2017-02-612

Project Title: Development of a remote sensing tool for golf course irrigation management: proof of concept.
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Objectives:

The objective of this one-year project is to develop preliminary datasets which demonstrate the viability of thermal sensors for use in conjunction with unmanned aircraft systems (UAS) to monitor soil moisture stress of golf course fairways.

Start Date: 2017
Number of Years: 1
Total Funding: $10,000

Background and Rationale

Water used for turf irrigation is widely considered the number one restriction to advancement of the game of golf in many regions of the U.S. During periods of low rainfall, inefficiencies in irrigation systems and topography can result in significant soil moisture variability. Currently, visual cues and, to a lesser degree, soil moisture sensors are being used to trigger irrigation events. A rapid, whole-course assessment of plant water stress would be advantageous to superintendents who seek to maintain consistency from hole to hole. Further, quantitative estimates of plant water stress have the advantage of bypassing any potential variability associated with soil or rooting depth. Several technologies have become available which allow for plant stress to be remotely sensed. Among the more commonly used are RGB-visible cameras, multi-spectral reflectance sensors, and thermal cameras. To date, these technologies remain cost-prohibitive for many situations. Furthermore, how to incorporate remote sensing into current BMP's is not well understood.

Soil moisture sensors have become increasingly popular among golf course superintendents as cost has declined and user-friendly interfaces have been developed. It is reasonable to predict that remote sensing with multi-spectral or thermal sensors will similarly become more feasible in the future. Availability of guidelines for proper site selection, installation, and use of new technologies will be critical to initial adoption and long-term success of these precision turfgrass management tools. In this project, we have developed a small-scale remote sensing system which utilizes an unmanned aerial system (UAS) and thermal camera to measure turfgrass water stress as predicted by surface temperature.

Methods

In the first phase (proof of concept), we have integrated a thermal camera (Zenmuse XTR) with a UAS (DJI Inspire 1 v.2.0) and gathered preliminary data from a Riviera bermudagrass research plots (Fig 1) mowed three times per week at 0.5-in. Plots were subjected to one of four irrigation levels (0, 33, 66, 100% ET_c) from Aug 1 through Sept 24, 2017. Irrigation was hand-applied using a calibrated hose-end nozzle onto 4-ft by 4-ft square plots randomly assigned across the field in order to mimic random soil drying that might occur on a golf course fairway. Surface temperature data from the UAS was compared to ground-based measurement of soil moisture (Pogo, Stevens Water Monitoring Systems), NDVI (Greenseeker, Trimble Ag), and turf quality (NTEP Scale). Ambient temperature and accumulated solar radiation were also measured by a nearby weather station.

Early Results

Due to delays in obtaining the UAS system and significant rainfall in August, we were unable to develop a complete dataset from an extended drought period. Preliminary data show reasonable correspondence between UAS canopy temperature and ground-based canopy temperature. Relationships between UAS canopy temperature and soil water content and NDVI are less strong, presumably because of lack of significant drought severity. Further analysis of ambient weather conditions and sensitivity of the measurements is still needed.

Future Expectations

In 2018, data will be collected from irrigation studies at the experiment station to reach a more severe drought stress. Measurements will also be taken at two golf courses in the area. These data will provide a more complete view of feasibility of the system and major pitfalls needing further research.

A secondary goal of this project is to provide valuable preliminary data and equipment to pursue federal, state, or private funding in the future. The PI has initiated discussions with research faculty in other departments and universities to advance these ideas for development of a multi-state collaborative effort.

Summary Points:

- A DJI Inspire 1 v2.0 UAS was purchased and implemented with a Zenmuse XTR thermal camera.
- The UAS plus thermal camera system was able to detect differences in canopy temperature that correlated with ground-based measurements.
- Heavy rainfall in August did not allow for further data collection on golf courses or other sites in 2017.
- A multi-disciplinary research team is being assembled to conduct a more intensive investigation of remote sensing for turf management.

Fig 1. Riviera bermudagrass field used for evaluation of UAS – thermal camera system.

