Calibration model of a low-cost air quality sensor using an adaptive neuro-fuzzy inference system

ABSTRACT

Conventional air quality monitoring systems, such as gas analysers, are commonly used in many developed and developing countries to monitor air quality. However, these techniques have high costs associated with both installation and maintenance. One possible solution to complement these techniques is the application of low-cost air quality sensors (LAQSs), which have the potential to give higher spatial and temporal data of gas pollutants with high precision and accuracy. In this paper, we present DiracSense, a custom-made LAQS that monitors the gas pollutants ozone (O3), nitrogen dioxide (NO2), and carbon monoxide (CO). The aim of this study is to investigate its performance based on laboratory calibration and field experiments. Several model calibrations were developed to improve the accuracy and performance of the LAQS. Laboratory calibrations were carried out to determine the zero offset and sensitivities of each sensor. The results showed that the sensor performed with a highly linear correlation with the reference instrument with a response-time range from 0.5 to 1.7 min. The performance of several calibration models including a calibrated simple equation and supervised learning algorithms (adaptive neuro-fuzzy inference system or ANFIS and the multilayer feed-forward perceptron or MLP) were compared. The field calibration focused on O3 measurements due to the lack of a reference instrument for CO and NO2. Combinations of inputs were evaluated during the development of the supervised learning algorithm. The validation results demonstrated that the ANFIS model with four inputs (WE OX, AE OX, T, and NO2) had the lowest error in terms of statistical performance and the highest correlation coefficients with respect to the reference instrument ($0.8 < r < 0.95$). These results suggest that the ANFIS model is promising as a calibration tool since it has the capability to improve the accuracy and performance of the low-cost electrochemical sensor.

Keyword: Air quality monitoring; Low-cost sensor; Quality control; Machine learning