Advanced IoT-Enabled Technique for Tracking Precarious Aerial Swaggers

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ABSTRACT

Emergency response teams are accused with ensuring citizen safety from life-threatening events such as structural fires, gas leakages, vehicle accidents, and precarious material spills. While overseeing such occasions is dangerous, the release of precarious materials, such as toxic chemicals, into the atmosphere is particularly challenging. Upon landing in a scene, response teams must quickly identify the precarious substance and the contaminated area to limit exposure to nearby population centres. For airborne toxins, this appraisal is confounded by natural conditions, for example, alters in wind speed and course that can cause unstable, elevated swaggers to move powerfully. Without a way to dynamically monitor and assess atmospheric conditions during these events, response teams must conservatively predict the extent of the contaminated area, then orchestrate evacuations, and reroute traffic to ensure the safety of nearby populations. In this paper, we propose outfitting drone with Internet of Things (IoT) sensor platforms to enable dynamic tracking of precarious aerial swaggers. Augmenting drone with sensors enables emergency response teams to maintain safe distances during precarious identification, minimizing first response team exposure. Additionally, we integrate sensor-based particulate detection with autonomous drone flight control providing the capability to dynamically identify and track the boundaries of aerial swaggers in real time. This empowers specialists on call for outwardly recognize swagger development and better foresee and disconnect the effect zone. We describe the composition of our prototype IoT-enhanced drone system and describe our initial evaluations.

Keywords - IoT, Drone, Sensors.

I. INTRODUCTION

Motivation

Bhopal Disaster: The Bhopal disaster also referred to as the Bhopal gas tragedy, was a gas leak incident on the night of 2-3 December 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh, India. It was considered as of 2010 to be the world's worst industrial disaster. Over 5 Lakh people were exposed to methyl isocyanate (MIC) gas. Nearly, 3000 deaths and 4 Lakh injuries have been occurred. This effect is still impacting on new born babies like Handicaps and Mental disorders.

Precarious material incidents constitute critical emergencies as toxic substance releases can threaten public health, radically impact the environment, and in the worst case cause fatalities. At the point when spills happen, response teams should rapidly recognize the operators included and build up a constant intend to constrain introduction to specialists on call and encompassing networks. While all types of precarious spills are difficult to manage, airborne releases of toxic chemical agents in gaseous form, commonly used within industrial processes, are

particularly challenging [1]. The odourless, invisible nature of gaseous toxins makes released swaggers difficult to assess, track, and manage. Changing environmental conditions, such as temperature, humidity, wind speed and direction combined with obstructions such as buildings, vehicles, and natural land features further complicate the identification and tracking of moving toxic swaggers. Despite these challenges, first responders must rapidly identify the spilled substances and mitigate the impact with limited information. Emergency response organizations arriving on scene initially maintain a conservative distance to minimize first responder exposure. Colleagues quickly wear defensive rigging and navigate to the spill site to distinguish the contaminant at the source. After identification, the protected separation edge is re-adjusted dependent on the substance. Many response teams then leverage computational fluid dynamics (CFD) models using on-scene laptops to input observed environmental parameters to recognize how the airborne swagger may move and which zones are well on the way to be influenced [2]. While this increases the safety margin, such measures can further exacerbate traffic disruptions, cause unnecessary evacuations, and temporarily halt operations critical to the economic health of the region. Response operations face two huge difficulties when taking care of airborne precarious material spills. First, time is critical. Minimizing the time needed to safely identify spilled toxins and engaging all available response personnel is crucial to minimize the threat. Second, the prediction model used during these emergency events is critical to effectively managing these events over time. However, while these models are helpful in managing airborne swaggers, validating on-scene generated models is difficult. Moreover, it is difficult to convey swagger movement to on-scene responders actively working the scene. Drone have been progressively conveyed to distinguish changing ecological conditions [3][4][5][6]. In contrast to past work, we propose incorporating IoT stages onto

drone to enlarge their detecting capacities for identifying and overseeing air borne unstable swaggers. By using a drone for toxin identification, we enable response teams to initially maintain safe distances but also minimize identification latency. Additionally, we transmit all drone-collected sensor data, including GPS positions, particulate concentration levels, and time stamps to record swagger movement during response events. This provides the key missing piece to localize the generic CFD models used today - the data to validate the predicted path of a precarious swagger.

