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Sensing a Healthy Harvest

Imaging system should help improve scheduling of irrigation while reducing costs.

by Joe Singleton/jsingleton@nttc.edu

Farmers could soon reduce water, energy, and labor costs by using new MDA-funded imaging technology that analyzes crop health.

Opto-Knowledge Systems, Inc. (OKSI; Torrance, CA), has developed modeling and simulation software to work with a hyperspectral imager to analyze and monitor the health of crops on large multiacre farms. Hyperspectral imaging produces computer-enhanced graphic depictions based on a targeted object's spectral absorption, reflectivity, and thermal radiance.

The ability to analyze and monitor spectral data is critical for MDA. Through a 2005 SBIR Phase II contract, the Agency funded OKSI to enhance its existing modeling and simulation algorithms to discern live warheads from clutter and countermeasures. Such technology would be used with hyperspectral imaging sensors on space-based missile defense platforms.

After the MDA contract concluded, OKSI began considering commercialization potential for the technology. If the software could be used with a hyperspectral imaging system to detect and analyze spectral signatures of objects in space, what about monitoring something closer to home? OKSI decided that the best use of the software and imaging system combo on land was in agriculture—due to the difficulty of monitoring the health of acres upon acres

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▲ Software developed by MDA-funded Opto-Knowledge Systems, Inc., analyzes hyperspectral data on crop health to help farmers determine which areas of their fields need irrigating.

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of individual plants. The company's decision was not a simple brainstorm; it was based on more than 10 years' experience in designing remote-sensing programs for DOD and NASA.

From idea to scientific challenge

With the technology and application idea in hand, OKSI met with some farmers who grow the nearly 750,000 acres of cotton in the San Joaquin Valley of California, as well as with experts from the U.S. Department of Agriculture, local county government, and the University of California. What company researchers found was a problem endemic to farmland in Southern California—the land is desert that relies heavily on irrigation canals from the northern part of the state. Because of the natural lack of water, farmers tend to irrigate—typically mixing nutrients in with the water—and apply chemicals and insecticides on fixed schedules. But the typical means of irrigating does not really take into consideration the balance between the health of the crops and environmental concerns. Crops will die if not watered or protected against insects. But if too many nutrients, chemicals, and pesticides are applied, the environment may be adversely impacted.

So OKSI gathered a team of biologists, entomologists, and other experts in the area to size up the problem and determine how OKSI's technology could directly benefit the cotton growers of the San Joaquin Valley. They collected data—including specific spectral signatures and stress caused by lack of water, lack of nutrients, salinity of the soil, or insect infestation—on cotton plants grown in San Joaquin Valley. The scientists determined the spectrally significant features of cotton are generally found in the visible spectrum and near-infrared wavelengths, rather than midwave infrared, as is the case with missiles. OKSI and its team were then able to incorporate the information into the software suite for use with hyperspectral imagers and sensors.

▲ Farmers in California's San Joaquin Valley are using OKSI's software to help monitor the health of their cotton crop.

OKSI's technology differs from similar products on the market because its hyperspectral imager and proprietary software use preprogrammed spectral signatures of specific crops to analyze and produce detailed maps of fields. Most other technologies are not programmed with the high spectral resolution signatures of specific plants, and simply do a "color" analysis of an entire field, without regard to the type of crop being viewed. Furthermore, the level of detail provided by OKSI's equipment offers farmers either a macro-view of the entire field, to locate where unhealthy plants are grouped, or a micro-view of individual plants in a dying cluster, should such specificity be desired.

From map-making to irrigation

To get a clear view of a large cotton field, OKSI goes airborne. The hyperspectral imager and thermal cameras are mounted in a camera pod on the underbelly of the aircraft, which is linked to a laptop computer positioned in the cockpit. Once the aircraft is flying over a cotton field, the imager is turned on; its sensors and software begin crunching the data being received. The end result is a series of color-coded maps, each showing a 0.5-square-mile section of the field, with blue representing good health, and red meaning extreme stress. After mapping the field, the team returns to OKSI's laboratory, where the gathered data is analyzed and converted to maps and a user-friendly information report that a farmer can download within 24 hours of data collection. The information in the report is very specific and provides the exact geographic coordinates of the particular section of field. And to help lessen the burden of finding specific stressed plants or areas of stressed plants, the maps can be easily downloaded to a personal data assistant and hand-carried to the crops needing assistance.

By being able to discern which areas of a field are unhealthy and need irrigation, farmers can save many thousands of dollars a year just by reducing the amount of water normally used, according to OKSI. The cost of irrigating

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cotton—primarily done by flood irrigating—is one of the largest expenses facing farmers in the San Joaquin Valley.

OKSI's technology also is used in conjunction with crop-dusting aircraft to ensure that insecticides are spread in areas where needed, not in one blitz with the hope that everything is covered. To ensure insecticides are spread over infested areas, a farmer could take the data acquired through the OKSI analysis and match the unhealthy areas with coordinates plugged in to a global positioning system (GPS) device. Company tests of this technique were successful and resulted in less pesticides being used.

During the early part of the growing season, the farmer could drive out to the OKSI-specified unhealthy area, guided by GPS navigation, and make a firsthand determination of the need for spraying insecticides. The farmer could then contact a crop-duster pilot and request a particular area be sprayed. This selective spraying process could save farmers thousands of dollars annually.

Near harvest time, the crops are often too tall for vehicles to effectively navigate without damaging plants. So to get very precise location details, farmers can install a differential GPS antenna, according to OKSI.

From farmers to museum curators

Beyond managing resources used to grow cotton, OKSI has been using its hyperspectral imager in a laboratory setting to inspect old oil paintings. The company recently inspected a 16th Century painting in which the layers of oil on the canvas were carefully analyzed. The analysis revealed that another painting was beneath the original's surface. Hyperspectral imaging allowed OKSI researchers to look through several layers of paint.

The company is now looking ahead to numerous business opportunities. In the agricultural arena, OKSI researchers are studying the characteristics of other crops—mainly tomatoes and corn—to see if hyperspectral imaging could benefit those farmers. The company is particularly interested in fielding this technology outside of the San Joaquin Valley, particularly in the Midwest and the South, where much arable land exists. OKSI is also interested in working with museums and art collectors to help unlock mysteries of centuries-old paintings. OKSI also has been successful in demonstrating its technology onboard unmanned aerial vehicles.

CONTACT INFO
Nahum Gat
Opto-Knowledge Systems, Inc.
Tel: (310) 756-0520, ext. 237
E-mail: nahum@oksi.com
Web: www.oksi.com

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