

Electronic Noses for Healthcare Applications

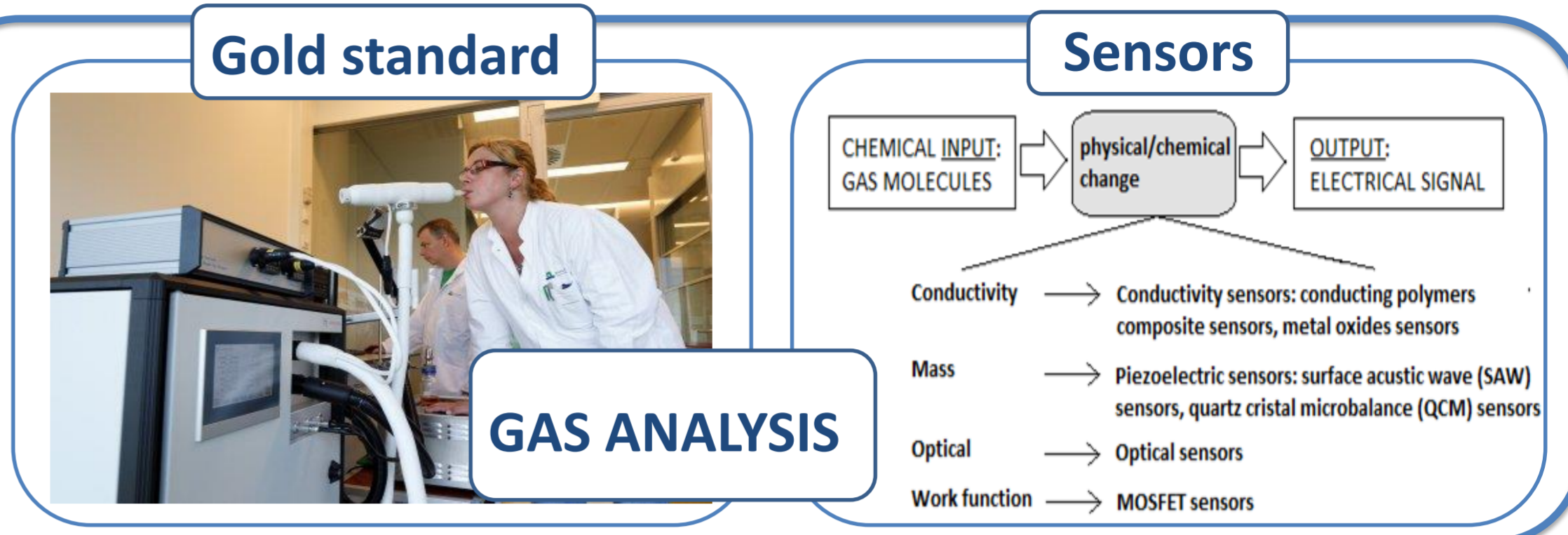
AIM Development of a portable, low cost, customizable device for human breath analysis

MOTIVATION

Since the time of Hippocrates, early medical practitioners recognized that the presence of human diseases changed the odors released from the body and breath.

For its unobtrusiveness and its inherent safety, breath analysis may be used to detect disease, monitor disease progression, or monitor a therapy.

