Detection of an Intruder and Protecting Automated Teller Machine using Seismic Sensor

Avinash Kumar, Rashmi P Mahajan

Abstract— Main motive of this proposed work is to develop an accurate security system for the Automated Teller Machine (ATM). High security is achieved by detecting harmful movements at the location. The proposed system uses Fuzzy logic and KNN classifiers to detect the motion accurately and take appropriate action. Fuzzification is implemented to work on larger data set and to observe different smaller data. Furthermore data is processed through the k-NN classifier to get the nearest result like it is intrusive behavior or normal behavior. If it is intrusive behavior then the door is locked and camera starts recording simultaneously message will be sent to the concern authority to take the counter action. Sensing system is developed with the help of geophone sensors, microcontroller. The proposed system achieves the accuracy of 98 percent to detect the harmful action.

Keywords— Arduino Uno, Camera, Fuzzyfication, Geophone Sensor, GSM , KNN

I. INTRODUCTION

The intrusive behavior of intruders with the help of unattended ground sensor [1] is an important area of research in present time. The security system equipped with the advanced predictive analysis can play a vital role in security of not only military parameters but also of vulnerable areas like bureaucratic buildings and ATM machines. As most of the ATM machines are installed with the surveillance camera but merely it is used for recording the video. Also all ATM machines do not have security personnel. Even the ATM machines which have security personnel are poorly armed compared to the assaulters who may have the dangerous weapon. A few studies have been carried out for detecting intruders with the help of vibration sensor, PIR sensor, toxic gases or GSM technology to send data and motor to lock the door [2]-[6], applying biometric system [7]-[8] in ATM entrance to avoid the unknown individual. But these sensors were not highly sensitive and cannot be camouflaged. In this paper a Geo Phone sensor which is highly sensitive and can be camouflaged anywhere in the ground has been implemented to detect the intruder.

The main objective of this paper is to detect the intrusive behavior of an intruder with a high degree of accuracy using fuzzification and k-NN classifier. A geophone sensor is used to detect the events. Steps are taken to give better accuracy for data acquisition, event detection, feature extraction and classification.

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The main contributions of this paper is to detect the events by the geophone sensor which is highly sensitive and to classify the movements as intrusive or non-intrusive using fuzzification [9] and k-NN classifier by extracting the statistical features of the seismic signal and finally to show their behavior as hammering or knocking in MATLAB.

In this implemented system a SM24 geophone sensor of 28.8V/m/s has been used which works on the principle of electromagnetic induction for sensing the hammering or knocking movement. The relative motion between the suspended coil and the magnetic case of geophone induces output voltage corresponding to the events detected. Fig.1 shows the experimental method of my proposed implemented system. The geophone sensor was buried near the ATM machine to pick up the seismic events generated from various activities like knocking or hammering. 10 bit ADC converts the analog data into digital signal. Arduino microcontroller with ATMEGA328 performed the algorithm for feature extraction and classification using k-NN [10]-[11]. MATLAB was used to show the knocking and hammering characteristics corresponding to the impact.

This paper has eight sections including Section I represents Introduction, Section II presents the literature survey, Section III deals with the methodology, Section IV deals with the data acquisition, Section V deals with the Event detection , Section VI deals with the feature extraction, Section VII deals with the results and analysis and finally Section VIII deals with the conclusion.

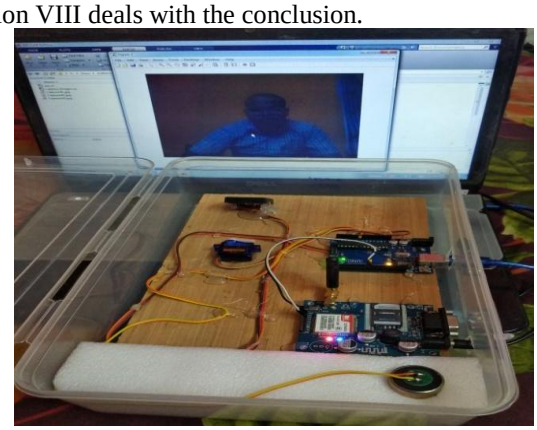

Fig.1 Experimental set up of implemented system

II. LITERATURE SURVEY

In this paper we have anticipated the condition of movement of a gatecrasher by utilizing a geophone sensor. We have predicted the state of motion of an intruder by using a geophone sensor.

