



Early Warning System for Improvised Explosive Detection Using Wireless Sensor Networks: An Intelligent Information Directed Approach

Mradul Jain, Puneet Goyal, Anmol Jain

Department of Computer Science & Engineering, ABES Engineering College, Ghaziabad, Uttar Pradesh, India

Abstract: This paper focused on wide-area observation of public environments for prospective IEDs (improvised explosive devices) using wireless sensor networks. This paper explored magnetic and infrared sensors to detect replicated prone to detect IEDs in a Air Port, Railway Station Market Place, Schools, Shopping mall and Hospitals. The terrorization scenario was IED emplacement in a scrap container. A network of these wireless sensors was built and positioned in these environments with human intervention (Generally carrying ferromagnetic materials and per oxide Based Explosive) and proceeding toward a container. Results indicate that magnetic sensors could detect suspicious ferromagnetic materials and per oxide based explosive, though not all replicated IEDs contained enough to prompt detection. Infrared sensors were not effective for such task responsibilities as there is much background infrared radiation. The design of network is such that data could easily be aggregated over wireless sensor Networks. This suggests that the technology can be effective for shielding above given areas such as airports and urban areas. These sensors has integral communication component which can be used to communicate to close proximity nodes. The power consumed by sensors will be very small, which makes it appropriate to use thin-film batteries or solar cells so the prices of these sensors are very low than sensors used in current system.

Keywords: Explosive Detection; Magnetic sensor; Wireless sensors; Automatic explosive detection system; Ion-mobility spectroscopy; Tera-Hertz (THz) detection

I. INTRODUCTION

It is the time when peoples paid a lot of attention to the development of methods and device for the detection of explosives. These explosives are the reason to kill thousands of people and injured millions at Air Port, Railway Station Market Place, Schools, Shopping mall and Hospitals because these are prioritized targets involving a lot of people. New innovative forms of explosive attacks are more modish, more hazardous, using remote control of Improvised Explosive Devices (IED). Use of mobile phones allows terrorists to start a bomb immediately. Therefore, to use reliable detection system having enough efficiency with a broad range of IEDs is a crucial problem.

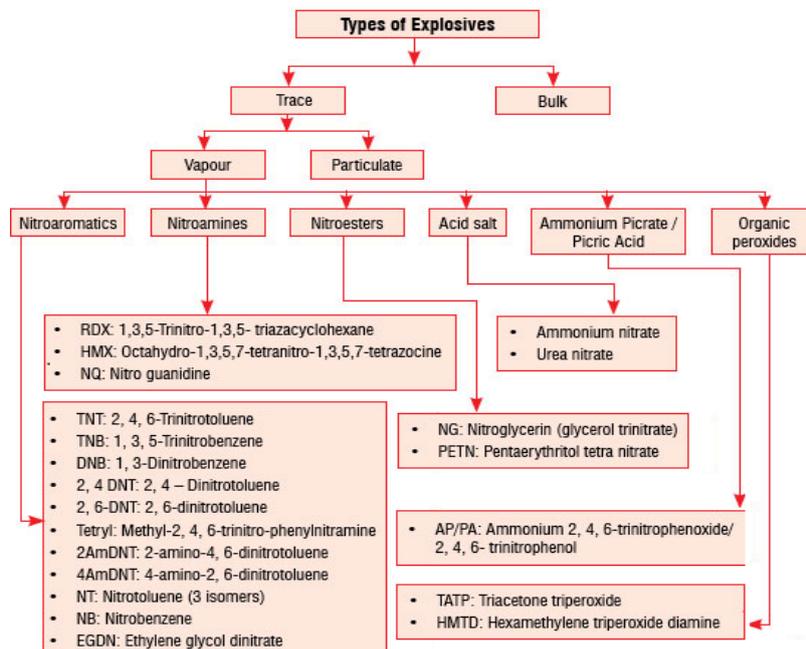


Fig. 1 Type of explosives

Conventional explosive detection systems are large in size, heavy in weight, more costly, and always require physical significance. The public visibility of this system allows the intruder to easily bypass the system using another path. A wireless sensor network has several types of autonomous sensors to monitor a particular activity. The system consists of a processor, a sensor, battery and wireless transceiver equipment. The system gathers the sensor data, to act upon local processing and broadcast the essential information to the security officials. A classification of type of explosive [6] is given in figure 1.

