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Development of an Automated Coin Slot Sales Tracking System Using Microcontroller

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Abstract: This study addresses the prevalence of fraudulent activities and revenue inconsistencies in Pisonet businesses caused by reliance on manual monitoring methods. The primary objective of the project is to develop an Automated Coin Slot Sales Tracking System using a microcontroller to enhance financial transparency and operational efficiency. The system was developed using the Modified Waterfall SDLC model, covering requirements gathering through deployment, and was built using ESP32 microcontrollers, Firebase Firestore, Next.js, and Tailwind CSS for its implementation. It is intended for Pisonet business owners and branch partners, offering features such as real-time coin counting, automated financial reporting, offline data synchronization, and multi-branch management. Testing and evaluation show that the system achieves high accuracy in recording transactions, maintains stable connectivity via a dedicated network, and provides an organized interface that simplifies sales verification. The project effectively establishes a transparent digital audit trail that minimizes human error and prevents fraud, though physical security against altered coins remains dependent on the coin slot hardware.

Keywords: *Pisonet, Automation, Sales Tracking, ESP32, Internet of Things, Next.js, Firebase.*

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I. INTRODUCTION

Innovations in Information Technology have revolutionized the business sector by automating many manual tasks, greatly improving efficiency. This is evident in the ever-growing industry where technology is almost everywhere, integrated even in day-to-day lives. These innovations have enabled business owners to have a more comprehensive view of their entire business and allow better management.

[1] Among these advancements, vending machines have become a popular means of delivering products and services, evolving into various types to meet functional demands and customer needs, including IoT-based and nonIoT-based models (Ratnasri & Sharmilan, 2021). Microcontrollers are one of the biggest reasons why these advancements are possible, because they allow what normally couldn't be done with a regular computer, mainly due to their size, which makes these machines compact and can be easily maintained and transported.

While this progress has enabled vending machine owners to simplify their operations, it has also contributed to a rise in fraudulent activities within the Pisonet industry, more specifically when dealing with sales, where there is no proper sales monitoring when it comes to Pisonet units Fraudulent activities in the vending machine industry can lead to significant financial losses, compromising business stability and reducing stakeholder trust. Without an effective tracking system, business owners may find it challenging to identify discrepancies or ensure fair revenue distribution. This highlights the relevance of developing an automated and real time sales tracking system to improve accuracy and prevent revenue losses. [1] Moreover, recent studies show a growing preference for automated operations, cashless payments, and advanced technologies in vending machines, further supporting the need for modernized systems (Ratnasri & Sharmilan, 2021).

The primary stakeholders include Pisonet business owners, employees, and business partners. Real-time sales tracking empowers owners to manage multiple branches efficiently. The ability to monitor sales remotely on a mobile or web application should allow the owner to fully trust their employees in managing the harvest. The transparency brought by the system should build greater trust between all the parties involved, especially business partners. All these benefits should improve financial planning and ensure transparency with stakeholders.

The research and development will focus on Gapuz Computer Services, a business located in Tablon, Cagayan De Oro City. This establishment operates 350 computer units with coin slots, making it a sizable player in the Pisonet industry. Gapuz Computer Services is an ideal subject for this research due to its size, automated nature, and reliance on manual sales tracking methods, which are vulnerable to fraudulent activities. By designing a Coin Slot Sales Tracking System, the researchers aim to provide a secure and transparent method for monitoring sales, which is a crucial step in preventing fraud within the Pisonet industry.

Gapuz Computer Services faces multiple challenges that hinder their operations and financial stability. The business heavily relies on micromanagement due to difficulties in trusting employees, causing high stress for management. A major concern is fraudulent activities, where some employees deliberately steal a portion of the revenue before recording it in their manual sales logs. This practice, enabled by their reliance on pen-and-paper records and error-prone mobile apps, results in inaccurate sales data, making it difficult for management to track revenue properly. As a result, the business faces financial losses, disputes with business partners, and challenges in budgeting and financial planning. These issues affect the company's overall efficiency and limit its ability to maintain stable operations.

The Coin Slot Sales Tracking System using a microcontroller addresses these challenges by providing an automated solution for sales monitoring. The system integrates a standalone microcontroller with the business's existing coin slots to accurately record every coin inserted, including its type. This data will be stored in a cloud database and presented through a mobile and web application for real-time tracking and reporting.

