Micro-sensors for indoor air quality: from deployment to data treatment

Luiz Miranda

12/09/2022

Sensors

What is inside of it ?

CO2

PM

Temperature

Humidity

NDIR

30 € to 100 €

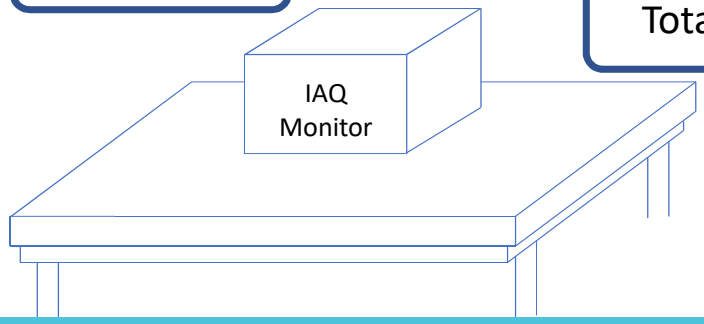
OPC

~ 280 €

T/HR cluster

~ 20 €

Total VOC



VOCs

- Irritation in eyes, throat and nose;
- Headaches;
- Nausea;
- Allergic reactions;

Individual gases

Electrochemical

10 €

Metal Oxide

8 €

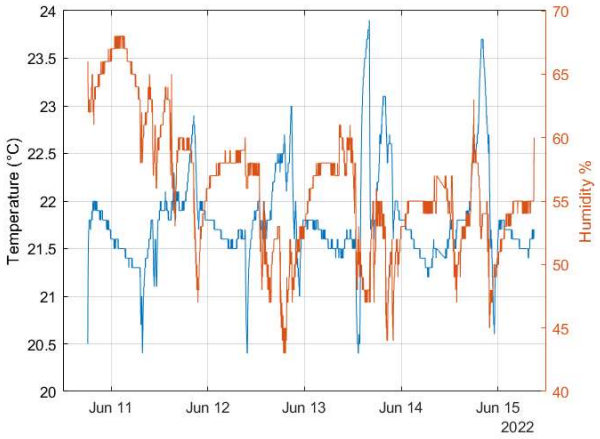
Characteristic	Electrochemical	Chemoresistive
Cost	*low*	*low*
Lifetime	*short*	*long*
Sensitivity	*high*	*high*
Selectivity	*good*	*poor*
Response time	*fast*	*fast*
Size	*medium*	*small*

Adapted from

NERI, Giovanni. First fifty years of chemoresistive gas sensors. **Chemosensors**, v. 3, n. 1, p. 1-20, 2015.

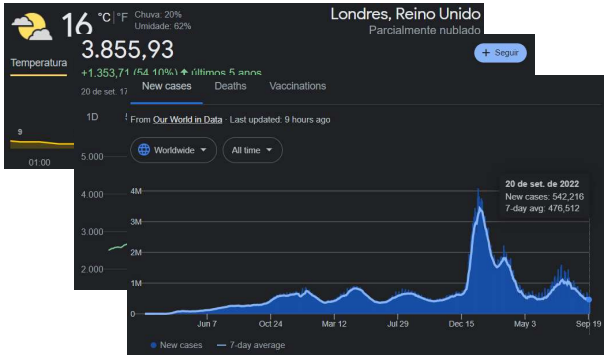
Data Treatment – Time series

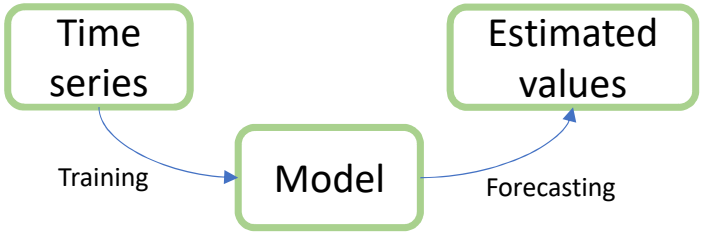
What kind of data do we get ?



