New Implementation of Wireless Sensors Network for Explosives Detection

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Abstract - Explosives represent a threat on public life, several types of Explosives were improved during last year's. All explosives have different types and shapes, several types of detection techniques were implemented to detect and defusing explosives. In modern life its appears a need for an advanced techniques for detecting and defusing explosives, the using of the sensors have a wide spread in many applications. This research provides an advanced new technique for detecting Explosives using sensors network.

Keywords- Explosives, detection, defusing, sensors, network

I. INTRODUCTION

There are several types of bombs detection techniques, all detecting techniques fall into 2 basic strategies Bulk detection and Trace detection. Bulk detection uses the characteristics of computer vision to detect the shapes of wires, Trace detection depending on vapors emitted from the bombs itself. [1]. There are different types of explosives with different shapes and different sizes. Each explosive type has a special characteristics can be used either in bulk detection or Trace detection. Sensors devices can detect much of the characteristics of bombs were these bombs have either a mechanical or chemical characteristics that can be detected over a sensors [2]. Sensor devices are electrical devices sense the environment characteristics produces the environment characteristics on numerical form for processing and analyzing [3]. For better production and quality in data extraction a network of sensors is used to gain more data in multiple measurement spots distrusted over a specific area.

1) Explosive Types

There are several types of explosives according to the area of use [4]. The main types of explosives is:
1- Military Explosive
2- Commercial Explosives
3- Improvised Explosives

A. Military Explosives

Military Explosives designed to work upon a war area. These explosives designed to accomplish a maximum destruction power with large size and big shapes makes it the strongest bomb type such an explosives used to hit a military Troops on land or tanks or even a ships. [5]. Figure bellow shows a prototype of military bombs.
The creation of such a bomb type need a Government or specialist in the Explosives of the army due to the hardness in manufacture and Cost of Implementation. Military bombs are to expensive there is a Military bomb types cost can be millions of dollars. In the Counter of Military explosives a special radar is used to detect such a bomb since the range of the detection should be wide for more safely due to the blast range of such a bomb is large [6]. These radars is special types of devices have the ability of detecting Military explosives from a very wide range. Since the Military bombs needs a wide range detection.

B. Commercial Explosives

Commercial explosives is a type of explosives made for a commercial usage as in mining on coal and gold. The main purpose of this type of explosives is to breaks the rocks and stones for mining in caves or make a road directory. Commercial explosives also used for old building destruction. A commercial explosives made of chemical materials and highly exploded materials. These types of chemical and exploded materials' can be detected throw a Trace or bulk detection. [7]

C. Improvised Explosive Devices (IED's)

Improvised Explosive Devices is a Devices placed or manufactured using chemical and Destructive materials like TNT, these types of explosives are highly used in Iraq and Afghanistan hitting U.S troops. This type of explosives manufactured using electronic equipment using a highly exploded material (e.g. C4). These devices targeted vehicles and tanks. IED's uses a Timer associated with the bomb to initiates the explosion. [8]. IED's can be detected using Bulk detection and Trace detection since the chemical and exploded component of the IED emits a sensible characteristics that can be measured by using appropriate sensor.
II. Wireless Sensor System

A wireless sensor network is multiple sensors working together to gather multiple information's from environments were sensors are used in multiple applications such as industrial and scientific applications. A wireless sensor network (WSN) contain multiple sensor types were each sensor works together to have multiple data types. [9]

A) Sensor Network Applications
There are multiple types of applications that is uses wireless sensor network: [10]
A- Gathering Environmental data: the scientific research needs to collecting multiple environmental sensor data for research analysis
B- Security Monitoring: WSN can used in Security field were a camera sensors, heat sensors, and multiple other sensors can be used in monitoring the security of a building or a street.
C- Positioning Tracking: a wireless sensor network can be used in tracking a location of a certain node. This Node can be located using Global Positioning System (GPS).
D- Medical Diagnosis: a wireless sensor network can be used in multiple points in human body for measuring a certain data about the patient state.

B) Sensors Types
There are multiple types of sensors were each sensor type extracting different type of information's, multiple sensors used in the WSN. The following table showing the basic sensor types and a brief description [11].

