Chonnam National University

Development of a Crop Information Delivery System using Unmanned Aerial Vehicle Remote Sensing

Jonghan Ko and Seuntaek Jeong

Chonnam National University

Contact: Jonghan.ko@chonnam.ac.kr

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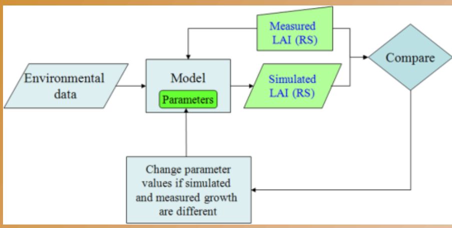
Modeling Scheme

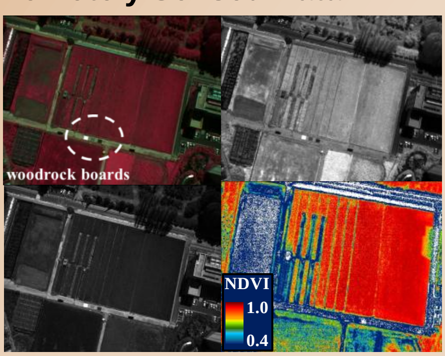


Model that uses remote sensing data : model parameter values are adjusted to obtain agreement between simulation and measurement

Multi-copter System

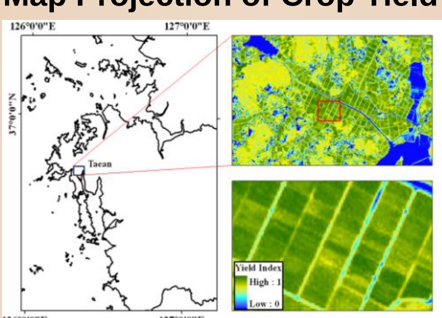
The system components: multi-copter (HFK Inc., www.uavrobot.com) and ADC-L (TETRACAM Inc., www.tetracam.com)

Remotely Sensed Data



Determination of NDVI : pseudo color image from ADC-L (a), RED and NIR images (b and c), and NDVI map (d)

Map Projection of Crop Yield



INTRODUCTION

Crop modeling and remote sensing are different techniques suitable for evaluation of crop growth and yield. By combining the advantages of remote sensing and simulation modeling, the strengths of one technology may make up for weaknesses in the other. There have been previous efforts to combine these different techniques. One such effort was GRAMI (Maas, 1992), which includes a within-season calibration method allowing the model simulation to fit measured values using an iterative numerical procedure. An advantage of this procedure is that it can use infrequent observations to calibrate the model. These observations can be obtained through nondestructive techniques such as remote sensing.

An Unmanned Aerial Vehicle (UAV)-based remote sensing system can monitor terrestrial vegetation information more efficiently and widely than any other ground-based observation systems. In this study, we built up a Crop Information Delivery System (CIDS) using a multi-copter UAV equipped with 8 propellers and an Agricultural Digital Camera-Lite (ADC-L). As a CIDS component, a model that uses remote sensing data was formulated and evaluated using data obtained from the paddy rice field at Chonnam National University, Gwangju, Korea from 2009 to 2011. The proposed model is potentially applicable to regional rice growth monitoring and yield mapping projects. An effort of the on-going research is presented below as a case study.

DEVELOPMENT OF A CROP INFORMATION DELIVERY SYSTEM

Daily Crop Growth Simulation

The four processes involved in simulating daily rice growth are (1) calculation of growing degree days (GDD), (2) absorption of incident radiation energy by leaves, (3) production of new dry mass by the leaf canopy, and (4) determination of LAI partitioning of new dry mass. At the end of the simulated growing season, the model uses the within season calibration procedures. The proposed rice model uses the same within-season calibration procedures used in GRAMI (Maas, 1992), in which the simulated crop growth is compared with measured values. If the simulated growth is sufficiently different from the measured growth, model parameter values are adjusted, and the crop simulation is repeated from the planting date. This process of model integration and comparison is repeated until the difference between simulated and measured growth is minimized.

System Components of the CIDS

A crop growth monitoring method of the CIDS has been set up using a multi-copter equipped with 8 propellers and an ADC-L, and a CROPSCAN. The multi-copter is possible to fly to an altitude of approximately 500 ~ 600 meters. The ADC-L loaded on UAV has features that have light weight and can take three spectral bands (Red, Green, and NIR approximating TM2, TM3, and TM4 Landsat bands). A LCD monitor shows real time images, optionally presenting the accurate flight location information acquired from a GPS receiver. The CROPSCAN used can take sixteen spectral bands information that ranges from 460 nm to 1700 nm. It was adapted to calibrate the reflectance data obtained using the UAV system.

Obtaining Remote Sensing Data

Reflectance data derived from the UAV system were used for determination of crop growth information by utilizing processed vegetation indices and/or bands information itself. For this proposed purpose, we selectively used Normalized Difference Vegetation Index (NDVI). To calibrate the reflectance data, we set up Pseudo-Invariant Targets (PITs) next to the paddy rice fields, which were made by commercially available woodrock boards of three different colors (black, gray, and white). The reflectances were determined using the linear regression method for the relations between CROPSCAN-derived reflectances and UAV system-derived digital values. A time-series pattern of the estimated NDVI showed correspondence to that of the CROPSCAN-derived NDVI.

REFERENCES

Ko, J., Maas, S.J., Lascano, R.J., and Wanjura, D. 2005. Modification of GRAMI model for cotton. Agronomy Journal 97: 1374-1379.

Maas, S.J. 1992. GRAMI: A crop growth model that can use remotely sensed information. ARS-91. USDA, Washington, DC.

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