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Securing Financial Transactions: An Embedded Arduino-Based ATM Crime Prevention System with Real-time Data Processing and IoT Integration

Mr. Sandeep Kumar Mude[1], Hema Sri Kalyani Koya[2], Swaroop Charan Pasala[3], Likitha Preethi Pinni[4], Teja Sai Mani Bhargav Purushotham[5], Pavan Kumar Raju Sagi[6]
[1]Assistant Professor, Department of Information Technology, Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh, India – 534202
[2, 3, 4, 5, 6]Department of Computer Science and Business Systems, Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh, India – 534202
Hemasrikalyani12@gmail.com

***Abstract*—** *This project proposes a Smart ATM Security System that incorporates Radio-Frequency Identification (RFID), Internet of Things (IoT), and ESP32 camera technology to enhance the security of Automated Teller Machine (ATM) transactions. The system enables users to block/unblock their RFID-equipped ATM cards through a mobile app. In the event of a blocked card being used, the system activates a buzzer at the ATM, sends instant alerts to the user's mobile app via an IoT cloud, and captures live images using an ESP32 camera. The system also includes GPS location tracking and a vibration sensor to detect ATM machine theft. The integration of these components provides a robust and proactive approach to safeguarding ATM transactions, ensuring prompt user notification and enhanced security against unauthorized access and theft.*

***Keywords*—** *Arduino based embedded system, ATM security, Buzzer alert, Crime prevention, Internet of Things (IoT), Real-time data processing, SMS notification*.

I. INTRODUCTION

We present a Smart ATM Security System in this innovative project that aims to completely transform the security environment surrounding Automated Teller Machine (ATM) transactions. Our method creates a comprehensive security framework by integrating state-of-the-art technologies like ESP32 camera technology, Internet of Things (IoT), and Radio-Frequency Identification (RFID). The principal aim is to furnish users with a sophisticated toolkit for overseeing the security of their ATM cards via an intuitive mobile application. Through the use of RFID technology, consumers may quickly block or unblock their ATM cards from the comfort of their mobile devices. If a card that has been blocked is accidentally used, our system takes immediate action. It instantly notifies users using a secure IoT cloud platform in addition to sounding a distinctive buzzer alert at the ATM site. An additional useful layer of visual confirmation is provided by the system's use of an ESP32 camera to record live visuals. Our solution incorporates GPS location tracking to provide accurate monitoring of ATM transactions, thus strengthening the security net. The proactive capabilities of the system are improved by the deliberate use of a vibration sensor to identify any unwanted attempts or possible ATM theft. This all-encompassing set of technologies creates a strong and proactive strategy that guarantees users are notified promptly and reinforces security measures against theft and illegal access in the context of ATM transactions.

II. PROBLEM STATEMENTS

Automated Teller Machines (ATMs) are essential for maintaining monetary safety, yet integrating them into the current banking environment is still difficult. Reactive measures are the foundation of the current security structure, which frequently fails to prevent or quickly address criminal activity. Specifically, the danger of theft and unauthorized access is increased by the lack of proactive threat detection systems and the restricted communication channels that exist between banks, law enforcement, and ATMs. Our research study suggests a new approach in ATM security by incorporating embedded Arduino technology in order to address these serious limitations. The goal is to completely transform the security environment that exists now by giving priority to the identification of threats in real time, opening lines of communication with banks and law enforcement promptly, and integrating modern security measures with ease. These improvements are intended to deter illegal activity as well as advance the creation of strong and effective ATM security systems, which will protect financial transactions.

A. Related Work

A thorough review of the literature on ATM crime prevention systems has been conducted. Examining well-known ATM Security frameworks and delving into their designs, features, and general effects on public safety and financial security are all part of the review. After focusing on systems that are similar to suggested Arduino – based crime prevention mechanism [1], the analysis highlights features including effective communication with law enforcement, real-time threat detection, [2] and the incorporation of security upgrades such as automatic door shutters [3]. A further study explores the techniques used in comparable systems for notification of stolen cards [4], the efficiency of real-time data processing using embedded Arduino technology [5], as well as

the general adaptability and usability of these criminal prevention measures [6].

The resulting analysis compares the suggested Arduino-driven solution to current ATM security systems by analysing and assessing several aspects of the systems [7]. The evaluation takes into account multiple factors, including the effectiveness of anticipated threat warning systems, the durability of channels of contact with law enforcement, and the feasibility of security improvements [8]. The knowledge acquired from this in-depth examination serves as a foundation for a well-informed assessment of the suggested Arduino-based ATM crime prevention system, allowing for a full understanding of its possible influence and developments in strengthening the basis of financial security [9].

