GSM Based Automated Detection Model for Improvised Explosive Devices

Rajat Sharma, Vikrant Bhateja and S.C. Satapathy

Abstract The most destructive crimes that are been committed by terrorists, tops the chart in perpetrating the world's worst crimes. Nowadays, explosives are planted at crowded places to create a loss to multitude of people lives. Special bomb detection squad is required to search and diffuse the bomb herein termed as Improvised Explosive Devices (IED's). Yet, there is dearth of independent techniques where detection of IEDs could be carried out in an automated fashion without the usage of man-force. This paper presents an automated approach for simplified detection of IED without the physical presence of bomb diffusion squad. The detection model proposed in this work consists of infrared sensors, AVR programmer, ATMEGA micro-controller and GSM module. The operational principle of the proposed model is based on the idea that an individual/machine carrying IED is detected by the sensors and at the same time this information is forwarded as a text message to the nearest workstations. The demonstration of prototype model reports the effectiveness of the detection approach with minimal complexity.

Keywords Improvised explosive device (IED) · Infrared sensors · GSM module

R. Sharma (✉)
SOPRA STERIA Pvt. Ltd., Noida, U.P., India
e-mail: march10rajat@gmail.com

V. Bhateja
Department of Electronics and Communication Engineering,
Shri Ramswaroop Memorial Group of Professional Colleges
(SRMGPC), Lucknow 227105, U.P., India
e-mail: bhateja.vikrant@gmail.com

S.C. Satapathy
Department of Computer Science and Engineering, ANITS,
Visakhapatnam, A.P., India
e-mail: sureshsatapathy@gmail.com

S.C. Satapathy et al. (eds.), *Information Systems Design and Intelligent Applications*, Advances in Intelligent Systems and Computing 434,
DOI 10.1007/978-81-322-2752-6_66

1 Introduction

The world is growing on the great heights of advancements and in this saga of developments; the explosives have also witnessed enhancements to fulfill the destructive requirements rather than constructive ones. These devices are termed as Improvised Explosive Devices (IED). Thus, IED's are needed to be detected in the fastest possible way, so that "It's not too late". Hence, there exists two types of detection techniques for IEDs so far stated as: bulk detection and trace detection techniques [1]. The major limitation of the existing explosive detection devices lies in the fact that they only serves the purpose of effective detection if the location of the bomb implantation is known via some third party. These processes are cumbersome and time consuming, at times leading to fatal and massive destruction. Remedial solutions are rare, which could confirm pre-detection of the explosive material (being carried by an individual) or planted/installed at some location. There is a need to devise sophisticated explosive detection techniques so that such hazardous objects could be effectively tracked within minimum span of time. Literature in the past is available with diverse techniques developed for the purpose of explosive detection. Roy et al. [2] presented an Associated Particle Technique (APT) system in single-sided geometry comprising of D-T neutron source and bismuth Germanate (BGO) detectors fixed on a portable module. This system was well suited to detect benign samples and explosive simulants under laboratory condition. Silva et al. in their work [3] proposed design and fabrication process for an electrochemical "electronic nose" type sensor. This metal oxide based system focuses on the detection of ammonia as a possible sign of ammonium nitrate based explosives. Bauer et al. [4] have shown that powders themselves scatter the laser radiation used in the excitation of the spectra, making other components more difficult to discern. The preliminary work done by the authors with Laser Induced Breakdown Spectroscopy (LIBS) showed that metal powders are easily detected and identified and that fuel compounds in flash powder mixtures are easily classified with Principal Component Analysis [5–8] into those containing oxygen and chlorine or those containing oxygen and nitrogen. In another work, Fransisco [9] proposed to include dispersing a mixture containing a fluorescent material uniformly over a ground cover, illuminating the ground cover with wavelengths of visible light or Ultraviolet (UV) light causing the fluorescent material to fluoresce in a visible light spectrum, and have detected where the mixture has been disturbed on the ground cover by visually observing inconsistencies in the fluorescent material on the ground cover that is fluorescing to indicate a location of the improvised explosive device. Phelan et al. [10] devised a Stepped-Frequency Radar (SFR), vehicle-mounted forward-looking ground-penetrating radar; designed for high-resolution detection of buried landmines and improvised explosive devices. The work of Kamarul and Shawal [11] is based on Infrared Thermography (IRT) technology. Huri et al. [12] presented a study of four types of pyrotechnics explosives packed in pipe bombs were utilized via sampling exercise. They have determined anionic inorganic constituents of improvised explosives by using ion chromatography. In the same sequence, Peters et al. [13] developed Microfluidic Paper based Analytical Devices (μPADs) for rapid, on-site detection of improvised explosives. Daniel [14] proposed a sensor design for the detection of triacetone triperoxide (TATP). Their design entailed a thermodynamic gas sensor that measures the heat of decomposition between trace TATP vapor and a metal oxide catalyst film. The techniques reviewed and discussed so far are functional only if the location of the implanted explosives is known by the detection. But there are no such automated and sensitive devices which could be placed in overcrowded/suspected to raise an alarm by sensing such hazardous material/object. The work presented in this paper deploys a circuit model consisting of sensors, AVR programmers, multi-controller and GSM module to sense, detect and respond at once via message circulation to the programmed workstations for an earliest possible action to be taken. The remaining part of the paper is structured as follows: Sect. 2 describes the materials and methods covering the proposed methodology and its implementation in presented in Sect. 3. Section 4 concludes the work and outlines the future scope.

