



ENHANCED AUTOMATED MULTIMODAL SECURITY FOR ATM AND ITS USERS

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Abstract: With increase in convenience and advancement in digitization, the number of digital users also increased. This usage has increased comfort ability in conjunction with threats. ATM is one such concept of digital transaction and is also prone to many attacks. In this paper we present a novel Automated Multimodal Security for user of ATM and to the ATM itself. This system comprises of many advanced sensors, which regularly monitors the various physical attacks that are carried by criminals such as threatening the users with weapons to perform transaction against their will, forcefully accessing the cash compartment in the ATM or lifting the ATM from the booth. We have used Xtensa LX6 Micro-controller with ESP32 module with in-built Wi-Fi, Tilt Sensor, Smoke sensor and Metal detector. Whenever there is a disturbance in the position of the ATM, difference in threshold of MQ2 sensor and detection of metal in the ATM booth, a message will be sent to the concerned through the Wi-Fi of ESP32 module. Further, we discuss the implementation of our hardware along with the major components used.

Index Terms - Automated Teller Machine (ATM), ESP32 module, Tilt sensor(TS), Micro-controller, Metal Detector(MD), Smoke Sensor(MQ2), Global System for Mobile communication (GSM), Global Positioning System(GPS).

1 INTRODUCTION

ATM is one of the important aspect of everyone's day-to-day life. The first ATM in India was set up in 1987 by HSBC in Mumbai [1]. The ATM is a self-service banking terminal. Earlier, these machines were only used for withdrawal of money, but the enhancement in the technology has led to even depositing of money in ATMs. ATM's are initiated by inserting the card provided by the bank, which can be a debit or a credit card. The card is inserted inside the card reader slot. The card will contain the PIN (Personal Identification Number) and account details of the customer in magnetic tape or on a chip. The customer feeds the card in the card reader slot of ATM machine, then the ATM terminal communicates with the bank, verification of card is done with the code associated with it is punched by customer, after successful verification, a transaction is made by the user.

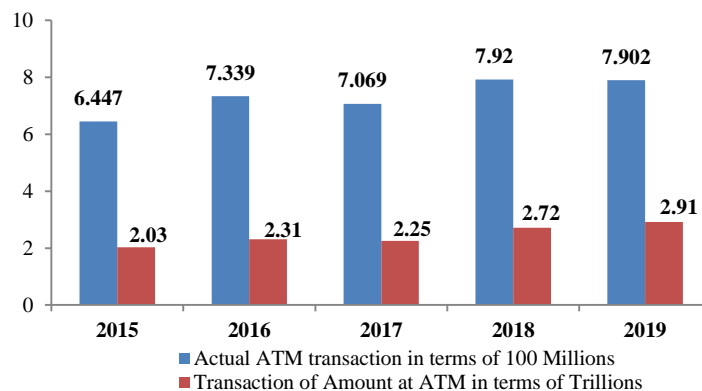


Figure 1: Actual ATM transactions and Transaction of Amount at ATM [Source : RBI]

As per the Reserve Bank of India (RBI) data [2], the usage of ATM across India is significantly increasing with number of actual transaction accompanied by the transaction of money. The figure 1, shows how the usage of ATM for transaction is been increasing in India, from few years (Data until December 2019 is considered, leaving out the pandemic years).

Whenever and wherever we use money there is a risk of criminal offences associated with it, such as thefts, looting, hostage situations, assaults, killings, etc., and these risks are no different at ATM. Such incidents are rising up, which are frequently reported in various mass media.

ATM attacks or fraud are categorized into three categories, which are as follows [3],

- Physical attack: Brute force attack is exerted on ATM machines with a clear intention of gaining access to the cash in it.
- ATM Fraud: Theft of bank card information of the rightful customer and using it unlawfully
- Software Attack: Theft of sensitive information

In this paper we concentrate on physical attack, where one can see the perpetrator present before, during or after the crime[4]. It involves the use of physical force to compromise the machine.

