EXPERIMENTAL SENSORS FOR ARTIFICIAL LUNG CANCER BREATH DETECTION

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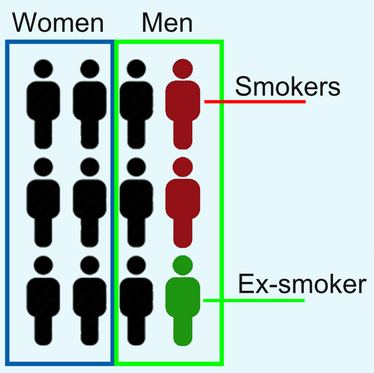
Sensing of Atmospheres and Monitoring

OBJECTIVES

- Using prototype sensors in a Instrumental Odour Monitoring System (IOMS or e-nose) to evaluate their ability for artificial breath discrimination in a lung cancer screening context.
- Evaluating the feasability and quality of a sensor benchmark using real healthy breath with biomarkers (VOCs) additives.
- Gathering data on the variability of breath across and its effect on breath classification.

MATERIAL AND METHOD

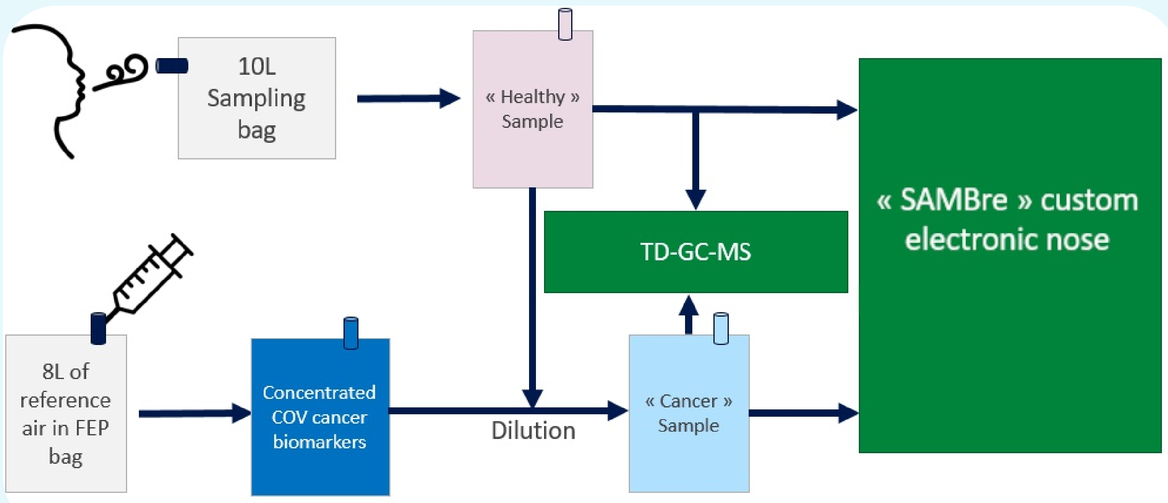
- Three experimental sensors (1,3 and 5% Fe-doped ZnO) and 6 commercial sensors:
  - 1430T, 3530T, 8530T, 2530T (Umwelt Sensor Technik™)
  - MP901 (Winsen™), TGS2603 (Figaro Engineering™)
- Homemade IOMS with temperature, humidity, O_2 and CO_2 measurements. Constant flow (200mL/min), with either 40% RH synthetic air at 20°C or breath samples.



- 12 volunteers amongst the campus staff participated in 9 days of sampling across 3 weeks, resulting in 29 distinct breath samples resulting in 57 data points (29 without VOCs addition, 28 with VOCs addition)
- Breath was stored in FEP bags using a electrostatic breath filter in home-made teflon holder and mouthpiece.
- Breath samples were analysed with both IOMS and TD-GC-MS to check the samples' content.

BREATH SAMPLE SYNTHESIS

- "Cancer breath" is imitated by adding VOCs to healthy breath:
  - 5 ppb 2-butanone, 5 ppb dodecane, 60 ppb 1-propanol, 245 ppb 2-propanol, 310 ppb ethanol, 5 ppb 2-pentanone, 295 ppb acetone, 5 ppb hexanal, 10 ppb toluene.
  - Concentration was varied during the experiment (concentration was doubled while keeping the same ratios)
- Sample creation and handling is as shown below:



