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A novel approach for prostate cancer diagnosis using a gas sensor array

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Abstract

It is widely accepted that alterations inside human body are reflected in metabolism products and thus in their volatile part. Volatile compounds of human biological fluid such as urine, sweat, skin transpiration and obviously breath, could be a non-invasive access point to the individual health-state evaluation. Canine olfaction has already shown this ability with skin, and urine. Artificial olfaction is nowadays largely applied in a research context for breath analysis, and its utilization in urine headspace analysis could be of great interest. Indeed some results have been presented on the use of gas sensors array for urine samples volatile characterization for bladder cancer diagnosis[4]. Prostate cancer diagnosis is a challenging application for such technology to, due to non invasivity advantage in hospital routinely exams: haematological PSA (total Prostate-Specific Antigen) measurement, urine PC3 (Prostate Cancer gene 3) evaluation, digital rectal exploration (DRE) and biopsy.

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1. Introduction

Nowadays prostate cancer represents with lung cancer one of the most important male tumour. It is widespread in the occidental country and in North America [1].

Given the high incidence of prostate disease in individuals who have exceeded 50 years and above, given the continuing spread of prostate cancer in the population, doctors tend to advise patients that fall in this age group to undergo a periodic series of tests that allow to discover the state of health of the prostate.

Digital rectal examination is the first diagnostic approach to patients presenting symptoms referable to a prostate disorder. When indicated, transrectal ultrasound allows a more thorough exploration of the prostate, extended to the anterior, central, and allows to define tumor size and extent of possible injury [2].

At the same venue, the doctor may also perform a biopsy, or take a sample of cells to examine under a microscope. Another test that is indicative of the state of the prostate is the PSA that is done through a blood test.

The PSA (prostate-specific antigen) is the protein that is secreted by the prostate, a small amount of which is normally present in blood. Patients with prostate cancer tend to have higher levels of PSA in the blood. However, this check is not always reliable, as PSA levels rise with age and following the presence of other prostatic disease [3]. In this scenario identifying a non-invasive technique and ability to identify cancer at an early stage are key-points, and the analysis of volatile compounds of fluids related to metabolism could be an optimal solution. Canine olfaction has already shown this ability with skin [4] and urine [5, 6]. Artificial olfaction is nowadays largely applied in a research context for breath analysis, and its utilization in urine headspace analysis could be of great interest. Indeed some results have been presented on the use of gas sensors array for urine samples volatile characterization for bladder cancer diagnosis[7].

2. Experimental

In this pilot study two urine samples from each of the 21 subjects have been collected before a biopsy exam. The samples were referred to the first and second urination of each patient.

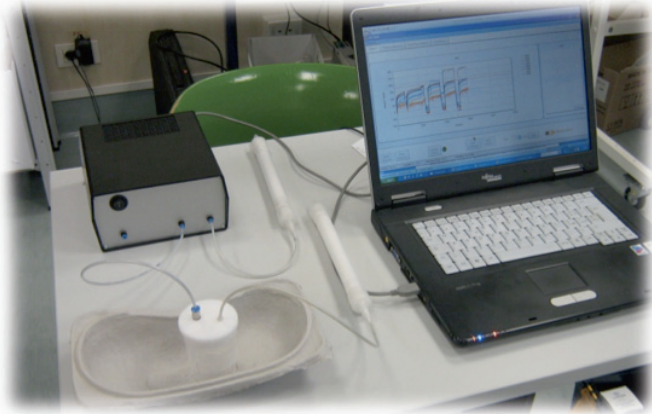


Fig. 1. Experimental setup for the measurements of urine headspace with the electronic nose.

The aim of this work is the investigation of a possible discrimination between the first and second part of urine to be used as tumor diagnostic mean. The samples were collected in sterile urine boxes. A dedicated top was developed for the used boxes to extract the headspace of urine for electronic nose analysis, see figure 1. The electronic nose used in this work is the last version developed at University of Rome “Tor Vergata”. This device is equipped by eight non-selective gas sensors. Each sensor is coated with different metallo-porphyrins. These materials have a large affinity towards a lot of volatile organic compounds. The final output consists of a fingerprint of the eight sensor responses registered for each sample. All data can be processed by a multivariate analysis. In this work we have used PLS-DA (Partial Least Square – Discriminant Analysis).

3. Results

The results obtained by this pilot study are promising. The best results have been obtained analysing the electronic nose data related to the first part urine. Figure 2 reports the scores plot of the latent variables 1 and 3 obtained by the PLS-DA model. It is evident the discrimination between control subjects (label 0) and tumor cases (label 1). A similar result has been obtained considering the data fusion between the first part and the second part of urine (figure 3). In this case two control subjects have been misclassified as ill subjects. The first evidences emerging from this pilot study consists of a concrete possibility to identify a volatile fingerprint of urine headspace of ill subjects. The qualitative results obtained by this pilot study are encouraging if we think of an electronic nose, as a useful partner for prostate cancer diagnosis.

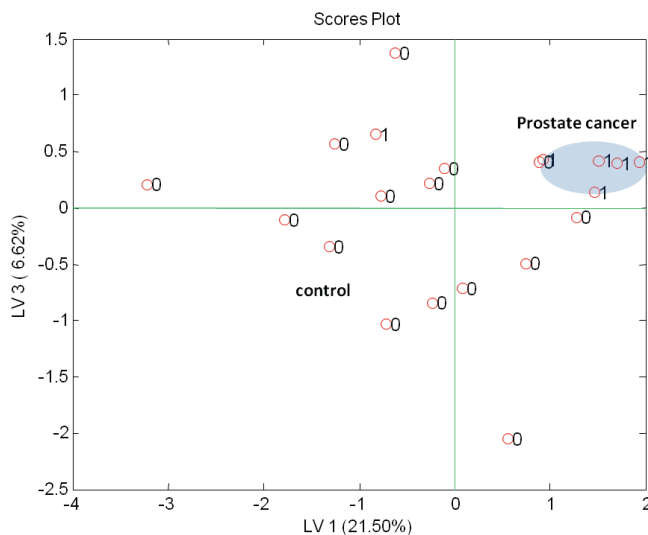


Fig. 2. Scores plot of the latent variables 1 and 3 of the PLS-DA model built on the first part urine e-nose data

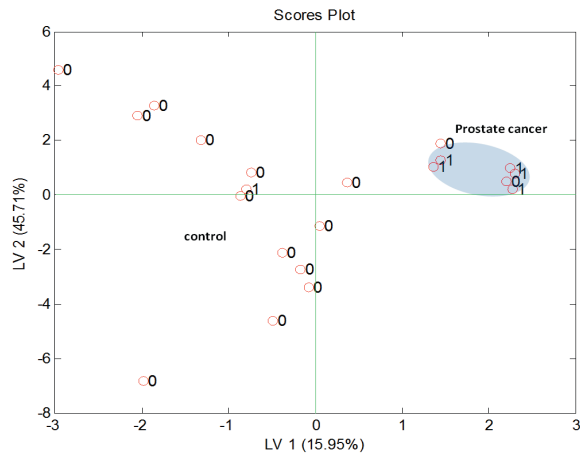


Fig. 3. Scores plot of the first two latent variables of the PLS-DA model built on the first and second part urine e-nose data.

4. Conclusions

Non invasive diagnosis is a must for prostate cancer pre-screening campaigns. Canine olfaction provided some evidences on volatiles potentialities as diagnostic tool. Urine headspace has shown to be a sample with a rich informative content when analyzed via electronic nose. Beside this pilot study has to be enlarged in terms of population and the urine sampling procedure must be standardized.

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