May include backup power (battery or UPS) for uninterrupted operation.

F. Display Unit:

- An LCD display may be included to show messages like “Color Detected,” “Dispensing Item,” or error/status notifications.

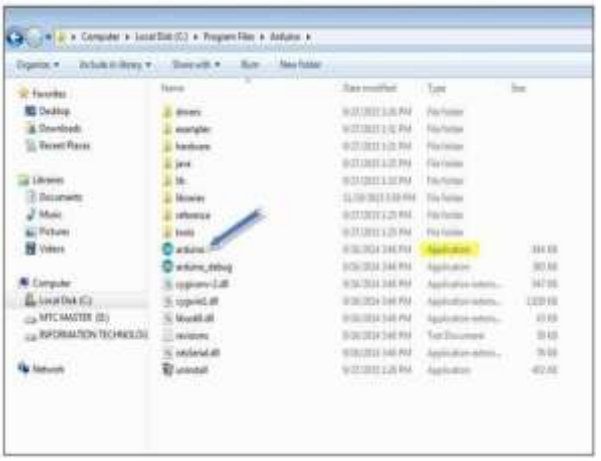
IV. WORKING PRINCIPLE

The smart vending machine operates by using a webcam to monitor a live video feed and detect the color of an object presented by the user. Using OpenCV, the system processes each frame and identifies the dominant color within a specific region. Once the color is recognized, the Python program sends a corresponding command to the Arduino via serial communication. The Arduino receives this signal and triggers the appropriate servo motor, which rotates to dispense the product assigned to that color. An LCD display shows the detected color and dispensing status, making the process simple, contactless, and fully automated. This integration of computer vision with microcontroller-based actuation forms the core working principle of the smart vending machine.

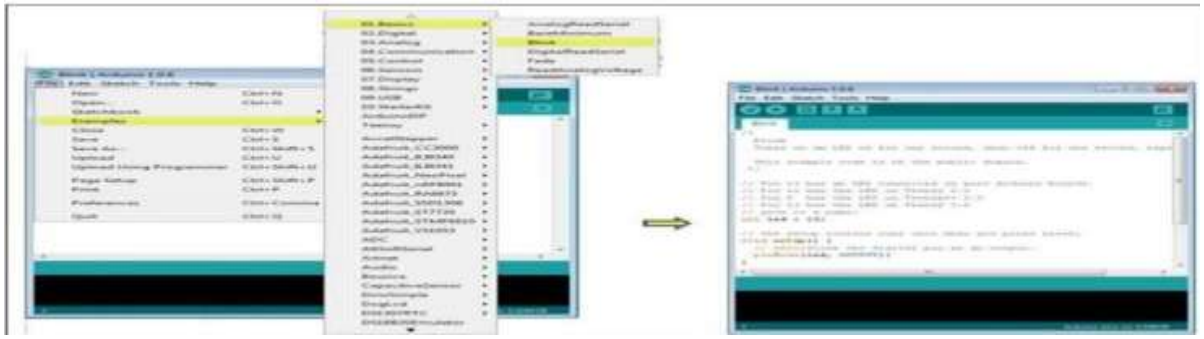
The webcam captures a live video stream and sends it to the processing unit **and** computer vision algorithm identifies the dominant color within a defined ROI. The detected color is compared against stored color-product mappings. If a match is found, the system sends a signal to the microcontroller. The microcontroller activates the appropriate motor to dispense the corresponding item.

Arduino IDE Software, you can get different versions of Arduino IDE from the Download page on the Arduino Official website. You must select your software, which is compatible with your operating system (Windows, IOS, or Linux).

After your file download is complete, unzip the file.



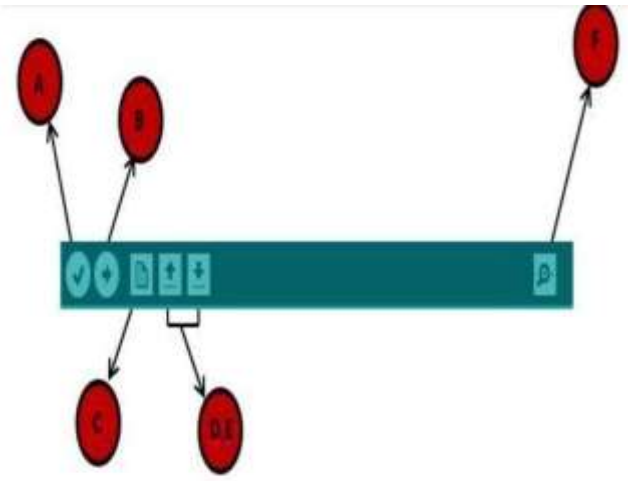
Here, we are selecting just one of the examples with the name Blink. It turns the LED on and off with some time delay. You can select any other example from the list. Select your serial port. Select the serial device of the Arduino board. Go to Tools -> Serial Port menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your Arduino board and re-open the menu, the entry that disappears should be of the Arduino board. Reconnect the board and select that serial port.



Before explaining how we can upload our program to the board, we must demonstrate the function of each symbol appearing in the Arduino IDE toolbar.

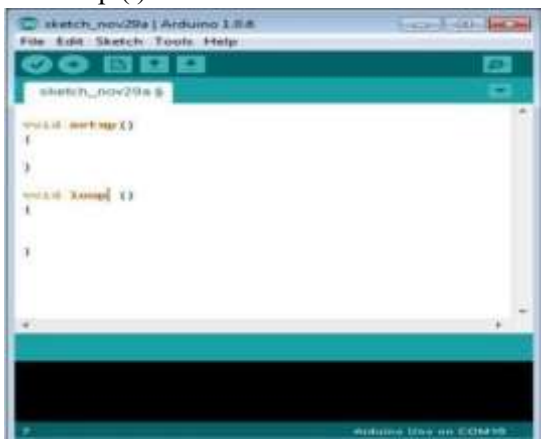
A- Used to check if there is any compilation error.

