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From Traditional to Digital: An Analysis of Vending Machine System Evolution

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Abstract

This paper proposes a smart vending machine system that makes use of Internet of Things (IoT), Unified Payments Interface (UPI), Radio-Frequency Identification (RFID), product level detection, and GPS/GPRS notification to provide a more efficient, secure, and easy vending experience for operators and customers. RFID is used for user authentication, and UPI facilitates payment transactions so that users can quickly make purchases without using cash or credit cards. Product level detection makes sure that products are always available, and it notifies the vending machine operator via GPS and GPRS when product levels fall below a set threshold, allowing for timely replenishment. The technology provides vending machine operators with a number of benefits. Operators may remotely monitor inventory levels, sales data, and equipment status thanks to the IoT platform's real-time monitoring and management features. By using this data, you may lower operating expenses, improve customer satisfaction, and optimize product mix and price. In conclusion, the suggested smart vending machine technology has the ability to completely transform the vending machine market. IoT-enabled vending machines can increase sales and profitability by giving customers a more convenient and secure experience, reducing operator expenses, and delivering insightful data about customer behavior.

Keywords: Smart vending machine, IoT, UPI, RFID, product level detection, GPS/GPRS notification.

INTRODUCTION

Even though they have been around for a while, vending machines are still a common way to buy food and beverages. Traditional vending machines do, however, have a few drawbacks. For instance, it can be challenging to refill them and they only accept cash payments [1–3].

Internet of Things (IoT)-enabled smart vending machines overcome these constraints by providing users and operators with an enhanced, safe, and effective vending machine experience. IoT sensors are used by smart vending machines to gather machine data, including temperature, status, and inventory levels. Operators of vending machines can then examine this data by sending it to the cloud. Operators of vending machines can manage inventory levels, optimize the product mix and pricing, cut expenses, and raise consumer happiness by using the data gathered by smart vending machines. Furthermore, smart vending machines provide a safer and more convenient shopping experience. Customers can, for instance, examine the machine's inventory, make purchases, and even place pre-orders via mobile apps. Customers might also be offered loyalty programs and other incentives by smart vending machines.

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All things considered; smart vending machines have the power to completely transform the vending machine market. Vending machines that are enabled by the IoT can enhance sales and profitability by delivering a more convenient and secure experience for customers, decreasing expenses for operators, and offering insightful data about customer behavior [4].

PROPOSED METHOD

The Raspberry Pi 3 Board will be used in the smart vending machine system project to gather data from sensors and Radio-Frequency Identification (RFID) tags [5, 6]. The data will then be sent to the cloud for processing and analysis. After that, the data will be utilized by the cloud-based system to manage the vending machine, including product dispensing, payment processing, and operator notifications.

BLOCK DIAGRAM

Block diagram of proposed method is shown in Figure 1.

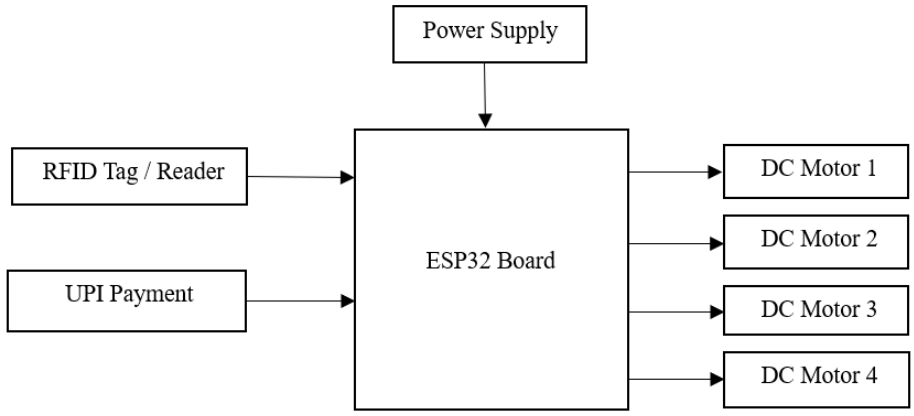

Figure 1. Block diagram of information flow.

LITERATURE REVIEW

A review of scholarly materials (books, journal articles, theses, etc.) pertaining to a particular subject or research question is called a literature review. It is frequently written as a component of a research paper, thesis, or dissertation to help you place your work in context with what has already been discovered. These are some data that we gathered from our survey. In order to provide a comprehensive picture of the state of knowledge on the topic, a good literature review (as shown in Table 1) does more than just list sources; it also analyzes, synthesizes, and critically assesses.

