Fire Detection Simulation (#1)- Sensae

Following is the variable analysis of the fire detection simulation which took place at 16:00 on 17/05/2022 for a duration of 20 min. The fire was contained in a relatively small surface area of <1m^2. The burning material composition was limited to pine wood. The experiment took place between sensors #2 and #3 which are mounted at a height of 11 m.

Figure 1. Sensor installation locations. The experiment was conducted between sensors #2 (T/H) and #3 (CO_2/T/H/Pressure).

Results

Relative Humidity

Figure 2. Relative Humidity variation during the experiment. A slight increase before followed by a drop after the experiment can be observed across all sensors.

#1 Before: (64 %); After: (60 %); (4:00 – 4:14PM); (dt: 14 min); (d%: 4%)
#2 Before: (64 %); After: (50 %); (4:00 – 4:09PM); (dt: 9 min); (d%: 14%)
#3 Before: (65 %); After: (56 %); (4:03 – 4:14PM); (dt: 11 min); (d%: 9%)
#4 Before: (65 %); After: (59 %); (4:00 - 4:12PM); (dt: 12 min); (d%: 6%)
#5 Before: (63 %); After: (60 %); (4:00 – 4:14PM); (dt: 14 min); (d%: 3%)

Temperature:

Figure 3. Temperature variation during the experiment. A slight temperature increase can be observed during the experiment across all sensors.

#1 Before: (23.1 °C); After: (24.3 °C); (4:00 – 4:14PM); (dt: 14 min); (dT: 1.2°C)
#2 Before: (23.1 °C); After: (28.8 °C); (4:00 – 4:08PM); (dt: 8 min); (dT: 5.7°C)
#3 Before: (22.9 °C); After: (25.8 °C); (4:03 – 4:14PM); (dt: 11 min); (dT: 2.9°C)
#4 Before: (23.0 °C); After: (24.0 °C); (4:00 - 4:12PM); (dt: 12 min); (dT: 1.0°C)
#5 Before: (23.0 °C); After: (24.0°C); (4:00 – 4:10PM); (dt: 10 min); (dT: 1.0°C)

CO2 / Pressure

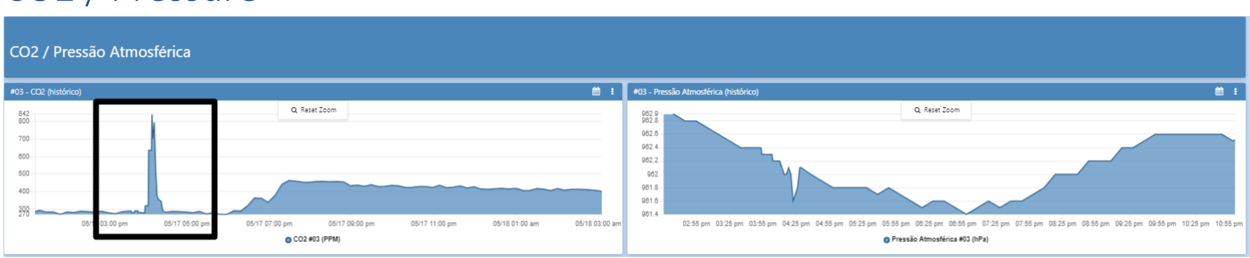

Figure 4. CO2 variation during the experiment. A large increase in CO2 concentration can be observed in #3.

#3 Before: (319 PPM); After: (842 PPM); (4:00 – 4:06PM); (dt: 6 min); (dPPM:523)

There is no observable difference in atmospheric pressure.

We can observe that there is a large variability in values obtained of which the magnitude is reversely correlated to the distance of the burning epicenter. Sensors closer to the burning epicenter display larger numerical outliers.

Temperature

It can be observed that within 8-10 min after the start of the experiment all sensors display an increase between 1 – 5.7°C as a result of the burning fire. Sensor #2 which is a T/H sensor and located downwind to the burning fire also detected the larger increase in temperature of 5.7 °C or **0.71°C/min.** This value is beyond what is expected during normal weather variations.

Humidity

It can be observed that within 8-10 min after the start of the experiment all sensors display a 3 - 14% drop in humidity with the larger drop occurring from sensor #2 at 14% 9 min after start of the experiment. This equates to a drop of **1.55%/min**. This value is beyond what is expected during normal weather variations.

CO_2

It can be observed that within 6 min after the start of the experiment the CO_2 sensor displays a increase in concentration from 319 PPM to 842 PPM after which it steadily decreases to pre-experimental values. This equates to a increase of **87 PPM/min**. This value is beyond what is expected during normal weather variations.

Discussion

The fire simulation in this experiment was of relatively small scale compared to the 3000m^2 chicken farm the experiment was carried out in. This is however a very valuable experiment to calibrate the detection algorithms to detect the fire as early as possible.

From the results we can observe a change in both Temperature, Humidity and CO_2 as a consequence of the fire. Furthermore their rate of change (ROC) is beyond what is expected during normal conditions. From the measured variables, the CO_2 concentration displays the largest relative increase and rate of change (87 PPM/min) followed by the humidity (1.55%/min) and temperature (0.71°C/min).

To optimize the detection window we suggest to not only monitor for the magnitude of the measured variables, however, we also advise to take into account the ‘Rate of Change (ROC)’ (slope of curve) in the detection algorithm. This way, alerts can be set for variables that change rapidly. This way outlier events like fires can be detected sooner. We furthermore suggest to carefully correlate the rate of change between monitored variables to increase the robustness of the detection algorithm.

Sound Level and Fire Detection

When animal life is present during a fire, the increase of smoke, CO_2 and other volatile elements makes it hard to breath. We hypothesize that this will significantly increase the desire to flee and thus greatly increase their sound output. We therefore suggest to include sound level in the fire detection algorithm. Beyond fire detection monitoring sound level of animal activity provides further important insight into the animal state of mind.

Points of consideration

1. The experiment was executed during stable/ideal conditions. The effect on the obtained data of having biological life active in the experiment area cannot be neglected.
2. Very little ventilation was active during the experiment. During normal operation the additional ventilation provides a significant oxygen supply which can significantly increase the burning rate and thus impact the rate of change of the monitored variables.

Suggestions for further experiments

After implementing the current optimizations we suggest the following improvements:

1. Decrease the detection time of the CO_2 Sensor.
2. Install at least 1 additional CO_2 sensor to increase the detection area.
3. Take into consideration the sound level.
4. Explore the possibility of adding a water resistant photoelectric sensor, will this work?
5. Experiment with TIR sensors, how does biological life impact the measured values?