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Communication Architecture for Enhanced ATM Surveillance – A Proposed Model

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ABSTRACT: This paper discusses the mechanisms to be followed and measures to be taken for improving the surveillance system in the ATM machine and provide great convenience to its users. In the proposed model two LED sensors are used. One of them keeps track on the threshold limit of the denominations where as the other tracks the complete exhaustion of denominations in the denomination slot. The deployment of the proposed model in the ATM's enhances the convenience of both the customer (during withdrawal) and the banker (during replenishment). The communication architecture of the proposed model (that involves both the LED sensors) is outlined and algorithms citing the process flow are given.

KEYWORDS: LED sensor, Electronic Journal, denomination slot, GSM modem.

I. INTRODUCTION

Security of valuable financial assets is of at most importance to most of the people. Fraudsters find it quite easy to deceive a person, which is hindering the safety of their property. So, they safeguard their assets (which include liquid cash and collaterals) in banks. The cash instruments are secured in banks by maintaining accounts and the collateral assets are safeguarded in locker systems. Traditional way of withdrawing currency from accounts was a long process, which involves:

- Going to a bank
- Filling up the withdrawal form
- Holding token and waiting until turn comes
- Finally, withdraw amount

Putting an end to all this, the ATM's (Asynchronous Transfer Mode) has emerged. Apart from simple withdrawals ATM's also support the following:

- Accepts deposits
- Cheque deposit
- Fund transfer between accounts
- Account information
- Collects bill etc [2].

Among various delivery channels available, the ATM's are the most prominent delivery channel for various banking transactions [1]. Emerge of ATM's have not only provided convenience to its users but also reduced the burden on banks. In the modern world, the life of people has become so busy that hardly any one goes to a bank for withdrawals. Most of them depend on ATM's for transactions. So it has become quite mandatory for the ATM vendors to see that the user's time is saved by reducing latency in transactions and also provide them with at most convenience. It is also the responsibility of the ATM vendors to see that the banks get proper updates about the status of the ATM.
The internal architecture of an ATM system is depicted in figure 1. The most important part of an ATM is the vault, which consists of three sections:

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1. The denomination cartridges
2. The deposit cartridges
3. The Electronic journal

1. The denomination cartridges: It is from here withdrawal requests of users are deduced. There are four slots for holding denominations in an ATM, which are:

- 50 denomination cartridge (Only accessible to platinum card holders)
- 100 denomination cartridge
- 500 denomination cartridge
- 1000 denomination cartridge

Other than these four cartridges there is another cartridge called the rejection bin. This cartridge holds the currency which was rejected during transactions.

2. The deposit cartridges: The cash may be deposited in envelope or as bundle. If cash is deposited in bundle, the ATM counts the cash in different denominations and re-fills the dispensing cassettes. A customer can deposit money at Fast Track and avoid a long queue at the branch counter for depositing money. The customer can also get service for the extended hours from the Fast Track for depositing money.

3. The Electronic journal: It is used to store files of data which contains information regarding the total amount present in the ATM machine. All the information (like bill counting) associated with a transaction is recorder on a journal. The information in the journal is periodically printed out and a hard copy is maintained by the vendor. During replenishment process, bankers replenish amount into the machine using this information present in the electronic journal (E.J).

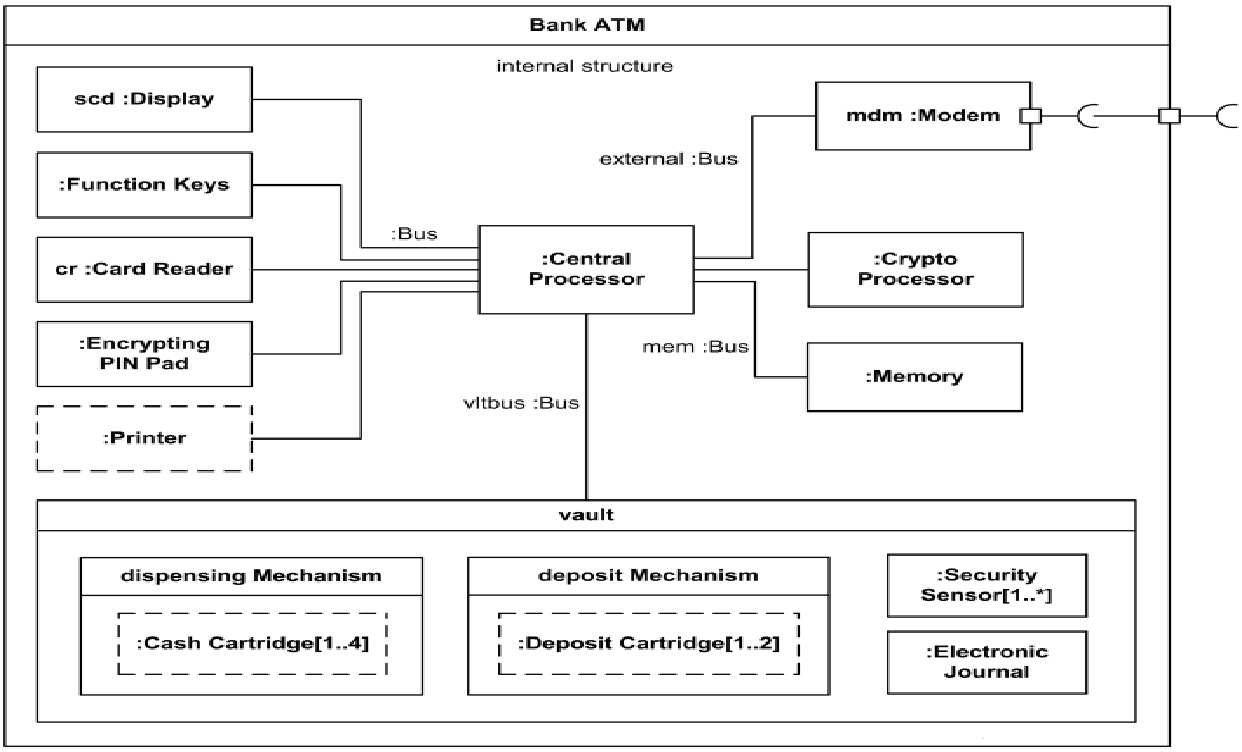

Fig 1: The internal architecture of an ATM machine

In addition to these there are also sensors present in an ATM, which are used for various activities:

