Integrating Sensors and Development of Data Mining Tools to Manage Tubers in Potato Storage Facilities

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I Objective

❖ **Thermal cameras and 3D LiDAR sensors** are used in potato storage facilities to monitor crop conditions over long periods.

❖ Low temperature, high humidity storage conditions can disrupt sensor operation.

✓ The first objective of this research was to create an **automatic fan ventilation system** to cool down **internal sensor electronics.**

Background

❖ Potatoes are an important crop - stored for up to 12 months to meet demand.

❖ They are vulnerable to bacterial and fungal diseases that can lead to severe economic losses.

❖ Potato rot can be detected early by monitoring sinkage or volatile organic compounds (VOCs) released by infected tubers.

Fig. 1. Potato Tuber Storage Facility, Othello, WA.

II Objective

❖ **Field Asymmetric Ion Mobility Spectrometry** (FAIMS) is useful for rot detection, allowing new ways to explore non-invasive methods to detect early spoilage in stored potatoes.

❖ To tackle the current limitation of relying on visual inspection of FAIMS data.

✓ Build an **automated analysis pipeline** using image processing and **machine learning** techniques to streamline spoilage detection and classification.

Materials and Methods

❖ **Raspberry Pi 3:** Single-board computer used to receive and send signals.

❖ **Digital Humidity-Temperature 22** (DHT22) **Sensor**: Measures ambient temperature and humidity levels in the environment.

❖ **TIP31C NPN Transistor:** Functions as a switch, allowing the Raspberry Pi's low-power GPIO pin to control the higher-power fan circuit.

❖ **5V DC Fan:** Circulates air inside the camera enclosure when activated.

❖ **Python Script:** Continuously reads temperature & humidity values from DHT22 and activated fan when reaching predefined threshold.
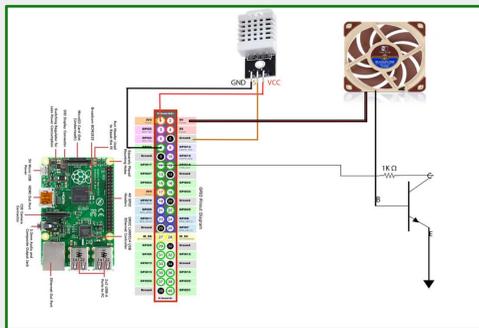

Fig. 2. Fan Ventilation Wire Diagram

❖ **Validation Experiment:**

▪ The temperature of a glass chamber was increased using a space heater to simulate elevated sensor enclosure temperature.

▪ Damp tissue was placed inside to raise humidity.

▪ The developed system was powered, and real time temperature and humidity were logged.

▪ The relative humidity conditions were modified (up to 95%) to test the activation of the fan.
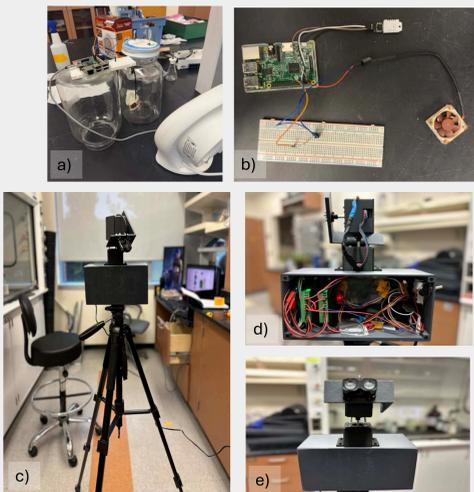

Fig. 3. (a) Experiment (b) Ventilation Setup (c), (d), and (e) Camera Setup

Results – Obj. 1

❖ The temperature and humidity sensor worked within the chamber, while accordingly turning the fan on and off.

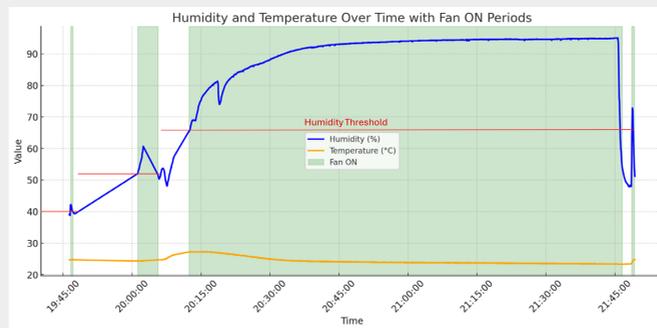❖ The script correctly logged temperature, humidity, and fan status.