We have proposed a new algorithm using fuzzy logic and KNN classifier to detect the event and to classify the movement between hammering and knocking which detects and extracts portions of the signal that represent an event.

Bodhibrata Mukhopadhyay et al [1] have predicted the presence of an individual and its state of motion (walk, jog or run) in out-doors scenarios. A geophone is used for the detection of human footsteps. Steps were taken to reduce the time for data acquisition, event detection, feature extraction and classification. With the rapid development of Internet of things (IOT), the predicted data can be uploaded to a common data base. The data can be further used for developing new algorithm.

Sudhakar Hallur et al. [2] have proposed the provision to give physical security to the ATM using various techniques like CCTV camera, GSM technology and toxic gases.

Kunde Archana et al. [3] have proposed ATM security system using ARM controller, DC motor to lock the door, GSM to send the message, LCD displays to show the output message.

V. Nagasumathi et al. [4] have proposed the idea of generating a signal using vibration sensor whenever someone tries to tamper the ATM machine.

K.C. Hanchinal et al. [5] proposed to secure the ATM system using vibration sensor and GSM modem. They used the chloroform to make the thief unconscious and lock the thief inside the room and used buzzer to activate the nearby people.

V.Sirisha et al. [6] have proposed the ATM robbery prevention using MEMS sensor ATMEGA328 microcontroller DC motor to lock the door, and Anesthesia powder to make the thief unconscious.

Santhi. B et al. [7] have provided the ATM security by using biometric system and making it secured by using Personal identification Image process. They used two phases of algorithm with two tier security to increase the security of ATM system.

Maik Anderka et al. [8] have expressed the idea to utilize automatic model generation techniques to learn patterns of normal behavior from the status information in an ATM. They also described three specific methods to identify the ATM fraud as a sequence based anomaly detection problem.

Shailey Thaker et al. [9] presented the analysis of fuzzification process of Fuzzy expert systems implemented in the domains of health care, education, career selection, real estate and finance. The parameters used for analyzing the systems were the input factors and type of membership function. Based on the analysis of the fuzzy expert system, they recommended for selecting appropriate membership function.

Yihua Liao et al. [10] have expressed new approach based on the k-nearest neighbor classifier to classify the intruders as normal or offensive.

Aman Kataria et al. [11] presented various output with various distance used in algorithm and helped to know the response of classifier for the desired application. They also represented computational issues in identifying nearest neighbors and mechanism for reducing the dimension of the data.

Vivek Ashokan et al. [12] compared the effectiveness of the various classifiers like Random Forest, SVM and KNN for recognizing human activities. They compared the events detected by these methods. Feature extraction was done by HOG technique.

III. METHODOLOGY

The given fig. 3 shows the system architecture of our security system in which seismic signals are collected by using a geophone SM24 of sensitivity 28.8V/m/s. A geophone is a device that converts ground movement (velocity) into analog voltage which is given to the 10 bit ADC of Arduino microcontroller, therefore whenever an intruder forcefully enters into an ATM, geophone detects the movement and inform the main controlling unit (here it is Arduino) about the same. CCTV cameras are not of high quality because this will require more memory. To avoid this, we are using a high quality camera and it will get switched on only for the time when geophone detects a ground movement.