1. Alerting activities (in case of frauds)
2. Other activities

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1. Alerting activities (in case of frauds): There are few sensor in ATM's for detecting a different physical phenomenon and used for alerting activities, they are:

- Temperature Sensor (This senses the change in temperature occurred due to opening of the vault in ATM's)
- Vibrating Sensor (Senses if any wedging/ cutting/ drilling activities are being performed) [5]

2. Other activities: Apart from the above mentioned sensors there are many other sensors present in ATM for detecting various aspects, which include:

- Magnetic Sensors: Magnet sensors have a sensing capability to measure total or vector components of magnetic field. This enables advanced magnetic pattern recognition and magnetic image retrieval for banknote validation in financial anti-counterfeit appliances [6]. These sensors are also used as banknote counters and a magnetic card reader.
- Macro Sensors: It ensures proper currency dispensing in ATM machines. It uses a technique called linear variable differential transformation (LVDT), which is used to tell the linear displacement in the position of currency notes [7]. The repeatability and reliability of the linear position sensor are of key importance in ATM's.
- IR sensors: These sensors are used during dispense of currency from the ATM's. They are used to check the thickness of the note arrived in the dispenser and if the thickness is found inappropriate any mismatch in the thickness with the normal thickness of the currency, it is directed towards the rejection bin.

II. CHALLENGES IN EXISTING ATM SURVEILLANCE

Though basic convenience issues for customers and burden on banks have been solved using ATM's, still there are few challenges that the user and the bank is facing, which include:

1. Lack of proper surveillance on currency availability in each denomination cartridge
2. Inconvenience to customer at the time of exhaustion of denomination slot

How the above mentioned two aspects are challenges is discussed below.

1. Lack of proper surveillance on currency availability in each denomination cartridge: The existing ATM system keeps a track on the total denominations available in the machine. But, their does not exist any mechanism that intimates the bank about the status of the ATM. Many a solution for this problem has been made. One of them is to maintain a central data system (i.e., Electronic Journal Manager) in the bank headquarters through a secured SSL connectivity [3] [4]. But, the problems with these solutions are:

- Power failure would probably interrupt the connectivity of the ATM system with the central server
- There is every possibility of cracking the secured connection through various mechanisms (like MIM attack)

The proposed model overcomes these issues and provides a new solution to the problem of surveillance in ATM's.

2. Inconvenience to customer at the time of exhaustion of denomination slot: When a customer goes to an ATM for withdrawal, he performs the following actions:

- Inserts the ATM card
- Gives his credentials
- Chooses the type of account in which he wants to transact
- Enters the amount
- Finally collects the cash

The last step will be possible only when the ATM machine has sufficient amount requested by the user. Else, it pops a message about the unavailability of currency. This is creating a lot of inconvenience to the user. The proposed model provides a solution for this inconvenience also.

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III. PROPOSED MODEL TO OVERCOME CHALLENGES IN EXISTING ATM SURVEILLANCE

The surveillance issues can be overcome by providing intimation to the banker as and when the denomination in the denomination slot reaches a threshold limit. The customer convenience related problems can be eliminated by popping up the status of concerned denomination slot when the denomination in it gets exhausted. This not only helps the customers during withdrawals but it also helps the banker during replenishment. These proposed solutions can be achieved by the advent of sensor technology. Two types of sensors could be used to solve the problem involved in the existing system, they are:

- Light Emitting Diode (LED) Sensor
- Pressure Sensor

The use of either of the above mentioned sensors in the proposed model has some effects which are tabulated in table 1.

Sl.No	LED Sensor	Pressure Sensor
1	Easy Maintenance	Difficult to maintain
2	Add on does not disturb the existing denomination slot	Add on slightly disturbs the existing denomination slot

Table 1: Comparison between LED and Pressure sensor

The above comparison enforces the use of LED sensors in the proposed model. The proposed architecture is given in figure 2.

