Sensors for early warning of disease?

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Gas Analysis 101  Previous Work  Future activities
Sensors @ Warwick University
Artificial Olfaction

- Invented at the University of Warwick in the early 1980s
- To replicate the function of the Human Nose
- Used as alternative to more ‘sophisticated’ analytical methods
- First company created in 1990’s
- School of Engineering works with commercial companies for over 20 years on sensors and sensor systems
Warwick’s Electronic Nose 101

The air from around an area of interest is sampled.

Many sensors within the electronic nose respond to different odours within the sample. These responses are then processed.
Common agricultural applications

- Process emissions & Gas/Liquid effluent
- Food and cosmetics
- Air quality
- Insect infestations
- Crop diseases

Applications areas
# Electronic Nose in Food and Agriculture

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**Tomato plant infections**

- **Blue/Green Algae**
- **E. Coli**
- **Potato Infections**

**Fruit ripeness**

- **Fish freshness**
- **bovine mastitis**
- **Fruit Infections**

**Host identification**

- **Insect induced plant damage**
- **Pathogen identification**
- **Post-harvest decay or rot detection**

**AHDB POTATOES**

[Logo]
Problem to be solved..

One major cause of potato tuber post-harvest loss in storage is caused by a disease of bacterial origin known as ‘soft rot’.
Problem to be solved II...

- The scale of the problem? E.g. Large store and localised issues
Research Goal

Aim

Pre-symptomatic evaluation and monitoring of potato soft rot under selected conditions and by means of gas analysis for future deployment in commercial potato stores.

Key Objectives

▶ Detection of soft-rot infection at different stages of disease progression by using available electronic nose technology in a laboratory environment.
▶ Development of data analysis for informed decision on sensor selection.
▶ Development of a prototype bespoke instrument for future store deployment.
Can we confirm a difference?

Measure mobility of ions in high electric fields:

**Pros:**
- Supersensitive
- Physical measurement (no drift)
- Repeatable/reliable

**Cons:**
- Expensive (>£30k)
- Requires infra-structure
- Best for Industrial/lab environment
- Easy to overload...

**FAIMS:**
Field Asymmetric Ion Mobility Spectrometry
FAIMS Results: Soft Rot

Healthy

Light infection

Heavily infected
FAIMS Results II...

- Can easily detect difference in diseased and infected tubers
- Chemical signature changes before physical signs
More interestingly...

5 DPI (5 days post inoculation)

2 DPI (2 days post inoculation).

Controls (cyan triangles) and infected (red circles)
Commercial Electronic Nose

**AlphaMOS Fox 3000 eNose**

**Pros:**
- 12 metal-oxide sensor
- Able to separate complex mixtures
- Uses cheap sensors (<£50)
- Fairly repeatable/reliable

**Cons:**
- Some humidity dependence
- Expensive as an instrument (£10-20k)
- Limited sensitivity(?)
With just 3 cheap sensors...

- We can achieve same results with three sensors
- Detecting early infection just after 2 days
- However these are *lab* conditions...

Controls (cyan triangles) and infected (red circles)
New Instrument Development

- PID sensor with increased sensitivity ('Detection' and 'Early Detection' time point)
- Metal Oxide gas sensors ('Detection' and 'Early Detection' time point)
- Electrochemical gas sensors ('Detection' and 'Early Detection' time point)

‘Gas analyser’ (enclosure)
The Future?

Indoor Environmental Quality

- **Temperature** (-30°C, 120°C)
- **Humidity** (1% - 100%)
- **Light** (light intensity, flicker)
- **Noise** (sensitivity of the human ear, stress)
- **Air Quality** (6 Gas sensors: CO, H2S and 4 Odor sensors)
- **Particles** (PM 1μm to PM 10 or 40μm)
- **Vibration**
Typical type of output

Output data giving an overall indication of environment quality
But what else?

- Soil quality/Bacterial load
- Gas Analysis
- Potato health infection
- Sprouting suppression
- Transport
Storage and transport of seed

AHDB

Strategic priority 3: Help the industry understand and deliver what consumers (customers) will trust and buy:

“Exploit existing overseas market access agreements for potatoes”
Latent infection in tubers during storage and transit

- **2,000** tonnes of Scottish seed denied entry to importing countries since 2013.
- **Soft rots** cited as the cause of rejection for **1500 tonnes**.
- Main concern are rots that appear **post inspection** on arrival;
- Stocks that have been passed by official inspectors but which have then degraded rapidly causing a total loss.
- **Latent infection** is a challenge for exporters as disease may not have had time to manifest prior to shipping or by the time of the official inspection.
Outline of work...

- Pre shipment testing - established molecular and microbiological techniques in use at SASA for statutory testing
- Monitoring transit conditions - \( \text{CO}_2, \text{O}_2, \text{VOCs}, \) temperature, humidity, light, and movement
- Post shipment testing
- Mimicking transit conditions at SBCSR

Seed bags \(~1.25\) tonne, and 1 tonne boxes
Prototype Unit

- 226 x 116 x 84 mm
- 3 month battery life
- E-ink display
- Available from Sep!
Conclusions

- Gas phase analysis offers considerable potential
- Understanding is needed on where best to deploy the technology
- Key is to produce dedicated – low cost systems to solve agricultural problems
- Distributed sensor networks will be with us...