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Editorial

Preface to State-of-the-Art in Real-Time Air Quality Monitoring through Low-Cost Technologies

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Air pollution represents one of the biggest concerns worldwide. Many studies have proven the existence of a direct link between exposure to air pollutants and issues concerning public health or climate changes. Poor air quality has negative effects, not just in outdoor environments, but also in indoor ones. Particulate Matter (PM), NO_2, O_3, CO, SO_2, and Volatile Organic Compounds (VOCs) are among the most relevant air pollutants which directly or indirectly threaten human health and affect air quality. National laws regulate air quality monitoring, and the equipment required to meet the standards established by such regulations is very costly due to purchasing fees, maintenance fees, and logistic issues.

The use of low-cost technologies for air quality monitoring is becoming increasingly relevant worldwide, not only for research and academic groups, but also for individual citizens. In recent years, a remarkable variety of low-cost sensors and complete systems for air pollutant monitoring have been developed, reporting contrasting outcomes. As a consequence, the application of these so-called low-cost technologies for measuring air pollutant concentrations is far from being a consolidated achievement. The technologies featuring the Low-Cost Air Quality Monitoring Systems (LCAQSs) and the Low-Cost Sensors (LCSs) for pollutant gases or PM allow the purchase of devices with costs ten or more times lower compared to the regulatory instrumentation ones, even though, the data quality provided by such devices is often questionable. Meanwhile, performance information provided by the manufacturers of LCAQSs/LCSs is limited in most cases. Several studies have already addressed this issue, and various strategies have been explored to improve the performance of such devices.

This book is composed of eight chapters, and it is aimed to provide a reference for researchers and academic groups to assess the state-of-the-art featuring the real-time monitoring of air pollutant concentrations performed through low-cost technologies, which potentially enable a more accurate evaluation of personal exposure to air pollutants, thanks to their low costs in comparison to the traditional real-time monitoring devices.

The first work exposed in this book [1] concerns a feasibility study to build a low-cost air quality monitoring system based on PM sensors. In this study, the use of a calibration model using an artificial neural network was evaluated to improve the performance of the sensors. The adoption of advanced techniques for sensor calibrations is a state-of-the-art approach for improving their performance.

In the second chapter of this book, a study focused on investigating the impact of various calibration models on LCS performance is presented [2]. Electrochemical sensors for measuring CO, O_3, and NO_2 were installed in a LCAQS designed and implemented in a research laboratory. Their performance was assessed by calibrating them through artificial neural networks, multivariate linear regressions, random forest regressions, and support vector machines. The experiment was conducted in a real-world scenario represented by an indoor environment during the everyday routine of a family.

The third chapter features a study aimed at assessing the use of PM sensors for characterizing occupational exposure to $PM_{2,5}$ inside an industrial facility located in Santa

Ana (CA) [3]. The study has demonstrated the utility of using LCSs combined with employee participation for the investigation of workplace air pollution exposure.

A low-cost method was developed to assess the solid component of an aerosol in the study featured in chapter four [4]. A catalytic stripper was applied to the inlet stream of a lung-deposited surface area instrument to assess PM composition and size.

The indoor environment of a ship was investigated in the fifth chapter of this book [5]. The authors of the article were allowed to compare sensor-based measurements performed on a 36-year-old ship dedicated to near-shore operations with measurements of reference-grade instruments. Additional behavioral information from sensors was obtained by measuring campaigns organized on several inland ships. This contribution demonstrated that trends registered by gas and particulate matter sensors are reliable, but that insufficient detection limits, higher noise, imperfect calibration, and sensor errors result in some reliability constraints.

The sixth chapter composing this book [6] regards an experiment involving a network of easy-to-use low-cost air quality devices to monitor fine particulate matter ($PM_{2.5}$) concentrations at fifteen sites in eleven cities across eight sub-Saharan African countries between February 2020 and January 2021. Annual $PM_{2.5}$ concentrations, seasonal and temporal variability were determined; moreover, time trends were modeled using harmonic regression.

The work presented in chapter seven [7] aims to understand whether a citizen-science-based monitoring system could be adequate to detect the effects, in terms of air quality, of solid and liquid fuel combustion for household heating. To address the limitations of the citizen science approach, the article authors carefully tested all the parts of the system and, in particular, the performances of the low-cost sensors. They highlighted that their precision is acceptable, while their accuracy is insufficient.

A novel, cost-effective non-dispersive infrared (NDIR) multi-gas sensor aimed at environmental air pollution monitoring is presented in the last chapter of this book [8]. The device described in the article is featured by a core that offers a resilient sensor solution for the increasing demand for compact monitoring systems in the field of environmental monitoring at reasonable costs for medium-to-high volumes.

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