Enhancement of Precision Agriculture Using Hyperspectral Imaging

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Abstract: Hyperspectral Imaging has expanded the applications of Precision Technology serving to be a boon by providing information about the estimation of the yield, soil and vegetation characteristics beyond the predictive results.Water is an inevitable factor in agriculture. By the expansion of hyperspectral imaging applications in agriculture we can ensure that sufficient nutrients, pesticides and water can be supplied to all crops in the field, thereby saving the water. The advantage of this technology includes simplicity in accessing, cheap price, harmless, accuracy, unvarying results and they are used in wide range of applications.

I. INTRODUCTION

The Hyperspectral Imaging Technique gathers data of a particular target across the electromagnetic spectrum from ultraviolet to long-infrared. This excessive information helps to identify the objects beyond what human eyes can see.It is a non-catastrophic, non-contact technology which makes it optimal for a wide range of trending applications.

A hyperspectral image cube consists of a group of images placed on top of one another. Each image represents one particular band of wavelength. This set of images form is termed as hypercube. In a hyperspectral image, each pixel consists of a spectrum over a suitable spectral region. Every object has a unique characteristic across these different wavelength bands. This unique characteristic is referred to its 'spectral signature'. Therefore this property which looks beyond the visible spectrum enables the identification of objects, their classification and evaluation to a high degree of certainity. For successful plant cultivation, it is essential to check the nutrients, attack of insects and the plant health altogether. The conventional method however was carried out by visually monitoring the crops in the field. Contrary to this, the modern precision agriculture is used to maximize the yield.

II. Fundamentals Of Hyperspectral Imaging

Precision agriculture requires more than primary Red Green Blue information. For example, video images taken from a field will not be able to accurately differentiate real plants from false ones. By looking at the spectral content in the pixels, hyperspectral solutions can disclose the green pigment chlorophyll or very small changes in colour on leaves. Color information can be beneficial to distinguish brown from green. For more finer details, the spectrum of each band should be analysed in detail. Hyperspectral imaging is a process by which the images are taken and the numerical values are assigned to each pixel thereby making use of a range of wavelengths across the electromagnetic spectrum which includes both visible and infrared regions. Through the use of specially designed software and mathematical analysis, these pixels are sorted and then characterized to differentiate between the groups of pixels or in the case of applications of precision agriculture like plant characteristics and environmental conditions. Former remote sensing technology, in specific multispectral imaging, fetch data at a few widely-spaced wavelengths. The data from each band of wavelength is put together into a three-dimensional hyperspectral 'data cube' for processing and analysis. Each layer of the cube show data at a particular distinct wavelength.

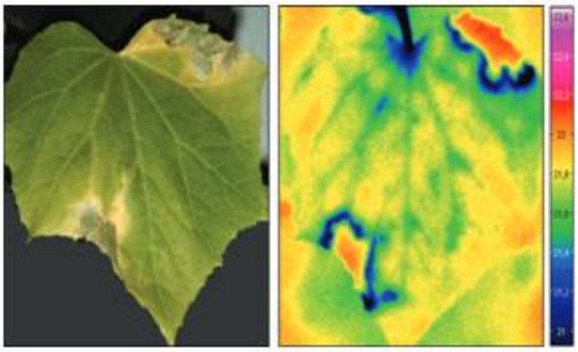
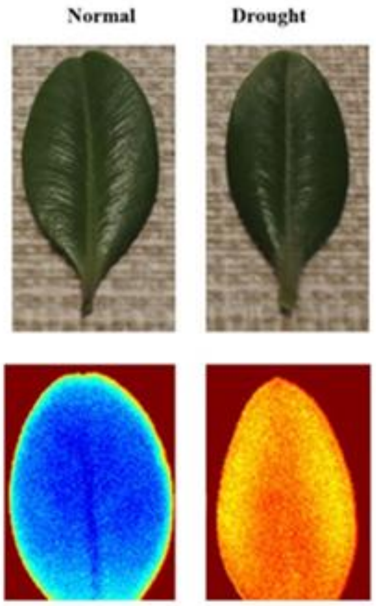


Fig 1: Thermal Imaging Of Cucumber leaves affected by fleecy fungusand environmental conditions

III. DROUGHT AND WATER STRESS

Drought is an important factor in anticipating crop yields and the conclusive successful growth of a crop. Quick identification of water concerned stresses in field crops can allow producers to spot specific areas for irrigation, saving water, energy, and time. They also allow them to supply water to crops before drought stress can result in yield losses. The SOC-700 hyperspectral imager was able to track the advancement of water stress four days before the consequences of the stress were detected with the naked eye. They remain one of the powerful and useful tools for evaluating water content at both leaf and landscape level. Greater levels of stress do ultimately manifest themselves in changes in photosynthetic pigments. These changes point to the well-known symptom of chlorosis when the reflectance of red wavelengths increases to equal that of green,thereby producing the typical yellow colour. These changes are revealed much earlier by hyperspectral imaging well before any change is visible to the human eye. The hyperspectral imager is used to determine drought stress in leaves of tropical trees and could certainly monitor the effect of dehydration over time on the individual green foliage of tree.



