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Smart ATM Security and Alert System with Real-Time Monitoring

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Abstract—The growing adoption of automated teller machines (ATMs) worldwide, ensuring the security of ATM transactions and protecting customer data has become a critical concern for the banking industry. In this research paper, we proposed an Internet of Things (IoT) based ATM security system using the NodeMCU ESP8266 module, PIR (Passive Infrared) sensor, LCD display with I2C interface, and the Telegram app. The proposed system utilizes the NodeMCU ESP8266 module, which is a low-cost Wi-Fi enabled microcontroller, as the main controller for the security system. The PIR sensor is used to detect motion or presence near the ATM, which can potentially indicate unauthorized access. The LCD display with I2C interface is used to provide real-time status information about the ATM, such as Motion Detected or NO Motion. When the PIR sensor detects any suspicious activity near the ATM, the NodeMCU ESP8266 module sends a notification to the ATM owner or security personnel via the Telegram app. The notification includes details about the detected activity, allowing the owner or security personnel to take immediate action. The real- time alerts enable prompt response to potential security breaches and help prevent unauthorized access to the ATM.

Keywords: IoT, ATM security, NodeMCU ESP8266 module, Telegram app, Alerting system, Banking industry, Customer trust, Security breaches, Enhanced security, Automated Teller Machine (ATM).

I. INTRODUCTION

Automated teller machines (ATMs) have become an integral part of modern banking, providing convenient and accessible banking services to millions of people worldwide. However, [1] ensuring the security of ATM transactions and protecting customer data from unauthorized access has become a significant concern for the banking industry. In recent years, Internet of Things (IoT) technologies have emerged as a promising solution for enhancing ATM security. An IoT-based ATM security system usingthe NodeMCU ESP8266 module, PIR sensor, LCD display with I2C interface, buzzer, LED, and the Telegram app [2]. The proposed system [3]aims to provide a comprehensive security solution for ATMs by incorporating multiple security features. The NodeMCU ESP8266 module,[4] which serves as the main controller,is responsible for integrating and controlling various sensors and actuators. The PIR sensor is used to detect motion or presence near the ATM, The LCD display [5] with I2C interface provides real-time status information about theATM, and the buzzer and LED serve as alerting mechanisms. When the PIR sensor [6] detects any suspicious activity near the ATM, the NodeMCU ESP8266 module sends a notification to the ATM owner or security personnel via the Telegram app. The notification includes details about the detected activity. In addition, the system also triggers thebuzzer and LED to alert nearby individualsabout the potential security breach [7].

The real-time monitoring and alerting capabilities of the proposed system, combined with the buzzer and LED alerting mechanisms, enable prompt response to potential security breaches and help preventunauthorized access to the ATM [8]. The system can be easily integrated into existing ATM infrastructures, providing an enhanced securitylayer to protect customer data and ensure secure access to ATMs [9]. K. Gavaskar et. al. [10] presented the detailed design, implementation, and evaluation of the proposed IoT-based ATM security system. The results of our research contribute to the body of knowledge on IoT- based ATM security and demonstrate the potential of this technology for improving ATM security and protecting customerinformation.

II. RELATED WORK

Dr. S Prabhavathi et. al. [11] presented an ATM centre monitoring system utilizing IoT devices and sensors, including tilt, shock, temperature, andsmoke sensors, to detect and alert authorities about suspicious activity. The system addresses security concerns and can improve safety in public spaces. With limitations like potential false alarms from sensor sensitivity, reliance oninternet connectivity for real-time alerts, and cost of implementing and maintaining the system. The study [12]

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suggests a new approach to ATM security that employs RFID and fingerprint technologies along with two- factor authentication and email approval for transactions. The goal of this method is to enhance ATM security, minimize the occurrence of fraudulent activities, and eliminate the requirement for traditional ATM cards. Two-factor authentication is also used toadd an additional layer of security. Despite these benefits, the implementation of this method presents challenges, and there ispotential for user resistance to new authentication methods.