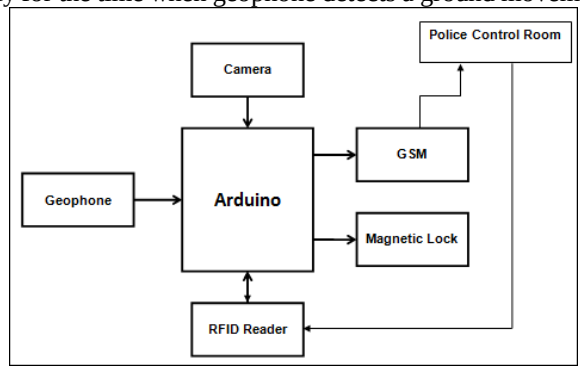

Fig.2 System architecture of security system

After that local police are alerted by sending them a text message using GSM module and magnetic lock will be closed temporally to lock thief inside the ATM. A magnetic lock opens only when a valid RFID tag is scanned in front of reader. Fuzzy logic is used to make different fuzzy set before applying k-NN algorithm.

IV. DATA ACQUISITION

Seismic signals were collected using geophone sensor of sensitivity 28.8V/m/s. The analog signal was sampled at 8 KHz and converted to digital signal using 10 bit ADC in Arduino microcontroller. The experimental setup was placed in the Hass chamber as shown in fig. 2. A Hass chamber is a specialized chamber which is capable of applying pseudo random vibration in relation to frequencies. In the Hass chamber the vibration of different gravity is given. The different impacts are given to the system and accordingly the output voltages across Geophone sensor are measured.

Fig.2 Hass Chamber for vibration testing

The given table shows the data sets for different gravity value.

TABLE-I
(DIFFERENT VOLTAGES CORRESPONDING TO GRAVITY VALUE)

Gravity Value	Voltage across geophone sensor	Output
0.7g	19 mv	No
0.8g	20 mv	Yes
0.9g	21 mv	Yes

It is clear from the table that when the Hass chamber is given gravity value of 0.8g and above then the sensor gives output to servo motor to lock the door and to camera to capture the image and to GSM to send the message to the police control room.

V. EVENT DETECTION

Interrupt based event detection technique has been implemented here to detect any event which produce some voltage ranging from 20 mv produced due to the geophone sensor. An interrupt is the software execution of the hardware event which is called trigger. Whenever any interrupt is given to the processor by hardware then it needs immediate action. It alerts the processor to interrupt the current code which it is executing. The processor executes it by stopping all the current activities and executing a function called an interrupt handler.

A fuzzy logic is used as the nonlinear mapping of an input data set to a scalar output data. In this system the ADC value (<140 and >150) are divided by 10 to get different fuzzy sets. Algorithm for fuzzification is as follows:-

1. Define the linguistic variables and terms
2. Construct the membership function.
3. Construct the rule base.
4. Convert the crisp input data to fuzzy variable using the membership function.

For classification of extracted features into intruder or known person a k-NN algorithm[12] has been applied. K-Nearest Neighbor is a supervised learning algorithm in which the results of the test events are classified based on the majority of K-Nearest Neighbor events. The purpose of this algorithm is to classify a test event based on the characteristics and training models. The k-NN classifier is based on the assumption that the classification of a new event is most similar to the classification of other instances that are nearby in the vector space. There are several ways to calculate the distance between two points in multidimensional space. Suppose we have two points *x*, *y* where each point is an n-dimensional vector then, distance measuring functions can be taken the following ways. We can define distance function *d* (*x*, *y*) between two points by measuring their distance according to Euclidean formula using formulas below:

$$d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

We used k-NN algorithm to analyze the raw data that we got from the hass chamber at different g value after fuzzification by microcontroller. Then we used comparing of data sets with training data sets, each time by calculating the Euclidian distance between incoming acceleration data and our training data sets.

