Electronic Airborne Chemical Detection (SNOUT)

TEXAS A&M UNIVERSITY Engineering

Project Lead: Anirudh Subramanian

Members: Zhengye Chen, Fredy Cortez, Odalys Garay, Sebastian Garcia, Srikar Kotha, Seth Powell, Caleb Snider

TEXAS A&M UNIVERSITY ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Intro & Problem Definition

Smell

- our least digitized sense
- remains one of the hardest for machines to replicate
- Current chemical detection relies heavily on trained animals, particularly dogs
  - Explosive and narcotics detection
  - Search-and-rescue operations
  - Medical scent detection (disease biomarkers)
  - Identifying hazardous industrial chemicals.
- Electronic chemical detection systems exist, but most are expensive, slow, or require laboratory conditions.

Our goal is to develop **SNOUT**, a compact robotic sensor that mimics biological smell detection by identifying chemicals through unique signatures.

Working Principle

SNOUT detects chemicals using **fluorescence spectroscopy**, a technique where molecules emit light after being excited by UV energy.

Fluorescence Process

1. UV light excites electrons inside the molecule.
2. The electrons jump to higher energy states.
3. As they relax back down, the molecule emits lower-energy visible photons—fluorescence.
4. The emitted wavelengths form a "spectral fingerprint," unique to chemical families.
5. These signals are read by a wavelength detector (AS7134).
6. A machine learning model classifies the chemical based on this fluorescent signature.

Why Fluorescence?

- Works on both organic and inorganic compounds
- Safe for volatile or hazardous samples

Fluorescence Uses

- Forensics
- Gas Cloud Analysis
- Mineral Identification

Figure 1: Various amino acids in a glass of beer fluorescing

Design Approach

Mechanical Design

- A horizontal column design ensures controlled airflow through the UV chamber.
- A small intake fan pulls ambient air or sample air into the chamber.
- Optional filters can be added to isolate specific excitation wavelengths.

Optical Design

- Two UV sources:
  - **254 nm** for inorganic and mineral-based signatures
  - **365 nm** for organic molecules, amino acids, and hydrocarbons
- The chamber is coated matte black to reduce reflective noise.
- Fluorescence is collected perpendicular to the excitation path to reduce direct UV contamination.

Electronics & Sensors

- **AS7134 spectral sensor** measures intensity at multiple wavelengths.
- **Microcontroller** (ESP32) handles data acquisition and transfers batches to the ML pipeline.
- Internal cables are shielded to reduce electrical interference from the UV LED drivers.

Design Specifications

There are 2 UV sources

- a 254 nm source
- a 365 nm source

254 nm is used for minerals and non-organic molecules. 365 nm is used for organic molecules.

The emitted wavelengths are detected

- AS7134 wavelength detector - to detect the exact color the molecule fluoresces at