Table 1. Narrative survey in tabulated form.

Title	Author	Methodology
RFID technology: beyond cash-based methods in vending machine	Aneeqa Ramzan, Saad Rehman, Aqib Perwaiz	The methodology integrates passive RFID cards and Arduino Mega with SPI protocol for secure authentication, featuring keypad password protection, LCD consumer information display, GSM-based SMS notifications, and a mechanical structure with DC motors for efficient product-oriented vending [6].
Modeling and optimization of item changes in vending machines	Gaku Nemoto, Kunihiko Hiraishi	This study focuses on optimizing item changes in Japanese beverage vending machines, with route men responsible for replenishment. Using an optimization model based on item utility values and vending machine state transitions, it achieves up to a 2.8% sales improvement compared to heuristic methods [1].
NuiVend – Next generation vending machine	Robert Gruen, Erich Liang	In this paper, we will discuss NuiVend's use of a variety of technologies. Such as: Microsoft Kinect, various Microsoft Cognitive API services, relay and sensor boards, as well as the overall logic of the control software. Finally, we discuss potential improvements to NuiVend, as well as Microsoft Language Understanding Intelligent Service (LUIS) techniques that can be applied to many other future NUI based projects [2].

COMPONENTS

Hardware

ESP32 Board

The ESP32 (as shown in Figure 2) is a low-cost, low-power system-on-a-chip (SoC) microcontroller that has Bluetooth and Wi-Fi built right in. Because of its advantages and versatility, it is frequently used in many different IoT applications [5, 6].

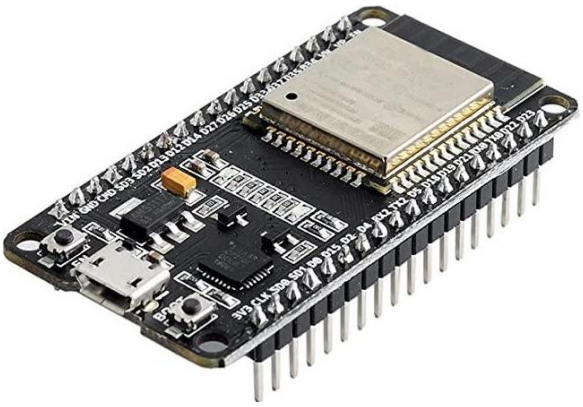

Figure 2. ESP32 board.

RFID

An RFID (as shown in Figure 3) tag is a tiny device that stores and transmits data using radio waves. RFID stands for radio-frequency identification. An antenna and a microprocessor make up an RFID tag. They can be used for tracking and identifying people, animals, or objects, among other things [7].

Figure 3. Radio-frequency identification.

Unified Payments Interface (UPI)

In India, UPI, or unified payments interface (as shown in Figure 4) is a widely used digital payment method. Utilizing their smartphones, users may send and receive money utilizing this real-time payment system. UPI facilitates interbank transactions and provides a number of advantages, such as instantaneous fund transfers, round-the-clock accessibility, and streamlined transaction processes.

DC Motor

An electric motor (as shown in 2D model in Figure 5) that is powered by direct current is known as a DC motor. Any electric motor's ability to operate depends on basic electromagnetism. When a current-carrying conductor is exposed to an external magnetic field, it produces a magnetic field; the force it experiences is proportional to the strength of the external magnetic field and the current flowing through the conductor. Excellent speed control is offered by DC motors for both acceleration and deceleration. Its drive design is inexpensive, straightforward, and easy to grasp [8].

Figure 4. UPI transfer.

Figure 5. DC motor.

Software Components

Arduino IDE

One well-liked open-source tool for programming microcontrollers is the Arduino IDE (as shown in Figure 6). It offers an easy-to-use interface for uploading and creating code. Numerous boards and microcontrollers that are Arduino-compatible are supported by the Arduino IDE. Because it uses the wiring language, which is based on C/C++, even beginners may use it. An integrated code editor with auto-completion and syntax highlighting is part of the IDE. Within the IDE, users can effortlessly control board configurations and libraries. The Arduino IDE provides a simple method for uploading code to linked devices and validating it. It works with multiple operating systems, such as Linux, macOS, and Windows. An active community of developers and enthusiasts maintains the Arduino IDE. It is still a well-liked option for academics, professionals working in embedded systems and electronics, and enthusiasts.

