

Harvesting Insight: Remote Sensing Application for Plant Protection

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Remote sensing refers to the collection of information about objects or phenomena from a distance typically from aircraft or satellites. This process involves using various sensors to detect and measure the characteristics of targets without direct physical contact. Remote sensing techniques can capture data across a wide range of wavelengths from visible light to microwaves and beyond allowing for the observation of features that may not be visible to the human eye. Certainly, remote sensing in agriculture refers to the use of advanced sensors and imaging techniques to monitor crop health, growth and yield from a distance.

Here are some key aspects of remote sensing in agriculture:

Basic Concepts and Applications:

Remote Sensing Technique: It provides an indirect approach to monitor agricultural landscapes. By collecting data from various sources such as satellites, unmanned aerial vehicles (UAVs), and aircraft, remote sensing enables efficient and consistent monitoring of crops and other agricultural features.

Spatial, Temporal, and Spectral Resolutions: Remote sensing data sources vary in terms of spatial resolution (detail level), temporal resolution (frequency of data acquisition), and spectral resolution (range of wavelengths captured). These characteristics are designed for specific purposes and applications.

Major Data Sources: Several satellites provide freely accessible remote sensing data for agriculture:

- **Landsat:** A well-known satellite series with moderate spatial resolution (30 meters) that captures multispectral data.

- **MODIS (Moderate Resolution Imaging Spectroradiometer):** Provides data at a coarser resolution (250 meters to 1 kilometer) but with frequent revisit times.
- **VIIRS (Visible Infrared Imaging Radiometer Suite):** Another satellite system that offers moderate spatial resolution and is useful for monitoring vegetation and land cover changes.
- **Sentinel-2:** Operated by the European Space Agency (ESA), it provides high-resolution multispectral data (10 meters) and frequent revisits.

Remote sensing used in plant protection

Landscape design based on remote sensing techniques

The utilization of remote sensing technology in the design of plant protection landscapes encompasses various facets. These include gathering and analyzing data on vegetation distribution, ecological conditions, land use, and more to facilitate the informed planning and design of such landscapes. By leveraging remote sensing data, insights into vegetation cover, including the spatial distribution of different types of vegetation can be obtained, furnishing foundational information for landscape design. This aids in the selection of plant species tailored to local climate, soil, and water conditions, thereby enhancing the ecological suitability of the landscape. Additionally, remote sensing techniques enable the evaluation of the ecological context surrounding a plant-protected landscape, encompassing assessments of factors such as soil quality, water availability, and climatic

variations to inform the creation of more ecologically balanced landscapes. Detailed monitoring and analysis of land use through remote sensing data further guide the strategic planning of plant protection landscapes.

A nuanced understanding of land use patterns across different areas empowers designers to devise more holistic solutions and integrate the landscape seamlessly into its local environment. Particularly in urban settings, remote sensing technology aids in evaluating metrics like urban green coverage and vegetation health, offering a scientific foundation for the planning and design of urban plant protection landscapes. The emergence of unmanned aerial vehicles (UAVs), particularly advancements in UAV swarming technology, has notably expanded the application domains of remote sensing technology, providing an efficient, adaptable, and cost-effective platform for its implementation.

Remote Sensing Technologies for Crop Disease and Pest Detection

Remote sensing technologies offer valuable tools for the early detection and monitoring of crop diseases and pest infestations. These technologies utilize various sensors and imaging techniques to capture data across different wavelengths, allowing for the identification of subtle changes in crop health and the presence of pathogens or pests. Here are some remote sensing technologies commonly used for crop disease and pest detection.

Multispectral Imaging: Multispectral imaging involves capturing images of crops at multiple wavelengths across the electromagnetic spectrum. By analyzing the reflectance patterns of plants in different spectral bands, multispectral sensors can detect stress indicators associated with disease or pest damage. This technology can identify subtle changes in plant physiology, such as changes in chlorophyll content or leaf reflectance, indicative of early-stage infections or infestations.

Hyperspectral Imaging: Hyperspectral imaging provides even higher spectral resolution than multispectral imaging, allowing for the detection of a broader range of biochemical and physiological changes in crops. Hyperspectral sensors can capture

detailed spectral signatures of plants, enabling the differentiation between healthy and diseased vegetation based on unique spectral features associated with specific pathogens or pests. This technology is particularly useful for identifying diseases with distinct spectral signatures, such as certain fungal infections or nutrient deficiencies.



