2017-09-619

Title: Smart Tools to Improve and Accelerate the Turfgrass Evaluation Process

Project Leaders & Affiliations:
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Objectives of the Project:

The ultimate goal of the proposed project is to develop a rapid, quantitative, multi-trait turfgrass quality rating platform to improve the efficiency of turfgrass management in golf courses, accelerate the selection process and improve the selection accuracy of turfgrass breeding.

The specific objectives:

(1) Establish a ground-based platform equipped with low-cost distance camera(s) to collect color-related and height-related traits based on the National Turfgrass Evaluation Program (NTEP) evaluation rating guidelines (Year 1)
(2) Establish a UAV-based platform equipped with a high-resolution RGB camera and a thermal camera for large-scale field screening and stress monitoring (Year 1);
(3) Develop a software package for image and data acquisition, image processing and analysis, statistical analysis, and user interfaces)(Year 1-2);
(4) Validate and optimize the performance of the developed platforms under field conditions using cool-season and warm-season turfgrasses at two locations (Kansas and Oklahoma) (Year 2-3).

Start Date: June 2017

Project Duration: 3 Years

Total Funding: $89,305

Summary: Bermudagrass (*Cynodon* spp.) is the most commonly used turfgrass for golf courses, lawns, parks, and sports fields in the southern USA and throughout tropical and warmer temperate regions in the world. At Oklahoma State University, the turf bermudagrass breeders have been conducting intensive research and field trials to develop new varieties with greater cold tolerance, enhanced turf quality, improved drought tolerance, increased host plant disease resistance, reduced requirements for mowing and fertilization, better shade tolerance, and faster divot recovery rate. Conventional breeding approaches normally take several to more than 10 years to develop a new variety due to the demand of sufficient observations and a large amount of field data to identify and prove the desirable traits. Similarly, quality screening of turfgrass is one of the major and tedious work inputs in golf course management. Current turfgrass evaluation is a *subjective* process based on visual estimates of traits related to turfgrass performance. Visual quality ratings of a turfgrass plot are widely used by turfgrass breeders and researchers. The collected data are highly variable, subjective, and difficult to repeat. The visual quality rating process is also time-consuming and labor intensive.

Recent developments in precision agriculture innovations and data-intensive computational approaches make it possible to accelerate the process of plant breeding with highly precise and accurate-field data acquisition and high-throughput field screening to rapidly quantify the traits of interest and to associate these traits with their genetic and genomic properties. High-resolution vision and spectroscopic systems have been installed on GPS-guided ground vehicles (autonomous or semi-autonomous) and/or unmanned aerial vehicles (UAV) and used in agronomic applications to enable trait specificity at centimeter-level or better. In this project, a field screening system which can collect quantitative data for multiple traits in every turfgrass plot in one field run will be developed to improve the efficiency of the selection and evaluation process, which could potentially result in faster release of better cultivars.

Preliminary study showed that most of the targeted traits of turfgrass could be measured through color directly or indirectly. Some traits could be measured through height or the combination of height and

color. In this project, a rapid, quantitative, multi-trait turfgrass quality and stress evaluation system, which includes a ground-based platform and a UAV-based platform is being developed, which acquires both high resolution RGB (red, green and blue) images and depth images simultaneously. Color-related and height-related traits of turfgrass plants are quantified from the images and displayed to users. Figure 1 shows a project work flow chart including the design components and procedures.

In 2017, a 2015 turf bermudagrass clonal nursery established by the OSU Turf Bermuda Grass Breeding Program on the OSU Agronomy Farm in Stillwater, Oklahoma was used for field testing. A ground-based sensing system was designed, assembled, and installed to an electric golf cart. This sensing system was intentionally designed as an add-on unit, which can be easily attached to any off-road vehicles. Figure 2 shows the current design of the system. The sensing system is mainly based on a range camera, Microsoft Xbox One Kinect (hereafter called Kinect), which provides an RGB color image, an infrared image, and a depth image in one measurement, and a high-resolution RGB camera (GoPro 6) which provides detailed color information of the sample. The sampling rate was set to six frame/second according to the vehicle speed of 3 miles per hour. The determination of the sampling rate of six frame/second was based on the size of hard drive of the laptop (256MB SSD) used. The sampling rate and the vehicle speed can both increase when a larger hard drive is used. With current setup, the quality of images are good enough for processing. The challenging task is to establish appropriate lighting mechanism, which can minimize interferences from sunlight, shadows from the vehicle and surroundings, and others. Two types of LED panels with different wattages and field-of-views were tested under laboratory and field conditions to measure their performance. More tests are needed. Calibration experiments were conducted for the Kinect sensor on distance (height) measurements and color shade measurements (Figure 3). An UAV-based sensing unit was also implemented during a field test in November, 2017. The collected images are being processed.

The next step of the work includes finalizing the design of both the ground-based sensing system the UAV-based sensing system, the selection of lighting unit, and the calibration of the cameras. The data processing and analysis software will also be developed based on the data collected in 2017. The plan is to have a ready-to-go system by the start of the spring 2018 for field evaluations.