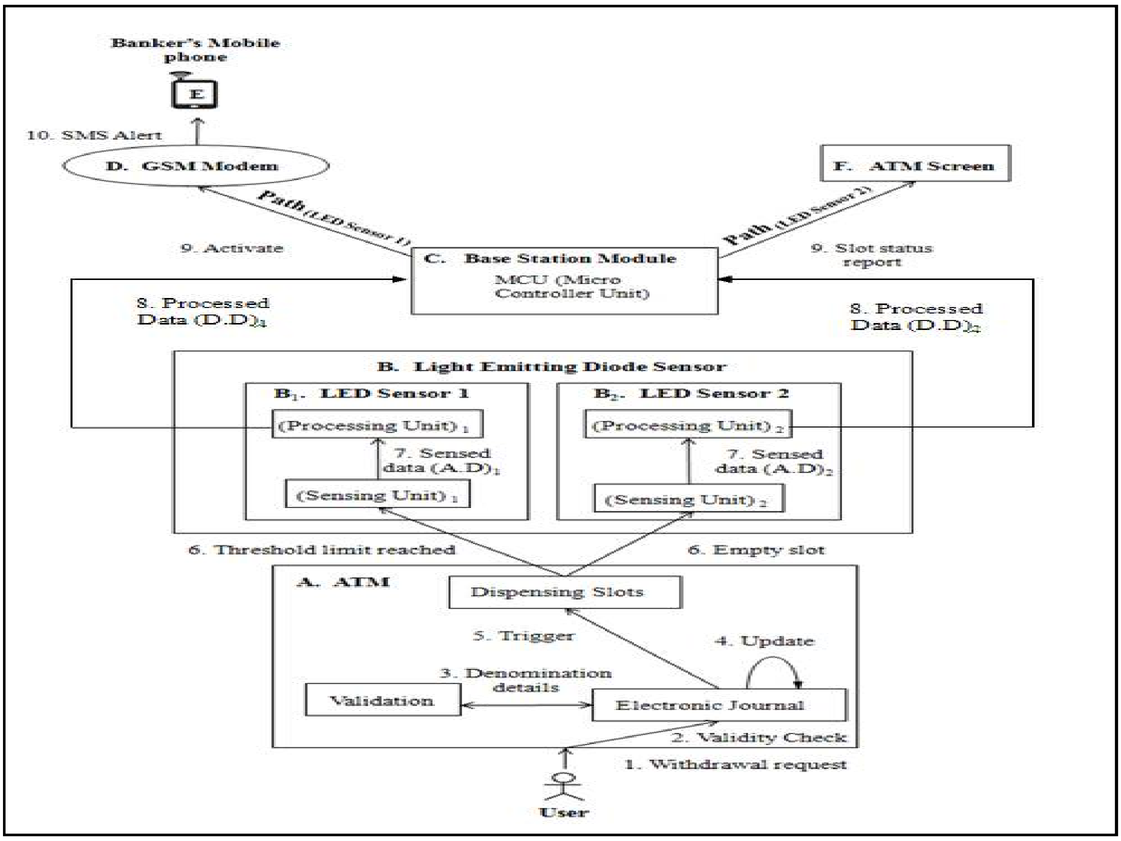

Fig 2: Process flow diagram of the proposed model

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The process model involved in all the sections of the architecture is detailed first and then the work flow process of entity 2 (LED sensor) is comprehended. The entities in the proposed model are:

A. ATM System: In the ATM system, as and when the user requests for withdrawal. Validation process is carried out for requested amount and money availability. Only when both are validated, the electronic journal updates the denominations and the dispensing slot dispenses the requested amount. The actual proposed model starts from hear.

B. LED Sensor: In the denomination slot LED sensors are fixed on either side. The LED sensor emits light and receives the light signal reflected by an obstacle in its path, the voltage sensitivity of the light signal is used as a basic parameter for LED sensor 1 to keep track on the threshold limit of denominations, and for the LED sensor 2 to trail on the exhaustion of the denomination slot. The detailed process flow is discussed in section.

C. Base Station Module (MCU- Micro Controlling Unit): A microcontroller is a small computer on an IC containing a core processor, memory, and programmable input/output peripherals. Here, the micro controller acts as a base station connected to the LED sensor (input), GSM modem and ATM screen (outputs). When a communication from LED sensor 1 is made, the MCU activates the GSM connected on it. When a communication from LED sensor 2 is made, the MCU displays an alert on the ATM screen.

D. GSM Modem: The responsibility of GSM (Global System for Mobile communication) modem is to trigger an alert message as and when activation by the MCU is made.

E. Mobile Phone: The banker is alerted as and when denominations in the slot reach a threshold limit. This provides an ease of convenience to the banker during replenishment of denominations in the ATM.

F. ATM Screen: The ATM screen displays the status of denomination slot. This improves the convenience for the customer.

3.1 Algorithm describing the complete process involved in the proposed model

Objective: Alerting the banker about the status of the denomination slot and displaying a pop up on the ATM screen about the exhaustion of denominations in the concerned slot
Notation: 1. U: User who requests for withdrawal 2. DM: Dispensing Machine (ATM) 3. X: Requested amount by the user 4. N [3] : Is a vector representing number of denominations to be withdrawn from a denomination slot (DS) 5. Z: Total amount in DM 6. E.J: It represents Electronic Journal that maintains a record on Z 7. D_M: Display message on the screen of DM 8. T_r (p) : Trigger p times the spring holder in DS 9. DS= {DS_p | p = 0 to 3}: Set of dispensing slots present in a DM 10. SS_v: Voltage signal strength sensed by a S.U of LED sensor 11. THD: Threshold limit on number of denominations in DS 12. S.U= {$S.U_p$ | p = {1,2}}: Sensing Unit present in LED sensor p 13. P.U= {$P.U_p$ | p = {1,2}}: Processing Unit present in LED sensor p 14. A.D= {$A.D_p$ | p = {1,2}}: Analog Data sensed by $S.U_p$ of LED sensor p 15. D.D= {$D.D_p$ | p = {1,2}}: Digital Data produced by $P.U_p$ of LED sensor p 16. MCU: Micro controller Unit 17. GSM: Global System for Mobile communication 18. A_L: An alert alarmed by GSM modem onto a mobile phone 19. M_B: Banker's mobile phone

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Input: Withdrawal request by the user
Output: (Alert message || Status report)

Algorithm:

```
While (1)
do
Step-1:/* When a user requests for withdrawal from DM for amount X*/

        U → DM: Req (X);
Step-2:/* Validity check on requested amount X */

        i = 0;
          While (i<=2)
          do
                IF (i≠0) Then
                {
                        y = 1000 / ((i^2 + 1) * i);
                }
                END_IF
                Else IF (i=0) Then y=1000;
                N [i] = X/y;
                X = X mod y;
          END while

Step-3:/* Check on sufficient amount in DM */
        IF (X == 0) Then
                Validate N [i] with E.J's data;
                IF (TRUE)
                        i=0;
                        While (i<=2)
                        do
                                Z = Z – N [i];
                        END while
                END_IF
          ELSE return (D_M (transaction cannot be performed));
          END_IF
          ELSE return (D_M (invalid amount entered);
Step-4:/* Dispense amount X from all denomination slots (DS)  */
        i=0;
          While (i<=2)
          do
                T_r (N [i]) → DS_i;
          END while
Step-5:/* Alerting the banker about the status of a particular D.S */

         IF (SS_v < THD) Then
          {
                IF (Count == 1) break;
                ELSE
                {
                        SS_v → S.U_1: A.D_1 → P.U_1;
```

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```
                    P.U1: A.D1 → D.D1;
                    D.D1 → MCU: Ac (GSM);
                    Ac (GSM): AL → MB;
                    Count++;
            }
            END ELSE
    END_IF
```

Step-6:/* Information display on DM screen about unavailability of denominations in a particular D.S */

