Optimization of a beacon for monitoring indoor and outdoor air qualities

ESIEE Paris coordinators: Emmanuelle ALGRE, Julien PAGAZANI and Georges HAMAOUI
Laboratory: ESYCOM, ESIEE Paris.
International partner: Letizia ABIS, Technische Universität Berlin (TU Berlin) (Germany)
Filière: DSIA, SEI, SE

Context and motivations:

People spend approximately 80% of their time indoor and breathes 15m^3 of air per day, making the understanding of the indoor and outdoor chemistry an important task for safety. Variety of pollutants might be emitted directly from indoor sources, from secondary chemistry initiated by oxidants and surface reactions or via infiltration of outdoor air. Among these pollutants we can find volatile organic compounds (VOCs), and particles emitted from various sources such as molds, viruses, bacteria, carpet alongside building materials and human activities [1–5]. These pollutants can affect the respiratory system and cause asthma, allergies, lung diseases (list drawn up in a report by the WHO in 2009). Since the Grenelle Environnement in 2007 [6], the principle of monitoring indoor air quality has been introduced into the environment code. Thus, public establishments welcoming vulnerable people will have to be equipped with monitoring and measurement systems starting from January 1, 2018, then education and training establishments on January 1, 2020, then the rest in 2023.
Nonetheless, the need to control the quality of the air in the indoor environment, whether in private homes or in public establishments, must be accompanied by maintaining thermal comfort while maintaining a certain energy sobriety.
It is therefore necessary to develop beacons for monitoring indoor air quality and thermal comfort in order either to alert sensitive people in the event of poor air quality or to regulate ventilation systems to avoid confinement without energy overconsumption.

Objectives:

The student will optimize a connected beacon (already developed in a previous students' projects) integrating various environmental sensors allowing a diagnosis of indoor air quality and thermal comfort. The measurements of the various environmental parameters are stored on a database using a web server which allows real-time monitoring of the data. The transmission of wireless data is currently achieved through Zigbee from an only one beacon to PC. The number of beacon needs to be increased to enable simultaneous measurements from different locations. Network data transmission must now integrate several nodes The packaging of the beacon will also have to be improved.
Finally, new measurement campaigns in different environmental conditions (different types of housing, level of occupation, etc.) at ESIEE Paris and later at TU Berlin need to be carried out, and the results will be compared and analyzed.
During the stay at the technical university of Berlin the student will detect at the same time the parameter of total VOCs and formaldehyde, humidity, PM10, temperature and CO2 with more precise instrument to evaluate the quality of the connected beacon created during the first part of his/her internship. The instruments will be moved to different locations within the locals of the technical university of Berlin. The three sampling locations will be chose following these

criteria: (I) number of people per day, (II) different room volume, and (III) same building age. We will sample in three different rooms: one with a high stream of people per day and a large room volume (i.e., room volume > 180 m3 , people capacity > 35), a second one with a medium stream of people and a medium volume size (i.e., room volume > 75 and < 180 m3 , people capacity >10 and < 35), and finally we will study a small room with a low stream of people per day (i.e., room volume >30 and < 75 m3 , people capacity > 1 and < 10). All these rooms will be chosen in the same building to avoid differences due to the age of the building.

Needed skills:

- Establish a state of the art of existing devices (sensors, beacons, transfer protocols and data processing).
- Develop news beacons for air quality monitoring (almost one)
- Create a sensor signal conditioning and acquisition board.
- Develop the data acquisition and recording program.
- Develop a web interface for displaying data.
- Prepare a measurement campaign (parameters to be varied: ex: different types of environments, etc.).
- Interpret and report measurement results.

Expected Results:

- Realization of a connected beacon integrating the different sensors, the acquisition, and the recording of data.
- Realization of a web storage and display server.
- Collection of data from different environmental conditions (indoors).
- Processing and comparison of the data obtained.

References:

[1] L.T. Stirchak, L. Abis, C. Kalalian, C. George, D.J. Donaldson, Differences in Photosensitized Release of VOCs from Illuminated Seawater versus Freshwater Surfaces, ACS Earth Sp. Chem. (2021). https://doi.org/10.1021/acsearthspacechem.1c00063.

[2] A. Depoorter, C. Kalalian, C. Emmelin, C. Lorentz, C. George, Indoor heterogeneous photochemistry of furfural drives emissions of nitrous acid, Indoor Air. 31 (2021) 682–692. https://doi.org/10.1111/ina.12758.

[3] C. Kalalian, A. Depoorter, L. Abis, S. Perrier, C. George, Indoor heterogeneous photochemistry of molds and their contribution to HONO formation, Indoor Air. 32 (2022) 1–13. https://doi.org/10.1111/ina.12971.

[4] C. Kalalian, L. Abis, A. Depoorter, B. Lunardelli, S. Perrier, C. George, Influence of indoor chemistry on the emission of mVOCs from Aspergillus niger molds, Sci. Total Environ. 741 (2020) 140148. https://doi.org/10.1016/j.scitotenv.2020.140148.

[5] L. Abis, C. Kalalian, B. Lunardelli, T. Wang, L. Zhang, J. Chen, S. Perrier, B. Loubet, R. Ciuraru, C. George, Measurement report: Biogenic volatile organic compound emission profiles of rapeseed leaf litter and its secondary organic aerosol formation potential, Atmos. Chem. Phys. 21 (2021) 12613–12629. https://doi.org/10.5194/acp-21-12613-2021.

[6] Government, Grenelle Environnement, (2007). https://www.vie-publique.fr/eclairage/268585-le-grenelle-de-lenvironnement-quels-engagements (accessed September 18, 2022).