CropTalker: an innovative IoT solution for multispectral and Structural Monitoring in small-scale agriculture

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1. The Challenge

The Need for detailed Field Monitoring

•Effective management and research in **small-scale agriculture** (e.g., experimental plots, high-value crops, vertical farms) require detailed, continuous data on plant growth and health.

•Traditional methods often lack the necessary spatial resolution, temporal frequency (hourly/daily), or integration of diverse data types (visual, structural, spectral, environmental).

•Key challenges include the **cost**, complexity, and deployment limitations of existing sensor technologies for autonomous, long-term, plot-level monitoring.

Introducing "Crop Talker“

•Crop Talker is an **innovative, integrated IoT device** designed specifically for affordable, high-frequency, multi-modal monitoring at the small-plot or single-plant level.

•**Core Concept:** Provide a deployable, autonomous sensor suite that continuously captures key aspects of plant status and the immediate micro-environment.
•**Primary Objectives:**
- Develop a robust, field-ready IoT monitoring system.
- Integrate complementary sensors for comprehensive canopy assessment.
- Enable autonomous, hourly data acquisition over extended periods.
- Ensure easy data access and management for researchers and growers.

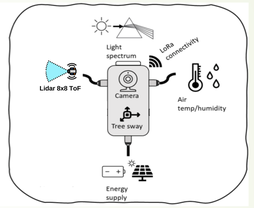
Integrated Sensor Payload

•Crop Talker combines multiple sensors into a single unit:
- **RGB Camera:** For high-resolution visual documentation and analysis.
- **Lidar ToF 8x8 Matrix:** For non-contact structural measurements.
- **TetraSpec® 28-band Spectrometer:** For detailed spectral signature analysis.
- **Air Temperature & Humidity Sensor:** For local environmental context.
- **3-axis Accelerometer:** For monitoring device orientation and stability.

2. System design and operation

System Architecture

•The device employs a modular design centered around a microcontroller managing sensor polling, data aggregation, and communication.



Key Hardware Specifications

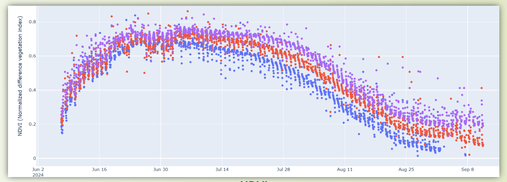
•**Lidar:** 8x8 pixel Time-of-Flight sensor providing distance matrix. A value of “mean height” is also given.
•**Spectrometer:** TetraSpec® unit capturing 28 spectral bands (e.g., VIS-NIR range, specify if known) covering from 415 nm to 940 nm.
•**RGB Camera:** 2MP resolution.
•**Processing:** STM32L0 chip integrated in a proprietary board.
•**Communication:** NB-IoT and LoraWAN connectivity for data transmission are avaliable.
•**Power:** Designed for low power consumption, suitable for a whole vegetative season data acquisition within a battery cycle.

Deployment & Data Acquisition

•**Mounting:** Typically deployed on a pole at ~1m height above the target canopy.
•**Field-of-View (FoV):** Monitors an area of approximately 1m².
•**Autonomous Operation:** Embedded proprietary software triggers synchronized measurements from all sensors **every hour**.
•**Stability:** Accelerometer data helps verify stable orientation.

3. Example Applications

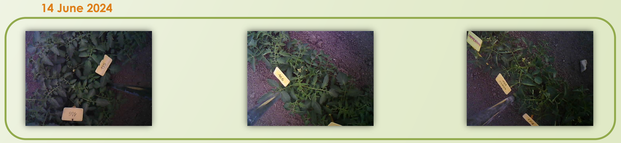
Crop Talker provides a suite of capabilities for detailed crop assessment. We illustrate these using data from a **3-month deployment (July-Sept 2024)** monitoring **tomato crops** with **three replicate devices**.



NDVI
Calculated from the spectrometer data of three CropTalker systems showing the start of the vegetative season and the slower decay when reaching the end of august

Mean Crop Height
Calculated from the Lidar data of three CropTalker systems showing growth patterns in accordance with NDVI data

14 June 2024



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