Rishabh Gupta et. al. [13] proposed a comprehensive security system for ATMs using RFID, vibration sensors, DC and servo motors, GSM, GPS, and Arduino. The system aims to prevent theft by detecting tampering vibrations and releasing gas to render thieves' unconscious, while notifying the bank and police. The motivation for the research is to reduce ATM robberies and improve security. Limitations include implementation challengesas well as false positives or wrong distinguishing between criminals and employees using the keypad. The study [14] proposed a video surveillance automation framework using deeplearning algorithms, such as Yolov3, for ATM machines to detect criminal behaviour and prevent fraud activities. The system aims to improve ATM security by real-time detection of weapons, sending alerts to police and banks, and triggering alarms. Limitations like detecting false activity, implementation challenges, and reliance on GPS for alerting.

The model from paper [15] implemented an ATM security system using RFID and a GSM modem to prevent theft and enhance customer security. Users gain access with an RFID card and receive a one-time password (OTP) via SMS for transaction authorization. Limitations include challenges in RFID card management, reliance on mobilephones for OTP verification, and potential falsepositives or negatives in reverse OTP entry.

Poornima et. al. [16] implemented an ATM security system using NodeMCU and vibrationsensors to detect theft attempts. The system locks the ATM room, releases chloroform to make the thief unconscious, activates a siren, and alerts bank authorities via GPS modem. Limitations include risk of false positives or erong detection from vibration sensor readings and reliance on chloroform as a security measure.

Yedidi Sai Mounika et. al. [17] microcontroller detected authorised persons,prompts for PIN via eye movement, and communicates with Node MCU to detect unauthorized individuals. Limitations include false eye tracking and reliance on RFIDtechnology for access control. Jalla Pavan Sai Kumar Reddy et. al. [18] introduced an ATM security system using IoT and GPS for surveillance and remote control. Alerts bank officials and triggers buzzer in case of physicalattack. Mobile app allows remote locking of doors and live video monitoring. Limitations may include collecting false sensor data and reliance on mobile app for remote control in case of network or connectivity issues.

I. *SYSTEM DESIGN*

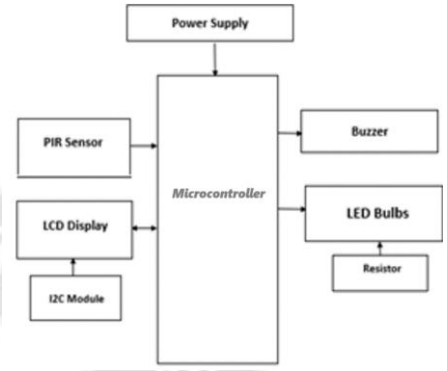

Fig. 1. Block diagram of Smart ATM Security and Alert System

Fig. 1 shows the block diagram of Smart ATM Security and Alert System

1. PIR Sensor: A Passive Infrared (PIR) sensoris an electronic sensor that detects changes in infrared radiation emitted by objects. It is commonly used in motion detection applications, such as security systems and automatic lighting systems. A PIR sensor [21] consists of a pyroelectric sensor that generates an electrical charge when exposed to heat or infrared radiation.

$$\text{Vout} = \text{Vref} \times (1 + \text{R2 R1}) \times (\text{C1} \times \text{f1} + \text{C2} \times \text{f2} + \text{Cn} \times \text{fn}) \quad (1)$$

$$V_{out} = \frac{\left(0.8 \times \text{D} \times \left(1 \pm \cos\frac{\theta}{2}\right)\right)}{2 \times \text{S}} \quad (2)$$

It typically has a detection range of several meters, although this can be adjusted. When motion is detected, the PIR sensor provides a digital output, such as a voltage or current signal.

2. I2C Module: An I2C (Inter-Integrated Circuit) module with an LCD (Liquid Crystal Display) display is a combination of hardware components that allow for communication between a microcontroller or other devices using the I2C protocol. *I2C Protocol*: I2C is a synchronous, serial communication protocol that allows for data exchange between devices using only two wires a data line (SDA) and a clock line (SCL). It is widely used for communication between microcontrollers, sensors, and other peripherals. *I2C Module:* An I2C module is a hardware component that facilitates I2C communication. It typically consists of a microcontroller with built-in I2C hardware, or an I2C controller module that can be connected to a microcontroller.

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The module acts as a master in the I2C communication, controlling the flow ofdata to and from the connected devices.