<table>
<thead>
<tr>
<th>Sensor type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerometer</td>
<td>Sensing liner acceleration force in m/s²</td>
</tr>
<tr>
<td>Pressure</td>
<td>Measures the pressures applied to a device</td>
</tr>
<tr>
<td>Gyroscope</td>
<td>Measures the degree of rotation of mechanical parts</td>
</tr>
<tr>
<td>Microphone</td>
<td>Measures sound waves in dB</td>
</tr>
<tr>
<td>Light</td>
<td>Measures the luminance of light</td>
</tr>
<tr>
<td>Magnetic</td>
<td>Measures magnetic field at a specific position</td>
</tr>
<tr>
<td>Temperature</td>
<td>Measures heat degree in cilices</td>
</tr>
</tbody>
</table>

C) MEMS sensor Technology
A sensors developed over time and the sensor scaled into a micro size sensor were the technology of Micro-Electro-Mechanical-System (MEMS) were created.. MEMS is the technology of scaling sensors into a micro size placed on a chip to server multiple applications [12]. MEMS technology taken place in many application's, Industrial, scientific, Intelligence, and security. All these fields are involved with the MEMS, [13]. MEMS has taken place in Vehicles’ Manufactures Company and Scientific applications. The following figure shows the main applications involves with the MEMS technology [14].
D) Sensor types used in WSN

There are several types of sensors works within WSN, these sensors works together to gather several information from the environment to produce an active detection effect. The sensors used in the WSN are:

E) Light sensor, Camera sensor: a light sensor or camera sensor is used in the WSN to extract image information from a certain area. These information's contain many spectrums that can be detected by a light sensor. A Camera sensor will detect the exact spectrum that emitted from the exploded materials. Explosives have different spectrums in computer visions, this spectrum is different from other spectrum as in Infrared Camera vision [15] were infrared camera Isolated the vision of a certain materials from other objects for area detection. This sensor type can be used in WSN to detect the spectrum if a Exploded materials (e.g. C4) were these materials has a unique spectrum and vision characteristics from other materials. Figure bellow shows a prototype of infrared vision in different places

![Infrared vision in different places](image)

An Infrared camera uses the light sensor to activate the thermal vision [16]. Thermal vision captures the image according to the heat emitted from the objects were each object have a different spectrum according to the heat emitted from the objects. The thermal vision used to detect the heat of an objects and used to detect the patterns from persons to identify the persons identification.
throw the face recognition techniques [17]. What is matter about the thermal vision is to use thermal characteristics to catch the explosive spectrums emitted from the bombs.

![Thermal Vision Example](image1.png)

**Figure 7**

Thermal vision can be used either to detect the handheld spectrum or vehicle spectrum or even a building spectrum as in figures bellow shows how thermal vision can detects an explosive materials or any other desire objects spectrum in different places.

**F) Magnetic field sensor:** a magnetic field sensor is used in several application such as in industrial and scientific applications. Each object in the environment has a magnetic field. Magnetic field can be sensed using magnetic sensor. A magnetic sensor measuring the change in the magnetic field that is caused by a magnitude effect [18]. A sensitivity of magnetic sensor depends on the magnetic field strength and the environment effects. A magnetic sensor can detects the magnetic field of a metals, magnets, and any other objects that causes magnetic field changing. Figure bellow shows the magnetic field sensor activates and how magnetic field distributed over the space. Following figure shows the magnetic field strength.

![Magnetic Field Sensors](image2.png)

**Figure 8**

Magnetic field changes by the effect of a magnitude object or a magnet. A magnetic field changes rapidly when a magnitude object entered the magnetic field range. Some of materials of explosives have its own magnetic field strength that can be effected on the magnetic field of a certain area. This characteristics can be used as an advantage on the explosive for the detection.
process. Since the explosive changes the magnetic field of the vehicle attached to it (e.g. Car bomb) the magnetic field of the vehicle can be detected using a high sensitivity magnetic sensor. The normal magnetic field of vehicle is measured by the magnetic sensor. When any different object inside the vehicle is become a source of a high magnetic field readings, the magnetic sensor catches the high magnetic reading [19]. Magnetic field sensor monitors the state of a car when a car is passing nearby the magnetic sensor, figure bellow shows a prototype of a vehicle magnetic field measurement and how to detect the magnetic field of a vehicle.