By automating the sales tracking process, the system reduces the risk of fraud, improve financial transparency, and most importantly enable the business owner to focus more on financial planning, unit maintenance, and improved time management. [1] Moreover, automation has been shown to provide significant advantages such as reducing labor costs, eliminating the need for constant manpower, offering time flexibility, and increasing profitability, making it a practical solution for modernizing business operations. (Ratnasri & Sharmilan, 2021).

This project integrates key IT principles such as database management, microcontroller programming, and mobile application. To store and retrieve data, a cloud database like Firebase Firestore was utilized. The database will store essential information, including the coin count, coin type, date of insertion, and the device identifier corresponding to the coin slot used. This approach provides a structured method for tracking sales data and organizing information for easy access through the mobile and web application.

In conclusion, this project introduces an innovative approach to sales tracking in the Pisonet industry by integrating a microcontroller-based system with existing coin slots. Unlike traditional manual recording methods, which are prone to manipulation and errors, this system automates data collection and stores it in a cloud database. By providing accurate and organized sales data, the system improves financial transparency and reduces the risk of fraudulent activities. This project highlights the practical application of IT concepts in addressing real-world challenges faced by automated businesses like Pisonet services.

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- To develop a hardware device capable of tracking and recording coin insertions in real-time
- To enable the device to transmit recorded sales data to an online record accessible through a mobile and web platform.
- To ensure that the system can still record sales even during internet disconnections and automatically sync them once the connection is restored.
- To evaluate the system's overall accuracy, functionality, and usability based on standard user feedback and performance testing.
- To develop a system that can maintain stable internet connectivity even after changes in the Wi- Fi password or network configuration.

II. RELATED WORK

A. Selecting a Template (Heading 2)

[2] [3] Existing research has established the reliability of microcontroller-based systems for automation tasks, particularly in financial tracking and data recording. Study like (Kahar and Lias 2024) vending machine monitoring and (Casaclang et al. 2024) coin counting system demonstrate microcontrollers' effectiveness in accurate data acquisition. However, these solutions focus on standalone operations without addressing the need for comprehensive sales monitoring in vending machine businesses.

The proposed system bridges this gap by combining ESP32's proven reliability with cloud-based data management, creating a specialized solution for Pisonet operations. While previous works demonstrate microcontroller effectiveness in financial tracking and IoT applications, none specifically target Pisonet's unique requirements for both precise coin detection and centralized multi-unit monitoring.

This innovation builds upon established microcontroller reliability while introducing crucial fraud prevention features

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absent in previous studies. By combining real-time transaction logging with centralized monitoring, the solution provides business owners with complete transaction visibility, enabling them to track all revenue regardless of employee collection schedules. The system's design and automatic data synchronization address the specific operational challenges of Pisonet franchises, offering both security and convenience that existing solutions cannot match.

The development directly addresses a documented need in the Pisonet industry, where decentralized, cash-based operations create financial risks, by automating revenue tracking to prevent theft while maintaining the proven accuracy of microcontroller-based systems.

[2] Vending machines have become a popular business model due to their ability to function autonomously, catering to various customer needs like food, drinks, and tickets (Kahar & Lias, 2021). This shift towards automation emphasizes the need for real-time monitoring and data tracking. (Kahar and Lias 2021) explored the use of microcontrollers to automate vending machine coin slot monitoring, integrating an ESP32 microcontroller with a GPS module, infrared (IR) sensor, and camera via IoT. The system detects obstructions in the coin slot, captures images, and sends real-time alerts with GPS coordinates. [2] The IR sensor detected blockages, while the ESP32-CAM handled image processing, enhancing vending machine operations and reducing downtime (Kahar & Lias, 2024).

[4] A similar system by (Lale et al. 2021) utilized infrared sensors and microcontrollers to monitor passenger temperature for fever detection. Using an ATMega328P-PU microcontroller and an MLX90640 infrared sensor, the system provides a cost-effective, easy-to-implement solution for automatic fever detection. [3] If a person with a fever passes through the sensor's range, an alarm is triggered (Lale et al., 2021). The study highlights the use of infrared sensors for automatic health monitoring, emphasizing the advantages of microcontroller-based solutions for real-time detection.

[5] Booc et al. (2020) proposed a smart home automation system where appliances are controlled via a mobile app. The system uses an ESP8266 (NodeMCU) microcontroller and a relay module to control appliances over the internet. This approach enables real-time monitoring and control from anywhere with an internet connection, highlighting the potential for IoT in sales tracking and remote management (Booc et al., 2020).

