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SELF-ORGANIZING MAP AS A SUPPORT FOR DATA FUSION IN MONITORING OF ENVIRONMENTAL PROCESSES

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Environmental processes are often characterized by dynamics that can be described by multiple heterogeneous measurands or indicators. Complexity of phenomena can be handled only considering multidimensional information, that is collected by different criteria (e.g. frequency, instruments), whose content need to be visualized synoptically.
Multi-sensor (and multichannel) technologies allow to follow variability of environmental phenomena with relatively high frequency (e.g. minute), as it is the case of odorous gas immissions monitored by Instrumental Odour Monitoring Systems [1] and of air particulate matter measured by Optical Particle Counters [2]. In environmental monitoring close to industrial sources, productive cycles as well as temporal periodicity (e.g. night/day cycles, working days/week ends, seasons) imply that similar signal patterns from multi-sensor systems occur repeatedly. The training of artificial neural networks known as Self-Organizing Map (SOM) algorithm, allows to identify a finite number of recurrent signal patterns (aka neurons or prototype vectors) that are organized in a bi-dimensional lattice (map) accordingly to their similarity. Prototype vectors can be clustered, leading to identification of typical states of the dynamic system under study. Every new signal pattern from the environmental monitoring can be projected on the map, identifying the best matching unit (BMU). A correspondence between each monitoring time and a neurons of the map is thus established, which is foundation for the data fusion procedure. Data from external sources – e.g. physical and chemical air quality parameters measured by means of standardized methods, measured with their own frequency, but also sparse data as citizen complaints, and plant faults - are linked to the BMU of synoptically collected multi-sensors patterns, and thus to clusters and typical states of the system. The finite number of typical patterns and system states is characterized on the SOM - thanks to the data fusion procedure - as normal/background states or states of the system polluted in different degree or from different sources. The adequacy of the trained SOM to represent new data, can be checked by examination of their quantization error (QE). Diverging QE indicate opportunity to check the systems for eventual hardware faults and to re-train the map. Trajectories of the system from normal to polluted states and back can be followed, making the SOM a multivariate control chart suitable for handling data from complex environmental systems. Till now the monitoring of odour [1] and PM [2] issues have been considered, but the approach appear suitable to analyze and visualize effectively multivariate data from long term monitoring of general environmental and industrial processes.

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References

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[2] Licen S., Cozzutto S., Barbieri G., Crosera M., Adami G., Barbieri P. " Chemometrics and Intelligent Laboratory System, 2019, accepted paper.