ELECTRONIC NOSE
History of E-Nose

• First appeared in a paper by Persuade and Dodd (1982).

• This was followed by several papers evaluating different sensor types.

• The E-nose was developed not to replace GC/MS techniques.
The Biological Nose

- sniffing
  - turbinate
    - mucus
      - Olfactory epithelium
        - neurons
          - olfactory bulb
            - hypothalamus
The Biological Nose

• The volatile organic compounds (VOCs) are basic to odors.

• Turbinate creates turbulent air flow.

  • molecules trapped by mucus.

• Then diffuses to epithelium

• It contains olfactory neurons
• Receptor proteins on the **cilia** of the olfactory neurons

• VOCs binds to receptor proteins

• Enzymatic reactions results in depolarization of the cells membrane

• Neurons responds to this by transmitting signals through axon
The Biological Nose

- Sensors are *broadly* tuned:
  - Single receptor recognizes multiple odorants.
  - A single odorant is recognized by multiple receptors.

- Neurons reach olfactory bulb

- Each Glomerulus (~2000) in the bulb receives signals from only one type of receptor cells.

- Approximately 2500 receptors converge into each Glomerulus.

- Olfactory information ultimately arrives in the brain, at the hypothalamus.
Physiological aspects of smell

• The volatile organic compounds (VOCs) are basic to odors.

• There are about 120 primary orders.

• These orders are not orthogonal.

• Humans are not capable to distinguish odors in terms of intensity.
Physiological aspects of smell

• detection threshold
  - absolute threshold of sensation for an odor.

• recognition threshold
  - lowest concentration at which an odor is first identified by 50% of the population sniffing it

• The recognition threshold (5 odor units/m3) is five times the detection threshold (1 odor unit/m3).
The Electronic-Nose

- system comprising of active materials which operate serially on an odorant sample.

- These active materials are
  1. an array of gas sensors
  2. a signal processing system.

- The output of the electronic nose can be
  --the identity of the odorant, or
  --the concentration of the odorant, or
  --the characteristic properties of the odor
The Electronic-Nose

• Each sensor in the array has different sensitivity.

• Each sensor in the array has a unique response profile to different odorants.

• The pattern of response across all sensors in the array is used to identify and/or characterize the odor.
Sensing an odorant

• Each sensors has been driven to a known state

• An air sample is pulled by a vacuum pump through a tube into a small chamber.

• The sensors are exposed to the odorant.

• A transient response is produced as the VOCs interact with sensor’s active material.
Sensing an odorant

• steady state condition is reached after few seconds.

• *response time*
  - period during which the odorant is applied

• Then, a washing gas vapor is applied.
• Finally, the reference gas is applied.

• *recovery time*.
  - period during which the washing and reference gases are applied.
Electronic Nose Sensors

• Electronic nose uses different type of sensors

• Electronic nose sensors fall in four categories:-
  • Conductivity Sensors
  • Piezo Electric Sensors
  • MOSFET Sensors and,
  • Optical Sensors.
1. Conductivity sensors

- There are two types of conductivity sensors.
  a. Metal Oxide Sensor
  b. Polymer Sensor

- Both of them exhibit a property of change in resistance when exposed to volatile organic compounds.
a. Metal oxide sensors

- Most extensively used
- oxides of Sn, Zn, Ti, W and Ir doped with Pt or Pd.
- resistive heat element at 200°C to 400°C
- VOC passes over the doped oxide material, the resistance between the two metal contacts changes in proportion to the concentration.
- Sensitivity ranges from 5 to 500 parts per million.

- A known reference gas used to initialize the sensor.

- The baseline response of metal oxide sensors is prone to drift.

- The sensors are also susceptible to poisoning (irreversible binding) by sulphur compounds.
b. Polymer Sensor

- Active material is a conducting polymer.
- Conductivity of these materials changes as they are exposed to various types of chemicals.
- Micro fabrication techniques are employed electrodes separated by a gap of 10 to 20 µm.
- Conducting polymer is electro polymerized between the electrodes.
• Sensor polymer material swells upon exposure to odor.

• Results in a long path for current, hence higher resistance.
Baseline Resistance

All of the polymer films on a set of electrodes (sensors) start out at a measured resistance, their *baseline resistance*. 
Each polymer changes its size, and therefore its resistance, by a different amount, making a pattern of the change.

If a different compound had caused the air to change, the pattern of the polymer films' change would have been different:
• Because conducting polymer sensors operated at ambient temperature, they do not need heaters

• detect odors at sensitivities of 0.1 ppm, but 10 to 100 ppm is more usual.

• it is difficult and time consuming to electro polymerize the active material

• susceptibility to water vapour can mask the responses to odorous VOCs.

• some odorants can penetrate the polymer bulk
2. Quartz Sensors

- Consist of a resonating disk, with metal electrodes on each side

- The device resonate at a frequency of 10MHz to 30MHz
• The reduction in frequency is inversely proportional to odorant mass absorbed by the polymer

• The response and recovery times are minimized by reducing size and mass.

• Their response to water dependent upon the absorbent material employed.
3. MOSFET Sensors