Figure 9

G) **Pressure sensor**: the pressure sensor measure the pressure force applied to a certain area. A pressure is a force applied on a certain area that generates a certain force either negative or positive pressure force [20]. A pressure sensor is a device build for measuring the pressure force applied on a sensor. Many pressure measurement devices are developed for this purpose. What is matter about the pressure sensor is the pressure sensor can measure the weight of objects from the pressure force applied by these objects on the sensor. The sensor measuring the pressure force applied by a passing vehicles were each vehicle registered in the database attached to the pressure sensor system. The database work as a decision resource for weight recognition process. A pressure sensor uses many techniques for measuring the pressure force and converts these force into measurable readings displaying on a screen for data analysis. [21]. As shown in figure bellow, the pressure sensor are put inside a vehicle bump to measures the care when raising on the bump. This process will gain weight data from the vehicles and process these information's.

Figure 10 (A)
III. WIRELESS SENSOR NETWORK IMPLEMENTATION

The implementation of the wireless sensor network is to constructing a network of sensors and joining them together with a central server. The implementation of WSN is made by connecting the sensors together wirelessly. There are different wireless networks that can be used to joining the sensors in a wireless network (e.g. Wi-Fi or Zigbee).

**Sensor Network**: the usage of the network in the WSN is necessary for the sensor connection and transmission data from sensor to another sensor. A Wi-Fi network can be used to joining the sensors together in a single server due to the wifi network easy implementation and reliability in connection many devices together in a single router device. A wireless router is used to connecting the sensors with a single server (e.g. PC). The PC act as the evaluation node in WSN for decision making. A Wi-Fi network can be used to joining the sensor with the internet for remote usage of the WSN. The low power, bandwidth, and the easy implementation of the Wi-Fi network is the best network for such a system [22]. A wifi network follows the IEEE 802.11 communication standard. The wireless network uses Wireless Protocol Security (WPS) [23]. This protocol with the development of the hacking technologies. Makes the WPS easy to break. Since the WSN is used in highly security places that requires a high degree of security in information processing, the Wi-Fi network is not compatible with WSN in the high security places. Wi-Fi network, as in figure bellow, can used to joining the sensors in a locations that is not required a high degree of security such as home applications or scientific applications. A WSN needs a better secured network for data transmutation between the network nodes. A more secured wireless network strategy is required for WSN when its used in highly security places. Such as explosive detection. When WSN is used for explosive detection it requires maximum level of data protection (closed communication Network). Such a network is used as in Arduino communication system [24]. were the system part are connected together in closed network manure that enables maximum communication security.
In WSN system, a communication channel needs to be fast, reliable, highly security communication strategy. Since the data of the WSN needs to be saved in a highly secured location. A wireless sensors transmitted the data to a central server (e.g. PC) that contain a special program to process the data for evaluation. The central server program evaluates the result of the WSN sensors data and then return the decision to the sensors for appropriate action.

1) Hardware requirements for WSN Implementation
The hardware required for the implementation of WSN are:
A- Sensors Devices (Camera sensor, magnetic sensor, etc.)
B- Wireless network devices (Router, Arduino chips, etc.)
C- Server (Personal Computer, Laptop)
D- Broadband Internet Connection (LAN cable providing internet services to the WSN)