1.2 Physical Attacks

Some of the known types of Physical ATM Attacks that are used by criminals around the world are [5],

- **Rip-Out Attacks:** In this type of attacks the criminals use sophisticated machines like backhoe or forklift to dismantle or break any wall or barrier holding the ATM in place, and try to lift out the ATM to some other place.
- **Pull-Out or Ram-Raid Attacks:** Criminals will use any power-towing vehicle and wrap a chain around the ATM with a hook attached to the vehicle. The vehicle then pulls out ATM from its place and then loaded off to some other place.
- **Attacks with Tools:** In absence vehicles mention in above two ways, criminals may cut open the ATM and there by gain access to the cash in the safe by using grinders or thermal lances. Thermal tools used as cutters are most successful tools to cut through the thick metal parts.
- **Explosive Attacks:** It is the most dangerous and rarely used physical attacks, in comparison with the other physical attack. In this kind of attack, the flammable materials are thrown inside the ATM and then flammable material is ignited which causes an explosion. The explosion damages the ATM and its safe, thus exposing the cash to perpetrators.

Due to increase in loss of employability, ATM theft has become one of the easiest ways to make money for the thugs. There were more than 100 instances of teller machine robberies in India alone in 2010[6].The frequencies of ATM crimes are exponentially increasing due to lack of security at ATM booth. The off-peak hours are the merry time for criminals to perform heinous crimes, such activities lead to 11% of transaction and 60% of crime on day to day routine. A statistics stated that, about 5500 crimes have been recorded per year[7].

As per the European Association for Secure Transactions (EAST), the physical attack on ATM machine is increasing every year[8], as follows :

| Year | 2015 | 2016 | 2017 | 2018 | 2019 |
|-------------------------|------|------|------|------|------|
| No. of Physical Attacks | 1232 | 1604 | 1696 | 2046 | 2376 |

Table 1: Physical Attack on ATM (Source : EAST)

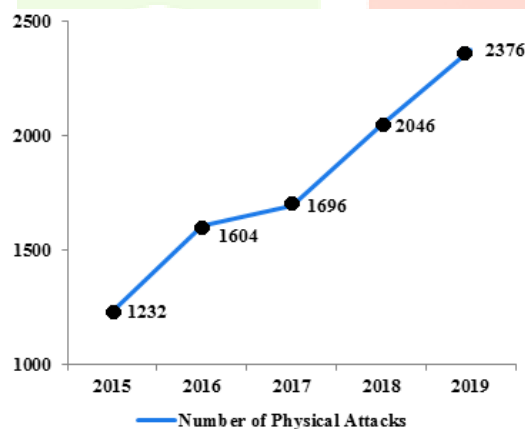


Figure 2 : Graph of Number of Physical attacks in past 5 years.

These physical attacks are one part of the Security concerns for the ATM. The other concern is the security of customer at ATM by the miscreants, who often use force and weapons to fear the customers to harm them physically as well as financially. One such brutal incident that took place in Bangalore, India where a woman was hacked mercilessly with machete in ATM, the incidence went unnoticed for more than couple of hours [9]. The proposed system aims in achieving two enhanced automation security goals, firstly the security for its user and secondly the security to the ATM itself(as shown in the Figure 3), from any of the physical attack which are discussed earlier.