3. LCD: An LCD is a type of flat-panel displaytechnology that is commonly used for visual output in electronic devices. It can display text, numbers, symbols, and graphics. LCD displayscome in various sizes and resolutions, and mayhave different interfaces, such as parallel or serial.

4. I2C with LCD: When an I2C module is connected to an LCD display, it allows for communication between a microcontroller or other devices using the I2C protocol and the LCD display for visual output. The I2C module acts as the master and controls the communication, while the LCD display serves as the slave device that receives and displays the data.

Implementation: Implementing an I2C module with an LCD display typically involves connecting the I2C module to the microcontroller's I2C pins, and connecting the LCD display to the I2C module using its specific pinout. The microcontroller communicates with the I2C module using software libraries or APIs that handle the I2C protocol, and sends commands and data to the LCD display for displaying the desired output. The specific implementation may vary depending on the microcontroller, I2C module,and LCD display used, and may require configuration of addresses, baud rates, and other parameters.

5. NodeMCU ESP8266: NodeMCU ESP8266is an open-source development board based on the ESP8266 microcontroller, which is a Wi-Fienabled chip used for IoT applications. It features a 32-bit RISC processor, built-in Wi-Fi connectivity, ample GPIO pins, and supports programming in Lua and Arduino IDE. With a large community and extensive libraries, itsused in applications like home automation. Basic security features like WPA2-PSK encryption are available. Overall, NodeMCU ESP8266 provides a cost-effective and versatile platform for building connected devices and integrating them into the Internet of Things ecosystem

6. LED and Buzzer as Alert System: A buzzer, also known as a piezo buzzer, is an electronic component that produces sound when analternating current is applied to it. It typically emits a high-pitched or loud buzzing sound, which can be used to draw attention or signal an event. To create an alert system using a buzzer and LED, you can connect them to a microcontroller or other electronic circuitry. For example, in a simple setup, you can connect a buzzer and an LED to a microcontroller's GPIO pins and program the microcontroller to control their activation based on certain conditions. When the conditions are met, the microcontroller can activate the buzzer to produce sound and turn on the LED to provide a visual indication. This can be used in applications like security systems, doorbells, emergency alarms, and other alert systems where both visual and audible cues are needed to alert users to a specific event or condition.

III. METHODOLOGY

Table 1: Components and Quantities

Components	Quantity
PIR sensor	1
I2C LCD	1
Buzzer	1
LED	1
Resistor	1
Breadboard	1

Table 1 shows the components and quantities required for system implementation. Following is the procedure of proposed system.

1. Gather the necessary hardware components:
   - NodeMCU ESP8266 module
   - PIR motion sensor
   - Buzzer
   - LED
   - Breadboard and jumper wires

2. Connect the hardware components to the NodeMCU ESP8266 module as follows:
   - Connecting the PIR motion sensor to the D1 pin of the NodeMCU ESP8266module.
   - Connecting the buzzer to the D2 pin ofthe NodeMCU ESP8266 module.
   - Connecting the LED to the D3 pin of the NodeMCU ESP8266 module.

3. Install the necessary software:
   - Install the Arduino IDE.
   - Install the ESP8266 board in theArduino IDE.
   - Install the Telegram Bot library.

4. Create a Telegram bot:
   - Create a new Telegram bot using theBotFather.
   - Obtain the bot token.

5. Write the code:
   - Write the code for the NodeMCU ESP8266 module in the Arduino IDE.
   - Use the PIR motion sensor to detect motion and trigger the buzzer and LED.
   - Use the Telegram Bot library to send anotification to the Telegram app when motion is detected.

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6. Upload the code to the NodeMCU ESP8266module:
   - Connect the NodeMCU ESP8266 module to the computer via USB
   - Upload the code to the NodeMCU ESP8266 module using the Arduino IDE
7. Test the system:
   - Place the PIR motion sensor in asuitable location.
   - Turn on the NodeMCU ESP8266module.
   - Trigger the motion sensor and ensurethat the buzzer and LED are activated.
   - Check that a notification is sent to theTelegram app.
8. Finalize the system:
   - Mount the NodeMCU ESP8266 module in a suitable location.
   - Ensure that the system is connected toa reliable power source.