[6] Similarly, (Eremić and Halas 2023) developed a cloud-based platform for monitoring meteorological data using microcontrollers and sensors like the DHT22 and BMP180. The system stores data in Firebase and displays it on a web application. [6] This real-time monitoring approach, while focused on environmental data, shows how IoT can be applied to sales tracking systems as well (Eremić & Halas, 2023). Both studies demonstrate the flexibility and reliability of microcontrollers in various IoT applications, from environmental monitoring to home automation.

[7] While IoT systems offer real-time monitoring, data security and transmission reliability remain crucial. (Litayem and Alsadi 2023) discuss the ESP32 microcontroller's security features, including TLS/SSL encryption, which protects data during transmission. [6] This makes the ESP32 a secure choice for cloud-based applications like sales tracking systems, ensuring confidentiality and protection against cyber threats (Litayem & Alsadi, 2023).

[8] (Le, Tran, and Chung 2020) presented an IoT system for large-area environmental monitoring with actuator control, leveraging Firebase for real-time data storage and interaction via a mobile app. [8] The system ensures secure data transfer using AES128 encryption, highlighting the importance of reliable and secure cloud-based data storage in IoT applications (Le et al., 2020). [9] Manop, Kamata, and Suksakulchai (2022) developed an IoT-based sales reporting system, where sensors detect sales transactions, data is processed by an ESP32, and the results are stored in a cloud database. The system enables real-time sales reporting via a web interface, demonstrating IoT's potential for automated sales tracking and reducing errors in manual methods (Manop et al., 2022). This study reinforces the importance of reliable data acquisition and cloud transmission, aligning with the goals of the Coin Slot Sales Tracking System.

III. METHODOLOGY

This chapter outlines the research methodology used in developing the Coin Slot Sales Tracking System using microcontroller. A modified waterfall Software Development Life Cycle (SDLC) model was chosen to manage project complexity and support incremental development. This iterative approach enables continuous feedback between phases, making it well-suited for integrating hardware and software components. The project anticipated an iterative development mainly on the IoT side, particularly in connecting the coin slot to the ESP32 and accurately reading coin data. The methodology allows for adjustments if challenges arise in hardware-software integration or data acquisition. While supporting studies did not specify their methodology, their system shares a similar structure: collecting sensor data, transmitting it to a database, and displaying it via an application. Like many IoT projects, multiple iterations are necessary to ensure proper functionality through trial and error.

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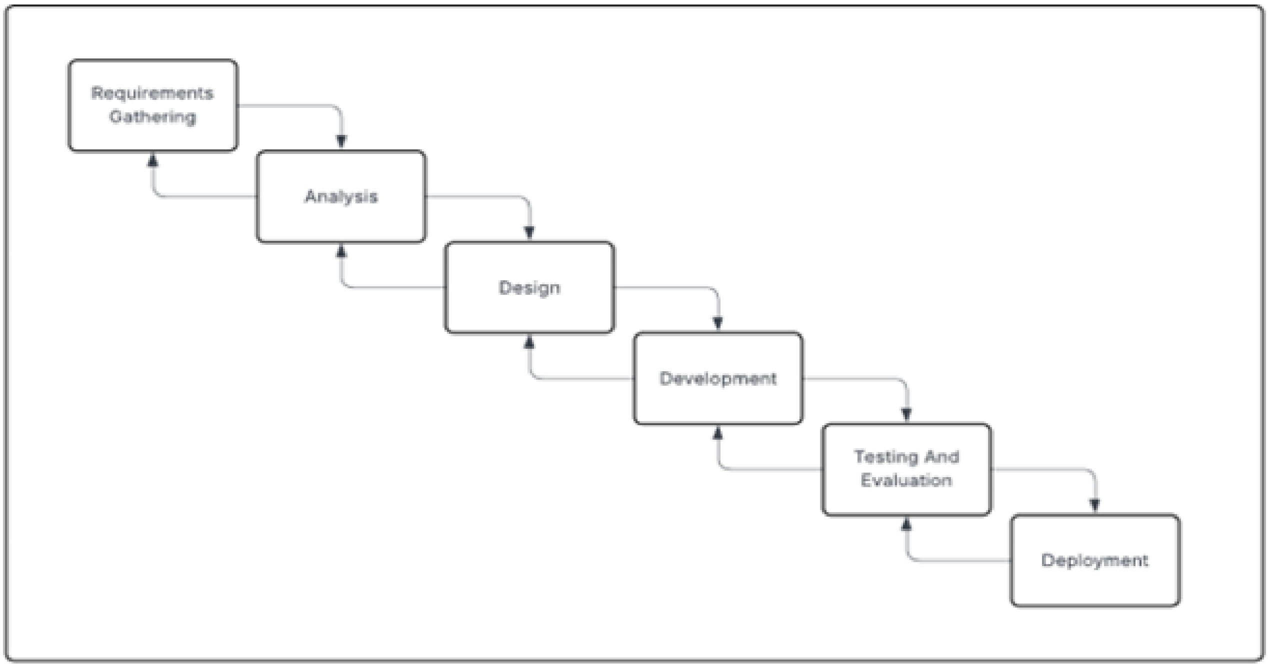