The algorithm that does the classification can be given as follows:

1. TS= {Set of templates describing each activity};
2. TT= {Target Template};
3. MD={Minimum distance between each element of training sets and target template};
4. MD= Calculate distance (TS[0], TT);
5. For each ts ϵ TS/TS[0]

   a. LD={Local value of distance between element of training data set and target element};

   LD=Calculate distance (Ts, TT)

   b. If (MD≥LD)

      i. MD=LD
      ii. Remember_Activity_Class ();

   c. Else continue;

VI. FEATURE EXTRACTION

Following statististic characteristic like mean value, variance value, standard deviation, RMS value, skewness, kurtosis value are extracted from input signal [13].

1. Mean

The mean or expected value for a continuous random variable can be shown as

$$\mu = E[X] = \int_{-\infty}^{\infty} x f_x(x)\, dx$$

2. Variance

The variance of the random variable X is given by

$$\sigma^2 = E[X^2] - \mu^2$$

3. Standard Deviation

Mathematically standard deviation is given by

$$standard\ deviation = \sigma = \sqrt{\frac{1}{n-1}\sum_{i=0}^{n}(x-\mu)^2}$$

where μ is mean value.

4. RMS value

RMS is a measure of accuracy.
It is given by

$$x_{RMS} = \sqrt{\frac{1}{N}\sum_{n=1}^{N}|x_n|^2}$$

5. KURTOSIS

Kurtosis is defined as the ratio of fourth order center moment and fourth power of standard deviation.

$$Kurtosis = \frac{(\mu_4)}{\sigma_X^4}$$

6. SKEWNESS

It is defined as the third order center moment. It is given by

$$Skewness = \frac{Skew(\mu_3)}{\sigma_x^3}$$

VII. RESULTS AND ANALYSIS

This implemented project is aimed at providing the ATM security with excellent performance by means of Geophone sensor and Fuzzification and KNN classifier. The various features are collected using Arduino microcontroller and the differentiation between knocking and hammering is carried out by means of Fuzzification and KNN classifier .Then the microcontroller sends the various information to the different module like camera to capture image, servo motor to close the door and GSM module to send the information. Then the door will be closed and the camera will start capturing image of intruder and the alert message will be sent to the police control room. The various results using the sensor are:

- The statistical property of the event of hammering and knocking as shown in table II and table III respectively.
- The graphical representation of the knocking and hammering activity as shown in fig. 5 & 6 respectively.
- The alert message sent to the Police control room.
- The captured output image of intruder who wants to temper the ATM machine as shown in fig.4

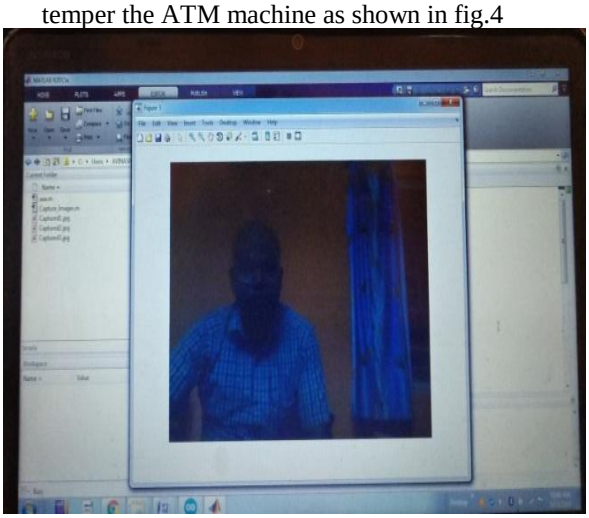

Fig.4 Simulated result of captured Image

TABLE-II
(STATISTICAL VARIABLE OUTPUT OF HAMMERING ACTIVITY)

Sl No.	Variable	Statistics Value
1	Mean Value	64.5500
2	Maximum Value	1023
3	Minimum Value	0
4	Standard Value	152.0958
5	Variance Value	23,133.7072
6	Kurtosis Value	20.7086
7	Skewness Value	3.8175
8	RMS Value	164.5251

