

ASSEMBLY RESULTS ON GHG AND PARTICULATED MATTER MONITORING USING LOW-COST SENSORS

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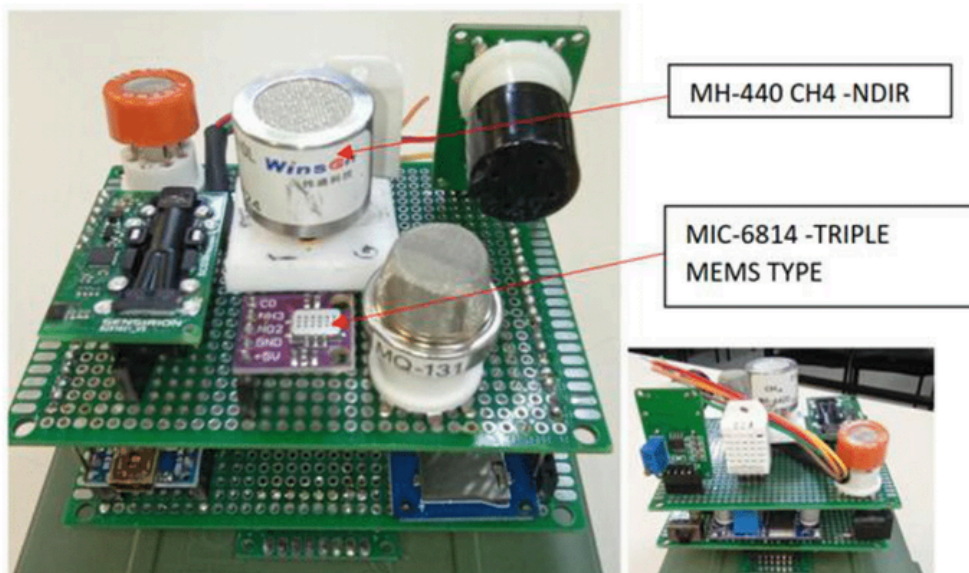
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Abstract: Abstract should be written with 8 font size, Trebuchet MS, justified, single line spacing. Objective, method and findings are summarized in this section.

Objective: This project aims to develop a tropospheric gas monitoring system with a focus on greenhouse gas emissions (GHG), through remote sensing with drones. Measurements will be taken to assess the concentration of these gases in areas such as landfills, sewers, areas with industrial facilities, roads, rivers and gas pipelines. The system in question will operate using electrochemical, electronic and optical sensor methods[1]. This survey will be used to map critical emission points and then monitored using the same sensors used in drones, but stationary for a long period of time. This sensing methodology, known as "STAND-ALONE", should be applied to the study of daily thermal inversions by identifying the moments of maximum concentrations (present in the decrease in night-time temperature) and subsequent dilution during warming throughout the day. Thus we will utilise the complementarity between the first prospecting done by the drone and the monitoring of continuous emissions recorded in sensor modules placed on poles. The fact is that the technologies available today offer rapid processing and diagnostics so that we can build a scenario in which we can systematically monitor the emissions and can mitigate the effects they generate[2,3], such an application becomes a significant device for promoting attitudes on the part of the various organisations interested in improving natural and social ecosystems.

Method: Initially, as a test, a conditioning study was carried out on some of the main sensors. Summarised here the main procedures carried out during assembly of the three main protoboards: sensor board (surface), power supply & acquisition (middle) and real time clock, RTC (bottom board). This assembly tested the electrical connection between the various components, the collection of individual data with alternating sensores and operating autonomy using all of them connected to a single power supplied by four Li-ion batteries. All measurements will be taken inside a protective module carried by the drone or positioned on poles, with no additional instruments required. This initial test proved the viability/feasibility of implementing this project, defining the main sensors to be used for monitoring sensors to be used for monitoring, as well as establishing a payload of 430 g for the drone used. The main parameters measured are: pressure, temperature, humidity, soot (PM2.5 and PM10), CH₄, CO and CO₂ emissions. The set of sensors includes carbon monoxide sensor, WinSen-SENSORS ZE07-CO, Particulate PM2.5 Plantower PMS5003, ZH06-IV also from WinSen-SENSORS (Laser Dust Sensor), GPS Neo-6m/antenna board with a dedicated Arduino Nano microcontroller, one Sensirion CO₂ sensor and the BOSH BME-680 for monitoring pressure, temperature and humidity. Since the set will be taking measurements at fixed points using poles, its power supply relies on six 7.3 V Li-18650 Li-ion batteries, so longer autonomy is expected, which is being worked on at the moment, as well as the construction of the code ("scripts") for acquiring and logging data extracted from the sensors.