2 Materials and Methods

The proposed work demonstrates a prototype working model that could be used to detect and prevent the explosion of IED's with following experimental setup and working methodology generating results through implementation phase. The proposed model is set-up in such a way that it could sense the presence of explosive device by using sensors assembled at its mouth, then the indication message will be forwarded to microcontroller showing that a device has been sensed by the sensor, now the AVR Programmer is also added in the model as it provides the required programming code by which microcontroller will establish its functioning and finally the signal is sent to attached GSM module about the presence of explosive device, thereafter the alarming message is forwarded to included mobile numbers for further actions to be taken.

2.1 Experimental Setup and Hardware Assembly

The proposed model has been assembled by using various electronic devices as mentioned in Table 1. The prototype model has been included with two IR sensors that will act as two nodes at two different sides for the detection purposes.

If signals are sensed by node 1 at one direction, then will inform the microcontroller at once or if the explosive device is been sensed by second sensor then it will also send the immediate signal to the microcontroller. Further, it is added up with one AVR programmer that facilitates the purpose of whole program coding which directs the microcontroller that what and when certain defined operations are to be followed to generate the desired output. Then, main part of the model i.e.

Table 1 Showing the names and quantity of the components used

Name of component	Quantity of the components used
IR sensor	2
AVR programmer	1
ATMega16 microcontroller	1
GSM module	1
12 V power supply battery	1
USB cable	1
Connecting wires	–

ATMega 16 microcontroller with quantity equals to one, is been used to give all the commands and signals wherever and whenever they are required by different components used in the model. Also, one GSM module has been circuited with the remaining set up to initiate the purpose of message sending from the project model to the registered workstations.

2.2 *Methodology*

The prototype model will come into the active mode when it will be connected with the power supply of 12 V adapter as the GSM module will start its function on getting the power supply. At the same time, the AVR Programmer is to be connected with the USB cable in the provided USB slot so that the AVR Programmer, ATMega16 microcontroller and IR sensor could come into active mode. The circuit diagram shown in the Fig. 1, specifies that two sensors are present each with three terminal nodes as-: OUT–To send the output signal for further processing; GND–Ground terminal and V_{CC}–Positive voltage supply terminal. Now, the above mentioned three terminals of both the sensors are in connection with the terminals of ATMega 16 microcontroller as –V_{CC} terminal of the sensor is connected with +ve volt supply terminal and GND terminal of the sensor is connected with –ve volt supply terminal whereas the OUT terminal of the sensor is connected with Port A of the microcontroller because Port A in the whole microcontroller works as the Analog to digital converter for signal conversion. Now, the AVR programmer is been used, to dump the hex code file so that microcontroller could get its functioning as per the coding is embedded. Now, another component which is been connected with the whole system is GSM Sim 900 module which facilitates the function of sending the message to the mobile numbers registered already in the code. The transmitter and receiver terminals of the GSM module come in connection with the Port D terminals that have Rx (receiver) and transmitter (Tx) terminals where the Rx terminal of the GSM module will be connected to the Tx terminal of the microcontroller and similarly, Rx terminal of the microcontroller will be connected to the Tx terminal of the GSM module. The power supply to the