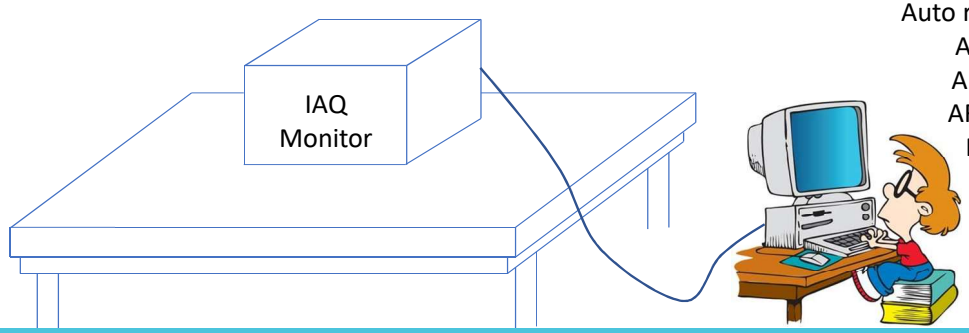
21	'10/06/2022 18:13:10'	21.10000038	64	601
22	'10/06/2022 18:13:20'	21.10000038	64	603

Time series





Moving average
Auto regression
ARMA
ARIMA
ARMAX
NN..




energies
MDPI
Article
Assessment of ANN Algorithms for the Concentration Prediction of Indoor Air Pollutants in Child Daycare Centers
Jeeheon Kim [1], Yongsug Hong [2], Namchul Seong [3,*] and Daeung Danny Kim [4,*]


Contents lists available at ScienceDirect
Automation in Construction
journal homepage: www.elsevier.com/locate/autcon
Review
Effectiveness of neural networks and transfer learning for indoor air-temperature forecasting
Andrea Bellagarda [a], Silvia Cesari [a], Alessandro Aliberti [a,*], Francesca Ugliotti [d], Lorenzo Bottaccioli [c,b], Enrico Macii [c], Edoardo Patti [a,b]


ORIGINAL ARTICLE
WILEY
A recurrent neural network using historical data to predict time series indoor PM2.5 concentrations for residential buildings
Xilei Dai[1] | Junjie Liu[1] | Yongle Li[2]


Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv
A predictive model of indoor $PM_{2.5}$ considering occupancy level in a hospital outpatient hall
Yuhe Zhou, Guangfei Yang *

Data Treatment – Modelling the sensors

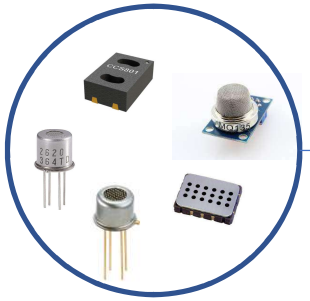
CO2

PM

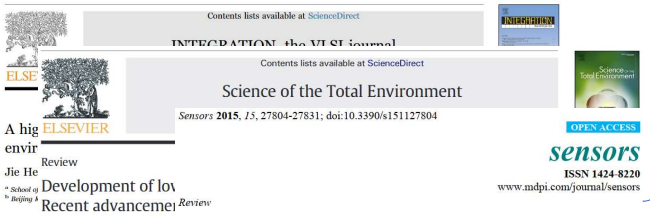
Good

Metal Oxide

- Overlapping sensitivity
- Different levels of sensitivity



Sensor array
E-nose



Review

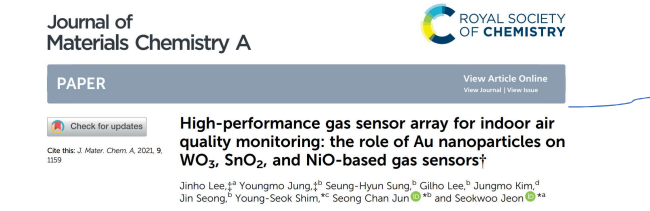
Development of lov
Recent advancemer

H. Chojer, P.T.B.S. Branco

Electronic Nose Feature Extraction Methods: A Review

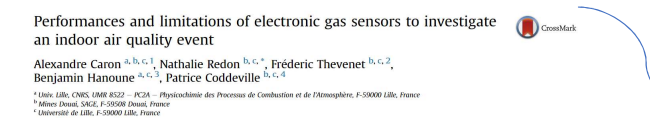
Jia Yan, Xiuzhen Guo, Shukai Duan *, Pengfei Jia, Lidan Wang, Chao Peng and Songlin Zhang