Fig 1: SDLC Modified Waterfall Model

The figure below illustrates the system's architecture, employing a four-tier structure to organize the flow of data and interactions. At the base is the Data Acquisition Tier, where the ESP32 microcontroller interfaces directly with the coin slot sensors to capture initial coin insertion events. The Network Tier then handles the transmission of this data, with the ESP32 utilizing Wi-Fi connectivity and the REST API protocol to send information securely to Firebase. "ReactJS is a JavaScript library used to facilitate interactive and reusable UI components" and "uniquely performs operations on both the client side and server side" [6] (Adetunji & Joseph, 2018, as cited in Eremic & Halas, 2024). Firebase itself constitutes the Middleware Tier, functioning as the system's core by storing, managing, and synchronizing the received data. "The Firebase Realtime Database is a cloud-hosted database. Data is stored as JSON and synchronized in realtime to every connected client. When you build cross-platform apps with our Apple platforms, Android, and JavaScript SDKs, all of your clients share one Realtime Database instance and automatically receive updates with the newest data" [10] (Firebase Realtime Database, n.d.). The Presentation Tier provides the user interface through which the owner interacts with the system, now implemented using Next.js, TypeScript, Tailwind CSS, and Progressive Web Application (PWA) features. Next.js was chosen as a modern React-based framework that supports server-side rendering (SSR), static site generation (SSG), optimized routing, and built-in API endpoints, improving both performance and scalability for the system (About React and Next.js, 2025). The interface is developed using TypeScript, which enhances code reliability by introducing static type checking, reducing runtime errors, and improving long-term maintainability. Styling is handled using Tailwind CSS, a utility-first CSS framework that streamlines UI development by allowing developers to apply design elements directly within HTML and component files. [11] As (Fitzgerald, 2020) notes, Tailwind enables rapid customization of layout, spacing, typography, and other visual aspects without the need for extensive custom CSS files, helping maintain a clean and organized project structure. The system also integrates Progressive Web Application (PWA) capabilities to provide an app- like experience while remaining web-based. PWAs can be installed on a user's device, run across multiple platforms from a single codebase, and continue functioning during limited or unavailable network connectivity. These capabilities are enabled through core technologies such as the web app manifest, which defines installability and appearance, and service workers, which handle offline caching, background synchronization, and efficient resource fetching, allowing the application to remain responsive even when the network is unreliable (Progressive Web Apps MDN, 2025).

