Canopy Sensing and Computational Systems for Real-Time Control and Feedback of Irrigation Technology

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Water is a valuable resource!

- Agriculture annually consumes approximately 80% of ground and surface water in the US
- Increasing irrigated acres, recent droughts, population growth, and escalating urban water demands have reduced the amount of water available for irrigation use
- Need for on-farm water management practices including spatial knowledge-based irrigation decision, scheduling and feedback
- The ***broad goal*** of this project is
  - to integrate sensing and computational systems
  - to quantify crop water stress variability in crops
  - to obtain dense spatial and temporal resolution
  - in order to most efficiently utilize available water resources
  - through precision irrigation technologies.

Crop Water Stress

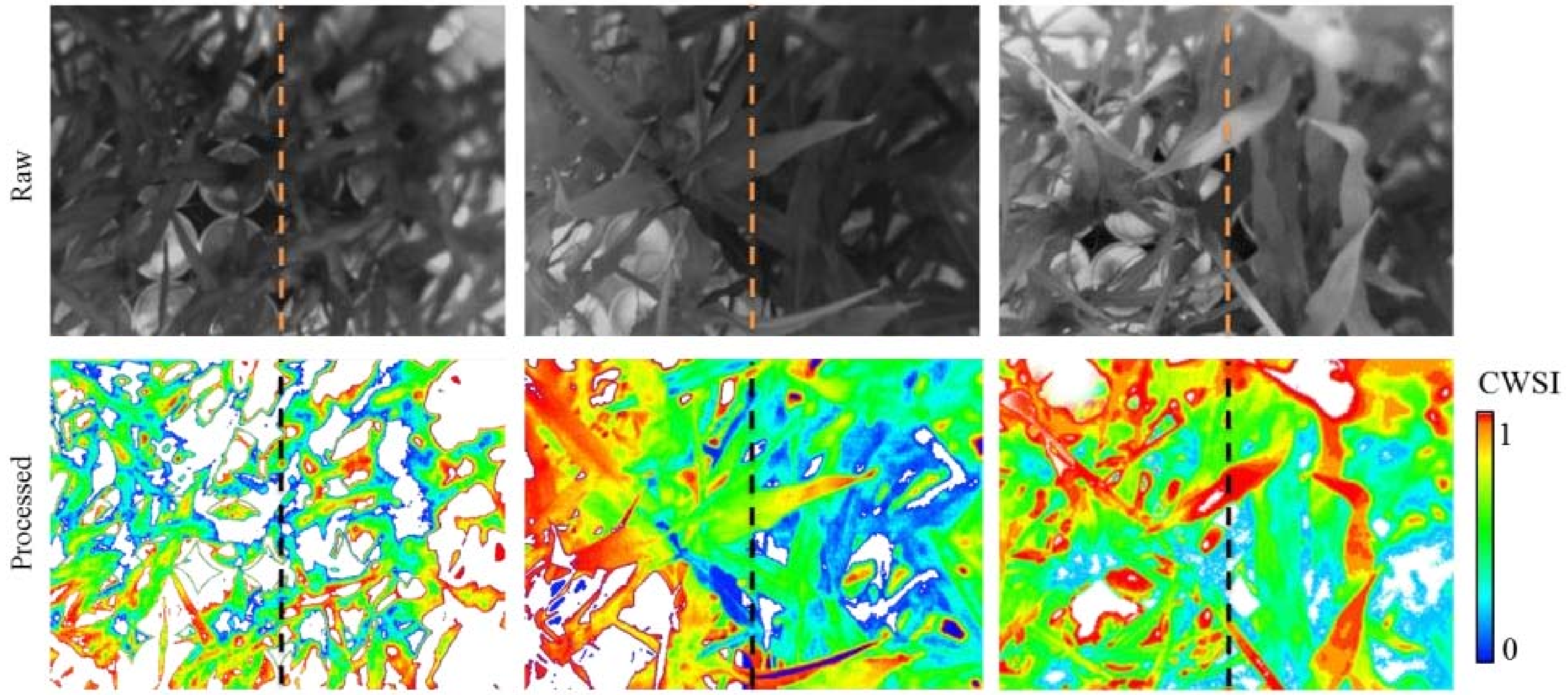
- Crop water stress is an indicator of water deficits in field crops
- Crop canopy temperature is an indicator of crop water stress
- Higher the temperature, higher the stress
- Goal: To obtain a high spatial and temporal resolution crop water stress index
- It can be used towards precision irrigation water management decisions and scheduling.

Crop Water Stress Determination

- Soil moisture sensors are used for crop water stress computation
  - Do not account for spatial crop variability
- Pressure chambers and leaf diffusion porometers to measure individual leaf and stem water potential and leaf stomatal conductance
  - Destructive, labor intensive, localized, and unsuitable for automation
- Thermal sensing approaches including infrared thermometers
  - Non-contact and less labor intensive, and offer non-destructive
  - Crop stress from leaf canopy temperatures
  - Challenge: crop temperature must be segmented from the measured temperature value to reduce the influence of soil background and shaded lower leaves
- **None of these scale to the high spatial and temporal resolution of crop water stress computation**

Goal of the project

- Use low cost and light weight infrared cameras mounted on small unmanned aerial vehicles to obtain thermal images of plant canopy
- TIR cameras can spatially map temperatures via a thermal image to measure subtle, heterogeneous characteristics of leaf dynamics
- Thermal imagery also requires systems and subsequent data processing techniques to capture, analyze, and interpret large amount of images



Day 10 Day 25 Day 50

Specific Tasks

- Task 1: Integrate and test sensors required to measure crop water stress under field conditions; and develop aerial image analysis and mosaicking package (AIAMP) to develop spatial-temporal canopy temperature and water stress maps for irrigation scheduling
- Task 2: Evaluate and validate sUAV with a sensor suite to measure crop water stress during critical growth stages for corn by measuring spatial canopy temperature; develop correlations between spatial canopy temperature maps and crop water stress indicators by conducting ground-based measurements
- Task 3: Develop and evaluate protocols for safe and effective use of sUAV at low altitudes for use by producers, service providers, and other stakeholders using sUAV sensing systems for precision irrigation applications

Team

- **Ajay Sharda**
  - Precision agriculture and automation
  - Developing, integrating and testing of sensing systems, preliminary field testing of the system, and field data collection
- **Guanghui Wang**
  - Computer vision and image analysis
  - Multispectral image analysis
- **Pavithra Prabhakar**
  - CPS verification and synthesis
  - Safe flying protocols