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Remote sensing and its applications in horticulture

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Abstract

Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without being in contact with it. Remotely sensed data, obtained either by aircraft or satellite, containing electromagnetic emittance and reflectance data of crop can provide information useful for soil condition, plant growth, weed infestation etc. This type of information is cost effective and can be very useful for site-specific crop management programs. It is a useful technology for precision agriculture as it can give data for parameters of the field relatively easily.

Keywords: Horticulture, mapping, near infrared, remote sensing.

Introduction

Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest.

Components of Remote Sensing

- Energy Source or Illumination (A) – the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.
- Radiation and the Atmosphere (B) – as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

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- Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.
- Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.
- Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).
- Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.
- Application (G) - the final element of the remote sensing process is achieved when we apply the information, we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

Application of Remote Sensing

Soil and drainage maps

- ***Soil maps:*** The grid sampling technique takes separate soil samples from uniform sized grids laid out over the field. A problem with this type of sampling is the variability that can exist in soil types within each grid. This variability makes it much tougher to determine soil characteristics within the grid for crop input management purposes. To minimise this problem smaller grids are required which then requires many more soil samples to be taken for a larger number of grids.
- ***Drainage maps:*** Colour infrared (CIR) aerial photographs have been shown to be an effective tool in locating unknown subsurface tile lines. The image data is digitised for pre-processing and then geo-referenced using ground control points. The CIR photographs show different tones of grey depending on soil type and moisture. By filtering out spectral reflectance differences due to soil type, soil moisture content in dry soils that have a higher reflectance can be identified from lower reflectance wet soils. The resulting image shows where the tile lines are located and whether they are working properly.

- ***Monitor crop health:*** Remote sensing data and images provide farmers with the ability to monitor the health and condition of crops. Multispectral remote sensing can detect reflected light that is not visible to the naked eye. The chlorophyll in the plant leaf reflects green light while absorbing most of the blue and red-light waves emitted from the sun. Stressed plants reflect various wave lengths of light that are different from healthy plants. Healthy plants reflect more infrared energy from the spongy mesophyll plant leaf tissue than stressed plants. By being able to detect areas of plant stress before it becomes visible, farmers will have additional time to analyse the problem area and apply a treatment.
- ***Water stress:*** The use of remote sensors to directly measure soil moisture has had very limited success. Synthetic Aperture Radar (SAR) sensors are sensitive to soil moisture and they have been used to directly measure soil moisture. SAR data requires extensive use of processing to remove surface induced noise such as soil surface roughness, vegetation and topography. A crop evapotranspiration rate decrease is an indicator of crop water stress or other crop problems such as plant disease or insect infestation. Remote sensing images have been combined with a crop water stress index (CWSI) model to measure field variations.
- ***Weed management:*** Aerial remote sensing has not yet proved to be very useful in monitoring and locating dispersed weed populations. Some difficulties encountered are that weeds often will be dispersed throughout a crop that is spectrally similar, and very largescale high-resolution images will be needed for detection and identification. The use of machine vision technology systems to detect and identify weeds places remote sensors directly on the sprayer equipment. Being close to the crop allows for very high spatial resolutions. Machine vision systems have the ability to be used in the field with the real time capabilities that are necessary to control sprayer equipment.
- ***Insect detection:*** Aerial or satellite remote sensing has not been successfully used to identify and locate insects directly. Indirect detection of insects through the detection of plant stress has generally not been used in annual crops. The economic injury level for treatment is usually exceeded by the time plant stress is detected by remote sensing. Entomologists prefer to do direct in field scouting in order to detect insects in time for chemical treatments to be effective and economical.

- ***Nutrient stress:*** Plant nitrogen stress areas can be located in the field using high resolution colour infrared aerial images. The reflectance of near infrared, visible red and visible green, wavelengths have a high correlation to the amount of applied nitrogen in the field. Canopy reflectance of red provides a good estimate of actual crop yields.
- ***Yield forecasting:*** Plant tissue absorbs much of the red light and is very reflective of energy in near infrared (NIR) wavebands. The ratio of these two bands is referred to as the vegetation index (VI). The difference of red and NIR measurements divided by their sum is normalised difference VI (NDVI). For crops such as grain sorghum, production yields, leaf area index (LAI), crop height and biomass have been correlated with NDVI data obtained from multispectral images. In order to get reasonably accurate yield predictions this data must be combined with input from weather models during the growing season.
- ***Soil Mapping:*** Soil maps are another type of maps developed using remote sensing data. These maps can be compiled based on airborne or satellite images acquired when the degree of soil coverage by plants is less than 30-50%. Soil maps present homogeneous soil zones with similar properties and conditions for plant growth. These maps are useful in determining soil sampling locations for detailed studies of soil, soil moisture sensors location or developing irrigation plans. Remote sensing is a good method for mapping and prediction of soil degradation. Soil layers that rise to the surface during erosion have different colour, tone and structure than non-eroded soils thus the eroded parts of soil can be easily identify on the images. Using multi-temporal images, we can study and map dynamical features –expansion of erosion, soil moisture.
- ***Land cover mapping:*** It is one of the most important and typical applications of remote sensing data. Land cover corresponds to the physical condition of the ground surface, for example, forest, grassland, concrete pavement etc., while land use reflects human activities such as the use of the land, for example, industrial zones, residential zones, agricultural fields etc Initially the land cover classification system should be established, which is usually defined as levels and classes.

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