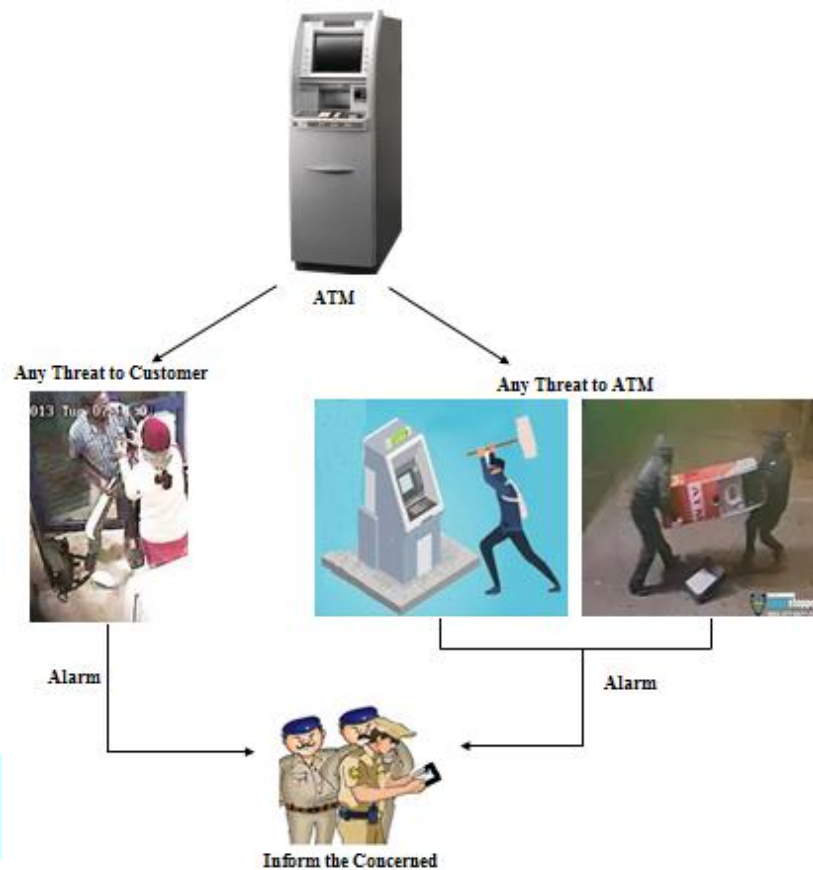


Figure 3: Security for Customer and ATM

*Pictures Courtesy : Google

In providing security to the user, the metal detector module in the system detects whether any of the individual enters the ATM booth with weapons in a pursuit of harming the other customer or threatening the customer to do transaction against his/her will. It can also provide security against Rip-Out, Pull-Out and Attacks with Tools. The security of the ATM is provided against the physical attacks like Rip-Out, Pull-Out and Explosive Attacks.

2 LITERATURE SURVEY

S.Shriram and et'al [3]: They proposed a system that would be built on the technology of embedded system and uses a number of smart sensors to detect an attack and avert it, like PIR (Passive Infrared) Sensor, ADXL335 Accelerometer, FSR (Force Sensitive Resistor) to detect motion, heat, change in orientation, sudden acceleration, force, and vibration. FSR detects any force applied to ATM to forcefully steal the cash, PIR is used to detect change in temperature. ADXL335 Accelerometer to detect motion of the ATM. The SIM900 is used to send message in case of any of the sensor is triggered.

Bharati M Nelligani and et'al [10]: They proposed a system where the access to ATM is given by RFID (Radio-Frequency Identification). If the system fails to authorize an individual then, he has to go for finger print scan. If a match was found then an OTP (One Time Password) will be sent to his/her mobile with the help of a GSM module, which has to be punched in ATM, thereby it authorizes a user to perform transaction.

Prachi More and et'al [11]: They proposed a system with two modules, first module which is a biometric is placed in the door, the verification of customer is done on the basis of finger print match and authenticated user can pass through. The second module uses Raspberry Pi, Camera, Vibration sensor RF Tx/Rx, Smoke detector, Sensor buzzer, and DC motor. The Raspberry Pi is connected to a computer via a LAN. Camera is invoked by the information provided by RF Tx/Rx to Raspberry Pi about the authorized customer entering the room, by this the author claims that power is saved and also it is a real-time monitoring system.

V.H.Kambale and et'al [12]: Proposed an embedded system for ATM crime prevention. The system consisted of three varieties of sensors - Piezo sensor, PIR sensor and microphone. Three scenarios that can happen while a robber tries to steal or break-in an ATM are taken into account. The piezo sensor senses any mishap that occurs to an individual, if the individual is targeted by the criminals then the victim will shout, that voice is captured by microphone, the input is compared by comparator with the reference voltage which is set earlier or if there is any uneven motion of an individual for longer duration of time, around ATM machine, then it will be sensed by PIR sensor. If one of the said conditions is sensed, then by using the GSM module, a SMS will be sent to the bank authority and the nearby police station so that they can take an immediate action to track the robbery. Also there is a buzzer connected to alert the surrounding people about robbery.

Raj M and et'al [13]: They proposed a system where RFID reader is placed on the outside of the shutter. The controller controls the shutter lock or unlock. The door opens after verifying and authenticating an Authorized customer. Linux operating system using Raspberry Pi and ARM11 processor are used for the implementation of the system. Real time monitoring was supported by Raspberry Pi camera. Smoke detectors are used in case of Fire in the ATM setup.

