From the Ground Up

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Active Remote Sensing: An Innovative Technique for Precision Fertilization

Raj Khosla

"*Remote sensing*" is a process of gathering information of an object of interest without being in physical contact with the object. "*Remote*" means from a distance, and "*sensing*" means gathering information using a sensor. While the concept of using mechanical remote-sensors in agriculture is some-what new, we have used our "eyes" to sense the health of crops since the beginning of crop production. Our eyes truly represent a pair of optical sensors (Fig 1). However, there are limitations associated with using our eyes as remote-sensors. For example, our eyes can only see the visible spectrum of the light, primarily the "Red", "Green" and the "Blue" light wave-bands, commonly referred to as R,G,B. In addition, our eyes can function only during daylight or with ambient light, because our eyes do not have their own source of light energy. Such remote-sensors or remote-sensing devices are referred to as "*passive-remote-sensors*" or "*passive-remote-sensing*". For example, remote-sensors mounted on the remote-sensing satellites, can acquire imagery only during the broad daylight. The remote-sensing satellites cannot acquire imagery during the dark period. Another limitation is the weather system itself. Satellite sensors acquire error free imagery only during a cloud free day. On overcast days or rainy days, images acquired from satellites are of little to no value.

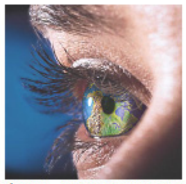

Figure 1. Our eyes represent a pair of optical remote sensors

Research around the world has shown that light wave-band beyond the visible spectrum is the most beneficial part of the light-spectrum, for the crop production purposes. "Near infra-red", commonly referred to as "NIR" is a light wave-band that is not visible to our eyes and yet, is very useful in detecting crop stress conditions, including nutrients and water stress and insect-pest or diseases infestations across a farm field.

When a ray of light strikes the crop leaf, three things could happen: (i) the ray light can be absorbed by the plant leaf, (ii) the ray of light can be refracted through the plant leaf, or (iii) the ray of light could be reflected by to the remote-sensor. For the purpose of remote-sensing we are most interested in the "reflected" component of the ray of light that strikes on the plant leaf. A healthy plant would reflect lot more light compared to a nutrient stressed or water stressed plant or the one that is infested with insect pest or diseases. Interestingly, research has shown that there is a unique reflectance signature of light reflected for most crop species for unique crop parameters and stresses (Fig 2). That is how remote-sensing specialist classifies or identifies the anomalous areas in the crop field.

Figure 2. Example of high resolution remote-sensing images acquired from Quickbird™ satellite on Sept 14, 2002 for north of Fort Collins, CO. On the left is the natural color image and on the right is the Color Infrared image. [Image Courtesy: Digital Globe, Inc.] Areas in red suggest high quantity of healthy green vegetation.

Past two decades has witnessed the development of precision techniques and technologies, including remote-sensing technologies to aid farmers in enhancing their farm productivity, profitability and environmental sustainability. A significant number of farmers have taken advantage of remote-sensing technology to make better crop management decision on their farms. However, there are a couple of over-arching issues with remote-sensing that continue to discourage farmers in its wide-spread adoption. The two issues are (i) cost of remote-sensing imagery and (ii) the time needed to acquire, classify and interpret imagery to make a crop management decision. For these reasons and technical limitations outlined above, there has been a compelling need for an alternative technique of remote-sensing.

"*Active-remote-sensing*" is the latest remote-sensing technique that overcomes the limitations outlined above. Firstly, it has its own source of light energy (hence called "*active*"), allowing it to work in daylight or night conditions. Secondly, it measure reflectance of light in both, visible and non-visible spectrum of light, making them similar to sensors mounted on satellites. Thirdly they are small, ruggedized, user friendly, easy to work with and relatively inexpensive compared to passive sensor images. Above all, the spatial resolution (fine details of the image) of the active sensors is very high since they are very close in distance to the object of interest or crop canopy. Sometimes active-sensors have also been referred to "crop canopy sensors".

There are a number of "active-remote-sensors" that are commercially available for the purpose of crop production and management. The two most popular ones or the ones that are widely reported in recent research papers are the NTech's GreenSeeker™ red sensor, and the Holland Scientific's Crop Circle™ amber sensor. Both sensors have their own source of light energy and are quite small to be mounted on the tractor looking downward measuring the health of the crop "*on-the-go*" or they can be used as a hand-held device linked to a data-logger.