II. SYSTEM ARCHITECTURE

We built a complete system consisting of IoT platforms, sensors, and drone to locate, identify, and track precarious swaggers in real time. Once located, drone transmits data about swagger boundaries so it can be tracked in real time including data points such as wind direction, speed, location, the chemical composition and density measured within the air. This enables ground-based responders to see a visual representation of the area occupied by the swagger in real time. Over time, this also enables immediate identification of high-risk areas that should be evacuated.
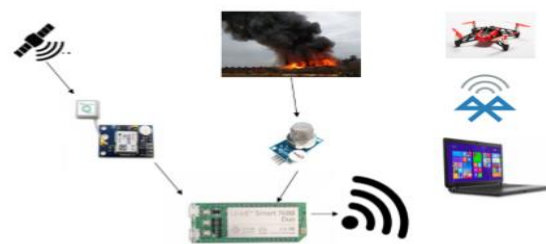

Figure 1: An overview of the system with single Drone

Our system consists of drone in the form of quad copters equipped with a microprocessor-based IoT board, onboard GPS receiver, node MCU and air quality sensors. This drone use air particulate and GPS data to locate precarious swaggers. Using this data, drone dynamically adjusts its heading and position based on current environmental observations. This data is also transmitted over the

wireless network to an on scene server, which stores the data for later analysis as well as displays the data in real time via browser as shown in figure 1.

III. EVALUATION METHODOLOGY

To evaluate our proposed framework we previously needed to recognize which parts to utilize. We begun by testing to distinguish which quad-copters and IoT stages to utilize. The assessment criteria we utilized included lift ability, strength, battery life, positional precision, and information correspondence trust worthiness. Our first challenge was to ensure our design did not exceed the lift capacity of the small drone. This turned out to be a key challenge that heavily influenced the design of the IoT platform we integrated. All components were tested individually as well as incrementally as we integrated components prior to full system testing to ensure that issues encountered during system evaluations could be easily identified and repaired. This demonstrated essential given the incorporation of different segments on drone. This testing depends on three key zones: physical parameters (estimate matters), framework between operability and inertness, just as joining with drone's self-governing control framework.

A. *IoT Platform and Drone Integration.*

1) Drone: For this work, we used the Parrot Rolling Spider drone. This drone was selected for several reasons. First, its size and weight made it an ideal candidate for an indoor evaluation. The small form factor enabled use in confined areas, while its weight allowed for nimble movement without requiring bulky, high output motors. This improved the stability of our autonomous systems with minimal weight, however, the small form factor also limited our payload capacity which impacted the IoT platforms we could use. The GPS, IoT board, air quality sensor and other sensors were chosen based on a compromise between weight, size, and functionality.

Before pairing drone with sensors and IoT board, we tested drone for mobility. Since our system does not require high speed maneuvering capabilities we ensured basic flights movements - lift, descent, forward, reverse, left, right, rotate right and rotate left. We then tested the battery life of drone under two scenarios: 1) motionless hovering and 2) minimum battery life with constant motion. We then identified drone's lift capacity under different battery capacities; in other words, how much weight drone could carry while maintaining stable flight characteristics. Battery selection was also critical to power the IoT platform, sensors, and drone. Ideally, drone should remain in flight for as long as possible to track aerial swaggers, but this requires larger-capacity batteries. Given the small form factor drone we used in this prototype system, we had to strike a balance between weight and power capacity. We first characterized the power load of the drone as well as the IoT platform during flight. Based on the components data sheet, each IoT board draws between 200 - 300 milliampere (mA), the air quality sensors require 150 mA, and the GPS requires 45 mA for a total of 400 - 500 mA per drone. Using a battery load analyzer, we found that a lithium polymer (LiPo) 3.7-volt battery would last for over 20 minutes before needing to be recharged.

2) IoT Platform: We used the Linkit Smart 7688 Duo IoT board given its compact size and weight. Board weighed 10 grams and the form factor closely aligned with the available drone footprint making mounting on the drone straightforward. This board is a dual platform architecture supporting both Linux and Arduino as well as file system memory expansion capabilities via an on-board SD card slot. The MQ-135, MQ-9 and MQ-2 air quality sensors was chosen based on its ability to provide real time data with minimal latency as well as its small form factor. After an initial burn-in period of 10 hours, each air quality sensor was required to run for at minimum of one hour prior to testing to ensure accurate readings.

Precarious air quality thresholds were identified by empirically testing the sensors with various gases and analyzing the results. As previously mentioned, we used a 250-milli ampere, 3.7 volt LiPo battery. We also integrated a GPS module and Node MCU that we connected to the IoT board via UART connection. We designed and developed a custom PCB, shown in figure 2, to combine all sensors with the IoT board that could be mounted on drone. We used the Eagle design tool for wiring schematics and built a two-layer board to include necessary components including the on-board step-up circuit to convert the 3.7 volt batteries to the 5 volts required for all components. To mount the IoT board, PCB, Node MCU and sensors on the drone, we used 3D modeling software and a 3D printer to create a custom case to use as a base mount as shown in figure 3. We mounted the base, with all components, to the drone by taking advantage of the wheel mounts to secure the platform.
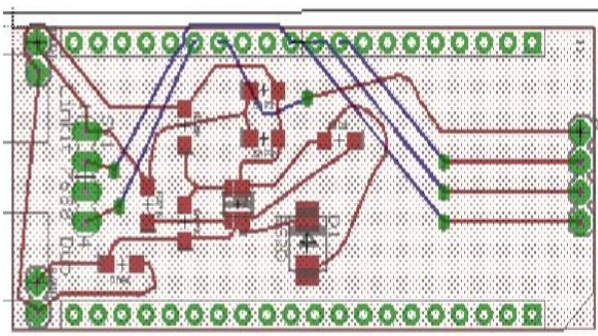

Figure 2: Board Mount design

Figure 3: Board Mount Prototype

B. Arduino IDE Tool

Arduino IDE is Arduino integrated development environment or we can say it is Arduino software. It consists of a text editor, where the code is written. A message area is given, which shows message or any error message. The tool bar contains buttons for common features. The programs are uploaded to Arduino board by USB connection. This process is called code-uploading or code-burning.