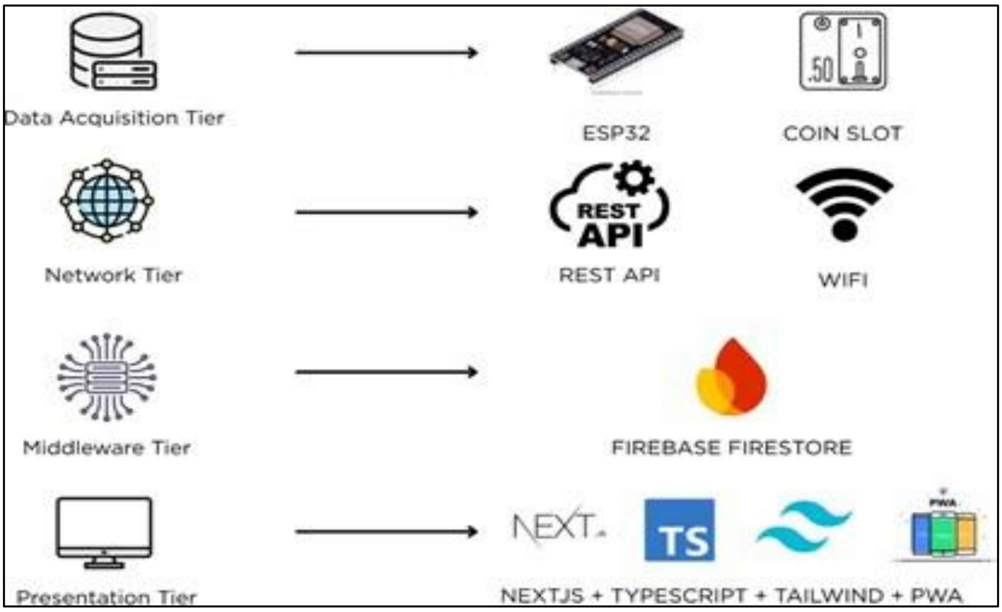

Fig 2: Architectural Design

IV. RESULT & DISCUSSION

This section summarizes the results of the 10-day testing period for the ESP32-based Automated Coin Slot Sales Tracking System across four Pisonet PCs. It demonstrates the system's accuracy in recording each coin insertion, consistency in maintaining digital logs, and reliability in transmitting data under real-world operating conditions. The findings highlight transaction accuracy, coin denomination patterns, internet performance, and the system's stability within the physical environment, providing a thorough evaluation of its effectiveness and robustness in a typical Pisonet setting.

The results in Table 1 show that the ESP32-based system recorded every coin insertion with complete accuracy during the whole 10-day testing period. Each of the four PCs produced clean and consistent logs. PC 1 recorded ₱339, PC 2 recorded ₱838, PC 3 recorded ₱499, and PC 4 recorded ₱1,269. The denomination counts were also correct. PC 1 logged 64 pieces of ₱1, 45 pieces of ₱5, and 5 pieces of ₱10. PC 2 logged 203 pieces of ₱1, 115 pieces of ₱5, and 6 pieces of ₱10. PC 3 logged 69 pieces of ₱1, 76 pieces of ₱5, and 5 pieces of ₱10. PC 4 logged 289 pieces of ₱1, 186 pieces of ₱5, and 5 pieces of ₱10. There were no ₱20 coins recorded at all, even though the system can read them. This likely happened because most users insert smaller coins little by little instead of putting a bigger amount in one go. Since the physical coins matched the digital logs, it shows that the system was recording properly without missing or repeating any transactions.

The system also did surprisingly well in terms of internet reliability. At first, the expectation was that the devices would have problems with unstable Wi-Fi, especially since Pisonet shops usually deal with weak or fluctuating signals. But during the testing, all four ESP32 units were able to send data to Firestore without any noticeable interruptions. Even though PC 4 had the highest activity and PC 1 had the lowest, all devices still sent their data smoothly. The dedicated Wi-Fi setup helped, but the ESP32 also handled the requests well, which shows that it can manage real-time logging even when the shop gets busy.

Another thing worth noting is how the system stayed stable even with the physical environment of the branch. The units were placed in an area that gets pretty hot and even gets hit by sunlight at certain times of the day. Normally, this kind of setup causes problems for microcontrollers because they can overheat or reset randomly. But during the 10 days, the devices stayed responsive and accurate the whole time. Because of this, the system seems suitable for real Pisonet conditions where heat and sunlight are things you really can't avoid. To ensure that the Coin Slot Sales Tracking System performed as intended, a series of functional test cases were created and executed. Each test case focused on validating specific hardware and software behaviors, including real-time tracking, database communication, reporting functions, and access controls. This evaluation helped confirm that the system met the technical requirements and was ready for usability testing

Table 1: Combined Daily Coin Transactions of All Four Devices Across Ten Day

Date	1 Peso	5 Peso	10 Peso	20 Peso	Total Amount
Nov 9 (Sun)	106	76	5	0	₱536
Nov10(Mon)	43	30	1	0	₱203
Nov11 (Tue)	39	22	0	0	₱149
Nov12 Wed)	26	27	1	0	₱171
Nov13 (Thu)	37	18	0	0	₱127

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Nov 14 (Fri)	86	69	5	0	₱481
Nov 15 (Sat)	93	77	2	0	₱498
Nov16 (Sun)	107	67	3	0	₱472
Nov17 Mon)	44	18	1	0	₱144
Nov18 (Tue)	44	18	3	0	₱164
GRAND TOTAL	625	422	21	0	₱2,945