STATE OF ART

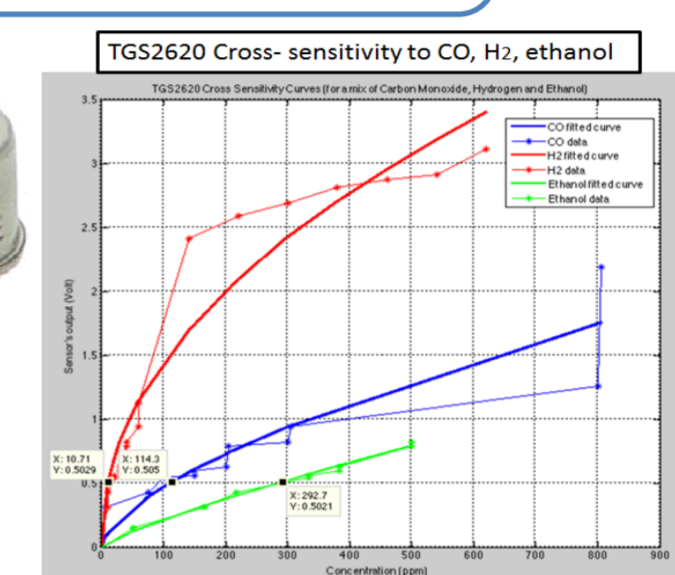


HARDWARE

- ❖ Real-time analysis
- ❖ Portability
- ❖ Use of low-cost technology
- ❖ Ease of use
- ❖ Modular and customizable design



Semiconductor Gas sensors



SENSORS DRIFT DUE TO HUMIDITY

Sensor	$\Delta V / \Delta hum$ (mV)
MQ7	296
TGS2620	60
TGS2602	82
TGS821	120
TGS2444	84

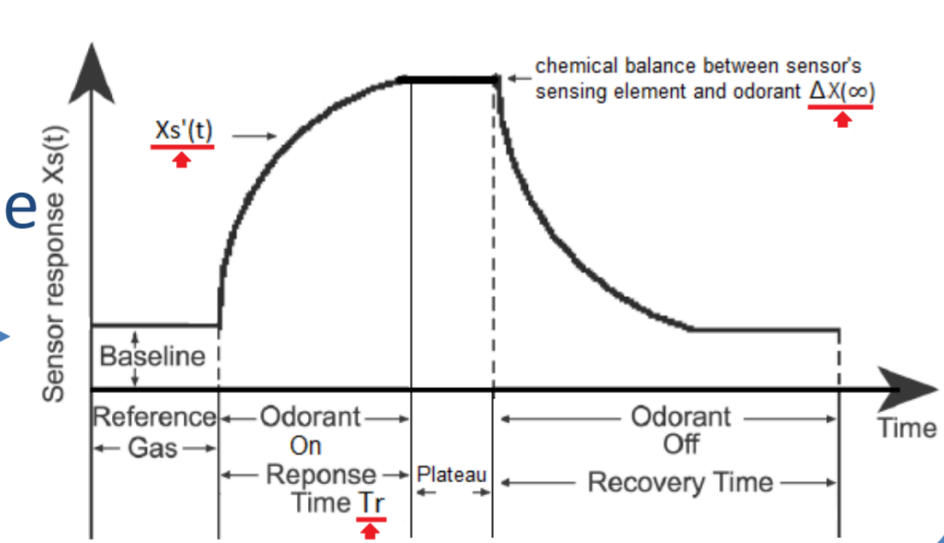
$$S_d = \frac{\Delta V}{\Delta hum}$$

$$R = R_0 * P_{O_2}^\beta * (1 + K_{gas}[gas])^{-\beta}$$

DATA ANALYSIS

Pre-processing

- ❖ Sampling of sensor output every 250msec
- ❖ Manipulation of baseline
- ❖ Check of the exhaled volume
- ❖ Feature extraction
- ❖ Transmission of the data



Data Processing

WS output: 3 features for each gas sensor

Aim: to evaluate individual's cardio metabolic risk from breath composition

FastICA Regression model

Risk Score (RS) = \sum Ground truth: AUDIT test, Fagerstrom test, Lifestyle test

0 to 5: very low risk
6 to 10: low risk
10 to 15: medium risk
16 to 20: high risk
>20: very high risk

