Explosive Vapor Sensors for Cyber Physical Systems to Protect Crowds

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***Abstract*—Currently, very expensive instruments/tools are being used to detect improvised explosive devices (IEDs) to protect the large gatherings in a closed venue, however all those systems lack in an open environment such as marathons. This project aims to solve this problem by using non stationary sensor systems, where low cost sensors are distributed uniformly across the venue and detect very small amount of gases, such as ammonia (NH_3), which is released by the IED. Particularly, the project is focused on NH_3 detection using low-cost off the shelf sensors by mimicking real life scenarios in a lab environment.**

***Index Terms*— improvised explosive devices, NH_3 sensors, explosive detection, open environment**

Introduction

Improvised explosive devices (IEDs) are compounds or mixtures of compounds that have explosive properties and are easily prepared in simple conditions for example, homemade bombs. They consist of explosive material that has one or multiple chemical compounds and oxygen to oxidize remaining combustible substance [1]. The problem and danger of IEDs are that the chemicals and materials used are easily accessible and can be bought over the counter. For example, ammonium nitrate (NH_4NO_3) is easily accessible. It is used widely for agriculture [2], and fuel oil is found as close as a nearby gas station. Put these two together and an IED is made.

There are many different ways of explosive detection. There is the terahertz technology, coupling sensors, and even canine detection [3]. In airports and stadiums, which are closed areas, there are already some technology that is used able to detect these IEDs, the problem with these are that they are very expensive and they are stationary. They are stationary as in there is a fixed entry point which a person enters, and sensors or equipment are placed at those points. Therefore, it can easily detect IEDs. But what about in an open venue with no entry point? There are no ideal ways yet to solve this problem in an open environment, in example marathons.

On April 15, 2013 two bombs exploded near the finish line of the Boston Marathon. The bombs were IEDs, they were contained in pressure cookers that were hidden in backpacks. Those bombs killed three people and injured at least two hundred and sixty-four pour people [4]. This isn't the only case that IEDs have been used to cause tragedies. There are has been many different times where similar cases have occurred. In 2015 there were 630 explosion related incidents and 400 bombings [5].

This project aims to solve this issue. Several experiments will be performed with low-cost sensors consisting of off the shelf components such as: Adafruit nRF52 development board, MQ-137 ammonia gas sensor, and 5V portable phone battery bank. The sensor is shown in Figure 1. The experiments will test the performance of such sensors such as sensitivity and selectivity, in recreated scenarios. The sensors will be put throughout both an open and closed area with predefined impermeable barriers and see if any ammonia (NH_3) is present. Performing the experiments will give a sense of how the performance of the sensor system is and what the working distances of the sensors are. That will help calculate how many sensors will be needed in an open area to detect NH_3, which exists in very low amounts, such as part ppm level, in explosives and homemade bombs.

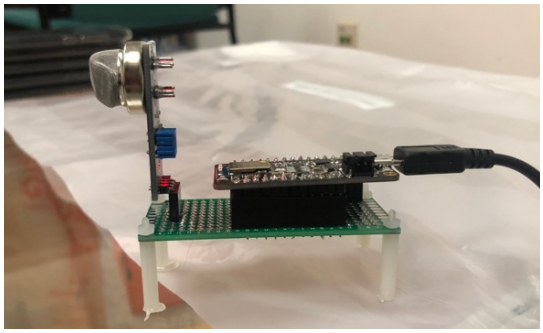

Figure 1: Low-cost sensor with off the shelf components.

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References

[1] H. Schubert and A. Kuznecov, *Detection and Disposal of Improvised Explosives*. Dordrecht: Springer, 2006.

[2] "Ammonium Nitrate," *Ammonium Nitrate | Mosaic Crop Nutrition*. [Online]. Available: https://www.cropnutrition.com/ammonium-nitrate. [Accessed: 14-Jun-2019].

[3] D. S. Moore, "Recent Advances in Trace Explosives Detection Instrumentation," *Sensing and Imaging: An International Journal*, vol. 8, no. 1, pp. 9–38, 2007.

[4] "Boston Marathon Terror Attack Fast Facts," *CNN*, 10-Apr-2019. [Online]. Available: https://www.cnn.com/2013/06/03/us/boston-marathon-terror-attack-fast-facts/index.html. [Accessed: 05-Jun-2019].

[5] United States Bomb Data Center (USBDC) (2017). *United States*

bomb data center (USBDC) 2015 Explosives Incident Report (EIR).