```
    ELSE IF (SSv == 0) Then
    {
            IF (Count == 1) break;
            ELSE
            {
                    SSv → S.U2: A.D2 → P.U2;
                    P.U2: A.D2 → D.D2;
                    D.D2 → MCU: DM (Empty Slot details);
                    Count++;
            }
            END ELSE
    }
    END_IF ELSE
END while
```

3.2 Work flow process in Module 2 (which involves LED sensor 1 and LED sensor 2)

An active LED sensor emits light and captures the light reflected by an obstacle in its path. This principle is used in tracking the denominations in the denomination slots. As shown in figure 3, we have two active LED sensors fixed on either sides of the denomination slot. The voltage sensitivity is calculated for the light signals captured by LED sensor using a multi meter. The voltage sensitivity proportionately increases/ decreases with the light signal strength.

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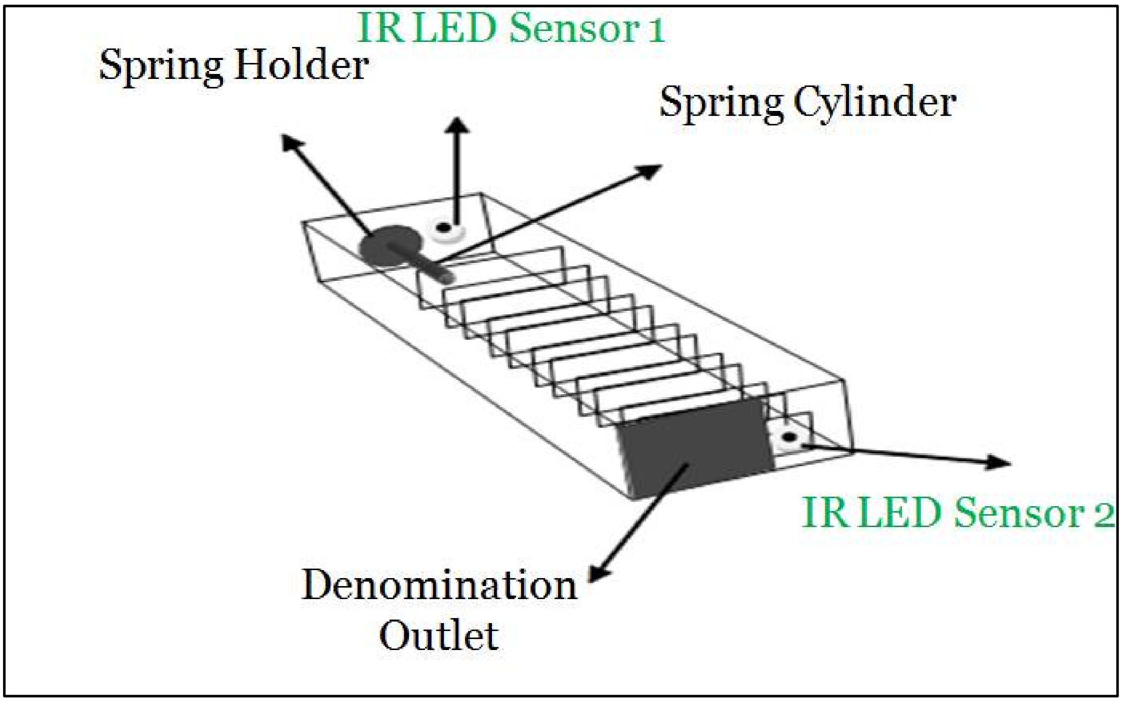

Fig 3: Denomination slot with embedded active IR LED sensors

The light signal strength captured by the LED sensor keeps reducing with increase in distance between the sensor and the denominations. Therefore,

$(S.S)_v \propto L.S \propto 1/(Dist)$ i.e., $(S.S)_v \propto 1/(Dist)$	Where, L.S → Light Signal received by LED sensor (S.S)v → Voltage sensitivity Dist → Distance between LED sensor and the denominations in the slot

Figure 4 represents the scenario of varying voltage sensitivity with distance (Dist).

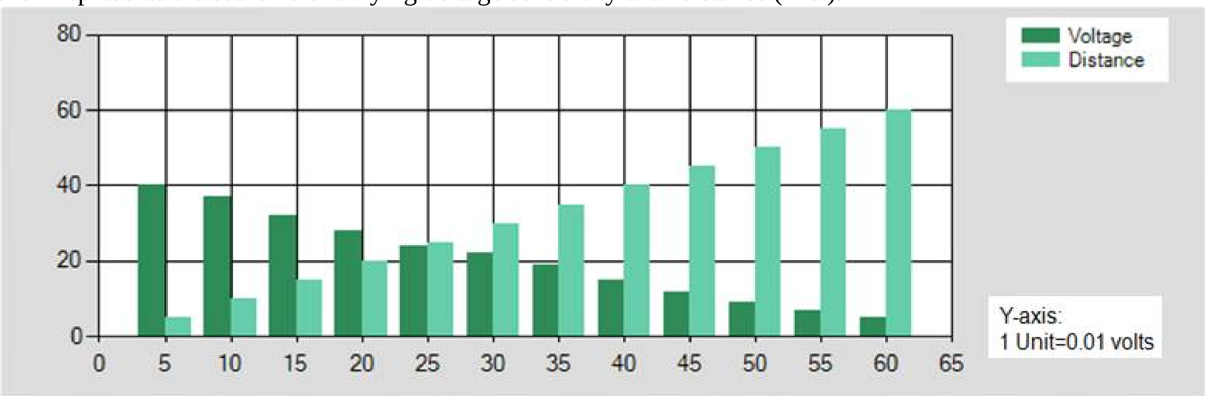

Fig 4: A graph plotted between varying voltage and distance

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The two LED sensors fixed on either sides of the denomination slot have different work flows. The working process involved with each of the LED sensors is discussed in below.

a) Work flow involved through LED sensor 1: In here, as and when the voltage sensitivity (which is calculated for the light signal captured) reaches a threshold limit (fixed prior), the MCU activates the GSM modem and this intern sends a sms alert to the bankers mobile.

b) Work flow involved through LED sensor 2: When the sensor does not receive the light signal (this scenario occurs when the denomination in the denomination slot gets exhausted), the MCU pops up an alert message onto the screen of the ATM about the status of the concerned slot.

Algorithm citing the work flow through both the LED sensors

Objective: Illustrating the work flow process via LED sensor1 and LED sensor 2

Notations:

1. DM: Dispensing Machine (ATM)
2. DS= {DS_p | p = 0 to 3}: Set of dispensing slots present in a DM
3. LED= {LED_i | i = {1,2}}: Set of LED sensors used in a D.S
4. D_M: Display message on the screen of DM
5. L.S: Light Signal received by an LED sensor
6. SS_v: Voltage signal strength sensed by a S.U of LED sensor
7. THD: Threshold limit on number of denominations in DS
8. MCU: Micro controller Unit
9. GSM: Global System for Mobile communication
10. M.M: Multi meter
11. A_L: An alert alarmed by GSM modem onto a mobile phone
12. M_B: Banker's mobile phone

Input: Light Signal (L.S)
Output: (SMS alert to banker && alert on screen of DM regarding status of concerned D.S)
Algorithm:

```
While (1)
{
Step-1: /*Light signal received by the LED sensor*/
        (LED)i ← L.S;
Step-2: /* Voltage sensitivity calculated for the captured light signal */
        M.M: L.S → SSv;
Step-3: /* Alerting bank about status of concerned slot */
        IF (SSv < THD) Then
         {
                IF (Count == 1) break;
                ELSE
                {
                        MCU: Ac (GSM);
                        Ac (GSM): AL → MB;
                        Count++;
                }
                END_IF
Step-4: /* Information display on DM screen about unavailability of denominations in a particular D.S */
         ELSE IF (SSv == 0) Then
        {
                IF (Count == 1) break;
```

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```
        ELSE
        {
                MCU: D_M (Empty Slot details);
                Count++;
        }
        END_IF
    }
    END_IF
```

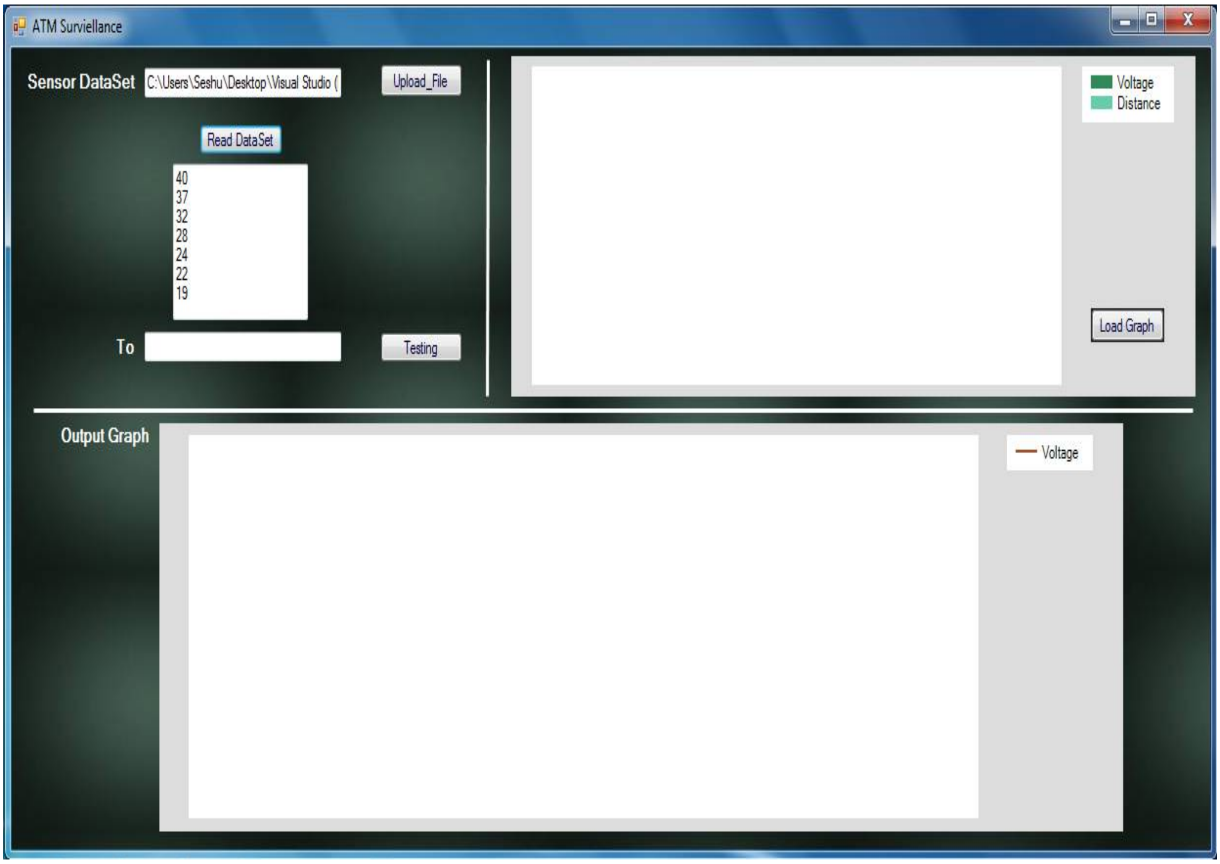
IV. RESULTS

Simulation of the proposed model has been carried out using:

- Language: c#
- Software: Visual Studio's 2010 ultimate

In the simulation process the threshold limit has been calculated by taking the average of mean values of voltages with varying distances. For delivery of messages, the services of the global gateway (clickatell) have been used. Simulation process is given below:

1. Data set of light signal's corresponding voltage sensitivity has been taken.



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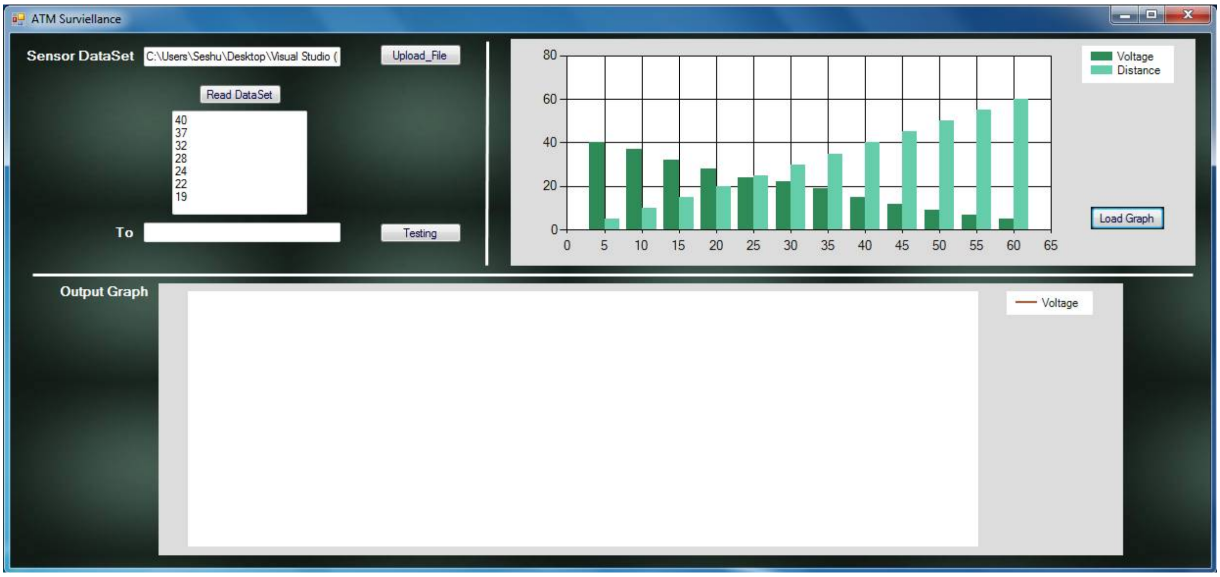
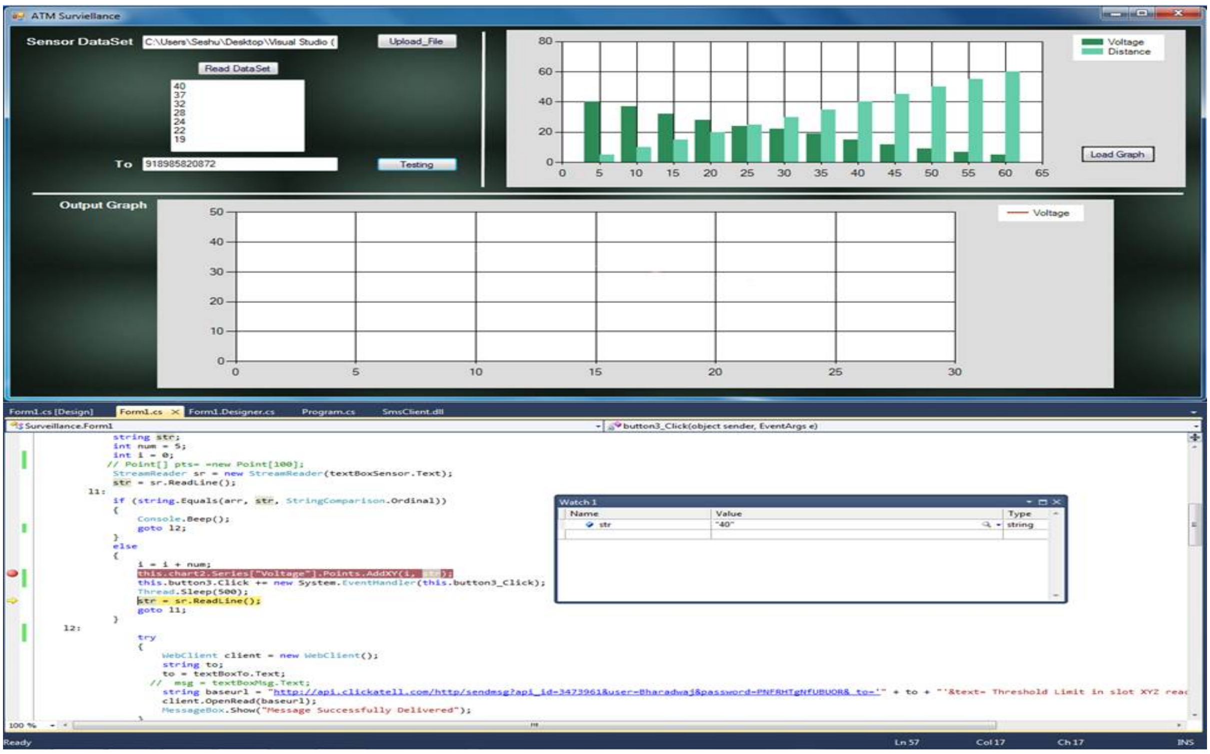
2. A graph between voltage sensitivities with varying distances has been plotted.