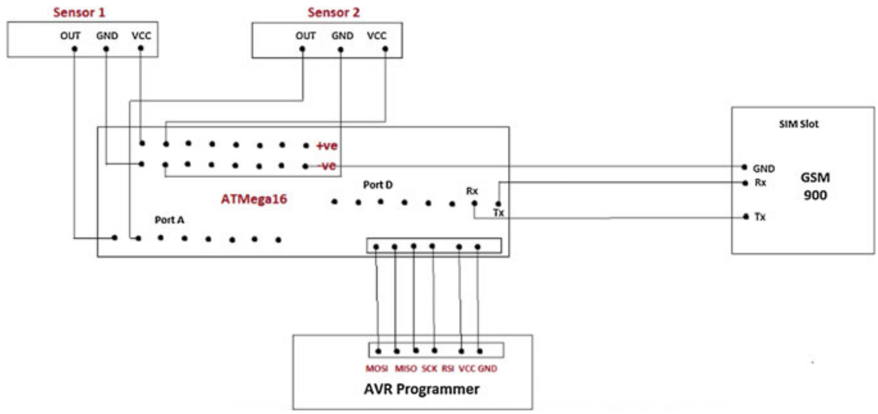

Fig. 1 Circuit diagram of the whole project model

whole project model is given by a 12 V adapter which provides a combination of the potential difference and current as-12 V::1 A. The list of the software tools that have been used in the project are- AVR Studio 4, AVR Dude GUI. The IR sensor after coming in the active mode is constantly sending the infrared signal from its transmitter and if the improvised explosive device is detected then the Infrared rays will be received by the receiver of the IR sensor and thus the signal of sensing an explosive device will be sent to the microcontroller. Figure 1 is showing image of the circuit diagram with connections that have been stated in earlier part.

The IR sensor is having its OUT port connected at the PORT A of the microcontroller so that the analog signal is converted in the digital signal and can be forwarded in the whole circuit as PORT A of the microcontroller is having ADC (analog to digital Converter). Now, the AVR Programmer which is having the dumped hex file consisting of the program which is to be executed on the required signal is activated and the microcontroller executes in the same manner as it's programmed. The program is dumped into the AVR programmer by using the AVR Program loader, once the program is compiled and is executed successfully by the software tool-AVR Studio 4. Now, the ATMega 16 microcontroller sends the signal by its transmitter (Tx) presented on the PORT D to the receiver (Rx) terminal of the GSM module which are connected together via jump in wires. The GSM module on getting the signal from microcontroller will activate its Sendmessage () function as per the programming done to send the message by its antenna to the satellite, indicating that an alarming message which is stored in the string format in the program code should be sent to the registered numbers of the nearest workstations or the control rooms to the detected location of the improvised explosive device,

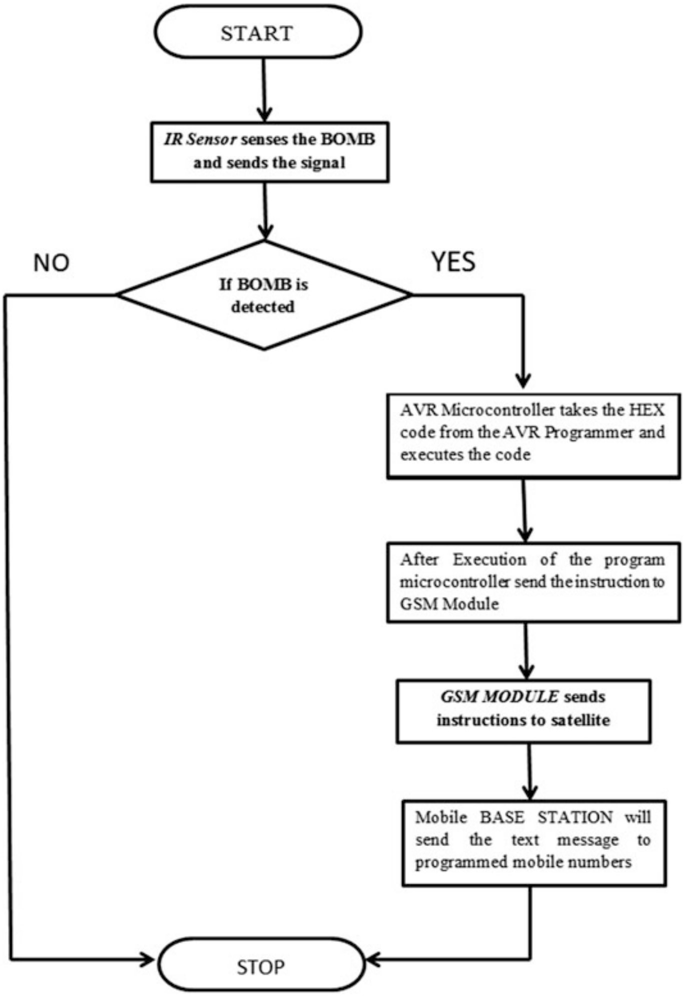

Fig. 2 Showing the flowchart of signal transmission in the proposed model

that are been preinstalled in the program code via base stations. Thus, in the final phase, workstations will at once get the message and will be doing the further precautionary measures with earliest effort to stop the destruction of the thousands of innocent lives. Now, Fig. 2 will show how the flow of signals will travel if an improvised explosive device is detected as well as will show that if no activity is taking place then the system remains idle.

