UNIVERSITY OF NEBRASKA AT OMAHA
INFORMATION SCIENCE & TECHNOLOGY

CMANTIC LAB

Passive Chemical Detection System for UAVs

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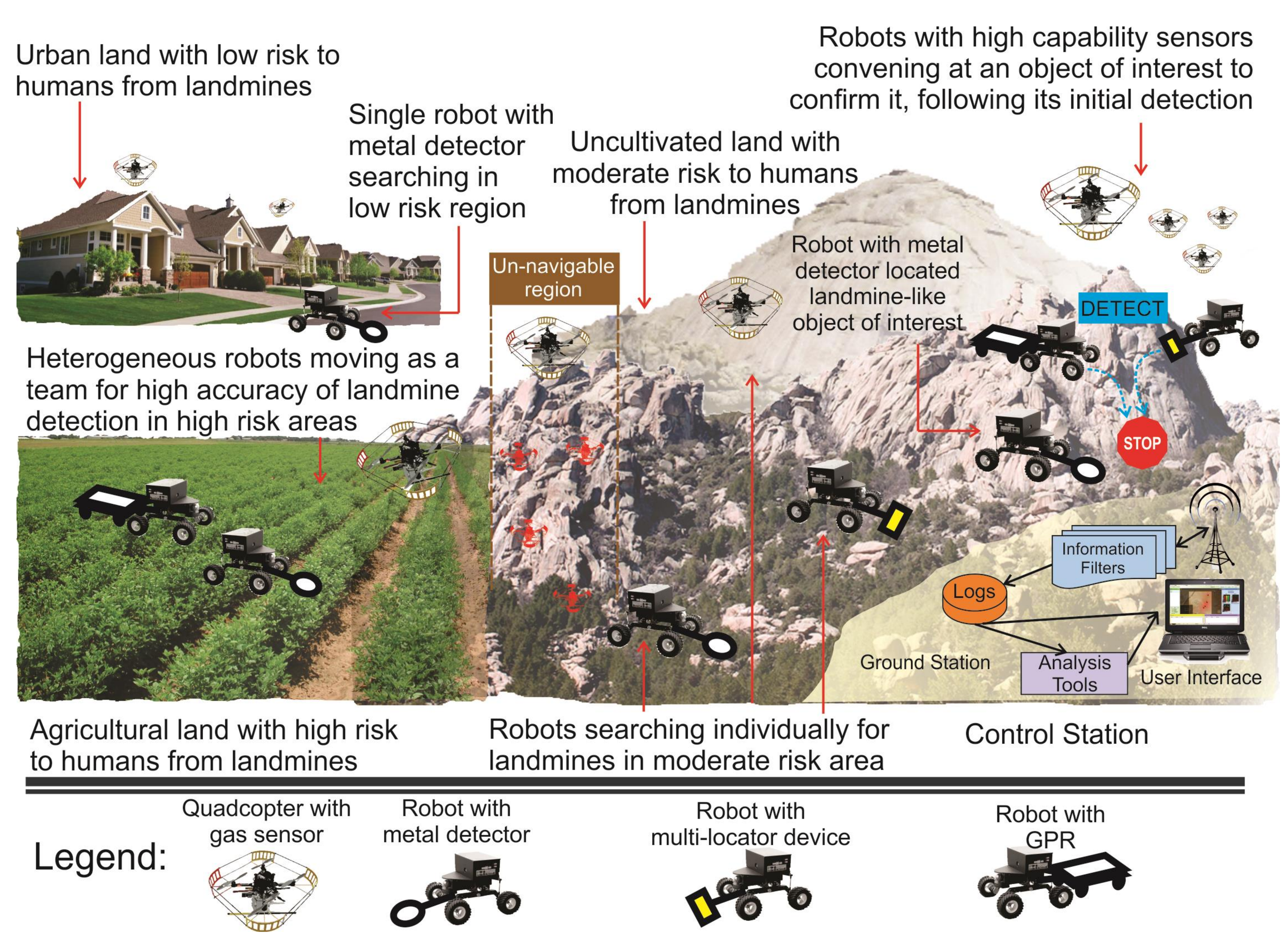
ABSTRACT:

