proceedings

Abstract

Data Processing Procedure for Real-Time Odour Concentration Estimation at Industrial Plant Fenceline by Sensor-Based Tools †

Christian Ratti, Beatrice Julia Lotesoriere *, Carmen Bax and Laura Capelli

Department of Chemistry, Materials and Chemical Engineering, "Giulio Natta", Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133 Milan, Italy; christian.ratti@polimi.it (C.R.); carmen.bax@polimi.it (C.B.); laura.capelli@polimi.it (L.C.)

* Correspondence: beatricejulia.lotesoriere@polimi.it

† Presented at the XXXV EUROSENSORS Conference, Lecce, Italy, 10–13 September 2023.

Abstract: The realisation of an electronic nose network for the monitoring of the odour concentrations at the fenceline of a waste treatment plant has been investigated. One of the main challenges for instrumental environmental monitoring concerns the interference of the daily variability of humidity and temperature of the ambient air to which sensors are exposed. In this study, we propose a solution to overcome this problem, implementing a specific normalisation pretreatment into the data processing procedure. The preliminary results obtained show a better classification and quantification performance whenever humidity model compensation is applied.

Keywords: real-time environmental monitoring; signal pretreatment; machine learning

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Citation: Ratti, C.; Lotesoriere, B.J.; Bax, C.; Capelli, L. Data Processing Procedure for Real-Time Odour Concentration Estimation at Industrial Plant Fenceline by Sensor-Based Tools. *Proceedings* **2024**, *97*, 4. https://doi.org/10.3390/proceedings2024097004

Academic Editors: Pietro Siciliano and Luca Francioso

Published: 13 March 2024

1. Introduction

The need to continuously monitor odour emissions from industrial plants is increasing due to their proximity to residential areas where citizens report olfactory harassment to the local authorities more and more frequently. This has led to the inclusion of odours among the environmental parameters to be measured and regulated for several typologies of plants, such as waste treatment plants [1]. Electronic noses are the only instruments that could potentially provide a real-time estimation of odour concentrations [2]. From the literature, one of the main limitations for the widespread use of this technology is related to the influencing factors affecting electronic nose sensor responses [3]. For environmental monitoring, humidity and temperature are pointed out as the main interfering parameters due to the variations of the ambient conditions. Thus, this work focuses on the development of a specific pretreatment for humidity and temperature correction within a real case of an electronic nose network for the real-time monitoring of the odour concentration at the fenceline of a waste treatment plant producing biomethane and high-quality compost.

2. Materials and Methods

Two electronic noses, produced and commercialised by Ellona (i.e., WT1 1179 and WT1 1180) were equipped with a temperature sensor and a humidity sensor, 4 MOX sensors with a high sensitivity to volatile compounds, 2 electrochemical sensors for the detection of H_2S and NH_3, and a photoionisation detector (PID) calibrated in isobutylene for the detection of volatile organic compounds (VOC) were installed at the plant fenceline. About 80 samples were collected at emission sources of the plant in five olfactometric campaigns carried out among different seasons to build the training set (TS) and validate it with an independent test set. The global data processing procedure developed to estimate the odour concentrations is described in Figure 1.

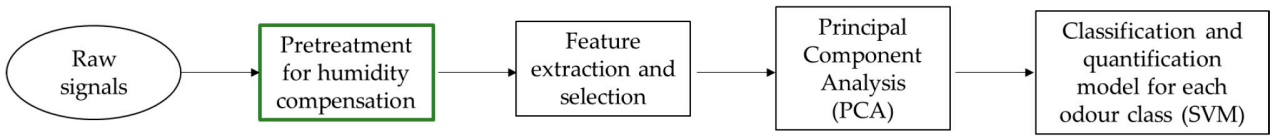

Figure 1. Data processing procedure.

One of the most innovative aspects of this work is the development of a specific pretreatment involving the normalisation of sensor responses associated with the variation of absolute humidity. The normalised resistance value (y_{norm}) is obtained as follows:

$$y_{norm} = \frac{y - y_{ref}}{y} \tag{1}$$

considering y as the measured resistance value and y_{ref} as the reference resistance value calculated by means of a regression model based on the resistance value of the sensors in non-odorous ambient air at different levels of absolute humidity.

3. Discussion

The preliminary results of this approach were evaluated comparing the performance of the model obtained with and without data pretreatment in terms of internal accuracy, internal Matthews correlation coefficient (MCC), and external accuracy (Table 1). For the electronic nose 1179, the performance obtained in internal validation resulted to be comparable between the two models, while the external validation shows a significant improvement for the corrected one (i.e., from 76% to 97%). For the electronic nose 1180, it is noteworthy that despite the slightly better accuracy obtained in external validation for the non-pretreated model, the internal validation shows worse results compared to the pretreated one. However, this is an ongoing project and further investigation will be carried out to confirm the preliminary results obtained.

Table 1. Performance comparison between the models obtained with and without the pretreatment for humidity and temperature compensation.

Parameter	WT1 1180 Pretreated	WT1 1180 Not Pretreated	WT1 1179 Pretreated	WT1 1179 Not Pretreated
Internal Accuracy	95%	80.5%	96%	97%
Internal MCC	87%	26%	90%	92%
External Accuracy	96%	100%	97%	76%

Author Contributions: Conceptualisation, B.J.L., C.R., C.B. and L.C.; methodology, L.C., C.B. and B.J.L.; software, C.R.; validation, C.R., C.B. and B.J.L.; formal analysis, C.R., C.B. and B.J.L.; investigation, L.C., C.B. and B.J.L.; resources, L.C.; data curation, C.R., B.J.L. and C.B.; writing—original draft preparation, C.R. and B.J.L.; writing—review and editing, C.B. and L.C.; visualisation, B.J.L., C.R., C.B. and L.C.; supervision, L.C. and C.B.; project administration, L.C.; funding acquisition, L.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are confidential.

Conflicts of Interest: The authors declare no conflicts of interest.

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