3 Hardware Implementation

The proposed model could be implemented as in the architecture shown in the following figures. The whole circuitry is maintained on a piece of cardboard having sensors fixed at two ends along with AVR programmer, ATMega 16 multi-controller and GSM Module that are connected with each other by usage of jumping wires, having the power supply from 12 V adapter. The photograph of the live working prototype model is shown Fig. 3.

Figure 4, shows the schematic diagram of the whole concept (discussed above in methodology section) which shows the live working of the proposed model when it will be in the working application phase at some location.

The alert messages will be forwarded to the mobile devices of the people as is shown below in Fig. 5 having the screenshot of the mobile showing the message

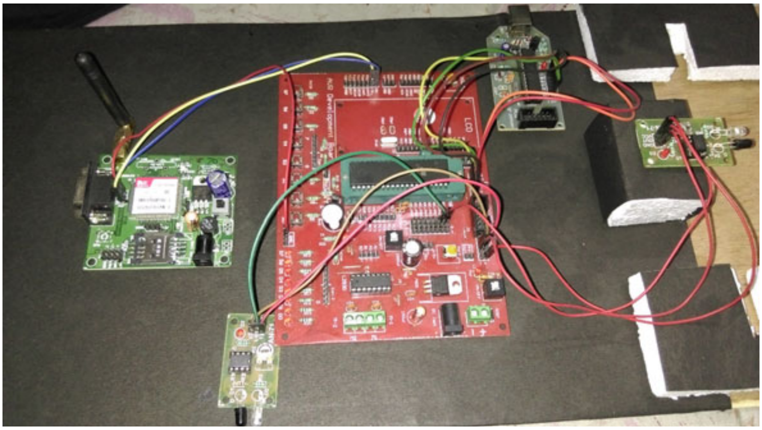

Fig. 3 Snapshot showing the full assembled architecture of the proposed model

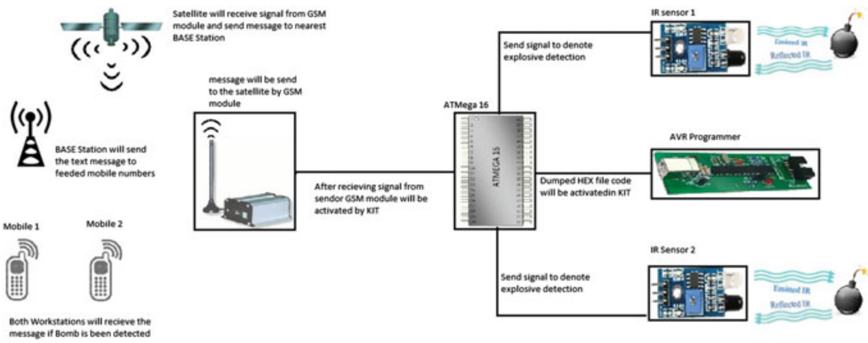

Fig. 4 Operational diagram of the proposed model

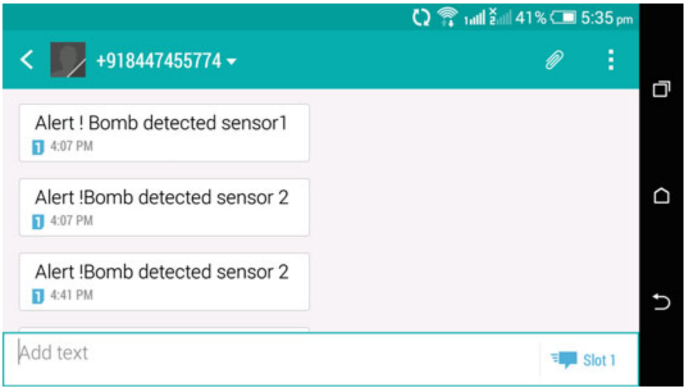

Fig. 5 Screenshot showing the messages that are received from GSM module of project

received on sensing any improvised explosive device passed by that region or vicinity.

The messages forwarded can be seen below:

Alert! Explosive device has been detected by sensor 1 (in case sensor 1 detects the bomb)
Alert! Explosive device has been detected by sensor 2 (in case sensor 2 detects the bomb).

4 Conclusion and Future Scope

The proposed work serves to provide for detection of an improvised explosive device. For this purpose, the device has to be installed in such a manner so as to sense/detect the explosive device; if such explosive content is present in the near vicinity of the device. The process is microcontroller programmed to direct the detection signals to the GSM module. This module is deployed for sending an alarming message to the nearest work stations available (from the detected location). Further for future enhancements, the device could include multiple sensors to detect different hazardous elements like metal, explosive chemicals (TNT, liquid explosives) etc.

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