In this project we address the problem of autonomously detecting airborne gas particles using gas sensors that are mobilized using unmanned aerial vehicles (UAVs). The main hypothesis we investigate is whether a commercially available, off-the-shelf gas sensor can be suitably integrated on a UAV platform to detect ambient gas particles. The main challenges in this problem include addressing the weight constraints of the UAV's payload and registering a consistent reading on the gas sensor in the presence of the turbulence in the air caused by the UAV's rotors. To verify our hypothesis, we designed a passive funneling mechanism for airborne particle gathering that is attached to a gas sensor on the UAV using 3D printed parts so that the sensor can be in the vicinity of the gas source, without the UAV's propellers causing disruptive air turbulence. The results of this project advance research in using UAVs autonomously in different missions that are very hazardous for humans including detecting smoke and carbon particles resulting from domestic or forest fires, detecting chemical fumes emitted by buried unexploded ordnance (UXO) such as landmines, and detecting hazardous emissions from chemical spills.



PROBLEM:

In 2014, the CMANTIC Lab at UNO developed the COMRADE (COoperative Multi-Robot Automated Detection) system for autonomous landmine detection by a team of robots. One of the key findings of the COMRADES project is that the detection and location accuracy of landmines can significantly improve, and false positives can be reduced, if multiple robots with different types of sensors can locate landmines. A potential limitation of COMRADES, especially while detecting landmines, is ground robots ability to accidentally trigger a landmine explosion due to the pressure exerted by the robot's weight in the vicinity of the landmine. In contrast, UAVs can enable non-contact, standoff detection of landmines and other unexploded ordnance (UXO) and provide a suitable way to mitigate their accidental explosion. Using a different type of sensor on UAVs, which complements the metal detector on the ground, robots can improve the quality of landmine detection. Many UXO, including landmines, have been reported to emit nominal, yet detectable quantities of gaseous fumes. Detecting these gaseous emissions using the appropriate sensor can provide an additional modality of detection in addition to electromagnetic detection used by the metal detectors on ground robots.

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APPROACH:

The two major factors when designing our passive UAV chemical detection system were payload, how will the UAV carry the chemical sensor and other appendages, and chemical detection, how will the UAV harness wind flow to detect chemical emissions. We must ensure the UAV can fly as well as detect chemicals.

