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Recognition of indoor events using gas sensors

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Abstract:
It is proposed to use gas sensors for recognition of indoor events. They are associated with human activities, which occur in inhabited spaces and cause temporary deterioration of indoor air quality. There were considered 26 types of events related to apartment weathering, heating, maintenance as well as cooking and eating. Events detection was based on responses of gas sensorsTGS8100, TGS2600, TGS2602, TGS2603, TGS2610, TGS2611, TGS2620. The obtained results show that sensor responses form a pattern which is largely event-selective and allows for their recognition. The error of individual event type recognition did not exceed 7 %.

Key words: gas sensor, indoor air, event, classification, pattern.

Introduction

Nowadays, the application of gas sensors is mainly focused on the detection of single air pollutants, determination of their concentration and classification of complex gaseous mixtures (e-nose). In this work we propose to use gas sensors for events recognition.

The subject of the study was indoor air. Recently, there is observed the deterioration of its quality. The diagnostics of this phenomenon requires relevant information. The traditional strategy is based on questionnaires and troublesome, time consuming observations. Thus, the approach based on monitoring of appropriate indoor air parameters and the analysis of measurement results is required.

It was recently demonstrated that indoor events related to human activities have their profiles of impact on indoor air [1]. The aim of this work is the recognition of such events based on indoor air measurements with gas sensors.

Experimental part

The experiment consisted in recording indoor events. The event was defined as the occurrence of household activity of a particular kind. Events were recorded by an observer for the sake of recognition model calibration. In parallel, indoor air measurements were done.

In the study, an apartment represented a space where indoor events take place. The one considered consists of two rooms, kitchen, bathroom, toilet and corridor (40 m^2). The space is inhabited by a family with a small child.

There following types of indoor events were distinguished: 1. Child room window opening, 2. Dining room window opening, 3. Kitchen window opening, 4. Child room door opening, 5. Oil filled electric radiator use, 6. Electric heater with fun blower use, 7. Convector heater use, 8. Vacuum cleaner use, 9. Wet dusting, 10. Wet mopping, 11. Washing, 12. Playing with the child, 13. Diaper change, 14. Getting child changed, 15. Dressing up for a walk, 16. Child bath, 17. Doing bed, 18. Water boiling, 19. Cooking, 20. Frying, 21. Eating, 22. Cosmetics use, 23. Presence of a smoker, 24. Electrical air-freshener use, 25. Christmas tree presence, 26. Wall painting.

It was assumed that the listed events change the characteristics of indoor air. In particular, the chemical composition of air could be varied due to their occurrence.

The device based on semiconductor gas sensors was applied in order to record chemical properties of indoor air in time. The following commercial sensors were involved: TGS8100, TGS2600, TGS2602, TGS2603, TGS2610, TGS2611, TGS2620. These sensors respond to wide range of volatile organic compounds [2]. The sensor response was .the conductance of the reference resistor.

The sensor device was located in central part of the smaller room, at the desk. Measurements were conducted continuously, in real time. The resolution of data collection was 1 s. The presented analysis is based on the data collected within two weeks, during wintertime.

Classification

The classification problem was solved for each type of events individually. The classification task consisted in distinguishing time moments when there occurred an event of a particular type (class - *event*) from all other time moments (class – *other*). The classification was performed with the temporal resolution of 1 s.

The basis for classification was the measurement data provided by gas sensors. Let $R_{i,t}$ be the response of an individual gas sensor i=1,…, 7, recorded at time point t=1,…, 604800. Two kinds of feature vectors **a** and **b** were considered. Vectors **a**=($R_{i,t}$), were composed of the response of one sensor. Vector **b**=($R_{1,t}$, $R_{2,t}$, …, $R_{7,t}$) was composed of responses of seven sensors.

K-nearest neighbors algorithm was applied for classification [3].

The classification performance was evaluated for each type of events individually. Ten folds cross-validation was used. Assume the test data set consists of n cases, $n=n_e+n_o$, where n_e are cases of event, while n_o are other cases. Let n_{ee} be cases of event classified as event and n_{oo} be other cases classified as others. The classification performance was determined using error of events recognition, $e_e=1-n_{ee}/n_e$ and error of other cases recognition $e_o=1-n_{oo}/n_o$. This approach is required due to $n_e<<n_o$.

Results

In Fig. 1 there are displayed errors of indoor events classification based on feature vector **b**. Fig. 2 presents errors obtained when using feature vector **a,** for gas sensor TGS8100. In case of this sensor there were achieved lowest average errors e_e and e_o.

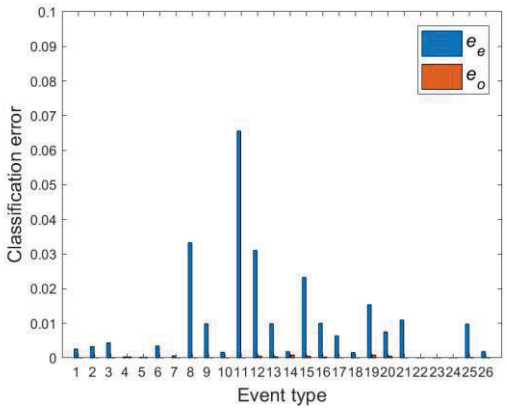

*Fig. 1. Performance of indoor events classification based on feature vector **b**.*

As shown in Fig. 1, indoor events were successfully recognized using gas sensor array. For this purpose, it was sufficient to consider jointly sensor responses recorded in single time point (feature vector **b)**. Errors of events recognition were small, in the range from 0 to 6.6 %. Just for several categories of events, namely 8, 11, 12, 15, 19, 21, 26 errors were greater than 1 %.

Based on Fig. 2, an individual gas sensor failed in classifying indoor events when using its single time point response (feature vector **a**). The classifier assigned almost all data to one class. In most cases, it was class ‘others’, which resulted in error structure shown in Fig. 2. However, it should be noted that other, more relevant sensor signal features could allow for achieving better results.

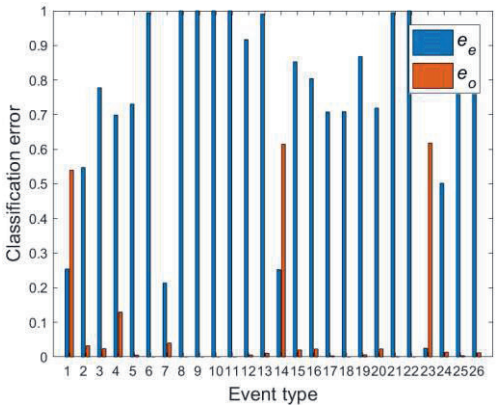

*Fig. 2. Performance of indoor events classification based on feature vector **a**, for gas sensor TGS8100.*

Conclusions

Our results show that indoor events are reflected in chemical properties of indoor air.

Chemical sensors are capable of detecting the variation of chemical properties of indoor air caused by such events.

Sensor responses form a pattern which is largely event - selective and allows for the recognition of events.

Acknowledgments

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References

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