II. INTERRELATED WORK

Ion mobility spectrometry (IMS) is one of the most extensively used techniques of explosive detection due to its capacity to characterise the sample of explosive material both qualitatively and quantitatively. This method also has very low detection limits which are often possible [1].

This method characterises a sample using the mobility of ions contained by the gas-phase of the device while an electric field is applied. The vapours of sample are ionised at atmospheric pressure before introduction into the drift tube. This drift times are linked to the mass of the ions and by calculating the mass/charge ratio, it is possible to categorize components in the sample by comparing them with accepted standards.

The key disadvantage of the IMS instruments is that it usually contains radioactive material in small quantity as an ionizing source and this presents health threat to the operator.

TABLE I TYPE OF DETECTION METHOD

Type of Detection Method	Principle	Explosive Detected
Electro chemical	Variations in the environment through changes in current, when chemicals (explosives) interact with the sensor electrodes	TNT
Photoluminescence	Change in the photoluminescence of sensor element in response to an analyte (explosives)	TNT, RDX, HMX, Ammonim nitrate
Mass Based	Change in mass sensor element as a result of adsorption of chemicals (explosives), which is detected by a travelling acoustics wave or by deflection of the surface	TNT, DNB
Fiber optic based	Fiber optical sensors rely on changes in frequency or intensity or electromagnetic radiation	DNT, DNB
Ion-mobility spectroscopy (IMS)	Detection depends on the speed of ionized molecules migrating inside a drift tube that is influenced by ion's mass, size and shape, and charge. IMS can identify a significant variety of molecules with part-per-billion sensitivity	TNT, RDX
Laser Induced breakdown spectroscopy	Determination of explosives material composition by detecting the surface plasma generated using an optical probe.	TNT, RDX
Surface enhanced Raman scattering (SERS)	Identification of Raman signal from trace amount of analyte molecules when they are absorbed on activated metal surface or SERS substrate	TNT, RDX, PETN
Tera-Hertz (THz) detection	THz explosive sensors are based on different absorption of a sample region illuminated with THz radiation of two frequencies, chosen for a specific explosive, and to maximize the contrast between presence and absence of an explosive	PETN, TNTRDX, HMX, TDX
Bio- Sensors	Devices that integrate a biological element on a solid state surface, enabling interaction with an explosive and signal transduction	TNT, RDX, PETN

Another method is Mass spectrometry (MS) in different forms has been used effectively for detecting explosives because it particularly identify substances and the speed at which analyses are done. As compared to the size and cost of previous MS devices, this method has not been commonly used within some security oriented settings. Mass spectrometry separates and analyses the chemical composition of a substance as per its' mass-to-charge (m/e) ratio. This may be achieved using two methods which include time separation and geometric separation based approaches. There is nos. of mass spectrometry, for example: quadrupole, ion trap, time-of-flight (TOF) and tandem based techniques (MS/MS).

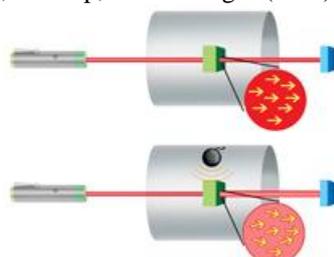


Fig. 2 Magnetic sensor

The terahertz (THz) spectroscopy has been investigated no. of times from previous years as a method for the detection of explosive vapour signatures [2]. But there are some drawbacks linked with this technology that have prevented its development into a viable system, and these comprise: the frame rate speed, a loss of attenuation as distance from sample increases, and, power requirements for the system [3].

