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Abstract

Optimization of a Drone-Based System for Instrumental Odor Monitoring Using Feature Selection †

Alessandro Benegiamo [1], Javier Burgués [1], Javier Alonso-Valdesueiro [2], Beatrice Julia Lotesoriere [3], Lara Terrén [4], Lidia Sauco [4], Mª Deseada Esclapez [4], Silvia Doñate [4], Agustín Gutiérrez-Gálvez [2] and Santiago Marco [1,2,*]

1 Signal and Information Processing for Sensing Systems, Institute for Bioengineering of Catalonia, The Barcelona Institute of Science and Technology, Baldiri Reixac 10-12, 08028 Barcelona, Spain; abenegiamo@ibecbarcelona.eu (A.B.); jburgues@ibecbarcelona.eu (J.B.)
2 Department of Electronics and Biomedical Engineering, Universitat de Barcelona, Martí i Franquès 1, 08028 Barcelona, Spain; javier.alonsov@ub.edu (J.A.-V.); agutierrez@ub.edu (A.G.-G.)
3 Department of Chemistry, Materials and Chemical Engineering, "Giulio Natta", Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133 Milan, Italy; beatricejulia.lotesoriere@polimi.it
4 Depuración de Aguas del Mediterráneo, Av. Benjamín Franklin 21, 46980 Paterna, Spain; lara.terren@dam-aguas.es (L.T.); lidia.sauco@dam-aguas.es (L.S.); desi.esclapez@dam-aguas.es (M.D.E.); silvia.donate@dam-aguas.es (S.D.)
* Correspondence: smarco@ibecbarcelona.eu
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Abstract: The application of Instrumental Odor Monitoring Systems (IOMS) for odor concentration estimation in wastewater treatment plants remains a challenge. We present the optimization of a heterogeneous gas sensor array mounted on a small drone to be used in dynamic conditions. The proposed method is based on the use of feature selection during the estimation of the best calibration model. The results show that the selection of an optimal sensor array and the proper time window decreases the multiplicative error a 25%.

Keywords: environmental monitoring; machine olfaction; machine learning; calibration

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1. Introduction

We have recently shown that it is possible to estimate odor concentration (OuE/m^3) using a chemical sensor system on a small drone flying over a wastewater treatment plant [1]. Starting with a 21-heterogeneous-chemical-sensor array, we present an optimization methodology that simultaneously finds an optimum sensor subset and the optimal measurement window. The optimization is based on the use of embedded feature selection methods when building a machine learning-based calibration model that uses transient chemical sensor signals to predict the odor concentration evaluated by a human panel following EN13725.

2. Materials and Methods

A small drone was fitted with a chemical sensor system featuring 4 electrochemical cells, 1 NDIR CO2 sensor, and 16 MOX sensors plus temperature and humidity. A full description of the chemical sensor has been previously disclosed [2]. Two measurement campaigns were carried out at the wastewater treatment plant of Molina de Segura (Murcia, Spain). The pre-treatment building, settlers, bioreactors, and deodorization chimney were identified as the most odorous sources. A total of 71 measurements were taken. All IOMS sensors' signals were acquired with a sampling interval of 6.6 s. The air sampler on the drone was activated for 1 min to fill a 10-L Nalophan bag. The odor bags were measured by dynamic olfactometry according to EN13725 [3]. System optimization was based on feature ranking based on Variable Importance in Projection (VIPs) and Interval Partial Least Squares (iPLS) to select the best sensor subset and the best measurement interval [4].

3. Discussion

First, we performed an initial sensor selection based on feature ranking. Only sensors with VIPs indexes bigger than one were retained. This step selected electrochemical cells for H_2S, NH_3, CO, and three metal oxide sensors. In a second phase, we ran iPLS using intervals of 20 s on the transient signals. In Figure 1 (left), the best measurement intervals (red bars) selected by iPLS are shown, with their order of selection. The horizontal dotted line represents the RMSECV obtained with all seven selected intervals. The RMSECV is expressed as a factor. The optimum configuration found selects seven intervals for NH_3, CO, and two metal oxide sensors. When tested in external validation, the optimized configuration reduced the RMSEP to a factor 2.0, compared to a factor 2.6 for the original system (Figure 1, right).

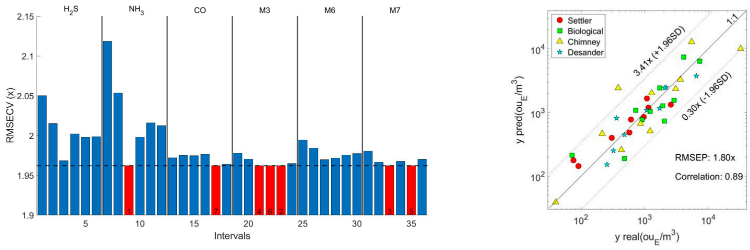

Figure 1. (**Left**) Bar plot displaying the RMSECV at iteration 8 for the addition of a new interval. Red bars are the selected interval. The intervals are 20 s long for each sensor. The first interval for each sensor is synchronized with the activation of the sampler. (**Right**) Predicted odor concentration vs. real odor concentration (in OuE/m^3) for the optimal sensor configuration.

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