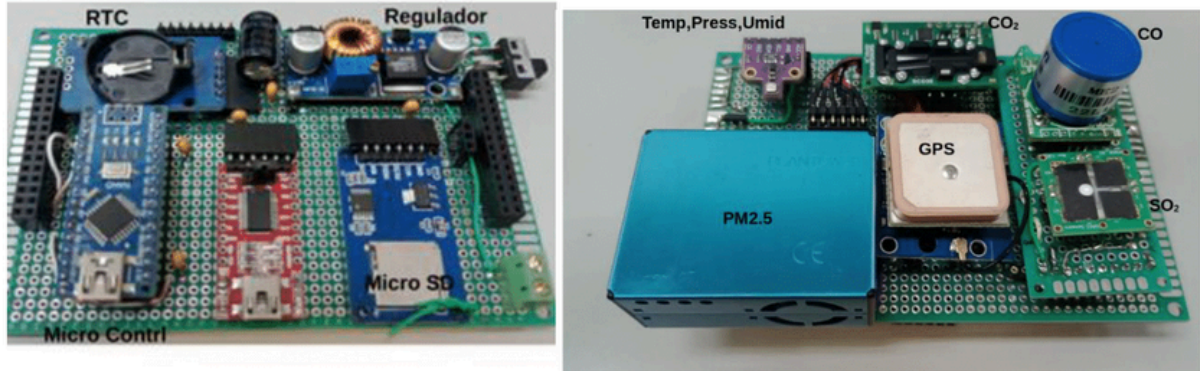
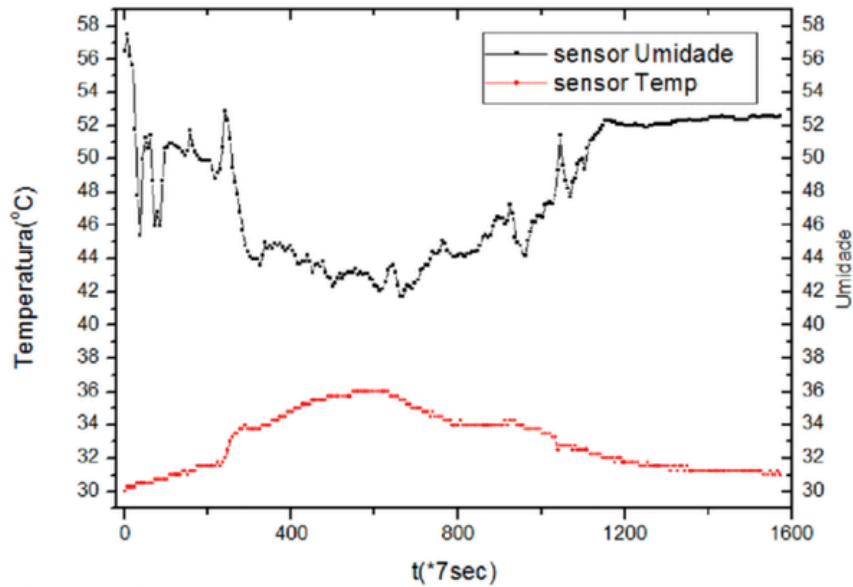
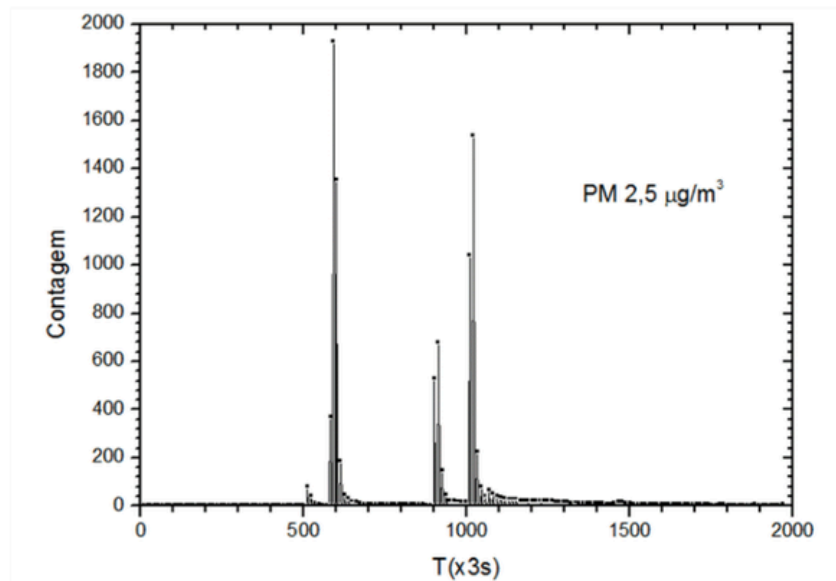


Figure 1: Three main Protoboards.