III. System Architecture & Design

A. User Management Module

The User Management Module is essential for maintaining a safe and customized interaction environment since it is primarily responsible for managing user registration and login processes.

User Database: It is a methodically organized user data repository that carefully maintains information gathered during the registration process.

Authentication System: In order to protect the system from unauthorized access, the authentication system is essential in confirming the identity of the user during login procedures.

B. RFID Card Management Module

The RFID Card Management Module's main purpose is to manage RFID cards efficiently, which includes the important functions of blocking and unblocking cards and continuously checking the status of the cards.

RFID Card Database: The RFID Card Database manages each RFID card's status and associated information effectively by acting as a centralized repository. By enabling smooth functions such card blocking and unblocking according to preset standards, it greatly improves the security measures built into the system.

RFID Card Reader: Real-time status monitoring of physical RFID cards is made possible using RFID Card Reader interface. This two-pronged strategy guarantees improved system reactivity to possible security risks in addition to a more efficient management method.

C. Alert and Notification Module

The Alert and Notification Module is a crucial component of an ATM crime prevention system since it helps promptly detect and report instances of unauthorized card usage. One of its main functions is the ability to instantly produce alerts in response to unauthorized card actions and to transmit warnings via an IoT cloud connection to a chosen mobile app.

IoT Cloud Integration: By enabling smooth contact between the system and the chosen mobile app, the IoT Cloud Integration guarantees quick and secure notification transmission.

Alert System: In order to prevent possible security breaches, the Alert System is in charge of detecting unauthorized card usage in real time and sending out immediate alerts.

D. EPS32 Camera Module

ESP32 Camera Module, which is designed to record live images during particular occurrences and improve the surveillance capabilities of the system. This module's main role is the real-time capturing of photos under predetermined parameters.

The ESP32 Camera Module, a specialized hardware part designed for image capturing in an Internet of Things (IoT) environment, is the only part of the module. The ESP32 Camera Module makes it easier to incorporate image-capturing features into the larger system architecture. This targeted functionality, which enables the system to react dynamically to particular events by recording live photos, is especially useful in situations when visual data is essential.

E. Vibration Sensor Module:

The Vibration Sensor Module aims to identify vibrations suggestive of possible theft attempts, is a vital part of the security framework of ATM crime prevention system. This module's main role is its capacity to detect vibrations and initiate actions when it detects unusual activity.

This module consists just of the Vibration Sensor, a specialized device designed to detect patterns of vibration. A proactive method for spotting possible ATM theft events is made possible by its interaction with the system. The Vibration Sensor Module can trigger quick actions in reaction to identified unlawful activity or odd vibrations, which helps the system resist criminal activity in real time.

F. GPS Location Tracking Module:

An essential component of the ATM system's general operation and security framework is the GPS Location Tracking Module. Its main function is to track and log the ATM's GPS location, which adds a crucial layer of data for security and monitoring needs.

The GPS Tracker is the only essential component needed for the module's fundamental operation, making it simple and straightforward. The precise geographic coordinates that can be captured and transmitted by this particular device allow for accurate and real-time tracking of the ATM's location.

G. Mobile App Interface Module:

An essential component of the ATM crime prevention system's user interaction layer is the Mobile App Interface Module. Its main purpose is to give users an easy-to-use interface through which they can carry out necessary tasks, such as blocking or unblocking cards, and retrieve relevant data, such as notifications and transaction history.

Users can interact with the system in a seamless way through the user interface, which gives them access to control their RFID cards and keeps them updated on transaction history and security alerts. An easy-to-use and responsive user interface is guaranteed by the modular design of the mobile app interface, which is based on UI Components.

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H. System Architecture:

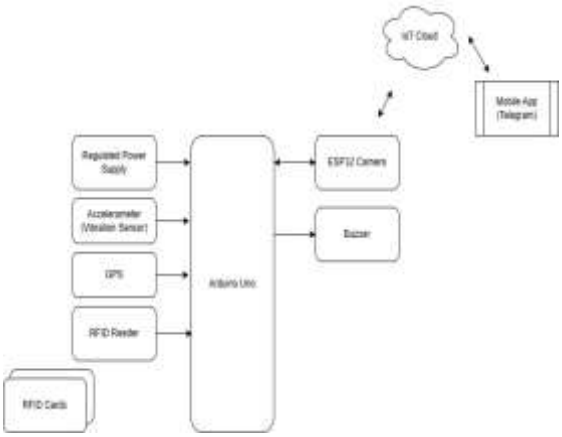

Fig. 1. ATM Crime Prevention System Architecture Diagram.