C.Rajmohan and et'al [14]: They proposed an **system for** ATM theft detection and prevention, using Internet of Things (IoT). They used heat, vibration and sound sensors. All the sensors are connected to the pic Micro-controller containing LCD display. Whenever there is a reading in temperature and vibration changes, the shutter of the ATM booth will be closed, and immediately it will notify the admin and a message will be sent to the nearest police station with the help of a GSM module. In case of change in reading of sound sensor, the shutter of ATM will not close, instead it will trigger the buzzer outside the ATM to ring and thereby notify the admin and a message will be sent to the nearest police station with the help of a GSM module.

Savitha Acharya N and et'al [15]: Proposed Smart Surveillance Robotic system for Weapon Detection, which can be used in areas that are difficult for human intervention. A live video is processed a harmful individual is identified, who might be carrying a knife or fire arm using the various machine learning algorithms. They claim an accuracy of 93.72% in detecting a harmful person and 81.23% in detecting weapons. As soon as an individual with weapon is detected an SMS alert notification is sent. They have two units in their system – One, a robotic car unit that consists of Raspberry Pi, the webcam, motor driven IC, GPS module, DC motors and power supply unit. The other, remote controlling unit consisting of Raspberry Pi, used to provide a control wireless network which is connected to the mobile hotspot and web based controlling of the robot.

Kande Archana and et'al [16]: They proposed a system that uses GSM, GPS, PIR sensor, DC and Stepper Motor, along with system program written in embedded C using ARMKEIL software and stored in ARM Controller. In their proposal they proposed on the basis of human motion the PIR sensor detects the robbery at ATM. An alarm rings on detection of robbery, then the DC motor closes the door of ATM booth and the stepper Motor leaks the gas, which turns the fringe element unconscious. The concerned bank and nearby police station will receive the alert message of miss-happening by GSM, continuous transmission of video and location of the place of miss-happening by GPS.

N.Nandhiniand et'al [17]: Proposed a spontaneous detection of weapons in ATMs. Their system uses Tetra Hertz Image scanner that scans the person completely. If by any means a person carries a weapon with him, then the system alarms and closes the door of ATM booth. The alarm is connected to the Galileo kit and GSM module, in conjunction with Arduino. The software associated with it instructs the person to keep the weapon outside if for him to access the ATM. The CCTV associated with this system, will account the every movement of the person. The Galileo kit also alert the guard and nearby police station with the location, regarding the person carrying an weapon.

Samir K. Bandyopadhyay and et'al [18]: Proposed to develop a new algorithm using a colour visual image and a corresponding IR image for such a concealed weapon detection application by the help of fusion technology. Their technique revolved around two types of image – a visual image and an IR image. A visual image is an RGB image. IR image is a thermal image. They perform two fusions; in first they fuse an RGB image with IR image. Then they convert IR image into Hue, Saturation, and Value (HSV) color model image. Then they perform second fusion which involves the HSV image and the resultant image of first fusion. They claim that after processing the resultant image of second fusion the weapon can be seen, which is then converted into a gray scale image. The fused gray scale image is binarized by using the Ostu's local threshold technique, after which weapon part from the image is extracted by calculation of all connected area components. Contour and canny edge detection is used to detect edges of weapon from the binary image.

Hanan A and et'al [19]: Have proposed an image fusion technique which utilizes fusion dependency rules with wavelet and inverse wavelet transform. The fusion rule selects the coefficient with the highest correlation rate. Greater the correlation, stronger the co-existed feature. Their experimental results show that their proposed algorithm is better in quality and meet the real time requirement as well. They also claim that their novel algorithms real-time response time, is lesser than other comparable algorithms by 40%. It outperforms other algorithms by superior PSNR (Peak Signal to Noise Ratio) of more than 10% of the comparable algorithms in average.

The study of above works revealed the limitations that, all the different physical attacks are not dealt by any of the system so far. It also revealed that if some of the physical attacks are dealt then weapon detection is not dealt and vice-versa. The proposed system takes care of all types of physical attacks and also deals with weapon detection in the ATM booth, providing a high security to the ATM and its users.

3 METHODOLOGIES:

The system is mainly built using Xtensa LX6 Micro-controller. The other essential and prime components of the system are - Tilt Sensor, Smoke sensor, Metal detector and ESP32 module.