Graph of the BOSH BME-680 sensor, for temperature and humidity measurements in operation on board the Phantom 3 drone over the IPEN area (11/03/2024). The two profiles show complementarity as we change the drone's height between 0 and 50 meters.



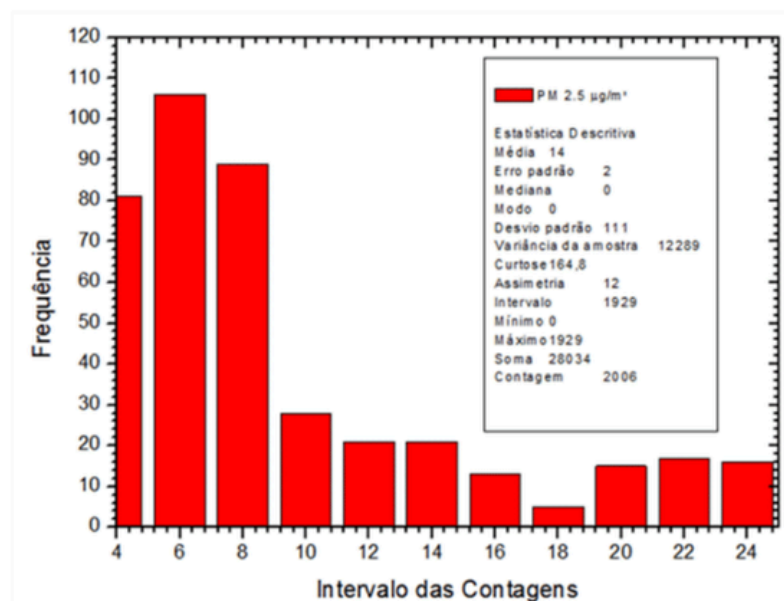
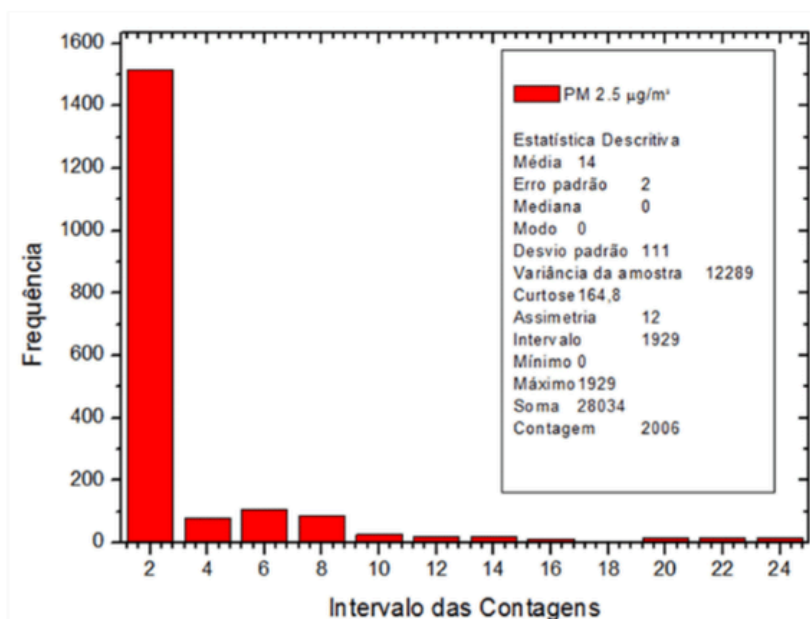
In the bench test, two ways of stimulating the sensors were tried (i) the burning of wood incense (first peaks in the figure) and then (ii) and then tin solder vapour (peaks around 3000s).



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As result for example in the above figure it was observed in the histograms for PM_{2.5} (right detail) that both the concentrations of 12 and 14 $\mu\text{g}/\text{m}^3$ and those of 20, 22 and 24 $\mu\text{g}/\text{m}^3$ show presence frequencies between 15 and 20 and the intermediate concentration of 18 $\mu\text{g}/\text{m}^3$ represents a gap (frequency of presence around 5) in the continuity decay to higher concentrations.

References

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- [2] Kunz, M.; Larvic, J. V.; Gerbig, C.; et al.; COCAP: a carbon dioxide analyser for small unmanned aircraft systems. *Atmos. Meas. Tech.* 2018, 11, 1833-1849.
- [3] Ali, N. B. H.; Abichou, T.; Green, R.; Comparing estimates of fugitive landfill methane emissions using inverse plume modeling obtained with Surface Emission Monitoring (SEM), Drone Emission Monitoring (DEM), and Downwind Plume Emission Monitoring (DWPEM). *J. Air Waste Manage. Assoc.* 2020, 70, 410-424.

Keywords: GHG emissions, Low-Cost Sensor, Arduino Platform, Particulate Matter.