College of Electronics and Information Engineering, Southwest University, Chongqing 400715, China;



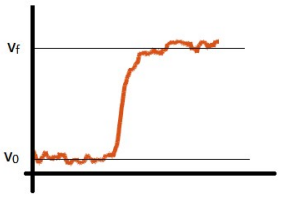
High-performance gas sensor array for indoor air quality monitoring: the role of Au nanoparticles on WO_3, SnO_2, and NiO-based gas sensors†

Performances and limitations of electronic gas sensors to investigate an indoor air quality event



Supervised Bayesian Source Separation of Nonlinear Mixtures for Quantitative Analysis of Gas Mixtures

Stéphanie Madrolle, Leonardo T. Duarte, *Senior Member, IEEE,* Pierre Grangeat, *Senior Member, IEEE,* Christian Jutten, *Fellow Member, IEEE*



Difference: $x = v_f - v_0$
Relative: $x = v_f/v_0$
Fractional: $x = (v_f - v_0)/v_0$
Logarithm: $x = \log(v_f - v_0)$

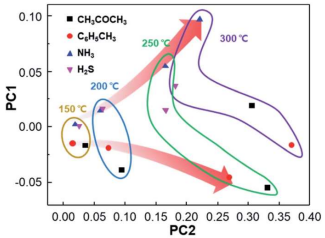


Fig. 4 PCA plots showing sensing result with PC1 and PC2 using responses of target gases as input data with operating temperature.

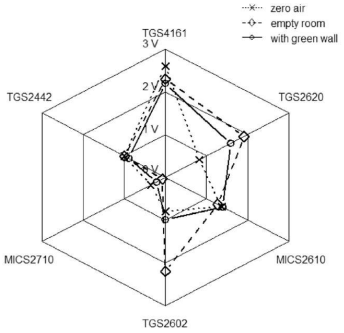
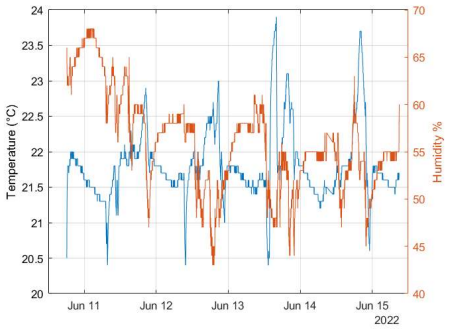
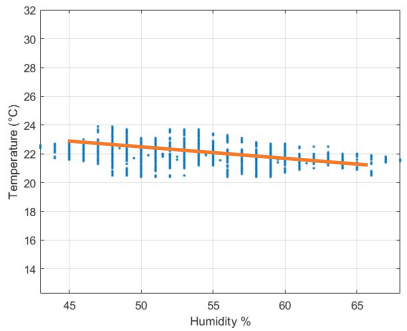


Fig. 5. Reference air zero pattern and experimental room patterns with and without the green wall (output voltage from the semi conductive sensors).