2) Sensors Placement
This part of the research is going to clarify the location of the sensors within WSN system. The sensors that assumed to be used in WSN needs to be distributed in a certain manure to produce the required effect on target. A sensors needs to works together for better evaluation of sensors data. There are multiple locations that can used to place the sensor within it. For better quality in results the sensors needs to be grouped together in the same area to measures the physical characteristics in the same time when a vehicle is passing or a person with a handbag that raises suspicions. An infrared camera is placed over the targeted area for better image extraction. It's possible to use more than one infrared camera at the same time to produce more quality for the WSN. A pressure sensor is placed in the ground to measures the car weight. A pressure sensor sends its information from the sensor to the central server. It's possible to use the magnetic sensor composed with the pressure sensor in the same car bumper. A car when passing over the bumper it will be measured both the pressure force and the magnetic field strength. The magnetic sensor measured the magnetic field of a vehicle, checking the vehicle for any magnetic explosives types, there are types of explosives has a high magnetic field that can be detected by using the magnetic sensor. a pressure sensor on the ground will measures the weight of the vehicle and compare the pressure force with the pre-stored weights data in the central sever. In the same time measuring the magnetic field strength under the vehicle. The car bumper under the vehicle is composed with a wireless adapter to sends the information through the wireless network. A wireless router must be in the center of the sensor group to coordinates the data between the network nodes. A server attached to the internet through a connection port (e.g. Broadband connection) to send results to other servers in order to produce a wider range coverage area for the WSN. After gaining information from the sensors it will be processed by the server and produces the results, monitoring the current state wither there is an explosives or not inside the measurement area. Following figure illustrate the sensors positioning with the WSN organization in general structure figure. Figure 11 (B) shows the connection and data transmission between the sensor and the server.
IV. WIRELESS SENSOR NETWORK RESULTS AND APPLICATIONS

A. WSN results in using magnetic sensors to detect magnetic explosives.

From the experiment on distributing a magnetic sensor over a specific area, using MEMS sensors for detecting magnetic field of a magnetic bomb. The following table shows the registered readings:

Table 1

<table>
<thead>
<tr>
<th>Distance in cm</th>
<th>Magnetic reading in µT</th>
<th>Mean</th>
<th>The variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directly under the car chassis</td>
<td>From 617 to 618</td>
<td>617.5</td>
<td>0.122198</td>
</tr>
<tr>
<td>5</td>
<td>From 350 to 351</td>
<td>350.5</td>
<td>0.126429</td>
</tr>
<tr>
<td>10</td>
<td>From 330 to 331</td>
<td>330.5</td>
<td>0.159396</td>
</tr>
<tr>
<td>20</td>
<td>From 102 to 103</td>
<td>102.5</td>
<td>0.093626</td>
</tr>
<tr>
<td>30</td>
<td>From 74 to 75</td>
<td>74.5</td>
<td>0.13781</td>
</tr>
<tr>
<td>40</td>
<td>From 69 to 70</td>
<td>69.5</td>
<td>0.118022</td>
</tr>
<tr>
<td>50</td>
<td>From 52 to 53</td>
<td>52.5</td>
<td>0.119396</td>
</tr>
</tbody>
</table>
The following figure shows the magnetic readings with the Variances of the value

![Magnetic readings with Variances](image)

**Figure 12**

**B. WSN Applications**

As a new explosive detector technique, the Wireless sensor network can be implemented on many public places, these places are:

**Government Departments:** Government departments are the most valuable targets for the terrorist, providing the most highly secured techniques in securing the Government departments and uses an advanced techniques for explosive detection.

![Government Department](image)

**Figure 13**

![Government Department](image)

**Figure 14**
Military Bases: the military basis needs the most secured techniques for securing the basis from threats. The Wireless sensor network can be used in the base gate were each vehicle passing will be examined by the WSN.

International Airports: Wireless sensor network is so valuable in the airports since the airports one of the most crowded places in the country, its needs to be secured with the modern technologies in the explosive detection. In the airport gates, the WSN can be implemented in the Entrance of the airports to protect this places from any explosive attacks. A wireless sensor network is used also to detect the handheld explosives that is carrying in the bags these sensors is invisible from the normal human since the sensors placed in an ambiguous places for better detection of suspicious objects.

Banks: the Banks buildings needs all available security techniques for securing the building from any type of threats. Using the WSN technology in the Banks gate will certainly makes the explosive detection process more efficient. Since the WSN system is placed on the banks gates, its possible also to joining more than one WSN in the banks, one WSN in the bank gates and the other in front of the bank building were both network are related together to produce more quality in data extraction and processing.
REFERENCES