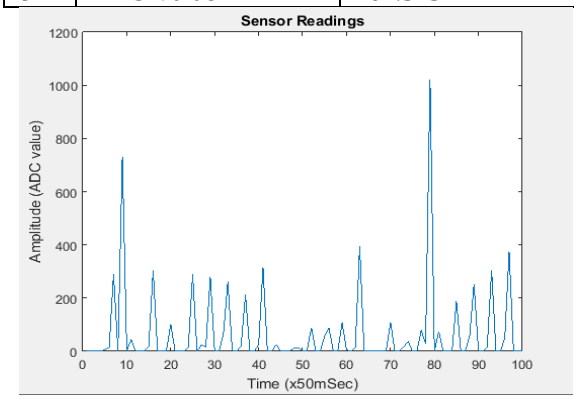

Fig.5 Hammering Graph

TABLE-III
(STATISTICAL VARIABLE OUTPUT OF KNOCKING ACTIVITY)

Sl No.	Variable	Statistics Value
1	Mean Value	10.3300
2	Maximum Value	52
3	Minimum Value	0
4	Standard Value	13.4292
5	Variance Value	180.3445
6	Kurtosis Value	3.5173
7	Skewness Value	1.1866
8	RMS Value	16.8893

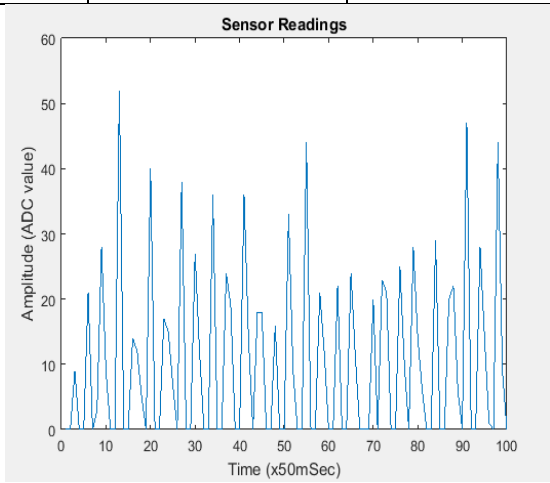

Fig.6 Knocking Graph

In the above results the graphical representation of the output of knocking and hammering activity has been shown. In knocking activity, the maximum ADC value is 75 which is

less than 150 while during hammering activity the maximum ADC value is 472 which is greater than 150 as specified. The table shows the different statistical values of variables of a signal to differentiate between knocking and hammering activities.

Visualize the final result with confusion matrix. The numbers in the bottom side of the matrix give the overall accuracy. We achieved the final accuracy of 98.9% as shown in table IV.

- Performed Experiment 1000 times
- Positive (P)= 700
- Negative (N)= 300
- True Positive (TP)= 696
- True Negative (TN)= 4
- False Positive (FP)= 7
- False Negative (FN)= 293

TABLE-IV
(RESULT WITH ACCURACY)

Events	**Detected**	**Not Detected**
Detected	696 [TP]	4 [TN]
Non Detected	7 [FP]	293 [FN]

The manual calculations are given below:-

$$\text{Accuracy} = \frac{TP+TN}{P+N} = \frac{696+293}{696+4+7+293} \times 100$$

$$= 98.9\%$$

VIII. CONCLUSION

In this implemented system we have predicted the ground movement of an intruder using a geophone sensor. In this system the Interrupt based event detection technique has been used which detects and extracts portions of the signal that represent an event. In this system we discriminate between hammering and knocking using fuzzy logic and KNN classifier algorithm. This project is able to safeguard our Automated Teller Machine using geophone, event extraction technique, classifiers by sending the report to the police control room to take the counter action at the earliest. The work can be extended by adding more states of motion like crawling, walking or running with payloads, moving in random patterns etc. Classification of vehicles and animals can also be incorporated. The system can be used for surveillance of different places like security in offices, home, shop etc.

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