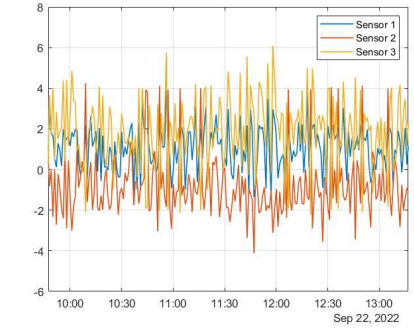
Data Treatment – Sensor space



Time-series

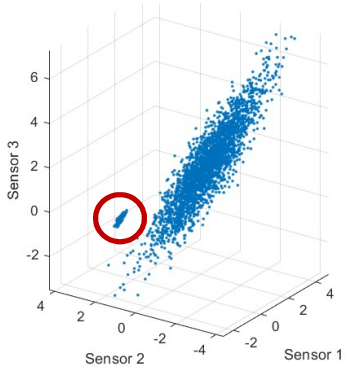


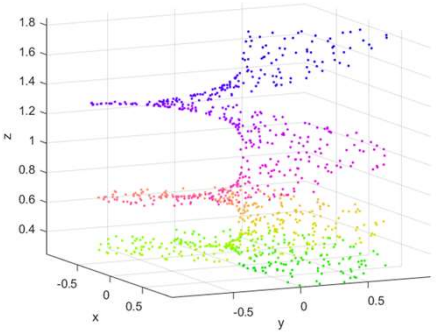
Scatter plot / sensor space



Sensor 1 independent from Sensor 2

Sensor 3 = Sensor 1 – Sensor 2





Intrinsic dimension estimation as a tool to sensor selection for an indoor air quality multisensory system

Luiz MIRANDA*[1], Caroline DUC[1], Nathalie REDON[1], Marie VERRIELE[1], Bernadette DORIZZI[2], Jérôme BOUDY[2], Jugurta MONTALVÃO[3]

[1] IMT Lille-Douai, Douai, France
[2] Samovar, Télécom SudParis, Institut polytechnique de Paris, France
[3] Universidade Federal de Sergipe, São Cristóvão, Brazil
* *Corresponding author: luiz.miranda@imt-lille-douai.fr*

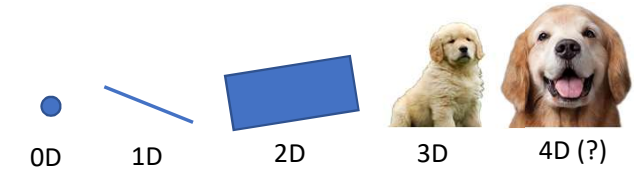
The intrinsic dimension of a structure is the number of free (independent) variables needed to represent the data without loss of information.
– Bennet, 1965

> 3 sensors ?

Dimensionality reduction

PCA

Intuitively:



ID < # sensors ?

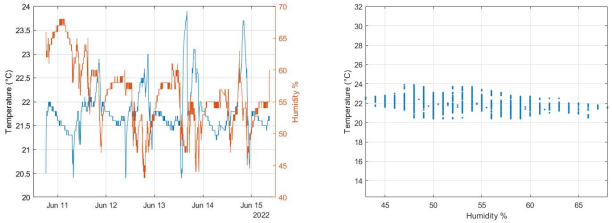
- At least 1 sensor is useless
- Interdependency between 2 or more sensors

JOURNAL OF COMMUNICATION AND INFORMATION SYSTEMS, VOL. 35, NO.1, 2020.

Bias-Compensated Estimator for Intrinsic Dimension and Differential Entropy: A Visual Multiscale Approach

Jugurta Montalvão, Jânio Canuto, and Luiz Miranda

Data Treatment – Pattern Recognition



Classifiers

- Supervised
- Separate between classes
- Ex:
  - Types of pollutants
  - Types of activities

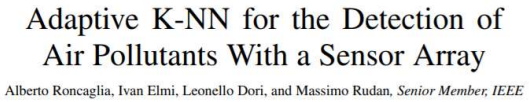
Clustering

- Unsupervised
- Define clusters according to a type of distance
- Ex:
  - Event detection
  - Model learning

Classifiers

- Artificial Neural Networks

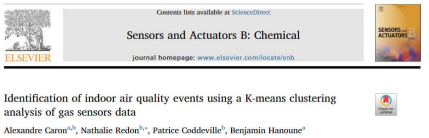
- K-Nearest Neighbors (k-NN)



- Support Vector Machines (SVM)

Clustering

- K-Means



- Gaussian Mixture Models

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ADEME
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Région Hauts-de-France

Thank you for your attention.
Questions ?

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from deployment to data treatment

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12/09/2022