RESULTS AND DISCUSSION

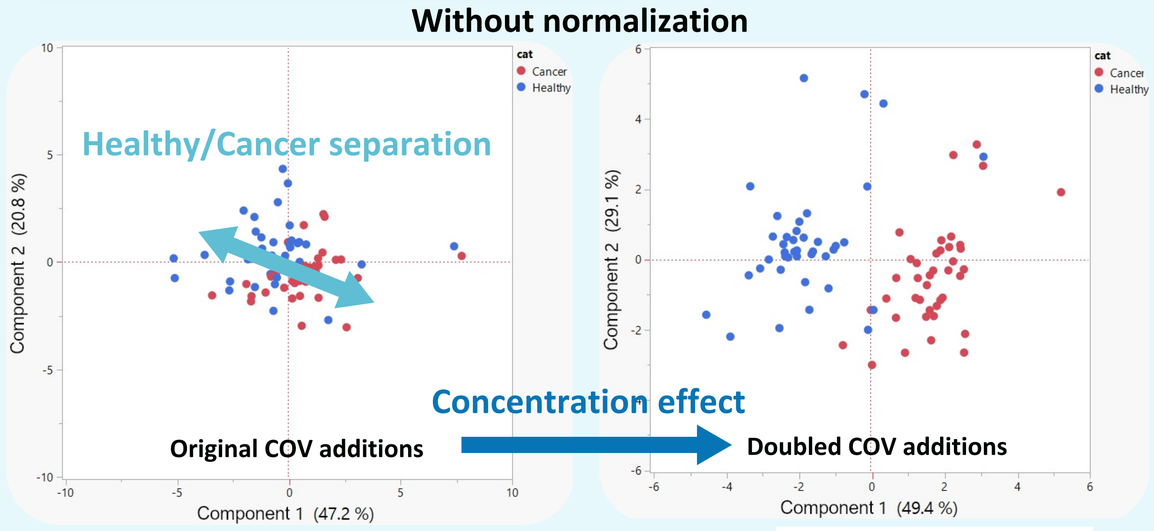
- Sensors MP901 and experimental sensors ZnO3% and ZnO5% are important for Cancer/Healthy mixture discrimination.
- Sensors more readily pick up a concentration effect that can lead to false conclusions. Working with normalized data is preferred but it lowers cluster quality and classification performance with LDA.
- Using breath samples from different people didn't hinder classification.

BOOTSTRAP ENRICHMENT

- The dataset was extended by generating 25 new "cancer" samples and 25 new "healthy" samples using a bootstrap method.
- Analysis is using the steady-state conductance of each sensor as a feature for analysis. Each conductance is baseline substracted, baseline being the steady-state conductance value in reference air.

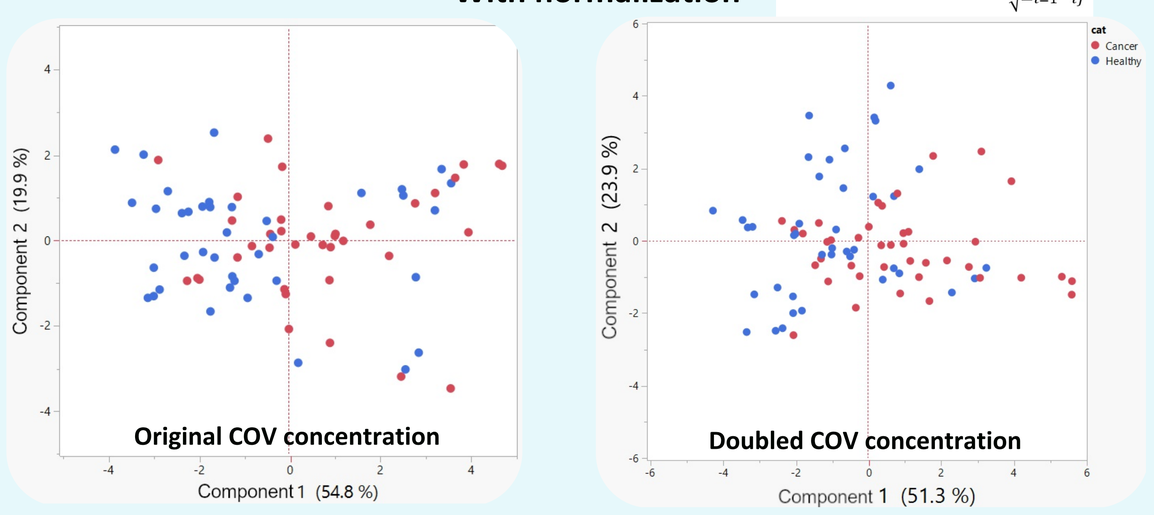
PRINCIPAL COMPONENT ANALYSIS

Without normalization



With normalization

$$\text{normalized data } x'_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$$



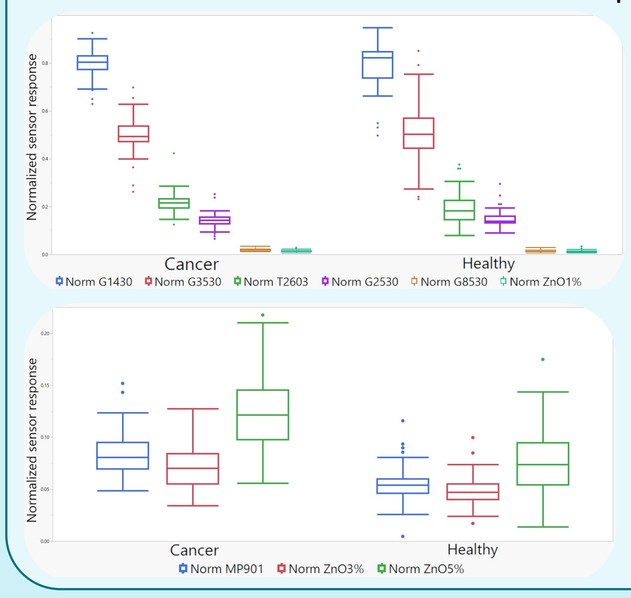
DISCRIMINATION ANALYSIS

Linear Discriminant Analysis (LDA)

Training : 22.9% misclassifciation
Validation : 37.5% misclassification

Training : 6.9% misclassifciation
Validation : 29.2% misclassification

- LDA was cross-validated using an external validation dataset (size equal to 30% of the training dataset).
- Minimum concentration necessary for good classification could be used as a metric of IOMS discrimination power (resolution).



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