Summary Points

1. A ground-based, imaging system for turfgrass evaluation was developed which could be attached on an off-road vehicle, preferably an electric vehicle to implement field data collection.
2. The results from the initial field implementation of the ground imaging system showed that the two selected cameras provided good data for most of the traits of interests. However, the green color shades were hard to differentiate from each other due to interferences from sunlight and shadows of surroundings. A better lighting and imaging system needs to be designed.
3. The UAV-based system provided very good information on the color and size comparison among the samples in the experimental field. A thermal camera may be another add-on to evaluate the stresses.

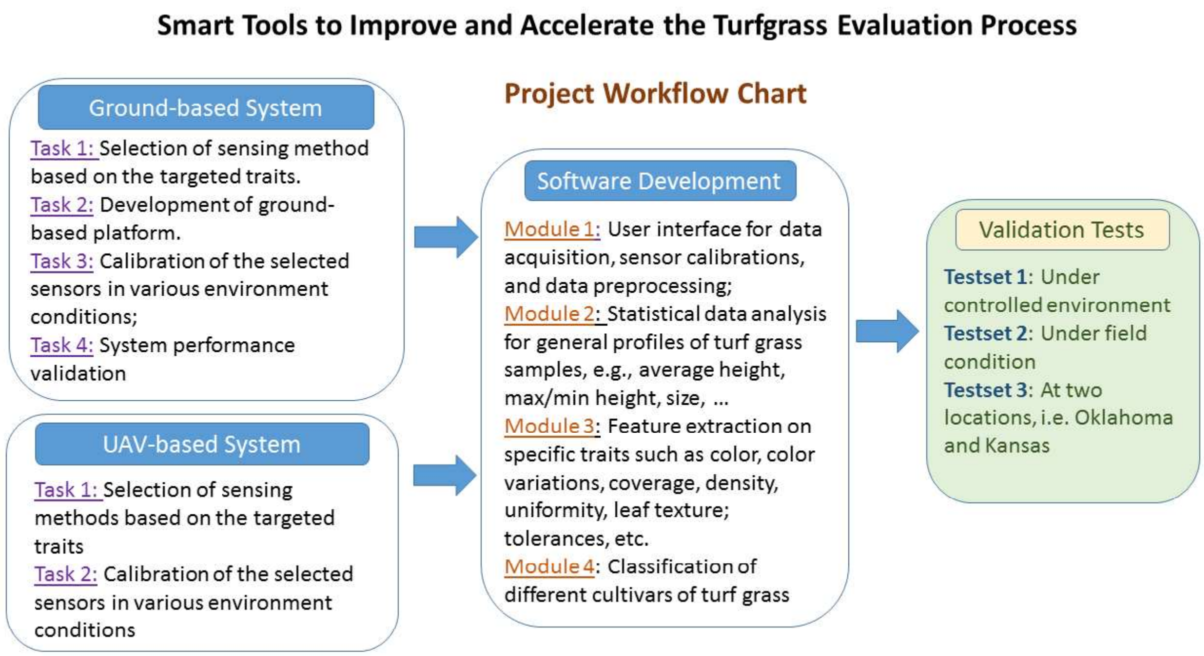

Figure 1. Project workflow chart

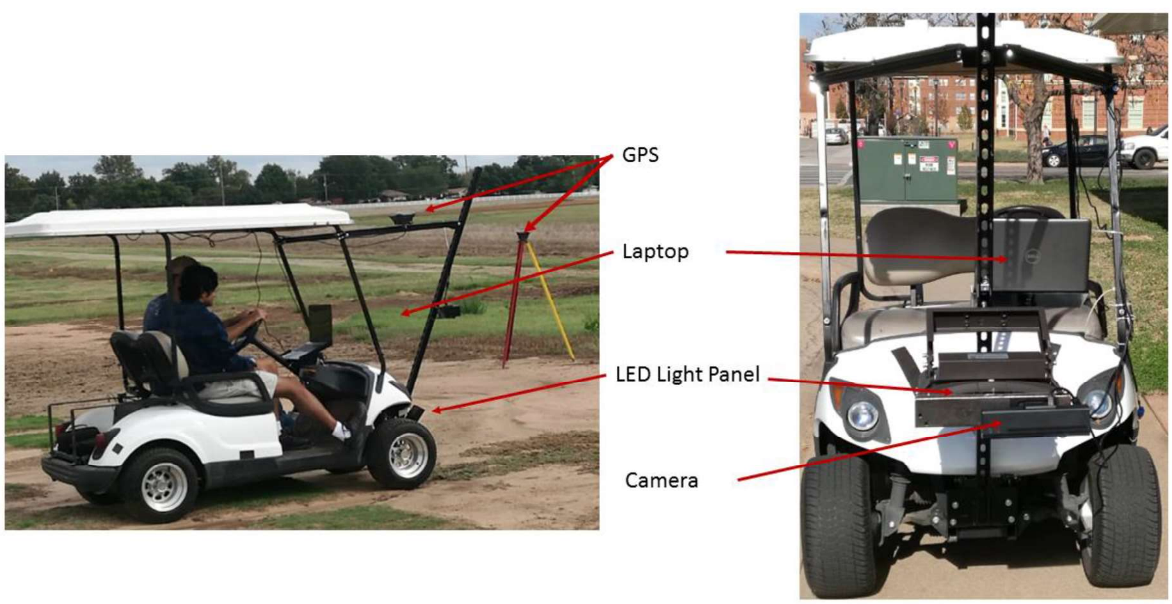

Figure 2. Current ground based sensing system

Figure 3. Camera Color Calibration