VALIDATION

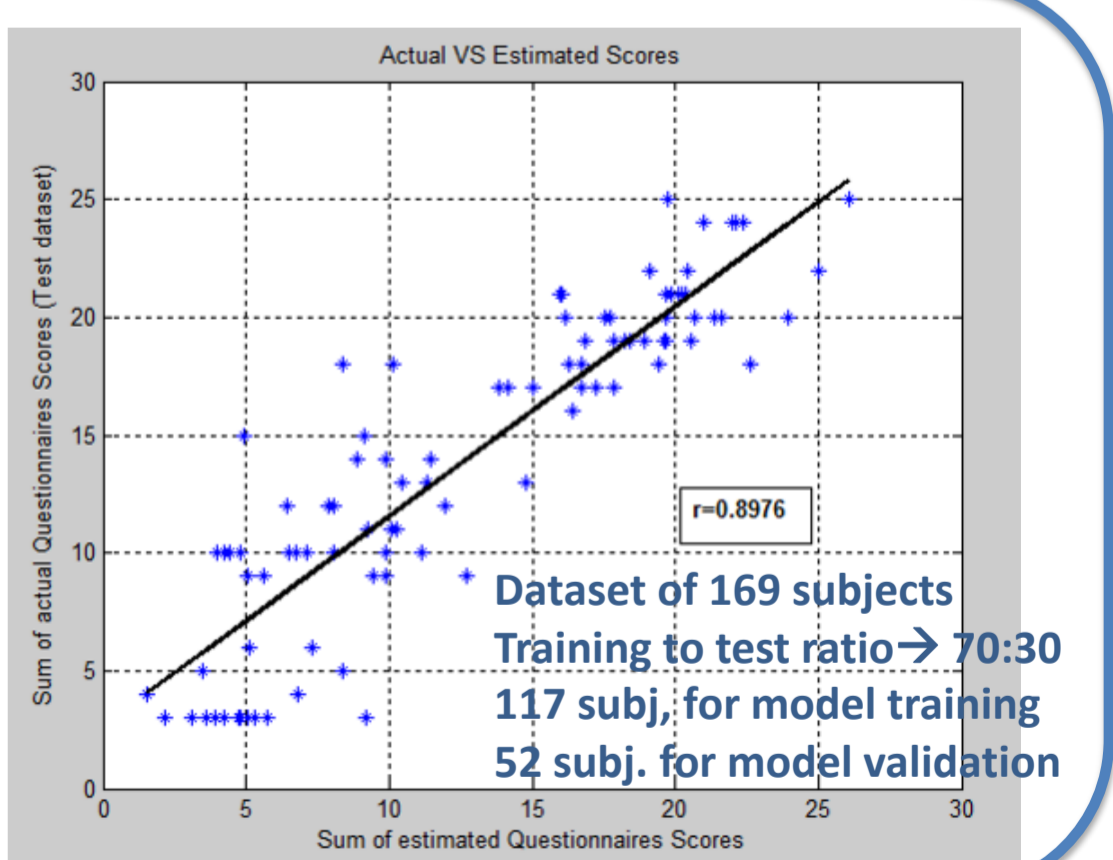
169 subjects involved (among which 77 sub. involved in SEMEOTICONS validation campaign)

80 women, 89 men; mean age range: 30-60 years old.