3. Real time comparison of voltage sensitivities with the prior fixed threshold has been made.

a. Voltage signal strength =40



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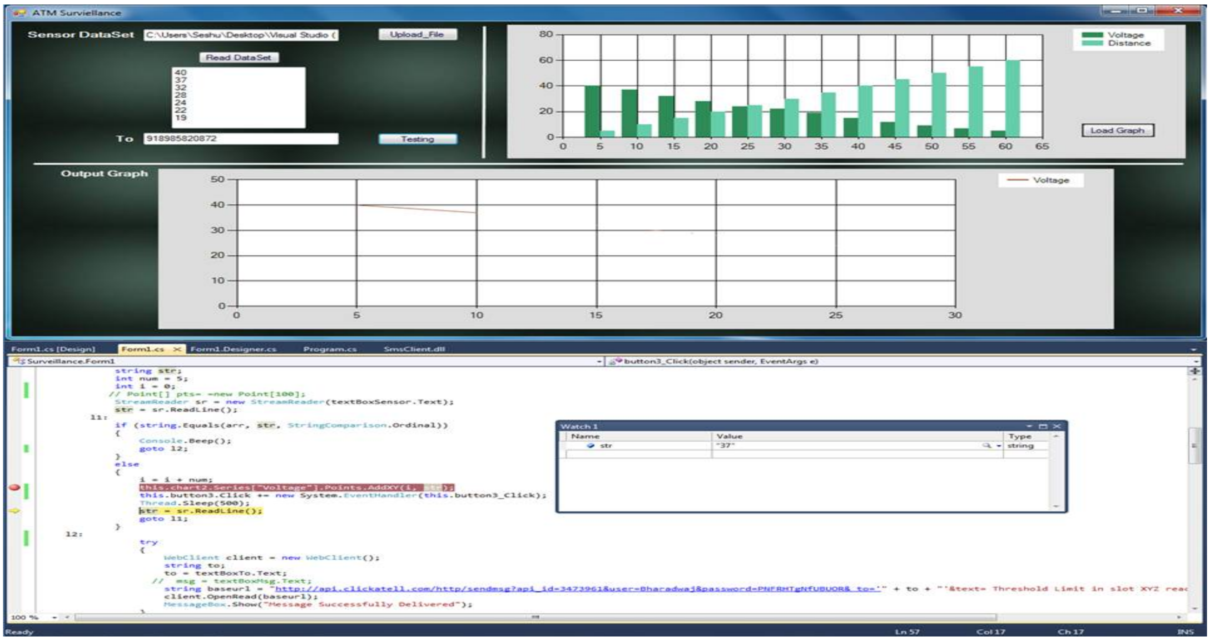
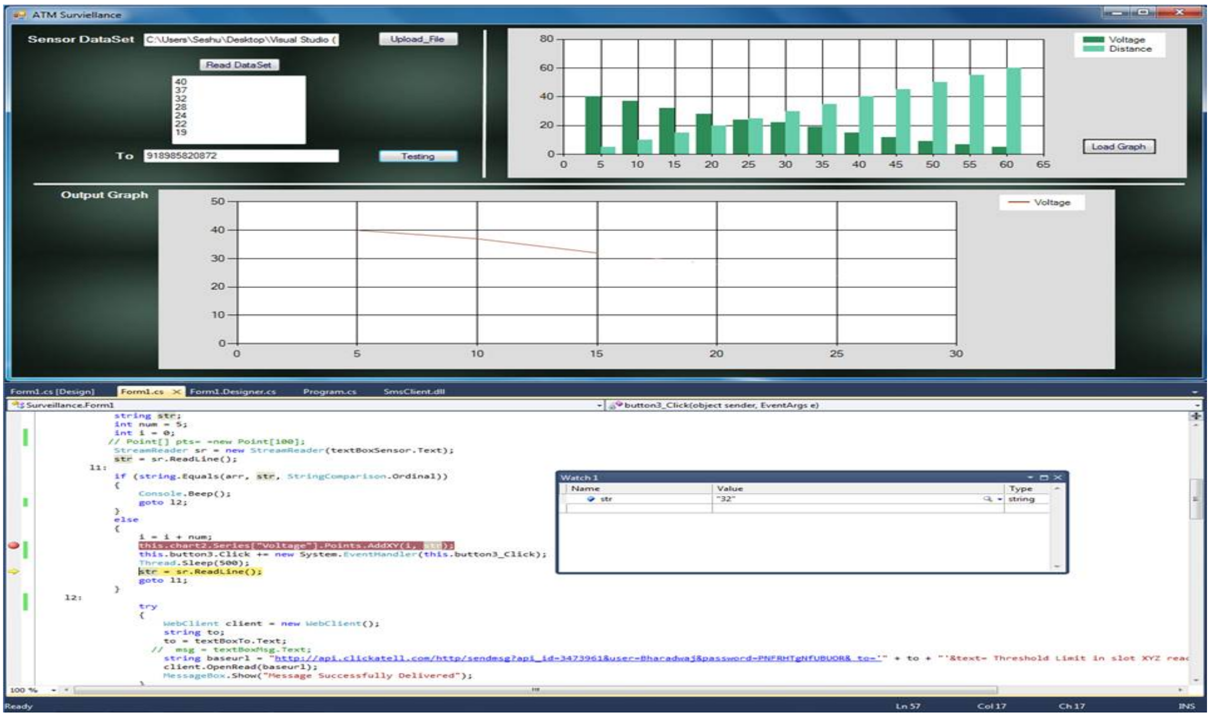
b. Voltage signal strength =37



c. Voltage signal strength =32



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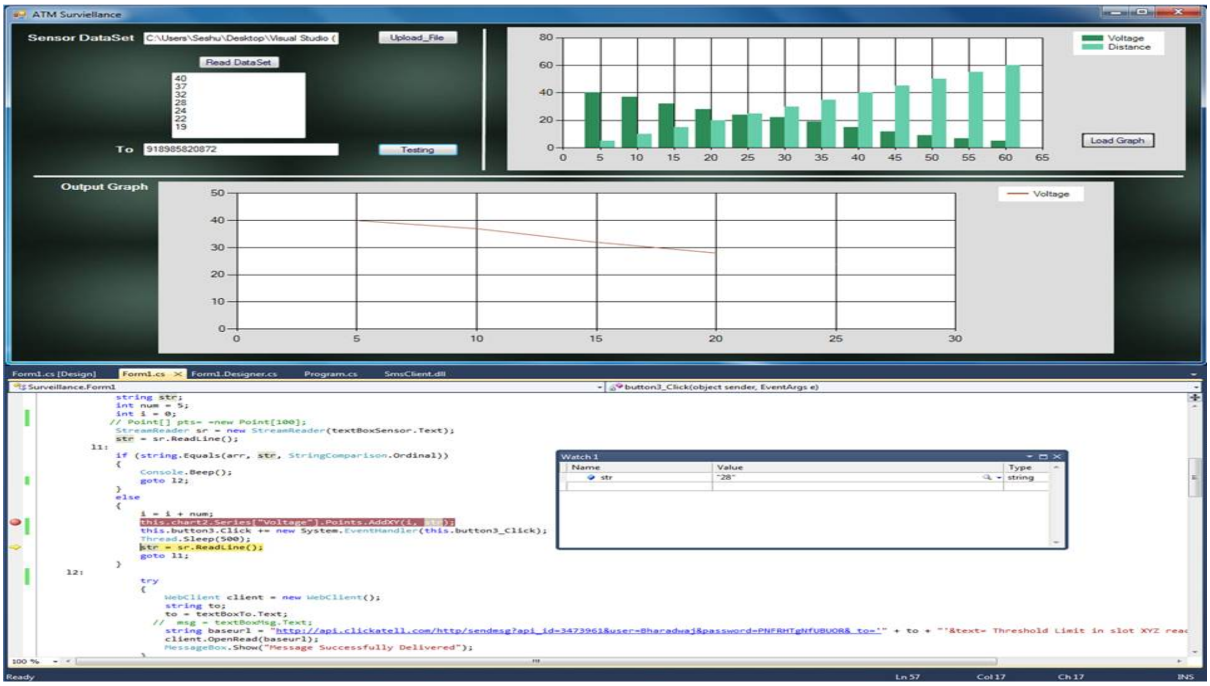
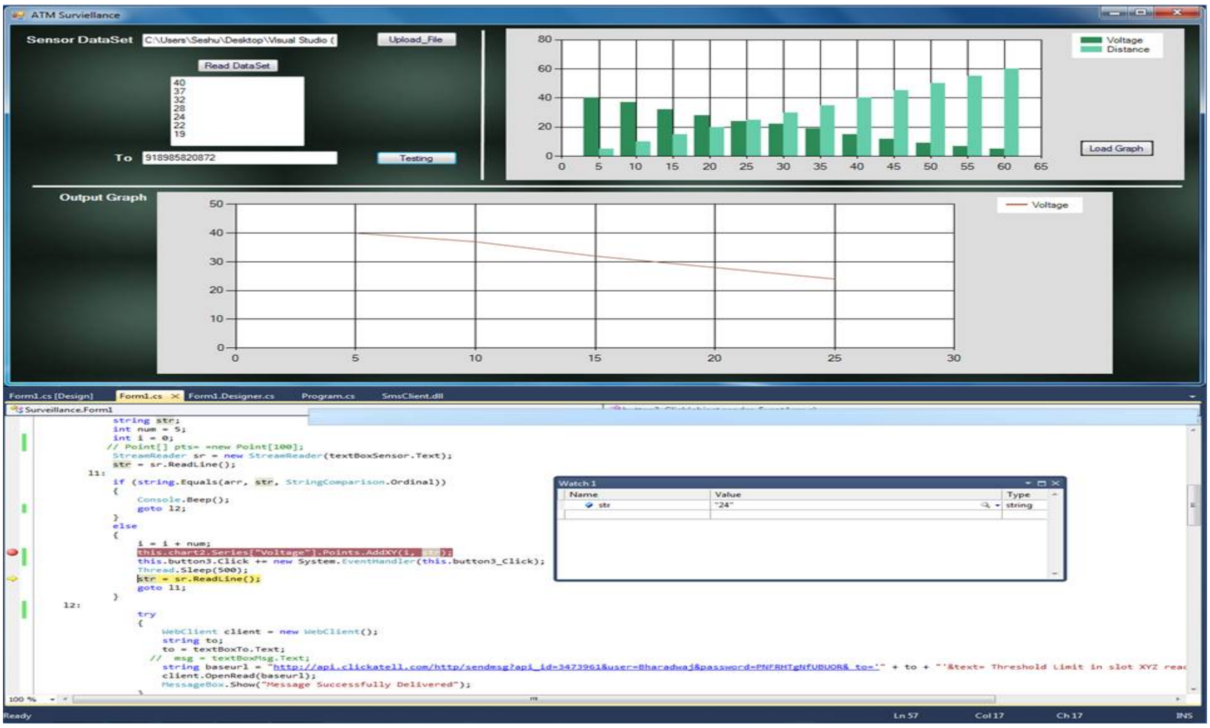
d. Voltage signal strength =28



