LIDAR and Photogrammetry to Map Alfalfa Yield and Quality Using Unmanned Aircraft Systems

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NAAIC North American Alfalfa Improvement Conference

LONG-TERM VISION

The long-term vision is to provide producers with whole field estimates of crop state to aid crop and machinery management decisions.

PROJECT ABSTRACT

The goal of this project is to enable alfalfa producers to map yield and quality (or more precisely nutritive value) across an alfalfa field using an Unmanned Aircraft System (UAS) at sufficient resolution to enable identification of the yield damage caused by wheel traffic. Alfalfa production has always involved tradeoffs between yield and nutritive value, and these tradeoffs have only become more complicated with the introduction of reduced lignin varieties. With field-wide maps, producers would be able to more accurately determine the quantity of forage that the field would produce and make decisions on whether waiting for more yield warranted the reduction in nutritive value from current levels. They would also be able to recognize the consequences of machinery management decisions on yield reduction from wheel traffic and better optimize their machinery use. Both yield and nutritive value are correlated with the physical structure of alfalfa plants and both LIDAR and photogrammetry, which are sensor systems that can identify this three-dimensional structure, will be tested in this project. Initial calibration tests will be performed weekly in the first season, and verification tests will occur once per cutting in years two and three and at additional locations in Georgia and Pennsylvania to ensure robustness of results. The basic testing procedure will consist of a flight to record sensor outputs and 1 meter-squared quadrat sampling to provide actual dry plant matter yield and nutritive value. The results of this project will be shared with producers and crop consultants through Extension events.

BACKGROUND

Yield

- The amount of biomass in a forage crop is highly correlated with sward surface height [1-5], but height alone can produce significant error [6, 7].
- However, stand density is also critical [8, 9].
- Yield prediction is more reliable with methods that rely on plant material density (rising plate meter, Robel pole) [10].

Reduced Lignin Varieties

- Plants use lignin to support plant height, but reduced lignin varieties have lower amounts of lignin and higher nutritive value at given stage of development [18, 19].
- Does this lower lignin level affect the nutritive value/height relationship?

Nutritive Value – Height Based

- Laboratory methods are the most reliable benchmark.
- Methods like PEAQ use easily observable height and maturity stage to estimate quality [11].
- The PEAQ results indicate that a height change of only 10 cm is equivalent in nutritive value terms to maturity advancing from the Late Vegetative Stage all the way to Flower Stage [12].
- A second equation based only on height also performed well, if not with the same accuracy level as PEAQ [13].

Nutritive Value – Yield Based

- The rate of growth in forage yield decreases as plant maturity increases and nutritive value decreases [14-17]

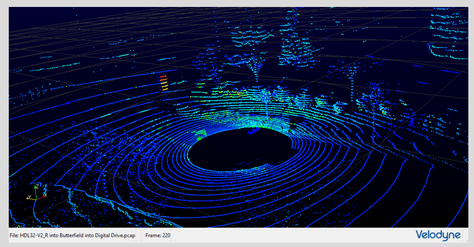
Photogrammetry

- Stitches many 2D images to create 3D models of surfaces

3D model created using photogrammetry

LIDAR

- **Li**ght **D**etection **A**nd **R**anging
- Creates a point cloud representation of scanned objects



Point Cloud generated from a vehicle mounted LIDAR

CURRENT WORK

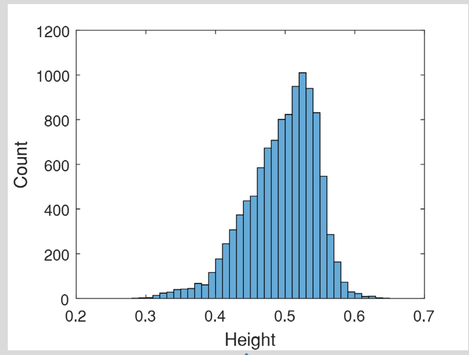
Current Efforts

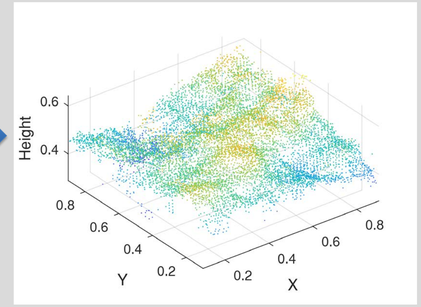
- Sample weekly with 20 quadrats all growing season
- Last year – all photogrammetry
- Focus on sampling quadrats
- Establish optimal performance
- Focus on processing using local and immediate data and statistical distributions of the point cloud
- Compared to Global Processing: Generating a field-wide point cloud or surface mesh of plant canopy and comparing with a point cloud or surface mesh of the bare ground.

Coming up:

- Test different field scanning methods
- Fly the LIDAR system
- Tests in areas with wheeled traffic damage – machinery management
- Tests in reduced lignin varieties
- Does PEAQ work in reduced lignin?
- Comparisons with PA, GA, and across cuttings

PHOTOGRAMMETRY PROCESSING EXAMPLE





Sample	F5T13
Location	KY
Date	July 11, 2018
Cutting	3rd
Yield (kg/ha)	4130
NDF (%DM)	38.35
ADF (%DM)	28.40
CP (%DM)	16.18
Weed (1-5)	< 5%
Disease (1-5)	< 5%
Insect (1-5)	< 5%
Man. Max Canopy Height (cm)	68
Man. Ave. Canopy Height (cm)	55
Maturity	4: Late Bud
Stand Density	54
Photo. Max Canopy Height (cm)	64
Photo. Ave. Canopy Height (cm)	50
Photo. Min Canopy Height (cm)	29
Points within Quadrat	10905

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