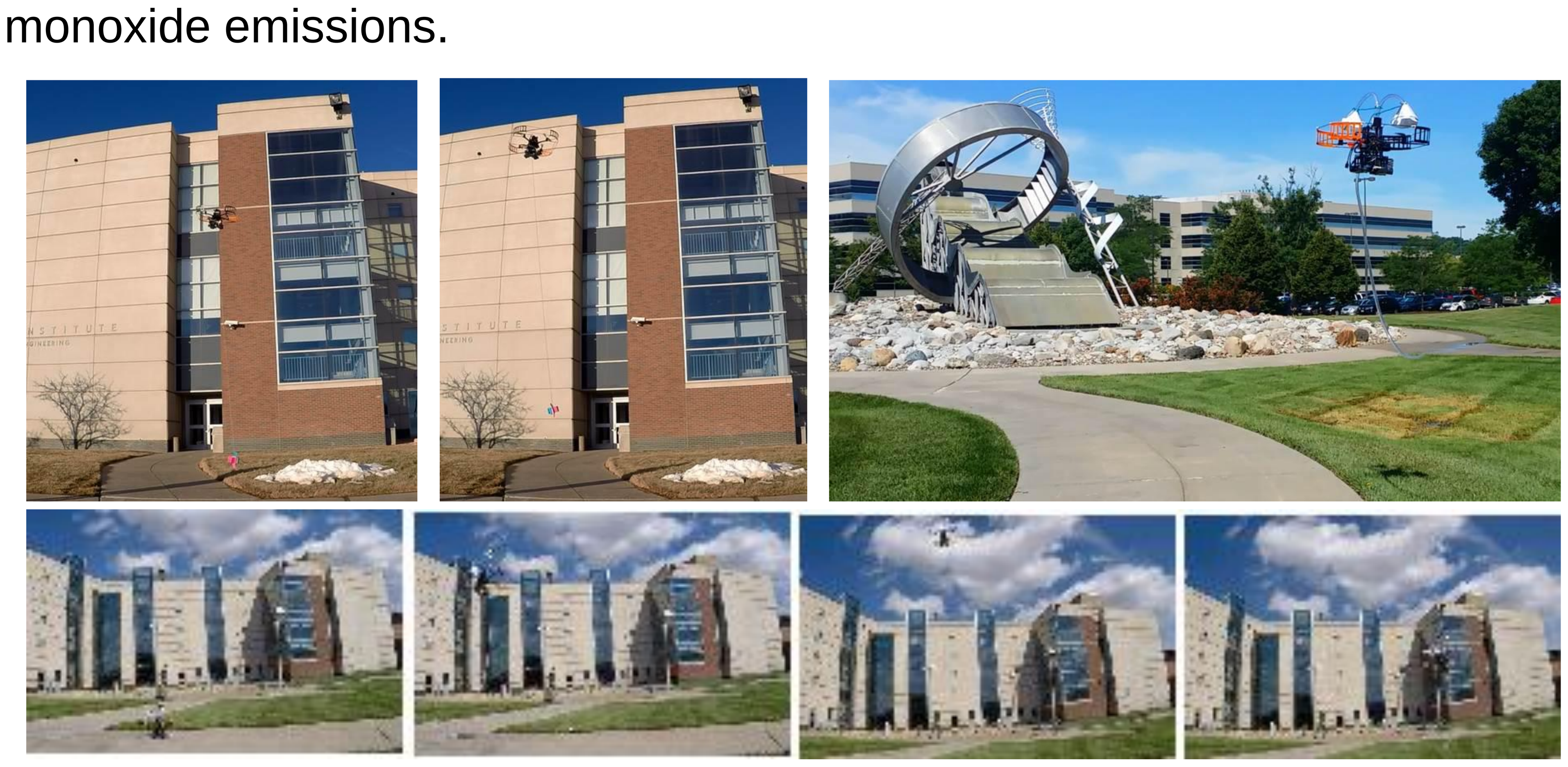
For this model the blue lines represent slow moving air particles with green lines representing moderately moving air particles, with lastly red lines representing the fastest moving particles. The bright red rectangles are rotors. In this model all of the deeper blue lines signify air particles coming in due to the propellers suction. Once these air particles come through the rotors the air particles are spewed out in a funneled manner below the rotors.

AscTec Pelican
The quadcopter offers plenty of space and various interfaces for individual components and payloads.

ToxiRAE Pro
Wireless single-gas and oxygen detector with interchangeable sensors.

Our UAV, Pelican's maximum payload is 650 grams. Pre-existing modifications, such as the infrared sensor, in total are less than 50 grams leaving 600 grams for a conservative viable payload. Our chemical detection sensor, ToxiRAE Pro, is 220 grams leaving a measly 380 grams, the weight of a football. Weight was the biggest restraint when designing apparatus.

The above diagram illustrates airflow on a UAV. Atop of the UAV air is pulled in from a wide angle due to the force created by the UAV's propellers. Once pulled in from atop air is then thrusted downward in a streamlined fashion. If the diagram was extended, one would observe air flow widens and slows down. Eventually this turbulent flow stops and what's left below it is still air. We found the optimal length from the base of the Pelican to get an accurate reliable reading with ToxiRAE Pro. Furthermore, to get effective readings from ToxiRAE Pro we analyzed how wind turbulence effects ToxiRAE Pro's reading by running experiments with ToxiRAE Pro attached to Pelican. We have found that Pelican in conjunction with ToxiRAE Pro are able to get accurate readings for carbon monoxide emissions.



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