Remote Sensing using Unmanned Airborne Vehicles (UAV’s) for Precision Agriculture

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Vector P Aircraft
See AeroView International, Booth 129

Abstract:
Remote sensing is a key technology for precision agriculture to assess actual crop conditions; however, high-spatial-resolution imagery from aircraft and satellites are expensive. Unmanned Airborne Vehicles (UAV’s) can be launched in narrow windows of good weather, fly large fields in preplanned patterns, and deliver the data rapidly to the user at lower cost. The Vector P aircraft from IntelliTech Microsystems, Inc. was fitted with five down-looking digital cameras, an up-looking quantum sensor, and computer controls based on GPS position. The internal near-infrared filters of the cameras were removed and external narrow-band filters at 550 nm, 610 nm, 676 nm, and 780 nm were fitted onto the cameras. Colored tarpaulins were used to calibrate the images; there were large differences in digital number (DN) for a given tarpaulin. When incident radiation was accounted for using the quantum sensor, the imagery matched the tarpaulin reflectance for a single date. There are many advantages of UAV’s for precision agriculture, however training users on image interpretation is required. Calibrated data will allow the use of automated algorithms to map early-season biomass and chlorophyll content.

Hunt et al. (2005, Precision Agriculture 5:359-378) used a commercial digital camera mounted on a radio-controlled model aircraft as an alternative for high-resolution, low-cost imagery for agriculture. The normalized difference of the green and red bands were saturated above 120 g m⁻² for corn, soybean and alfalfa. Furthermore, this index was not sensitive to nitrogen deficiency in corn. Whereas the system had very low cost, there were a number of problems that limited its usefulness.

The goal of a Cooperative Research and Development Agreement (CRADA) between USDA-ARS and IntelliTech Microsystems, Inc. is the development a low-cost Unmanned Airborne Vehicle (UAV) for precision agriculture. The Vector P has a longer flight time, so take off and landings do not have to be made adjacent to the field. The problem is to convert digital numbers into reflectance so that time and expertise required for image interpretation can be reduced.

Experimental plots in the Farming Systems Project from the USDA-ARS Sustainable Agricultural Systems Laboratory (Beltsville, MD) were used for initial test flights of the Vector-P aircraft. Pixel resolution of the photos are 4.3 cm at an altitude of 168 m. The area covered was 138 m by 107 m, which is about 1.5 ha. The pictures from the five cameras were registered to each other with a Root Mean Square Error (RSME) from 0.4 to 1.7 pixels, with lower RSME from images acquired at higher altitudes.

Left: Color infrared digital photo of the Farming Systems Project from the USDA-ARS Sustainable Agricultural Systems Laboratory. Right: Enhanced image using red and near-infrared bands to determine using the Normalized Difference Vegetation Index [NDVI = (\(R_{780} - R_{676}\))/(\(R_{780} + R_{676}\)), (black/cool colors – low NDVI, warm colors – high NDVI)].

Calibration of the cameras with known targets on 08/12/05. Left: Color infrared digital photograph; Middle: colored tarpaulins; Right: Digital Numbers versus tarpaulin reflectance. Light levels varied from 1.3 to 1.5 mmol m⁻² s⁻¹. Three photographs on 08/22/05 had the same calibration curve when corrected for light level for a single date, but not for different dates.

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