The subjects answered AUDIT, Fagerstrom and lifestyle questionnaires

Breath Test protocol:
Mixed respiratory breath sampling technique

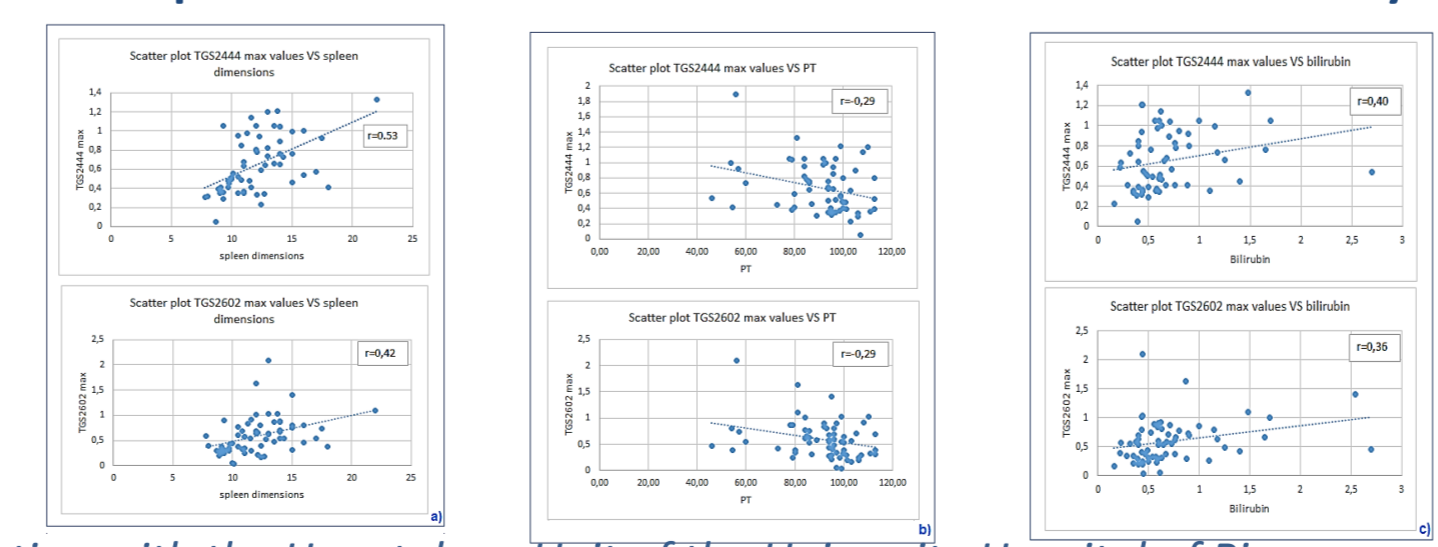
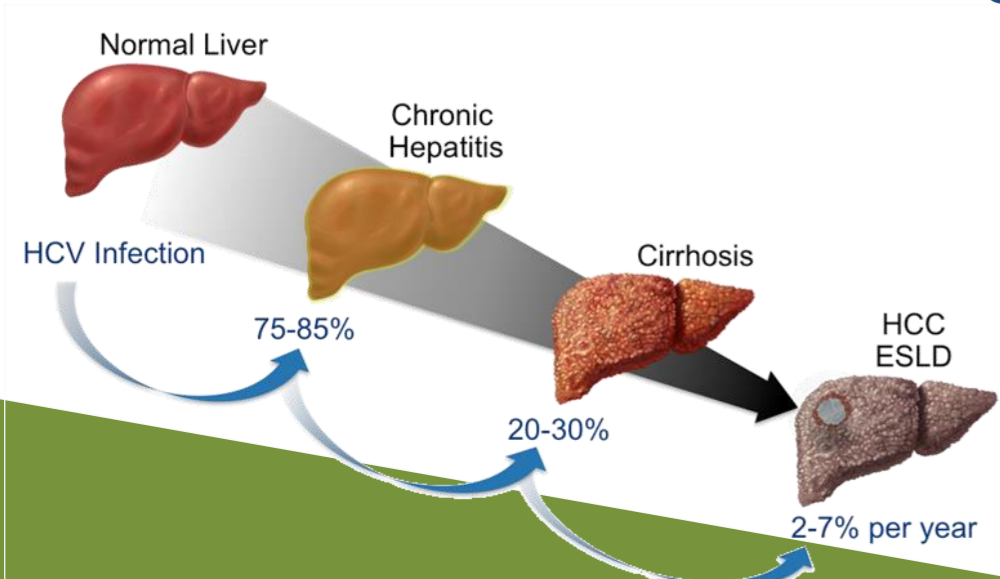
CORRELATION COEFFICIENT BETWEEN INDIVIDUALS' ACTUAL AND ESTIMATED RISK SCORE	0,8976
PREDICTION ACCURACY	79,77%
STANDARD ERROR OF PREDICTION (SEP)	1,27
COEFFICIENT OF DETERMINATION (R ²) OF THE MODEL	0,74



$$RS_{train} = k + a_1 * IC_{1train} + a_2 * IC_{2train} + a_3 * IC_{3train}$$

Remote Monitoring of Cirrhotic patients

Breath ammonia monitoring in cirrhotic patients to discriminate the severity degree of liver impairment



Correlations between ammonia gas sensors values and standard clinical tests

In collaboration with the Hepatology Unit of the University Hospital of Pisa