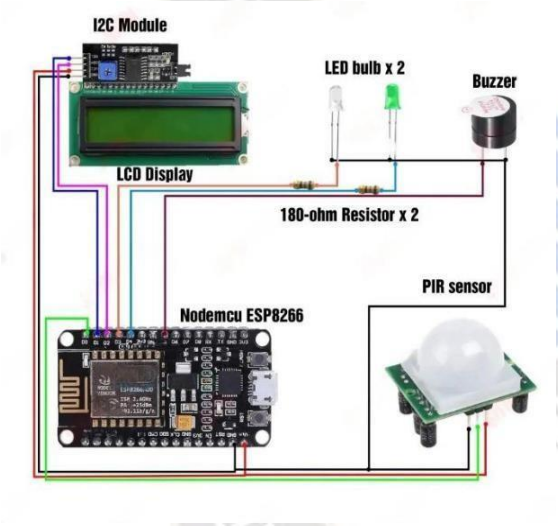

Fig. 2. Connection Diagram of ProposedSystem

A. Methodology for WIFI Connectivity:

WiFi connectivity is based on the ESP8266 Wi-Fi module, which enables wireless communication withWi-Fi networks. NodeMCU ESP8266 allows you to connect your project to the internet, communicate with remote servers, send/receive data, and perform various IoT tasks using Wi- Fi.

The Wi-Fi connectivity with NodeMCU ESP8266 involves including the ESP8266Wi-Fi library in your Arduino sketch, defining Wi-Fi credentials (SSID and password), and initializing the Wi-Fi connection using the WiFi.begin() function.

You can check the status of the Wi-Fi connection using WiFi.status() function, and perform desired actions once the connection is established.

B. Methodology for LCD and PIR Sensor:

The combination of LCD, LED, and buzzer creates a multi-modal security system that provides visual and audible feedback about detected events. This helps in improving the effectiveness of the security system, as the usercan be alerted through multiple senses, enhancing situational awareness, and enabling quick response to potential security threats.

C. Methodology for Telegram Notification:

The Telegram notification can provide real-timeupdates to the user even if they are not physically present near the security system. This allows for remote monitoring and quick response to potential security threats, enhancingthe overall effectiveness of the security system.The user can receive notifications on their mobile device or desktop, ensuring that they are promptly informed about any detected motion or intrusion.

IV. RESULTS AND DISCUSSIONS

Enhanced security: The combination of LCDdisplay, LED, buzzer, and PIR sensor can createa robust security system that can detect motionor intrusion and provide visual and audible feedback to alert the user. Fig. 3. Shows the LCD Notification for Motion Detected.

Fig. 3. LCD Notification for Motion Detected

Fig. 4. LCD Notification for No MotionDetected

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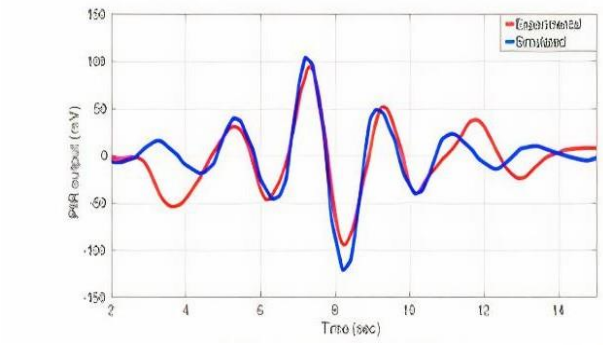

