Snap Bean Yield Prediction Using Fusion of UAS-Based LiDAR And Multispectral Imagery

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# Abstract

# Keywords

# Introduction

Fusion of LiDAR and MSI

# Methodology

## Experimental field

## Flight design and field measurements

## UAS data processing

The methods for processing the UAS-based LiDAR point clouds and multispectral imagery were mainly derived from what were described in [1], [2]. Moreover, for the LiDAR point clouds, we calculated multiple LiDAR-derived metrics from each elementary sampling unit (ESU) [3]. They were number of points, sum of point intensity, canopy height, LiDAR-derived leaf area index (LAI), top canopy area (TCA), Poisson mesh volume (PV), and Poisson-Mesh-to-Alpha-Mesh volume ratio (M2VR). Our assumption was that the six metrics positively correlated with the yield of snap beans. More specifically, several previous studies claimed the correlations of the number of points [cite], the sum of point intensity [cite], the canopy height [cite], and LiDAR-derived LAI [cite] to the yield, respectively. Based on these findings, we calculated the top canopy area, the Poisson mesh volume, and the Poisson-to-Alpha volume ratio, and we assumed that the larger the metrics were, the more yield we would have from the crop.

To calculate the TCA, we first extracted

Poisson surface reconstruction To calculate the PV,

Alpha shape volume

Add figure about the derivation of TCA/PV/PAVR

For the MSI, we computed 36 vegetation indices from five bands of the images using ENVI (v.5.5.2 L3Harris Geospatial Solutions, Inc.), as listed in *Table I*.

Table I Vegetation indices calculated from the Micasense RedEdge reflectance bands.

|  |  |  |
| --- | --- | --- |
| Name | Equation | Reference |
| Anthocyanin Reflectance Index 1 |  | [4] |
| Anthocyanin Reflectance Index 2 |  | [4] |
| Burn Area Index |  | [5] |
| Difference Vegetation Index |  | [6] |
| Enhanced Vegetation Index |  | [7] |
| Global Environmental Monitoring Index | ,  where | [8] |
| Green Atmospherically Resistant Index |  | [9] |
| Green Chlorophyll Index |  | [10] |
| Green Difference Vegetation Index |  | [11] |
| Green Leaf Index |  | [12] |
| Green Normalized Difference Vegetation Index |  | [13] |
| Green Optimized Soil Adjusted Vegetation Index |  | [11] |
| Green Ratio Vegetation Index |  | [14] |
| Green Soil Adjusted Vegetation Index |  | [11] |
| Infrared Percentage Vegetation Index |  | [15] |
| Leaf Area Index |  | [16] |
| Modified Chlorophyll Absorption Ratio index |  | [17] |
| Modified Chlorophyll Absorption Ratio index – Improved |  | [18] |
| Modified Non-Linear Index |  | [19] |
| Modified Simple Ratio |  | [20] |
| Modified Soil Adjusted Vegetation Index 2 |  | [21] |
| Modified Triangular Vegetation Index |  | [18] |
| Modified Triangular Vegetation Index – Improved |  | [18] |
| Non-Linear Index |  | [22] |
| Normalized Difference Vegetation Index |  | [23] |
| Optimized Soil Adjusted Vegetation Index |  | [24] |
| Red Green Ratio Index |  |  |
| Renormalized Difference Vegetation Index |  | [25] |
| Simple Ratio |  | [26] |
| Soil Adjusted Vegetation Index |  | [27] |
| Sum Green Index |  | [28] |
| Transformed Chlorophyll Absorption Reflectance Index |  | [18] |
| Transformed Difference Vegetation Index |  | [29] |
| Triangular Greenness Index | , where represents the center wavelengths of the respective bands and represent the pixel values of those bands. | [30] |
| Visible Atmospherically Resistant Index |  | [31] |
| Wide Dynamic Range Vegetation Index | , where the weighting coefficient ranges from 0.1 to 0.2. | [32] |

## Feature selection methods

Stepwise regression

B

## Yield prediction

# Results

# Discussion

# Conclusion

# Appendix

Table of acronyms

|  |  |
| --- | --- |
| LiDAR | Light detection and ranging |
| MSI | Multispectral imagery |
| TCA | Top canopy area |
| PV | Poisson mesh volume |
| M2VR | Poisson-Mesh-to-Alpha-Mesh volume ratio |
|  |  |
|  |  |

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