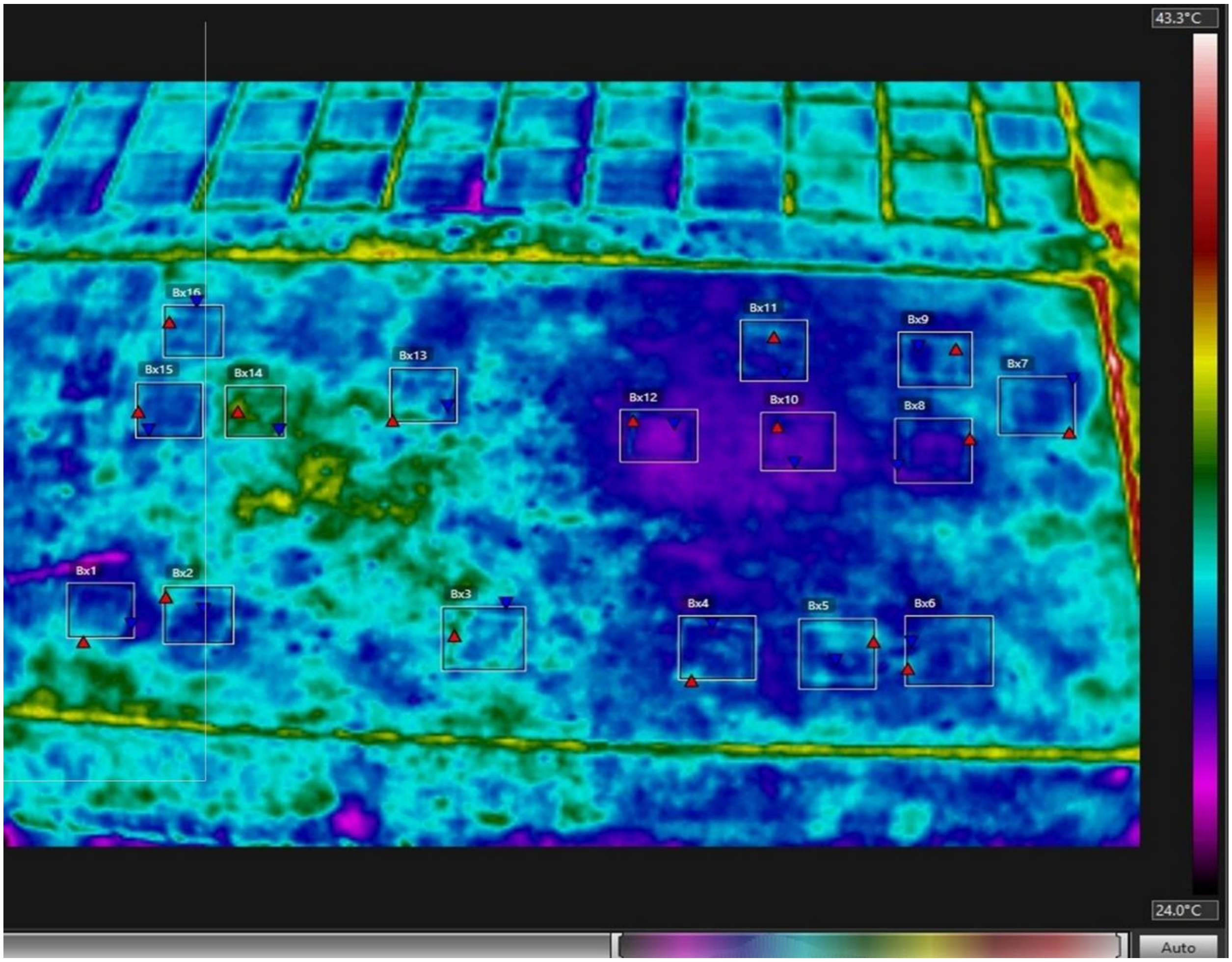

Fig 2. Thermal image collected from Riviera bermudagrass undergoing 4 irrigation treatments. Significant rainfall during August limited drought stress during data collection period.