The results of the 29 functional test cases indicate that the system successfully met the primary objectives of the study. Tests confirmed accurate coin detection, differentiation, real-time tallying, and counting, demonstrating the hardware's effectiveness in reliably tracking coin insertions for sales reporting. Data transmission to Firebase and real-time record updates verified the system's ability to deliver sales data to mobile- and web-accessible platforms. Offline mode, automatic backup creation, and data synchronization tests showed that the system can continue recording transactions during internet disruptions and reliably sync data once connectivity is restored. The generation of daily summaries, harvest reports, and PDF outputs supports accurate reporting across multiple time ranges. Additionally, branch and unit management functions, multi-device access, and multi-branch support validated the system's scalability, usability, and performance. Overall, the testing results strongly aligned with the project's intended goals.

Usability was evaluated using the System Usability Scale (SUS), as presented in Table 38. Following standard SUS scoring, each participant's adjusted score was summed and multiplied by 2.5 to obtain a final score on the 0 –100 scale. Final SUS scores were 72.5, 70, 62.5, 55, and 62.5, yielding a total score of 322.5 and an average SUS score of 64.5. This average corresponds to a "Good" adjective rating and falls within the "Marginal" acceptability range. The highest score of 72.5 reflected smooth user interaction, particularly under stable network conditions, while lower scores were mainly influenced by intermittent connectivity affecting system responsiveness. Despite this, offline functionality ensured uninterrupted access to essential features.

Overall, users were able to perform key tasks such as reviewing coin logs, monitoring branch activity, and navigating summarized reports. Minor usability concerns were noted, including interface clarity, visual indicators, and button labeling, which contributed to the system's marginal acceptability classification. The findings suggest that improvements in navigation clarity, system feedback, and user guidance could further enhance usability, especially for users with limited experience in digital monitoring systems. Nonetheless, participants consistently highlighted the system's value in reducing manual logging, minimizing reporting errors, and simplifying daily income verification, demonstrating that the system effectively achieves its core objective of streamlining and securing sales monitoring.

Table 2: Final System Usability Scale (SUS) Computation

Participant	***Sum of the Adjusted SUS Score***	***SUS Score (Sum × 2.5)***
P1	29	72.5
P2	28	70
P3	25	62.5
P4	22	55
P5	25	62.5
Average SUS score:	-	64.5

V. CONCLUSION & FUTURE WORKS

The study concludes that the Automated Coin Slot Sales Tracking System successfully achieved all its main objectives of automating sales monitoring, providing real-time data access, and generating detailed reports for Pisonet business operations. The system's high recording accuracy and ability to operate reliably using a dedicated network directly contribute to solving the client's problem of financial mismanagement by establishing a transparent, digital audit trail that minimizes opportunities for human error and fraudulent activities. The observed data trends simply showed when branches were busiest, giving the owner a clearer picture of peak activity periods and overall usage patterns.

However, one primary limitation was identified, while the system's digital accuracy is high, it cannot fully prevent all discrepancies between the digital log and physical cash due to its reliance on commercial coin slots that may accept altered coins. This is an inherent, external limitation that requires mechanical, rather than software, solutions.

Finally, the project demonstrated that the integration of low-cost microcontrollers (ESP32) with a modern web application (Next.js) is a highly practical, cost-effective, and scalable IT solution for the Pisonet industry. Users and stakeholders can learn that high reliability in sales tracking is achievable, but they must be aware that software solutions must be complemented by sound organizational policies and, in this case, by ensuring the use of high-quality, anti-fraud coin slots to achieve absolute financial security. Based on the findings and conclusions, the researchers present the following recommendations to support proper deployment, ongoing use, and future development of the Automated Coin Slot Sales Tracking System.

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A. *Recommendation*

- Deploy the system in active branches, as the testing results show the system is stable and reliable for real operations.
- Integrate geotagging of farmlands and high-yield crop zones for location-specific contextualization.
- Use high-quality, anti-fraud commercial coin slots to reduce discrepancies between digital logs and physical cash, since this limitation cannot be solved through software alone.
- Provide short training for branch staff and administrators so they understand how to navigate the interface, read sales data, and handle basic troubleshooting.
- Improve the user interface in future versions by refining visual cues, button visibility, and overall layout to address the issues reflected in the SUS score.

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