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APPLICATIONS OF PROXIMAL SENSING IN AGRICULTURE

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Abstract

Sensors play a crucial role in gathering crop plant data for farm management and breeding operations. Proximal sensing involves using sensors close to or in direct contact with plants, such as those on robots, tractors, and harvesters, to measure soil properties. Ground-penetrating radar uses high-frequency pulses to image subsurface layers and detect water content. Ground conductivity meters measure electrical conductivity to assess soil characteristics like water content and salt concentration. Magnetometry tracks magnetic field strength to identify iron-rich soils and industrial pollution. Portable X-Ray Fluorescence analyzes metal concentrations in soils. Optical sensors measure soil reflectance across the electromagnetic spectrum to identify various soil parameters. Gamma-ray spectroscopy detects radioactive isotopes in soil. Acoustic and pneumatic sensors study agricultural implement interactions with soil, while ion-selective potentiometry measures soil pH and nutrient availability.

Introduction

In order to gather information about crop plants for farm management and genotype selection in breeding operations, sensors are employed. The collection of technologies that employ a sensor close to or in direct contact with the object refers to proximal sensing. A few instances involve the application of sensors in close contact to the plants, including those seen on ground-based robots, tractors, and harvesters. The sensor either directly or indirectly measures a property of the soil. Since many of these sensors are imaging sensors, a large portion of the research focuses on image analysis to gather crucial information on how crops react to different environmental factors.

1. Ground-penetrating radar

An impulse radar system is a ground-penetrating radar system. It uses an antenna to send brief pulses of extremely high and ultra-high frequency electromagnetic energy (between 30 MHz and 1.2 GHz) into the soil and beneath layers. The amplitude of the reflected energy is measured by the receiving antenna. GPR can be used to image the interfaces between strata with varying water contents. It is also particularly useful for locating metallic items and spaces that are either water- or air-filled (like pipes). The existence, depth, lateral extent, and variability of diagnostic subsurface horizons are all recorded by GPR.

2. Ground conductivity meters

The components of these meters are a transmitter coil and one or more reception coils separated at predetermined intervals. Alternating electrical currents produced by ground conductivity meters go through the transmitter coil. By causing eddy currents to pass through the soil, this main field creates a secondary electromagnetic field. The receiver coil(s) measures the amplitude and phase of the primary and secondary electromagnetic fields. to investigate the soil's electrical conductivity (EC), which is generally measured in millisiemens per meter (mS/m). Temperature, the amount of water or clay present, and the concentration of soluble salts all contribute to an increase in apparent electrical conductivity.

3. Magnetometry

It keeps track of the strength of the local magnetic field on Earth. Its sensors, known as magnetometers, can be positioned in boreholes beneath the Earth's surface or on the surface of the ground. Iron-rich soils and industrial pollution have higher magnetic susceptibility due to the concentration, size, and form of strongly magnetic materials in the soil. Ferromagnetic minerals like magnetite, maghemite, titanomagnetite, and pyrrhotite are examples of strongly magnetic minerals.

4. Portable X-Ray Fluorescence (P-XRF):

X-ray fluorescence, the emission of X-ray energy, is the outcome of this process. It is possible to distinguish and measure distinct elements because the energy released as fluorescence is element-specific. The main use of X-ray fluorescence has been the evaluation of metals in contaminated soils. It sorts soil horizons according to the various metal concentrations. It is used to calculate the percentage of gypsum and measure the calcium content in gypsiferous soils.

5. Optical Reflectance (UV, vis-NIR, mid-IR)

The ability of the soil to reflect light across the electromagnetic spectrum is measured using optical sensors. Proximal sensors have the benefit of being able to be used both above and below ground. Additionally, a variety of soil parameters can be quickly determined in the lab using near- and mid-infrared diffuse reflectance spectroscopy. Numerous characteristics of soil, including its mineral composition, pH, clay content, cation-exchange capacity, color, moisture content, and organic carbon content, can be measured with optical sensors.

6. Gamma-Ray Spectroscopy

The most invasive radiation from man-made or natural sources, gamma rays are extremely energetic particles. A γ-ray spectrometer is used by active γ-ray sensors to detect photons of energy that are emitted by a radioactive source (such as cesium-137). A vehicle equipped with a γ-ray sensor can map the constituent isotopes of the soil. Analyzing metrics pertaining to potassium, thorium, and uranium isotopes or the overall count is one way to evaluate data.

7. Acoustic sensors

An agricultural implement's contact with the soil can be studied using both pneumatic and acoustic sensors. Acoustic sensors measure the change in noise level induced by an instrument interacting with soil particles, and have been used to detect bulk density, soil texture, or both.

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9. Ion-Selective Potentiometry

These sensors pick up on certain ions' activity. An ion-selective electrode is used to do the measurements (ISE). They can offer the most crucial kind of data required for precision farming: pH and soil nutrient availability.

Conclusion

Sensors are used in crop management and genotype selection for breeding operations. These technologies include ground-penetrating radar, ground conductivity meters, magnetometry, portable X-ray fluorescence, optical reflectance, gamma-ray spectroscopy, acoustic sensors, pneumatic sensors, and ion-selective potentiometry. Ground-penetrating radar uses pulses of high and ultra-high frequency electromagnetic energy to measure soil properties. Ground conductivity meters measure soil electrical conductivity, while magnetometry tracks the strength of the local magnetic field. Optical reflectance measures soil properties like mineral composition, pH, clay content, cation-exchange capacity, color, moisture content, and organic carbon content. Gamma-ray spectroscopy uses γ-ray spectrometers to map constituent isotopes of soil. Acoustic sensors measure noise levels and soil texture, while pneumatic sensors measure soil particle interaction.

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