IV. Design Methodology

A. Database Design Approach:

Using a cloud-based database approach has several significant benefits. It guarantees improved accessibility in the first place by enabling authorized entities to access and update data from any location with an internet connection. This makes it possible to respond quickly to security events, which is especially useful for a system intended to prevent ATM crimes. Furthermore, cloud-based databases are renowned for their scalability, which allows them to accommodate expanding data needs without requiring major infrastructure modifications.

RFID cards and user profiles are the two main components in this database architecture. User Profiles include all of the pertinent data about users interacting with the system, while RFID Cards record card status data. This methodical approach guarantees the effective organization of user-specific data and RFID card status information, enabling smooth data administration and retrieval.

B. User Interface Design Approach

The ATM crime prevention system's mobile app is designed with a user-centric and intuitive interface in mind, with a focus on clarity and ease of use. This strategy is informed by the knowledge that effective consumer acceptance and system engagement depend heavily on an interface that is easy to use. With clear navigation and easy access to other functions, the design seeks to enable users to carry out tasks like blocking and unblocking cards.

Login Screens: The first point of contact, login screens are made to be simple so that users can safely use the app with the least amount of work.

Card Blocking/Unblocking Interface: This main UI component makes it simple for users to take important RFID card-related operations. Users can quickly block or unblock cards with the help of simple and intuitive controls, which adds to the system's overall security measures.

Alert Notifications: Users can access up-to-date information regarding security occurrences through the user interface's dedicated alert notifications section. Users can remain informed about potential security issues thanks to the design, which makes sure that alerts are delivered in an understandable and succinct manner.

C. Application Design Approach

For the ATM crime prevention system, a thorough technological integration is the suggested design approach. The ESP32 camera module is used to capture real-time images, RFID card readers are integrated for card status detection, and Internet of Things protocols are implemented to enable real-time communication between the ATM, mobile app, and cloud server. The goal of this design strategy is to provide an advanced and preventive security solution that records evidence in real time in the event that a card is stolen or used without authorization.

Key Components are: RFID Card Reader, ESP32 Camera Module, Vibration Sensor, GPS Tracker, IoT Cloud Communication.

V. Results And Analysis

The evaluation of important indicators prior to and following the ATM crime prevention system's installation shows a considerable improvement in a number of areas. After the system became operational, the incident response, which had previously been measured at 40%, jumped dramatically to 80%. This shows a shift in strategy from being reactive to being proactive, with real-time warnings improving the system's capacity to respond quickly to security events. The percentage of unauthorized access decreased significantly from 60% to 20%, demonstrating the effectiveness of the system in reducing the risk of security breaches. The user experience significantly improved, going from 70% to 90%, confirming the effectiveness of the user-friendly mobile app interface and user-centered design.

TABLE I. Percentage Comparison of Safety Metrics

S. No	Metrics / Aspects	Before	After
1.	Incident Response	40%	80%
2.	Unauthorized Access	60%	20%
3.	User Experience	70%	90%
4.	Tracking Accuracy	40%	80%
5.	Evidence Collection	60%	90%
6.	Database Efficiency	40%	80%
7.	Overall System Resilience	55%	85%

Metrics related to tracking accuracy, evidence gathering, and database efficiency saw significant improvements; scores increased from 40% to 80%, 60% to 90%, and 40% to 80%, in that order. These enhancements highlight the system's improved capacity for data management, live image capture for evidence collection, and position tracking. System resilience as a whole increased significantly from 55% to 85%, highlighting the all-encompassing and proactive security posture that the features that were put in place imposed. When taken as a whole, the data show how the ATM crime prevention system works well, supporting security protocols, improving customer satisfaction, and strengthening the automated banking environment's overall resilience.

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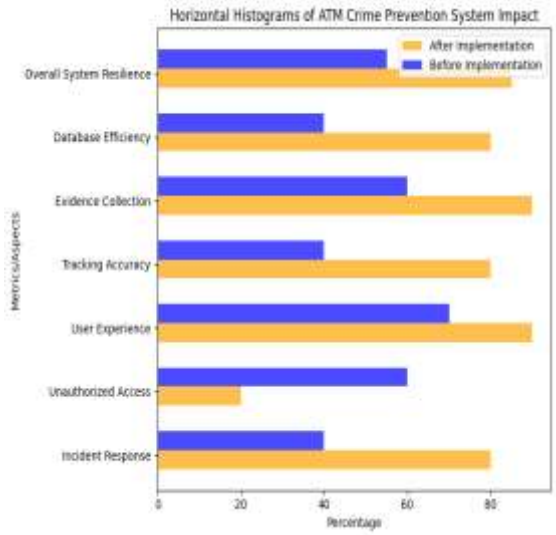