Fig. 5. Subject moving at 0.2777 m/s

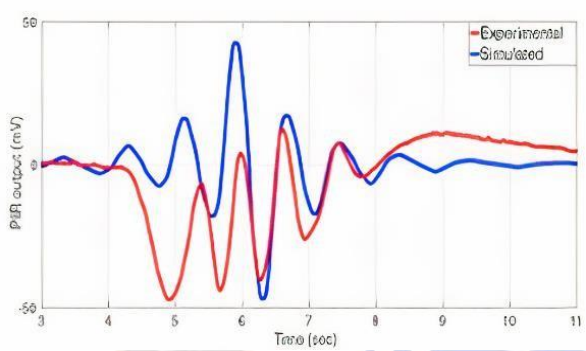

Fig. 6. Subject moving at 0.694 m/s

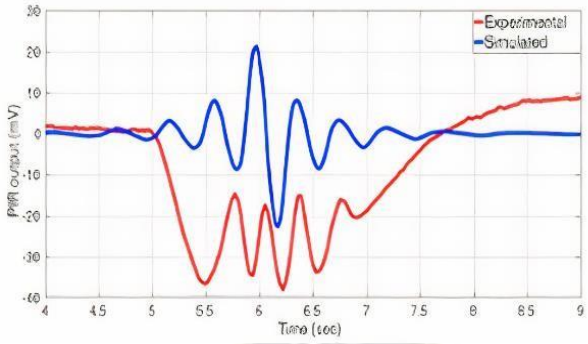

Fig. 7. Subject moving at 1.388 m/s

Fig. 8. Graph of PIR Sensor

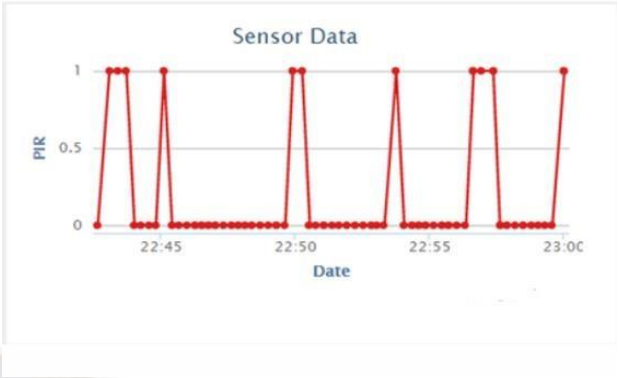

Fig. 9. Graph of PIR Sensor

Multi-modal alerts: The LCD display, LED, buzzer, and Telegram notification together cancreate a multi-modal alert system that provides visual, audible, and remote notifications, enhancing situational awareness and enabling quick response to potential security threats. Fig. 4. Shows the LCD Notification for No MotionDetected. Fig. 7, 8, 9 shows the Subject moving at 0.2777 m/s, 0.694 m/s, 1.388 m/s respectively. Fig. 8 and fig. 9 shows the Graph of PIR Sensor. Telegram Notification: The addition of Telegram notification can enable remote alerts and notifications to the user's Telegram account, allowing for real-time updates. Fig. 10. Shows the Telegram Notification.

Fig. 10. Telegram Notification

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A. Discussion:

Enhanced security measures: The combination of LCD display, LED, buzzer, PIR sensor, and Telegram notification adds multiple layers of security measures to protect against unauthorized access or intrusion. Real-time updates: Real-time updates refer to the immediate notification that a security system sends to the user when motion or intrusion is detected. With real-time updates,users can quickly respond to any security eventsas they happen, enabling them to take proactive measures to mitigate potential risks. This feature is particularly valuable for businesses and homeowners who need to manage securityevents promptly and effectively. Real-time updates help users to stay informed, maintain situational awareness, and take necessary actions to protect their property, assets, and people.

Table 2: Values from PIR SENSOR

Voltage	Sensor Value
0.2V	0
0.3V	0
2.4V	0
3.0V	0
3.3V	1
3.7V	1
3.8V	1
4.0V	1

Table 2 shows the values from PIR sensor. Peace of mind: The security system with LCD display, LED, buzzer, PIR sensor, and Telegram notification provides the userwith peace of mind knowing that their premisesare being monitored and they will be promptly alerted in case of any security events.

V. CONCLUSION

In conclusion, an ATM security system using Motion Detection with PIR sensor, and Telegram notification offers an effective solution for enhancing security. It provides real-time detection of motion events, visual andaudible alerts, and remote notifications via Telegram for added convenience and accessibility. The integration of different components and technologies allows for a comprehensive security solution that can becustomized and expanded based on individual needs. The future scope for this security system includes potential advancements in AI/ML, cloud-based monitoring, mobile app development, communication protocols, data privacy, and security. As technology continuesto evolve, the possibilities for further enhancingthe capabilities of such security systems are vast, providing opportunities for increased security, convenience, and sustainability in thefuture.

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