III. CURRENT MOVEMENT

Existing system uses wireless sensors that constantly monitors for the IED in that particular place. Basically the sensors detect the chemical vapours, released by some part of chemical compounds into the atmosphere. The sensors collect this data and pass this data to the expert system which is positioned at different places. The expert system process this input and uses some type of algorithm to know the type of IED. But this system is not able to know the exact location of the IED. The current system uses gas sensors and chemical sensors which are high cost, consume more battery power and the accuracy is low. Also the false rate will be high as the atmosphere contains many chemical vapours in addition to the chemical compound vapours of IED.

IV. PROPOSED SCHEME

This research focused on wide-area surveillance of public environments for potential IEDs (improvised explosive devices) using wireless sensor networks. The magnetic sensors are used to detect replicated emplaced IEDs (emplacement is the step most susceptible to detection) in a public mall and along a typical street environment. The threat situation was IED emplacement in a garbage container. A network of these sensors was built and positioned in these environments with human subjects entering (some carrying ferromagnetic materials and some not) and proceeding toward a container. Our network design was such that data could easily be aggregated over many sensors in larger networks. The sensitivity of the sensors was determined to be less than 50 cm for small objects (electrical circuit board and nails) and two orientations of these sensors were investigated (one of which was more effective).

A. Assumptions

The capabilities of the sensors can be heterogeneous, that is different sensors can have different sensing capabilities.

- Sensor nodes are stationary in the system, but the mobility of the user node is allowed.
 - No failures occur in sensors once this framework is initiated.
 - Wireless broadcast is used for communication.
 - The sensors are responsive of their arrangement, location and position.
- The basic proposed system model is shown in figure 2.

B. Framework to Detect IED

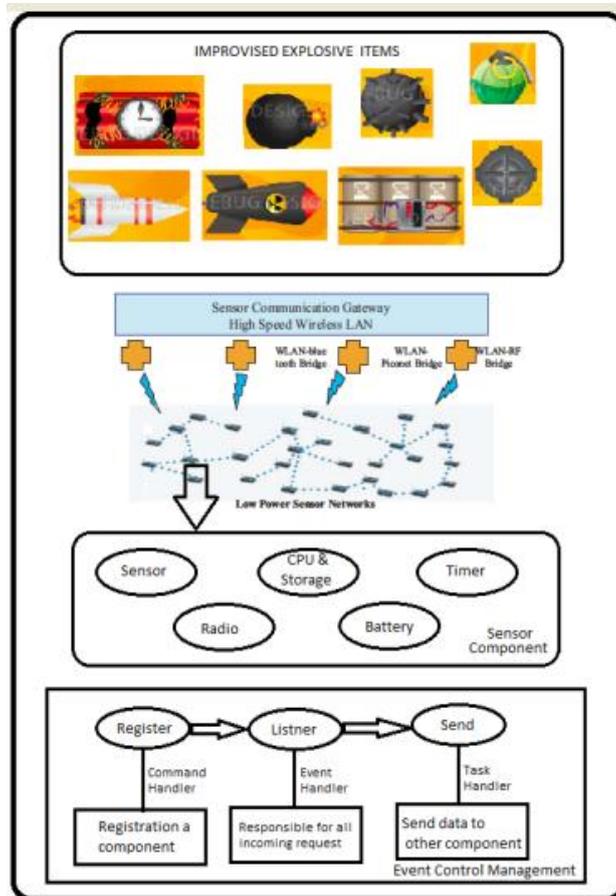


Fig. 3 Framework for IED

C. Components of Event Control Management System

Brief explanation about each component of event control management system.