Recent research in Colorado with irrigated corn has shown that both active-sensors, the red and the amber sensor, are equally good in identifying the crop nitrogen stresses across the crop field. Ideally for crop management purpose, a group of (2 to 4) active-sensors are mounted on a telescoping boom in front of the tractor, looking exactly on top of the crop row. The sensor collects the reflectance data and transfers that data to the computer on the tractor. Using the nitrogen recommendation algorithm developed by Precision Agricultural specialist at Colorado State University or elsewhere, the reflectance data is converted into the amount of nitrogen fertilizer needed by the crop. The calculated fertilizer amount is sent to the variable rate controller behind the tractor and a recommended amount of the nitrogen fertilizer is delivered on the portion of crop from where the reflectance data was measured. This process is repeated every second "*on-the-go*" mode enabling the farmer to apply the precise amount of nitrogen fertilizer as required by the crop at that particular crop growth stage.


Figure 3. A suite of active remote-sensing devices mounted on a high-clearance tractor, equipped with variable rate fertilizer controller in the back. [Photo courtesy: Oklahoma State University.

Dr. Khosla's precision agricultural laboratory will be conducting several on-farm-demonstrations about active-remote-sensing across north-eastern Colorado farm-fields over the next couple of years, by virtue of a project funded through USDA-NRCS-CIG grant. More information about the demonstrations will be available online at the Soil & Crop Sciences Extension Website http://www.extsoilcrop.colostate.edu/.

For more information about active remote sensing or other precision nutrient management techniques, please do not hesitate to contact Dr. Raj Khosla at raj.khosla@colostate.edu.

Current Events

Colorado State University Extension
CSU Clean Energy Supercluster

Introduction to Wind Energy

2-Day Workshop in Sterling, CO
February 17-18, 2010
Northeastern Junior College
Cost: $50 (Includes lunches and breaks)

The goal of the workshop is to provide basic wind education for Extension Agents, Natural Resources Conservation Service Agents, County or Municipal Government or other interested parties.

Feb. 17th sessions will focus on wind energy basics and residential-scale wind. Feb. 18th sessions will provide information on community wind, utility scale/leasing and will include a wind farm tour.

Speakers include:
Tony Jimenez, National Renewable Energy Laboratory
Mike Kostrzewa, CSU Dept. of Mechanical Engineering
John Covert, Colorado Harvesting Energy Network

Colorado State University Extension

TO REGISTER:
Go to: http://www.extension.colostate.edu/gilpin/windworkshop

Rocky Mountain Compost School

Hosted by Colorado State University's Department of Soil and Crop Sciences.

April 26-29, 2010

Cost: $495
Registration fee includes: 4 days of instruction, lunches, field trip and daily refreshments.

For specific questions or more information, please contact:
Adriane Elliott
(970) 491-6984
adriane.elliott@colostate.edu

To Register:
http://rockymountaincompostschool.info

Certified Seed – The Big Picture

Brad Erker, Director of Colorado Seed Programs

The Colorado Seed Growers Association (CSGA) is the official seed certifying agency for Colorado. But seeds don't always recognize state lines. Colorado's seed industry is very diverse, and a good deal of the seed produced here gets planted in other states, or even other countries. One good example is hybrid canola seed produced in the San Luis Valley – most of that seed gets cleaned, bagged, and planted in North Dakota or Canada. How do those farmers know they're getting a quality product from certified seed growers in Colorado?

The answer is AOSCA – the Association of Official Seed Certifying Agencies. Established in 1919, AOSCA is the national cohesive force for agencies like CSGA. AOSCA is dedicated to assisting its members in the production, identification, distribution and promotion of certified classes of seed and other crop propagation materials. AOSCA sets minimum standards for a huge variety of crops, which all states must meet to maintain membership. AOSCA now has a number of International member countries located in North and South America, Australia and New Zealand.

The diversity of crops certified by members of AOSCA is astounding, which corresponds to the geographical diversity of its members. AOSCA's "Acres Applied for Certification Report" lists hundreds of categories of seed crops, ranging from peanuts and rice in Southeastern states, to wheat, dry beans, and alfalfa seed produced mainly in the West. Some of the more unique seeds include things like fourwing saltbush (a woody plant) from Wyoming, purple prairieclover from Washington, sugarcane from Louisiana, and spelt from Ohio.

Visit AOSCA's website, www.aosca.org for current news, listings of certification agencies and foundation seed programs, Quality Assurance and Identity Preserved programs, OECD Seed Schemes, and more.

For additional information please contact Brad Erker at brad.erker@colostate.edu.