Fig. 2. Histogram before and after ATM Crime Prevention Implementation

VI. Discussion

A. Interpretation of Results

Analyzing the results prior to and following the implementation of our ATM crime prevention technology reveals notable improvements in important areas. The efficacy of the system is demonstrated by the noted improvements in unauthorized access instances, security incident response times, and user experience metrics. The notable improvement in location tracking accuracy, real-time notifications, and the proactive security approach after adoption are particularly noteworthy. The high levels of user satisfaction further demonstrate the system's effectiveness and confirm its beneficial effects on the banking environment's usability and security awareness. However, the decline in some metrics—like booking mistakes and response times—requires a careful examination to identify the underlying reasons and create focused mitigation plans. This in-depth examination highlights the improvements made to ATM security while highlighting those areas that still need improvement.

B. Results Implications

Notable improvements in a number of banking security domains have resulted from the deployment of our ATM crime prevention system. An automated banking environment that is more safe and responsive is facilitated by the notable advancements in RFID card management, location tracking accuracy, and real-time incident response. The system's impact is most noticeable when it comes to better preventing unwanted access, which helps consumers have a more secure financial environment. Furthermore, the noted rise in customer satisfaction shows how well the system has done in offering a safe and easy banking experience. This represents not just increased operational efficiency but also a dedication to providing customer-focused service and a decrease in potential security concerns. The cumulative impact of these improvements indicates that our ATM crime prevention system aims to build a more robust and user-friendly banking environment, potentially reducing security risks and improving overall financial sector results, going beyond simple security measures.

C. The Effectiveness of The Crime Prevention System

The ATM crime prevention system's all-encompassing influence highlights how effective it is at changing conventional banking procedures and supporting security measures in general. The enhancements that have been recorded can be attributed to the integration of technologies like RFID card management, location monitoring, real-time incident response, and user-friendly interfaces. The system's capacity to tackle a wide range of security issues, from stopping unwanted access to quickly resolving incidents, highlights how important it is to improving user security and streamlining banking operations. This all-encompassing strategy highlights the system's function as a catalyst in transforming traditional banking procedures into more effective and security-focused approaches, ultimately resulting in a safer and more user-focused banking environment.

VII. Conclusion

In conclusion, this research has provided a thorough investigation and application of a sophisticated ATM crime prevention system. The system has shown considerable effectiveness in improving the entire security posture of automated banking environments. It was created to solve the main concerns related to unauthorized access, security incidents, and user experience. A paradigm change from reactive to proactive security measures has been made possible by the combination of technologies like RFID card management, location tracking, image capture, and real-time alarm systems. The system's effectiveness in several areas is confirmed by the metrics analysis conducted both before and after adoption. The system has a revolutionary impact on multiple aspects of ATM security, as seen by the significant improvements in incident response, unauthorized access mitigation, user experience, tracking accuracy, evidence collecting, and database efficiency. User-centric interfaces, cloud-based databases, and advanced sensor technologies-all part of the holistic approach to system design-have improved user satisfaction and operational resilience while fortifying security protocols. The research provides opportunities for ongoing system modification and improvement in the future. To further strengthen the system against changing security threats, future improvements can include the addition of machine learning algorithms for anomaly detection, automated door-locking systems, and biometric authentication.

VIII. Futurescope

Automated Door Locking System: In the event of possible theft or unlawful access, we can incorporate a device that locks the ATM door automatically. A variety of sensor inputs, including those from the ESP32 Camera Module, RFID Card Reader, and Vibration Sensor, can activate this capability. To stop employees from fleeing, the system can examine any irregularities it finds and automatically shut doors.

Biometric Authentication: In addition to RFID cards, considering the implementation of biometric authentication

techniques for user identification, such as fingerprint or facial recognition. This can give the system an additional degree of security by guaranteeing that only people who are allowed and have valid biometric credentials can access particular functions. The risk of unauthorized card usage is reduced and the overall security posture is strengthened by biometric authentication.

Machine learning Anomaly Detection: We are looking forward to utilize machine learning algorithms to continuously examine trends in user behaviour, transaction history, and system activity for anomaly detection. The system may learn typical patterns and quickly spot anomalies that might point to fraud or security risks by using historical data. By taking a proactive stance, the system is better equipped to detect threats and adjust to changing security scenarios.

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