And analyzed in a Random Forest Model

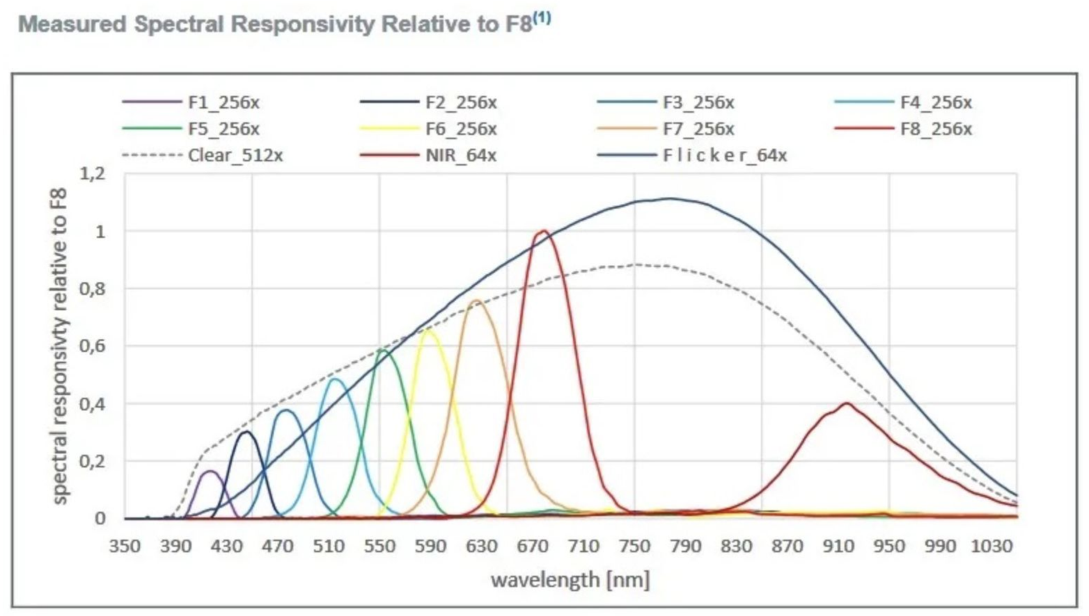

Figure 3: Spectrometer Output Graph

Software

The AI model used is a Random Forest Model. Random Forest is an AI based on decision trees, where an ensemble machine learning method that combines the output of multiple individual decision trees to produce a single, more accurate, and stable prediction.

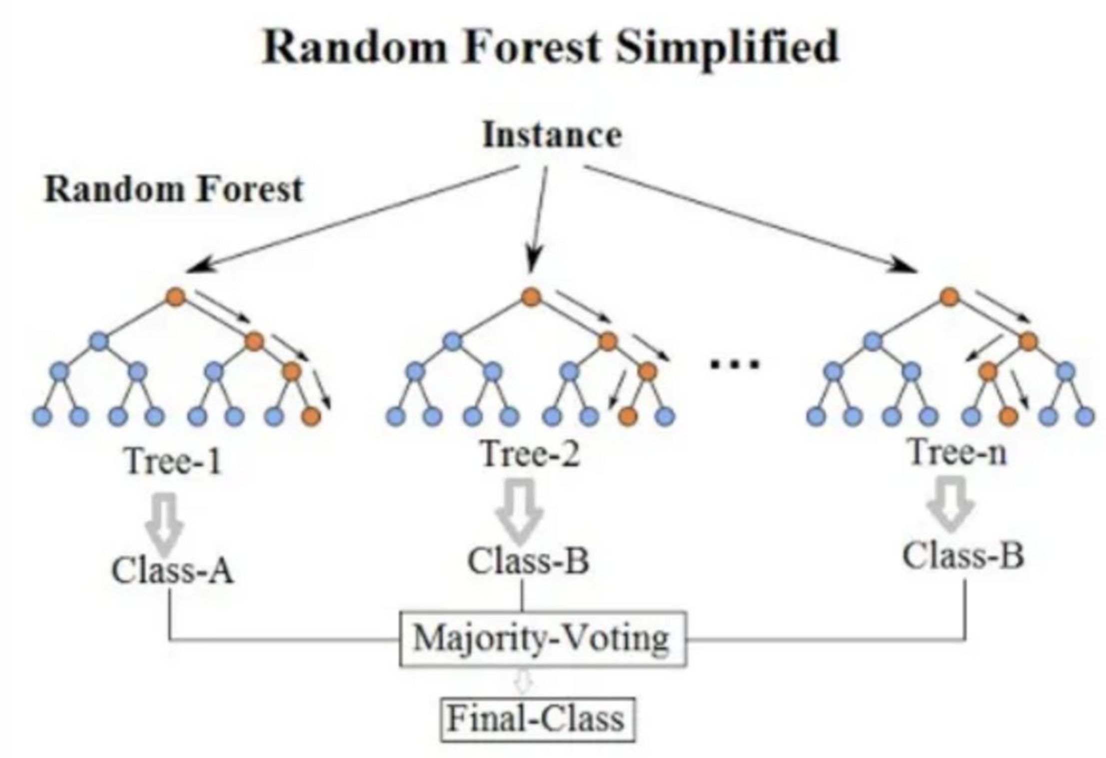

Figure 4: Random Forest Model

What We Accomplished

- Designed and printed the first airflow-controlled sensor chamber
- Calibrated the AS7134 sensor under both UV wavelengths
- Integrated LEDs and control electronics into a compact housing
- Implemented a working Random Forest pipeline for early classification tests

Next Steps

- Begin tests with various organic and inorganic compounds
- Increase dataset size with more chemical categories
- Integrate humidity and temperature sensing for environmental compensation
- Evaluate other ML models (SVM, CNNs on spectral images)

Last Notes

SNOUT is a step toward digitizing one of humans' least understood senses. By combining fluorescence spectroscopy with machine learning and robotic design, our system aims to create a low-cost, portable, and reliable chemical detection platform capable of performing tasks typically handled by highly trained scent-detection animals.

Texas A&M University Robotics Team and Leadership Experience (TURTLE) Lab