Figure 6. Arduino IDE.

ESP Board Support Package (BSP)

The Arduino IDE can be used to program ESP8266 and ESP32 microcontrollers with the help of the ESP BSP. Board specifications, core libraries, and a toolchain for uploading and compiling code are all included. The ESP8266 and ESP32 capabilities are demonstrated via examples and demos. Thorough documentation aids developers in comprehending requirements and features. All things considered, the ESP BSP simplifies development by providing a recognizable setting and tools designed specifically for Arduino-compatible devices.

METHODOLOGY

Hardware Innovation: Creating the hardware for the smart vending machine system is the initial stage. This will entail creating and testing the following parts:

Hardware for vending machines; IoT sensors; communication modules' strong and resilient design is required for the vending machine hardware in order to endure the demands of the environment. Accurate detection of product levels and other environmental variables should be possible with IoT sensors. Data transmission to the cloud by the communication modules must to be dependable and safe.

Algorithms

The smart vending machine system will make use of the following algorithms:

1. *Product Level Detection Algorithm*: To determine the product levels in the vending machine, this algorithm will use data from IoT sensors.
2. *Algorithms for User Authentication*: These algorithms will verify users' identities using the RFID tags.
3. The payment processing algorithm is designed to handle contactless payments through the use of UPI.

APPLICATIONS

1. *Retail Stores:* They provide intelligent vending machines with a large selection of goods and up-to-date inventory information in retail settings.
2. *Corporate Offices:* They install smart vending machines for workplace supplies, drinks, and snacks in office buildings.
3. *Manufacturing Facilities:* They provide industrial environments with refreshments and personal protective equipment for employees.

RESULTS

Payment mode and browsing of selection of product is shown in Figure 7(a) and 7(b) while product present in vending machine and product released while dispension is shown in Figure 7(c) and 7(d).

Future Scope

Predict User Preferences

To determine which products a particular user is likely to purchase, machine learning models can examine user behavior, past purchases, and product preferences. This may result in product recommendations that are more precise.

Dynamic Pricing

Depending on variables like inventory levels, demand, and the time of day, the system can dynamically modify prices. By incentivizing people to buy things that must be sold immediately, this can increase income and decrease waste.

Inventory Optimization

By anticipating when particular products would run out of stock and automatically placing reorders, machine learning algorithms can improve inventory management. This lessens the likelihood that customers would not be able to access things.

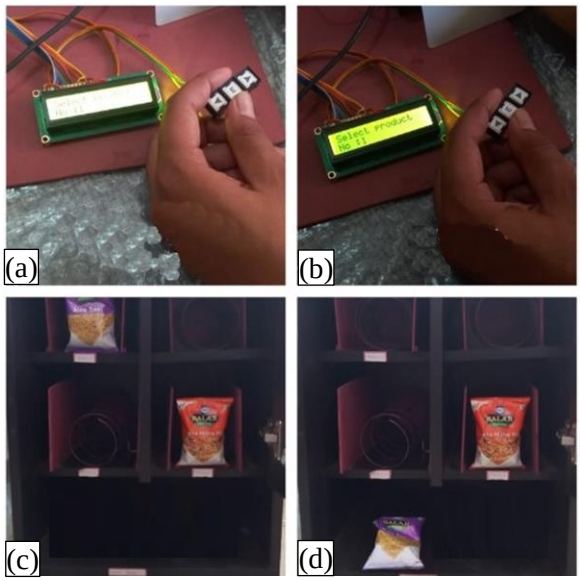

Figure 7. Panel (a) shows payment modes: RFID/UPI, panel (b) shows browsing the product, panel (c) shows products in the vending machine, and panel (d) shows product dispension.

CONCLUSION

In this article, it has been described how we used IOT technology to create a sales strategy for smart vending machines. It could comprehend vending machine marketplaces and purchasers. In an attempt to alter sales and boost profit, face recognition is used to assess the vending machine's primary source of income.

Acknowledgment

We are feeling very humble in expressing our gratitude. It will be unfair to bind the precious help and support that we got from many people in few words. But words are the only media of expressing one's feelings and my feeling of gratitude is absolutely beyond these words. It would be my pride to take this opportunity to say the thanks.

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