The system continuously monitors the ATM by sensing metals, smoke, tilting and movement of ATM. The basic architecture of the proposed system is as follows:

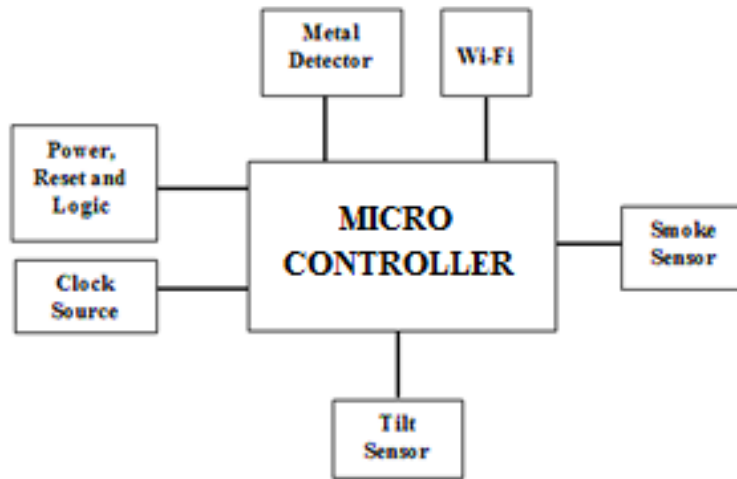


Figure 4: Basic Architecture of the system

The Flow chart of the proposed system is as follows,

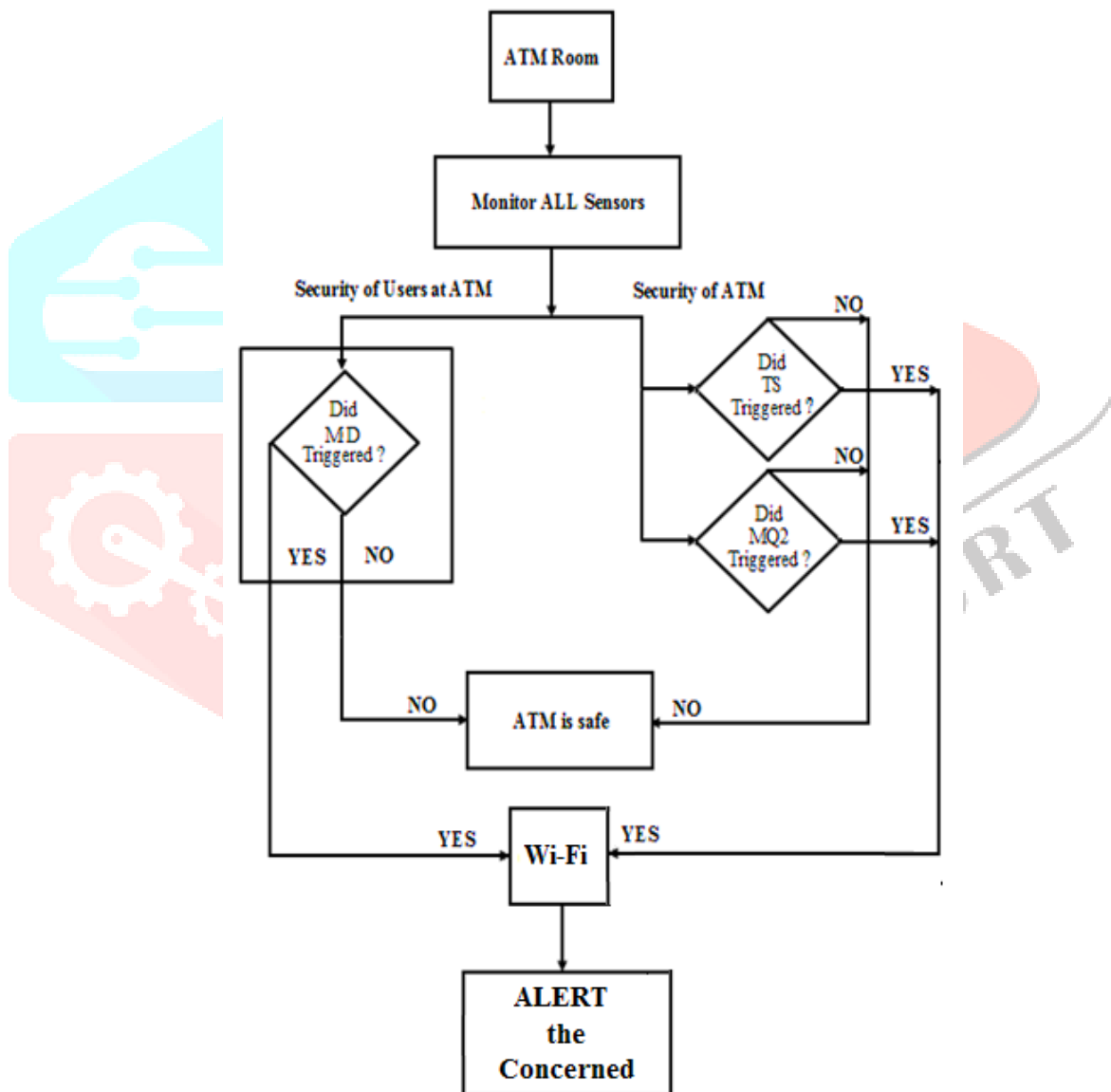


Figure 5: Flow chart of the proposed system.

The system will continuously monitor all the sensors, if there is any change in any of the sensor values i.e., if any of the sensor is triggered then the system identifies the attack on ATM and takes adequate measures by sending the alert message to the concerned. If none of the sensor(s) triggered then the ATM is considered to be safe.

3.1 Algorithm of the proposed system:

Automated Security of user and at ATM(MQ2,TS)

//MD is Metal Detector, MQ2 is Smoke Sensor, TS is Tilt Sensor

//Input: Prev_TS is 0, Crnt_TS is 0, Crnt_Snsr_Value_MQ2, Normal _Snsr_Value_MQ2 is 300

//Output: crnt_TS > 0; Rd_MQ2 > Snsr_TH_MQ2; send a message

Step 1: Initialize MD, MQ2, TS

Step 2: Define Input ports and directions.

Step 3: Check for MD, TS, MQ2

Step 4: if MD is triggered
Send an alert Message to the Bank
andPolice Station.

endif

Step 5: Prev_TS = Crnt_TS
Crnt_TS = read data
print "Sensor Value"
//Checkif TS is triggered
if(Prev_TS != Crnt_TS)