C. Aerial Swagger Testing

To test our framework we expected to securely discharge airborne contaminants without affecting our wellbeing. Given our air quality sensor detects carbon monoxide (CO), we used cans of compressed air. And for Ammonia, we gently heated a mixture of ammonium chloride and calcium hydroxide in water. Collect the ammonia from the upward displacement of air in a hood. Each release of compressed air emits small quantities of CO, which is part of the propellant. We tested our integrated gas sensor and found we were able to detect the increase in CO from each release of air from the can. This enabled us to selectively release a new CO swagger during our experiments.

IV. RESULTS AND DISCUSSION

In our initial experiments, our primary goal was to characterize how well our prototype drone detected and reacted to airborne swaggers. As previously described, we used compressed air canisters to simulate the release of CO in the air. And for Ammonia, we gently heated a mixture of ammonium chloride and calcium hydroxide in water. Each experiment was conducted within a large classroom. During testing, we continually refined the detection. We also logged the sensor values and movement commands from our control system during each flight and analyzed them after each experiment. We used these results to tune our drone navigation and control system. Although we have collected results

from a significant number of experiments, figure 4 depicts results after refining our control system from previous experiments.
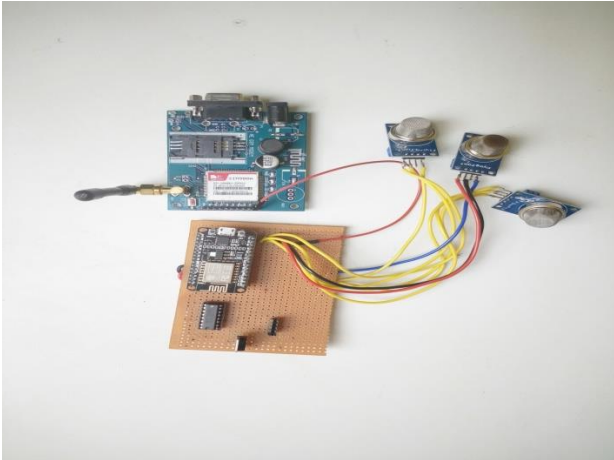

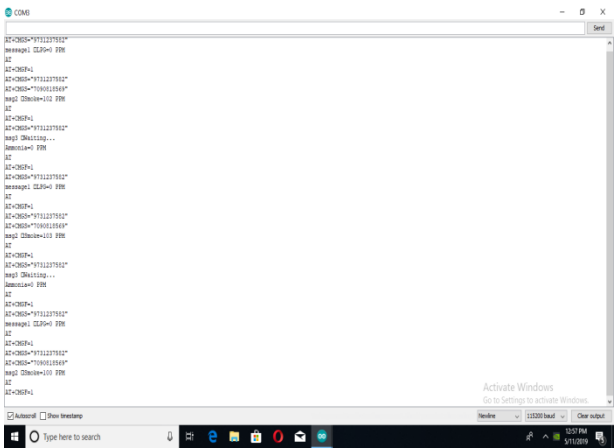**Figure 4: PCB Equipped with Sensors and Node MCU**

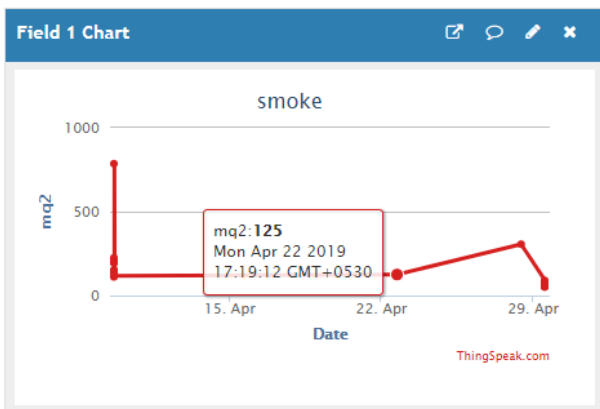**Figure 5: Sensor Values displayed via Arduino IDE**

Figure 6: Sensor Readings

V. CONCLUSION

In this paper, we have described the precarious swagger identification and tracking system we built by combining NodeMCU and sensors on drone. Our results reveal that we are able to accurately identify and track contaminant swaggers over time to provide a visual indicator to on-scene first responders as well as collect data that can be used to validate and improve swagger movement models over time.

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