Advanced tree-stress-detection technologies for citrus

By Reza Ehsani, Sindhuja Sankaran, Joe Maja and Francisco Garcia

The citrus industry is currently facing many challenges with recovery from hurricanes, drought, freezes and the discovery of various new invasive diseases including HLB. Growth conditions are seldom perfect. Frequent occurrence of tree stress in citrus groves combined with increasing costs of labor underscore the need for sensing technologies for the detection of stress in citrus. Moreover, with the relatively large size of citrus groves, it is challenging to scout the entire production area to identify stress conditions on a timely basis. The purpose of this article is to describe some new technologies for tree-stress detection in citrus.

Currently, scouting is the only option for monitoring and detection of the overall health status of trees. Scouting is time-consuming, costly and is prone to human errors. Aerial remote sensing is emerging as an important technique for rapid disease and stress detection via sensing and monitoring the physiological status of trees.

Remote sensing can provide multi-band or hyperspectral images. These images need to be further analyzed in order to be used for detection of stress and diseases. There are several vegetation indices such as Normalized Difference Vegetation Index (NDVI) that can be used to assess the overall health of trees from a multi-band aerial image with visible and near infrared bands. These techniques generally can separate healthy trees from stressed trees, but they are not very specific and cannot determine the exact cause of the disease, especially for a tree that is declining due to interactions from several different diseases and/or stress factors. While it is very difficult to pinpoint the exact type of disease from an aerial image, it is possible to develop a data processing technique, using advanced mathematical methods that look for a specific spectral pattern in the image, and detect and classify specific diseases or stress from an aerial image. The accuracy of detection using these techniques increases by raising the resolution of the image and number of spectral bands in the image.

Although there is a large body of scientific knowledge available which shows that remote sensing can be used for many different agricultural applications, most growers are not able to take advantage of this technology due to the cost and difficulty of obtaining timely high-resolution, multi-band aerial images. This all may change in the near future.

In recent years, the technology of drones or Unmanned Aerial Vehicles (UAVs) has significantly improved. Currently, small UAVs are commercially available. They are fully automated with waypoints navigation capabilities, and are very easy to operate. These small UAVs with sensors weigh as little as 2 pounds with 2.5 feet of diameter, and are capable of taking high-quality multi-band aerial images that can be used for monitoring groves, yet are very simple to use and operate.

The ease of operation of these sensor platforms makes them ideal for

agricultural applications where individual growers can use them on their own. According to the current regulations by the Federal Aviation Administration (FAA), small UAVs are only allowed for recreation use; however, things are changing. A new bill just passed by the Senate requires the FAA to develop new regulations for safe use of small UAVs and allows the commercial use of UAV after October 2015. If this happens, there will be a large variety of small UAVs in different shapes and sizes available to use for agricultural applications. These platforms will not be very helpful without development of specific procedures and image analysis software that can interpret the images and convert them to useful information for the growers.

Recently, at the University of Florida-IFAS' Citrus Research and Education Center, we have been working to develop specific applications for small UAV sensor platforms. One of the advanced sensor platform systems that we are working on is the multi-rotor remote sensing (MRRS) platform (Fig. 1) with portable visible-near infrared sensors capable of taking high resolution, multi-band aerial images of citrus groves. The major benefits of this MRRS system are low-cost, ease of use and the ability to provide very high-resolution aerial images. Our preliminary studies on thermal and visible-near infrared imaging on individual healthy and stressed (HLB-infected, drought-stressed) citrus trees showed the potential of multispectral imaging sensors for classifying the stressed trees from healthy trees with about 90 percent accuracy in detecting HLB-infected trees at a developed stage with symptomatic leaves in citrus canopy.

Using very high-resolution images (2-inch per pixel) improves the accuracy of detection. This high resolution is achieved with a combination of using the right sensor platform (such as MRRS platform) and a suitable camera. A single tree can be represented by about 5,000 pixels for an aerial image that is taken at 2-inch resolution, but the same tree can be represented by only 60 pixels if the resolution of the aerial image from a plane is 20-inch (Fig. 2). The difference in the number of pixels has a big impact and can improve the accuracy of detection. In the case of HLB, the accuracy of detection increased by 4 percent to 6 percent when we used higher resolution images. Moreover, the imaging sensors with the MRRS system also exhibited promising results, with a capability of identifying plant stress within other agricultural

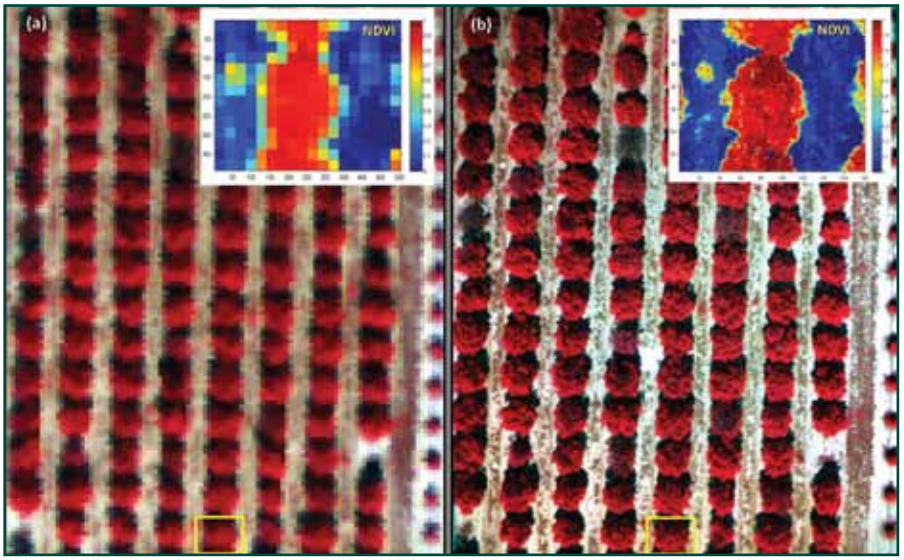

Fig. 1 (left). *A multi-rotor remote sensing (MRRS) platform with a six-band camera.*
Fig. 2 (above). *Multi-band aerial images from a citrus grove with NDVI images of one tree in each picture as an insert. Left, low-resolution image taken from airplane; right, high-resolution image taken with the MRRS system*

production areas for crops such as apples, sugarcane, etc.

The threat of spreading new diseases and continual challenges of dealing with existing diseases requires growers to use new tools and techniques to help them manage the grove more cost effectively. Disease- and stress-detection techniques, along with low-cost and ease of use for platforms such as MRRS system, are promising technologies. In the near future, the MRRS system or other similar platforms can be used as a sensing technique to complement scouting.

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