Send an alert Message to the Bank
andPolice Station.

endif

Step 6: Normal_Snsr_Value_MQ2 = 300
delay 20 seconds
Crnt_Snsr_Value_MQ2 = Read analog data
print "Sensor Value"
//Check if MQ2 Triggered
if(Crnt_Snsr_Value_MQ2 > Normal_Snsr_Value_MQ2)
Send an alert Message to the Bank,
Police Station and Fire Station.

endif

Step 6: System RESET [Go to step3].

The above algorithm implementation leads to the safety of ATM and User itself.

4 IMPLEMENTATION

Some of the main hardware components used in this system, and their specifications are as follows:

4.1 ESP32 Module [20][21]:

The ESP32 is a low-cost System-on-Chip (SoC) series created by Espressif Systems. It has in-built Wi-Fi and Bluetooth capabilities. It has LX6 32-bit Micro-controller. The board comes with 2 pushbuttons. One is labeled 'EN' which is the Reset button. The other button the Boot button, it is used to upload programs on the board. It has 32 GPIO (General Purpose Input Output) pins on the board that are brought out to the header pins. The pins are labeled GPIOx. When it is used in Arduino IDE, the GPIO pin number is same as the digital pin number, for example the GPIO4 is referenced as '4'. It has two 12-bit analog-to-digital converters and two 8-bit digital-to-analog converters. It has three mutually exclusive ways to provide power to the board.