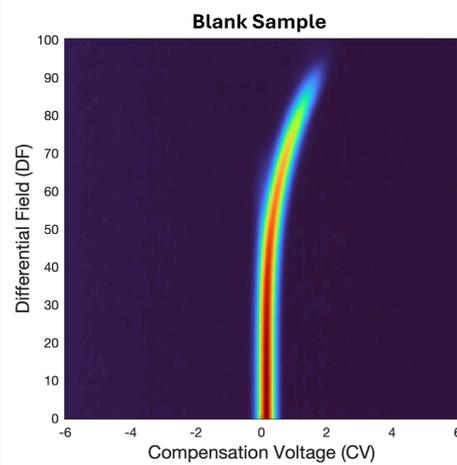Fig. 4. Temperature and Humidity Over Time with Fan ON Periods
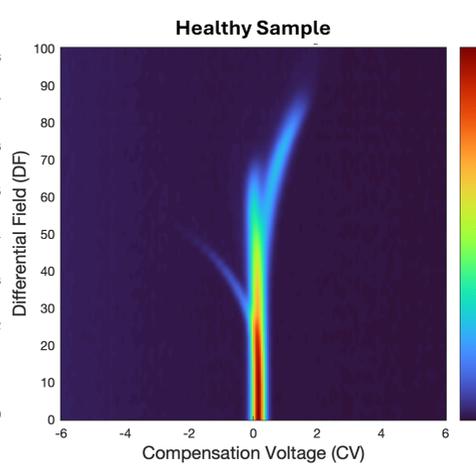

Fig.5(a). Blank FAIMS Spectra

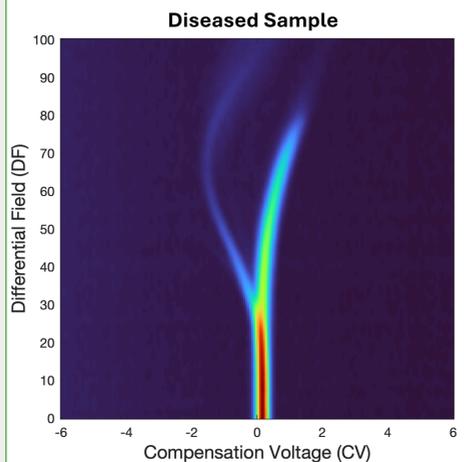Fig.5(b). FAIMS Spectra of Healthy Tubers at 14 Days After Inoculation

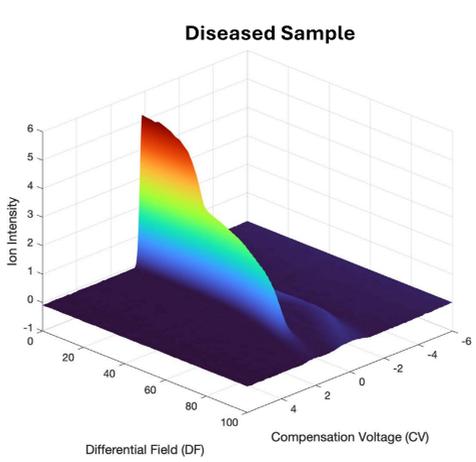Fig.5(c). FAIMS Spectra of Inoculated Tubers at 14 Days After Inoculation

Fig.5(d). 3D FAIMS Spectra of Inoculated Tubers at 14 Days After Inoculation

Methods

❖ Raw FAIMS data collected from **potato samples** were converted to **top-view dispersion plots** and images were converted to grayscale, highlighting regions of VOC activity.

❖ **DBSCAN** is utilized to identify spatial cluster in VOCs across samples.

➢ Up to 10,000 coordinates were randomly sampled for clustering to improve runtime efficiency.
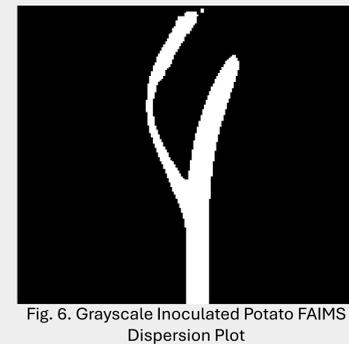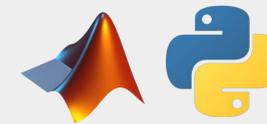

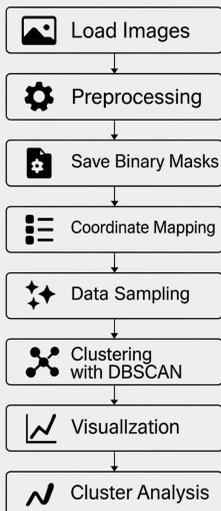Fig. 6. Grayscale Inoculated Potato FAIMS Dispersion Plot

Fig. 7. Flowchart of FAIMS DBSCAN pipeline

Load Images → Preprocessing → Save Binary Masks → Coordinate Mapping → Data Sampling → Clustering with DBSCAN → Visualization → Cluster Analysis

Results – Obj.2

❖ Binary VOC activation masks were successfully generated from all FAIMS images using grayscale thresholding and morphological preprocessing.

❖ Different Field (DF) and Compensation Voltage (CV) were mapped from VOC regions and clustered using DBSCAN, revealing distinct VOC dispersion patterns across different sample groups.

❖ Multiple clusters were identified, each associated with specific FAIMS image sets showing clear separation in VOCs, supporting feasibility for automated spoilage classification.
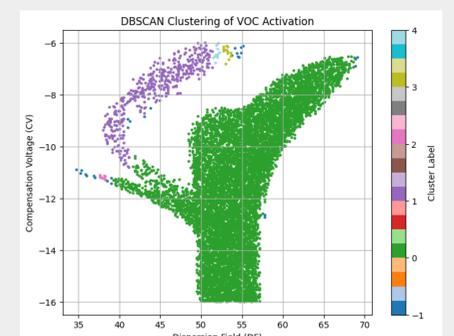

Fig. 8.DBSCAN Clustering of Sampled VOC Activation

Acknowledgement