From the above figure, the left image corresponds to the newly cut leaf. The right leaf was also cut from the same bush but was left for 12 hours at room temperature priorto the imaging. The top plane shows some apparent characteristics of the dryness which is darker green color and curling. Hyperspectral Images disclosed more changes, which became especially apparent by dividing the data at definite wavelengths. The resulting image clearly reveals the sudden change in the leaf providing strong evidence that the leaf was under the drought stress.Field crops are one of the applications in which hyperspectral imaging is fully utilized. This technology can alsobe used to assess water stress and scheduling of irrigation in turf grasses. From this it is inferred that hyperspectral imaging will be useful in examining grasses for drought tolerance.

IV. PLANT PATHOGENS

Fungal pathogens are causing severe losses to the yields and quality of the agricultural crops universally. Traditional methods of detecting these pathogens rely only on visual examination and often result as a major drawback process.In addition to prevent the individual producer losses, earlier detection will favour for the prevention of spread to the nearby fields or crops. Using distinctive symptoms of pathogens such asthe changes in leaf pigments, the leaf structure and the moisture content, hyperspectral imaging can assist in checking fields for plant disease management.

Mean spectral reflectance curves of healthy, early blight and late blight diseased leaves are elucidated in the figure. The general trends of the three spectral curves were relatively similar. At around 555 nm, there was a peak and at around 680 nm, there was a valley.The nitrogen absorption band was the peak at 555nm. Then Reflectance increased sharply with the wavelengths from about 680 to 750 nm. Wavelength at 700 nm is the red edge. From 700 to 1023 nm, the high reflectance was found because of the internal light scattering by leaf cells. The reflectance in the visible spectral region was seen to be lower than that in the near-infrared region. Also there were a few significant differences among the samples. Reflectance of the healthy samples was greater than that of the infected ones in the near-infrared region (750–1000 nm), which was caused by the disruption of the leaf cell structure on account of the disease spread. In the visible region (400–750 nm), there was a little overlapping found between healthy and diseased leaves. Moisture content of the healthy samples was greater than that of the ones attacked with diseases, resulting in obvious reflectance valley of healthy samples at 970 nm which was assigned to the O-H stretching first and second overtones. There are 512 bands occupying the full spectral wavelengths (380–1023 nm). Nevertheless, only 400–1000 nm was studied because of the noise present at the beginning and ending of the wavelengths. There are 477 bands available for the wavelengths of 400-1000 nm.

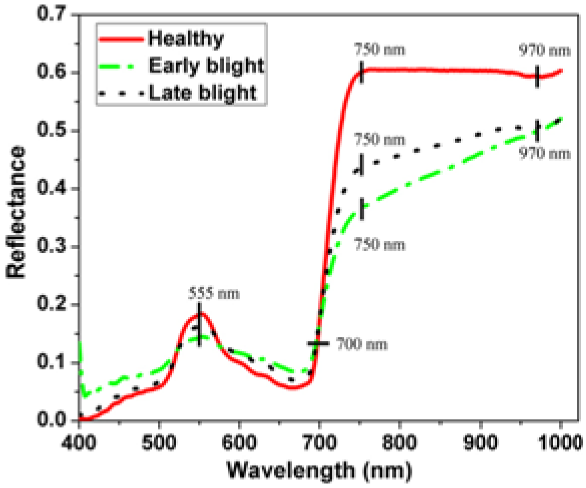


Fig 2: Average spectral curves of three different types of tomato leaves.

CONCLUSION

The results obtained from these technologies are endless as each species, soil property or nutrient are continued to be improving day by day. Estimation of chilling, heat, analysis of soil properties and nutrient insufficiency can also be determined using this technology. Presently many other applications of hyperspectral imaging are tested in post-harvest quality control, sorting of agricultural products,grading, insect and contaminant detection, and various other uses in food safety. This technology brings a new efficient prototype of agriculture.

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