- Micro USB port through the USB cable
- 5-9V applied to the VIN 5V pin
- 3.3V applied to the VIN 3.3V pin



Figure 6: ES32 Module

4.2 Tilt Sensor[22] :



Figure 7 : Tilt Sensor

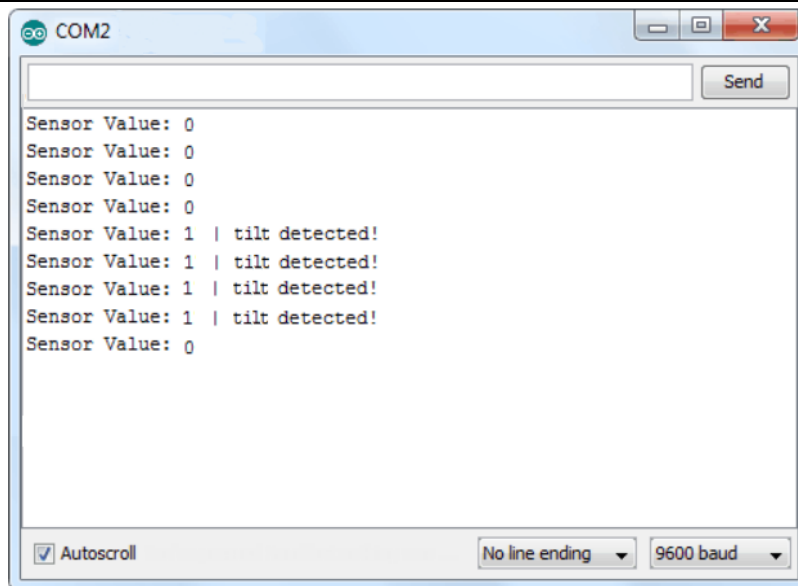


Figure 10: Output Screen from Tilt Sensor

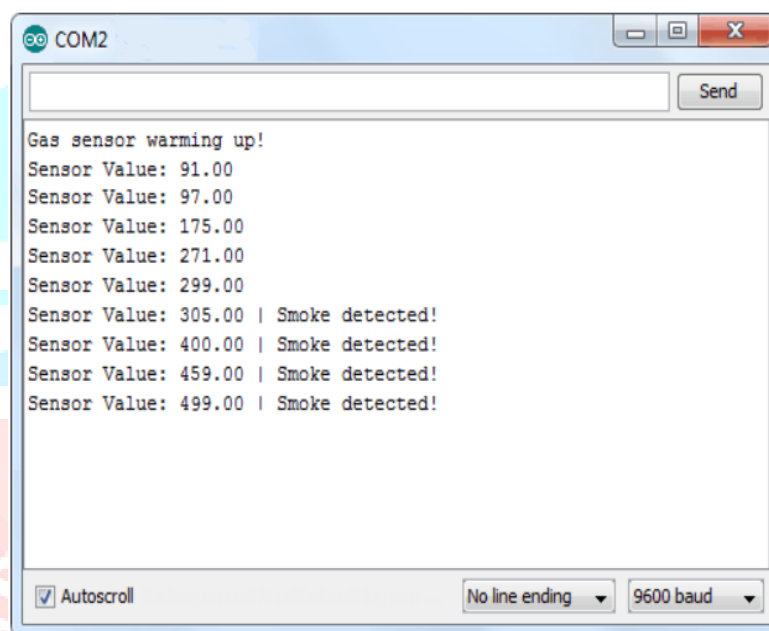


Figure 11: Output Screen from Smoke Sensor

The Metal detector is used to detect weapons in the ATM booth. All most all the known weapons are made from the ferrous metals, so detection of any metal in the ATM from the door of ATM booth is considered as a weapon. This proposed metal detector detects the metal object from a distance of 01-20 centimeters. Whenever a metal is detected, the Wi-Fi in ESP32 module sends a message to the Bank authority and police station on the instructions of LX6 micro-controller along with Bank details.

It is also observed that the detection of metal objects if small, its detection happens at a range of 01 – 10 centimeters whereas, the detection of object excels proportionally with respect to the size of the object i.e., larger the object, identification takes place from a distance of 01 – 20 centimeters.

6 CONCLUSIONS:

The proposed system is characterized by providing multimodal security for the users of ATM and to the ATM. Whenever, there is a physical attack on ATM and its users, the system successfully alerts the Bank authorities and to the police station based on ATM identifier. It also alerts the fire station in case the smoke sensor is triggered.

As everyone is aware of the fact that any man made system is not 100% perfect, hence there is always a scope for improvement, which is true in this proposed system also. The metal detector designed in the proposed system can only detect the metals at a distance of few centimeters which is needed to be bettered by at least 3-5 feet distance. This system provides security for only physical attacks at ATM, which can be further enhanced to provide security against ATM Frauds using the biometrics concept.

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