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# Advanced Instrumental Odour Monitoring System for the Continuous Management and Control of Environmental Odour in Complex Industrial Plants

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**Abstract**

Odour emissions from complex industrial plants may cause potential impacts on the surrounding areas and, as consequence, complaints with the local residents. The identification of specific odour control plan is therefore needed in the plant management. The current challenge is the definition of Instrumental Odour Monitoring Systems (IOMSs) that allow the continuous odour characterization. No regulation or standardized procedure exist at present. Limited data are available in the literature with reference to the characteristics and operational procedure of this systems for the environmental odours monitoring. The study presents a novel prototype of intelligent and integrated IOMS for the continuous classification and quantification of the odours emitted in ambient air by complex industrial plants, with the scope to control the plants emissions in an objective and continuous manner, thus avoiding odour impact. The architecture and the principal components of the IOMS are highlighted. The operational procedures are presented and discussed. Results highlights the importance and the flexibility of the proposed IOMS in the odour monitoring. Real-time and accurate information are provided by the system about the source and concentration of the odour emissions.

**Keywords:** environmental odour, odour classification, petroleum refinery, training, validation procedure.

## 1. Introduction

Instrumental Odour Monitoring Systems (IOMS), also now with the name “Electronic nose” (e.Nose) represent attractive tools for the continuous monitoring of environmental odours, with a view at obtaining real-time information, to support the decision-making process and for the implementation of proactive approaches (Belgiorno et al, 2012). The use of IOMS is of key interest since they offer the strengths of both sensorial and analytical instruments for the prediction of the odour concentration. Nowadays, among the most challenging problems related to the application of e.Nose for the environmental odour monitoring in ambient air, the composition of their architecture which includes their principal hardware components and the selection of the array of the sensors for the odour measures, are key topics (Giuliani et al., 2012; Zarra et al., 2018). Moreover, the needs to face with the complexity of gaseous mixtures from industrial sources, boosted the attention given to sampling technique, training phase and data analysis. The attention paid for data processing resulted in different possibilities definition of advanced statistical pattern recognition and prediction model (Fu et al., 2007). The rising number of e.Nose real applications in different industrial sectors have triggered the enhancement of these systems to overcome their main drawbacks and to increase the representativeness and the cross-sensitivities of the measurements (Wijaya et al., 2019). However, the application to environmental monitoring still presents difficulties that are the challenge of the current research, linked to the continuous variation of the measurement conditions and to the low concentrations of the odours to be detected, considering their application for the impact assessment. The study highlights the definition of an advanced IOMS for the assessment of odours and the control of their impacts, emitted from complex industrial plants, like petroleum refineries. The optimization of the components of the system, in terms of reproducibility of operating conditions, statistical elaboration of training and measurement dataset and system robustness, are presented.

## 2. Experimental Setup and Activities

Experimental studies in laboratory and at different complex industrial plants were carried out to find and optimize the best solutions to achieve and increase the reliability and accuracy of the IOMS for environmental odour monitoring.

The IOMS seedOA was used and developed with reference to all the principal units of its architecture:

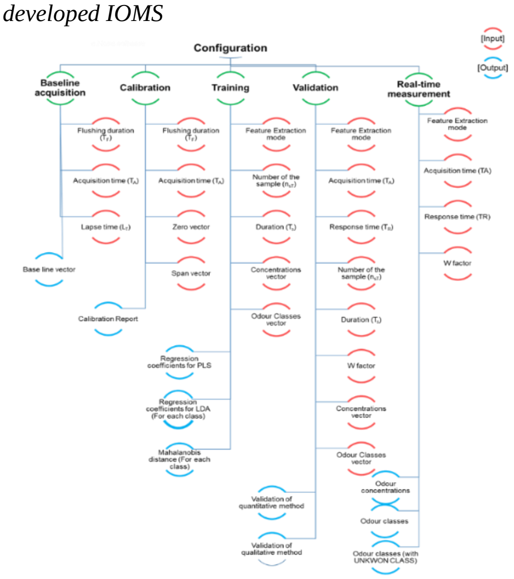
sampling, measurement and elaboration. The core of the seedOA is represented by its measurement unit, consisted of a patented chamber (Giuliani et al., 2012; Viccione et al., 2012; Zarra et al., 2018), acquired by SARTEC srl for industrial development.

To optimize the classification sensibility of the IOMS, different odour classes were analysed. The definition of a general "unknown class" was implemented to consider all the samples, odour or odourless, not related with the odour under investigation. Nitrogen samples collected from a certified gas bottle were used to define the baseline of each sensor representing the measurement array. Four different feature extraction techniques were analyzed for the signal processing to extract the most useful data from the gas sensors response and select only which carries the most useful information for a better accuracy. Auto calibration (span and zero) systems were defined and tested, to assess the IOMS during his measurement and allows the continuous control.

## 3. Results and Discussions

Figure 1 shows the configurations of the developed advanced IOMS.

*Figure 1. Operation and management mode configurations of the developed IOMS*




Five different operation modalities are identified and defined for system operation and management.

When "baseline acquisition" mode is selected, the pump has to inhale from an ozonized airline, to collect the baseline vector. When calibration mode is selected, the pump has to inhale first from the ozonized airline to collect the zero vector and then from a n-butanol permeation tube to collect the span vector. When training mode, validation mode or real-time measurement mode are selected, the pump have to inhale from the ambient air sampling point.

The implementation of the different operation modes generates different output elements. The dataset from the application of the Baseline Acquisition mode allowed to create the reference line to which compare the resistance values, while the values resulting from the calibration mode have been used to periodically re-align the recorded signals to the original condition. The training dataset, after the preprocessing with different types of features extraction, have been used to obtain the linear combination parameters, resulting from the application of Partial Least Squares and Linear Discriminant Analysis, for the prediction of the odour concentrations and odour classes respectively. Moreover, it has been validated an innovative method, using Mahalanobis distances, for the consideration of possible detectable unknown odour classes.

## 4. Conclusion

The high flexibility and the possibility to control and validate continuously the acquired data by the use of automatic auto calibration systems demonstrate the high potential of the developed innovative advanced IOMS for the monitoring of the environmental odours emitted from complex industrial facilities, like petrochemical plant. The possibility of recognized unknown odour classes and the application of different quantitative prediction models for each identified odour classes, highlight the reliability and robustness of the optimized system.

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