- 1) *Listener*: This component is responsible for receiving all incoming requests. Depending upon the message type it can take various actions such as forwarding to neighbours, adding message to its own buffer etc.
- 2) *Register*: This component allows registering a component locally. After registration the registered component is available for discovery.
- 3) *Send*: This is used to send data or alarm to specific base station or components present on various nodes.
- 4) *Update*: This is mainly for operation and updating of all working components. It also allows us to make even software updates to middleware components also and hence achieving adaptivity.

V. ALGORITHM

1. Initialize all the nodes in the network including sensors, CPU, Timer, Register Control Unit (RCU) and synchronize them.
2. All nodes go to sleep mode after synchronization to increase battery life as they consume energy from battery.
3. All sensors continuously check positive presence of explosives. If they sense presence of any explosive then
4. These Magnetic sensors (MS) trigger the Register Control Unit (RCU) from sleep mode to active.
5. Now RCU checks the validity of detected data, stores the data from MS, if it is valid.
6. Listener Unit (LU) combines the data and matches with the data base for identifying the explosive
7. If the chemical compound is known LU will mark the target with the name of the explosive and pass the information to the Send Unit.
8. If an unknown chemical compound is found, LU will make a data base entry and pass the information to the Send Unit.
9. LU will inform the presence of the target to the nearest neighbors and also feeds the current position coordinates of the target
10. The entire network gets alerted about the presence of the target and starts tracking.
11. Cluster heads will calculate the approximate amount of explosive present based on the data provided by the leaf node and informs the base station. Along with this base station will also get the current position of the target with node ID

VI. CONCLUSION

Experimental results found that magnetic sensors were useful in reliably detecting suspicious ferromagnetic materials close to and in the garbage container (though not all IEDs will contain enough ferrous substance to activate detection). The paper is focused on wide-area surveillance of communal environments for potential IEDs using wireless sensor networks for a proof-of- demonstration of concept. So the magnetic sensors are used to sense some actions that could be used in IED emplacement, emplacement is the step most vulnerable to detect in a public mall and along typical roadside or street environment indicating potential targets such as government buildings. The intimidation scenario was emplacement of IEDs in garbage container (which could be extended to other public installation such as postal boxes). A network of these sensors was built and positioned in these environments with human subjects entering (some carrying ferromagnetic materials and some not) and going on towards a garbage container. Results indicated that magnetic sensors could detect suspicious ferromagnetic materials, though not all replicated IEDs encapsulated enough to activate detection.

VII. FUTURE WORK

Two major areas are recognized for further research:

Further research is needed in the incorporation of multiple sensors to develop the decision-making process. The research should also examine the use of localization such as triangulation methods to determine the threat source. The ability of the sensor network to trace the threat source is just as crucial as its detection. A positive localization may reduce unnecessary disruptions like cordoning and crowd dispersal, by confining it to just a particular section in its place of the entire structure.

REFERENCES

- [1] N. Chalfoun, "Sustainable Design for ESRA; a Mobile and Adaptable Envelope System Research Apparatus." Graduate Technology Showcase, College of Architecture and Landscape Architecture, May, 2003
- [2] David Culler et al (2002). "TinyOs: An operating system for networked sensors." <http://tinyos.millennium.berkeley.edu/>
- [3] A. B. Kanu, P. Dwivedi, M. Tam, L. Matz and H. H. Hill, Jr., Ionmobility-mass spectrometry, J. Mass Spectrom. 43 (2008)1-22.
- [4] Balaji Hariharan and Arjun Sasidharan "iWEDS-An Intelligent Explosive Detection and Terrorist Tracking System Using Wireless Sensor Networks" IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 4, No 2, July 2011 ISSN (Online): 1694-0814 www.IJCSI.org
- [5] MEMS-Based Gravimetric Sensors for Explosives Detection; Richard Mlcak*, Dharanipal Doppalapudi, Paul Pyzowski, Patrick Gwynne, Scott Purchase, Jeffrey Bridgman, Gerald Schultz, Martin Skelton, David Pelletier, Harry Tuller; Boston Microsystems, Inc. IEEE 2010.