B- Used to upload a program to the Arduino board.
C- Shortcut used to create a new sketch.
D- Used to directly open one of the example sketches.
E- Used to save your sketch.
F- Serial monitor used to receive serial data from the board and send the serial data to the board.
Now, simply click the "Upload" button in the environment. Wait a few seconds; you will see the RX and TX LEDs on the board, flashing. If the upload is successful, the message "Done uploading" will appear in the status bar.



In this tutorial, we will learn about the Arduino software program, step by step, and how we can write the program without any syntax or compilation error. Let us start with the Structure. Software structure consists of two main functions:

- Setup ( ) function
- Loop ( ) function



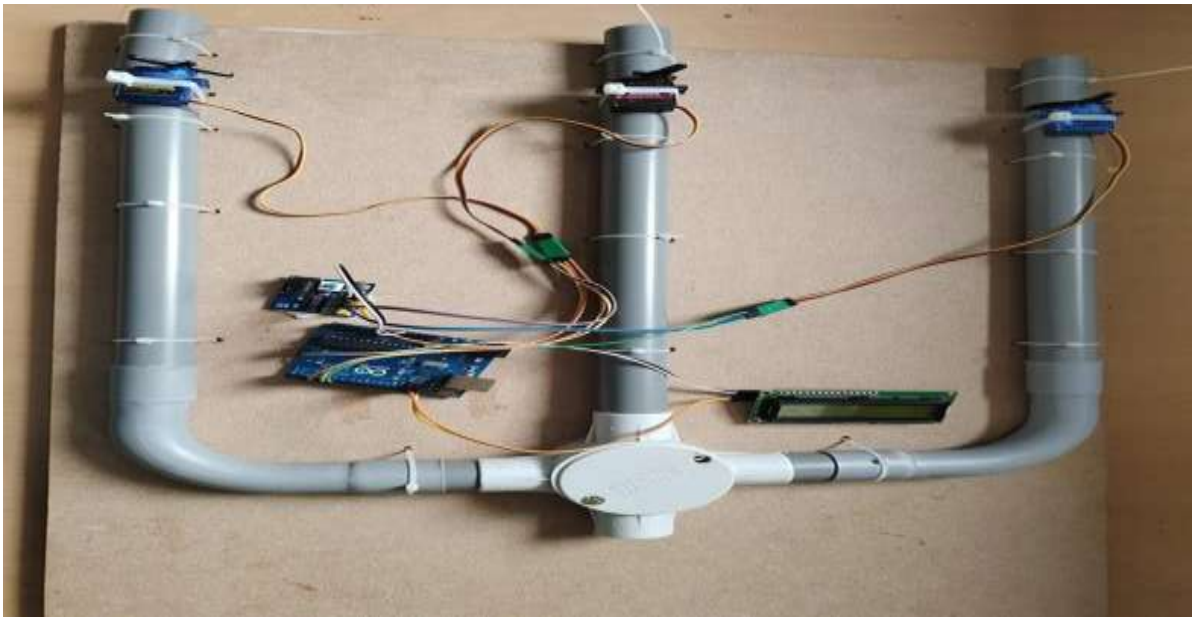
Data types in C refer to an extensive system used for declaring variables or functions of different types. The type of a variable determines how much space it occupies in the storage and how the bit pattern stored is interpreted. The following table provides all the data types that you will use during Arduino programming.

V. RESULTS

The prototype of the DIY Smart Vending Machine was successfully built and tested, demonstrating smooth integration of the webcam-based color detection system with the Arduino-controlled dispensing mechanism. When a colored object was shown to the camera, the system accurately identified the color and activated the corresponding servo motor to release the correct item. The hardware connections, including the Arduino, servos, LCD, and power modules, operated

reliably, confirming the effectiveness of the design. The physical setup matched the expected workflow, proving that the system can dispense products automatically and contactlessly based on real-time color recognition.

The developed smart vending machine prototype successfully validated the concept of color-based item dispensing using Arduino and computer vision.



VI. FUTURE ENHANCEMENTS

The future scope of the Color-Based Smart Vending Machine project is vast, with several opportunities for enhancement and real-world application. The system can be integrated with digital payment methods like UPI or NFC to support secure transactions, making it suitable for commercial use. Advancements in computer vision, such as AI-based object and gesture recognition, can improve accuracy and expand input options beyond basic color detection. Additionally, incorporating IoT features can enable remote monitoring, smart inventory tracking, and real-time system updates. For greater accessibility, alternatives like voice control, QR codes, or shape recognition can be added to accommodate users with color vision deficiencies. With these improvements, the system could serve not only in retail but also in healthcare, educational institutions, and public service environments, offering a scalable, hygienic, and user-friendly automation solution.

VII. CONCLUSION

The Color-Based Smart Vending Machine project successfully demonstrates the integration of computer vision and embedded systems to create an innovative, contactless product dispensing solution. By replacing traditional input methods with real-time color detection via a webcam, the system provides a more hygienic, accessible, and user-friendly interface—particularly useful in public and high-risk environments. Through the use of OpenCV for image processing and a microcontroller-based actuation system, the project effectively showcases how intelligent automation can enhance everyday machines. The flexibility to map multiple colors to different items, combined with the modular design, allows for easy customization and scalability.

Moreover, the low-cost components and open-source software ensure the system remains economical and practical for deployment in real-world scenarios. This project not only advances the concept of smart vending systems but also highlights the broader potential of computer vision in human-machine interaction. It serves as a prototype for future developments in intelligent retail, public automation, and assistive technologies.

VIII. REFERENCES

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