e. Voltage signal strength =24



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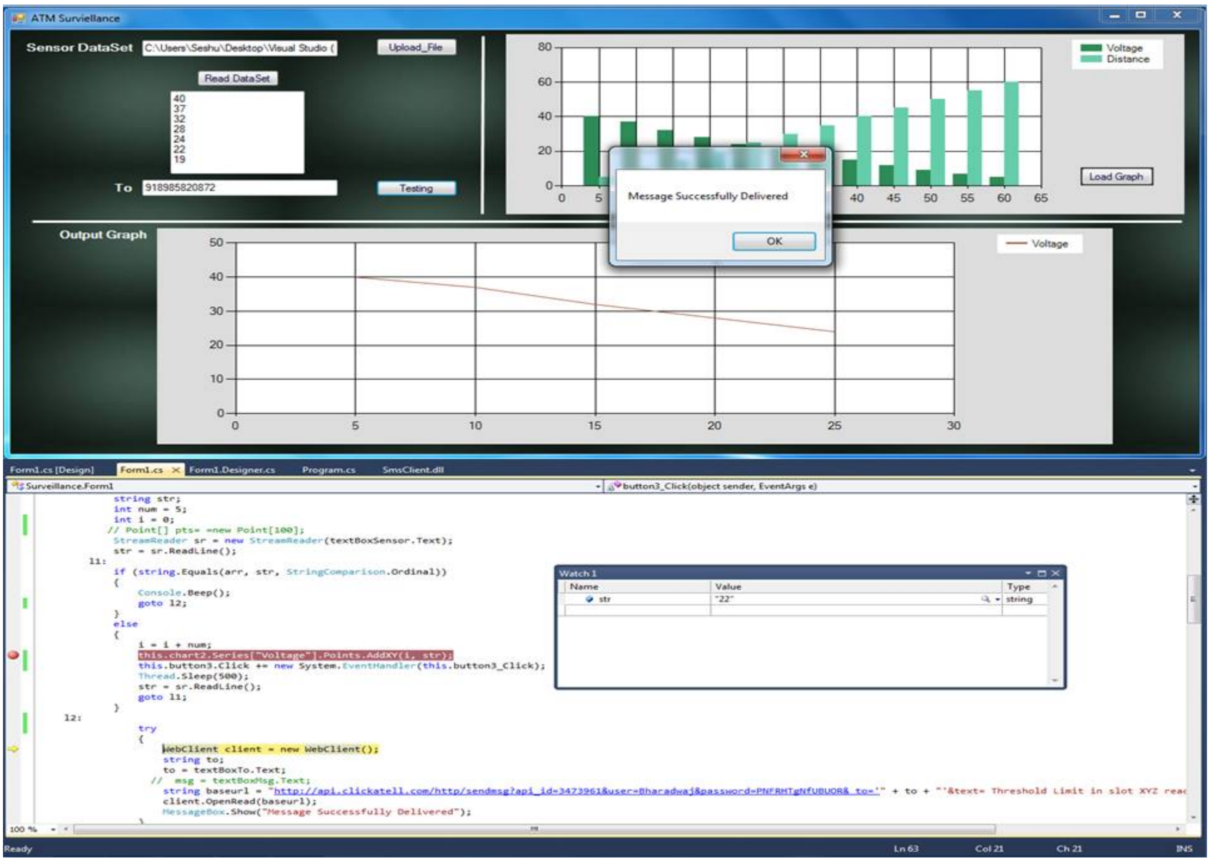
4. When voltage signal strength= 22, threshold limit is reached, and an alert sms is triggered using the global bulk SMS gateway.



V. CONCLUSION

This paper discussed the mechanisms to be followed and measures to be taken for improving the surveillance system in the ATM machine and provide great convenience to its users. The use LED sensors help in achieving this. The significant contribution is that, a new approach for solving the problems involved in the existing surveillance has been made. This approach is a different model and is a replacement of the existing solutions for surveillance problem.

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