Fig. 1 Satellite- and drone-based remote sensing of crops

Thermal Imaging: Thermal imaging measures the infrared radiation emitted by objects, including plants. Changes in plant temperature can indicate stress caused by disease or pest damage. Thermal sensors can detect temperature variations within crop canopies, identifying areas of localized stress that may be indicative of disease hotspots or pest infestations. Thermal imaging can be especially useful for detecting diseases that cause alterations in plant transpiration rates or metabolic activity.

Lidar (Light Detection and Ranging): Lidar technology uses laser pulses to generate high-resolution 3D maps of crop canopies. Lidar sensors can detect subtle changes in canopy structure and biomass distribution, which may be indicative of disease-related canopy thinning or pest-induced damage. By comparing lidar-derived canopy metrics over time, changes in crop health can be monitored, enabling early detection of disease outbreaks or pest infestations.

Unmanned Aerial Vehicles (UAVs): UAVs equipped with remote sensing payloads offer a flexible and cost-effective platform for crop monitoring and disease detection. UAVs can capture high-resolution imagery of crops from various altitudes, allowing for rapid and

frequent monitoring of large agricultural areas. By integrating remote sensing technologies such as multispectral or thermal imaging with UAV platforms, farmers and researchers can quickly assess crop health status, identify disease hotspots, and implement targeted management strategies

Applications

- **Crop Type Classification:** Remote sensing helps identify different crop types across large areas.
- **Crop Phenology Mapping:** Monitoring crop growth stages and changes over time.
- **Crop Yield Estimation:** Predicting crop yields based on vegetation indices and other factors.
- **Crop Water Use Monitoring:** Assessing water stress and irrigation needs.
- **Soil Moisture Retrieval:** Estimating soil moisture content for better water management.

Importance and Benefits

- **Crop Management:** Remote sensing assists farmers in making informed decisions about planting, fertilizing, and harvesting.
- **Early Warning Systems:** By monitoring plant health and environmental conditions, it can provide early warnings for natural disasters (e.g., droughts, floods).
- **Precision Agriculture:** Enables targeted interventions (e.g., applying fertilizers only where needed) to optimize resource use and increase crop yields.
- **Cost-Effective:** Compared to traditional field surveys, remote sensing provides cost-effective and timely information.
- **Environmental Monitoring:** Helps track land use changes, deforestation, and habitat loss.

Satellite- and drone-based remote sensing of crops

a. Large-Scale Monitoring: Satellites equipped with multispectral and hyperspectral sensors capture data over broad geographic areas, allowing for large-scale monitoring of crop conditions. These satellites can provide regular, systematic coverage of agricultural regions, offering valuable insights into crop health, growth, and variability.

b. Temporal Resolution: Satellite imagery can be acquired at regular intervals, ranging from daily to weekly or monthly, depending on the satellite platform and sensor characteristics. This temporal resolution enables the tracking of crop phenology, identification of seasonal trends, and monitoring of changes in crop conditions over time.

c. Spatial Resolution: While satellite imagery offers broad coverage, spatial resolution may vary depending on the satellite sensor. Some satellites provide moderate to high spatial resolution imagery, allowing for detailed analysis of individual fields or crop plots. High-resolution satellite data can be particularly useful for precision agriculture applications, such as variable rate input management and yield prediction.

Drone-Based Remote Sensing

High Spatial Resolution: Drones, or unmanned aerial vehicles (UAVs), equipped with multispectral, thermal, or RGB cameras offer high spatial resolution imagery of crops and fields. This allows for detailed monitoring and analysis at the field or even sub-field level, enabling precision agriculture practices.

Flexibility and Agility: Drones provide flexibility in flight planning and can be deployed quickly to capture imagery in response to specific crop management needs or field conditions. This agility allows farmers to obtain timely information for decision-making, such as assessing crop damage after extreme weather events or monitoring pest outbreaks.

Real-Time Monitoring: Drone-based remote sensing enables real-time or near-real-time monitoring of crop conditions, providing immediate feedback to farmers. This rapid turnaround time allows for proactive management actions, such as adjusting irrigation schedules, applying fertilizers or pesticides, or implementing crop rescue operations.

Integration with Other Technologies: Drone-based remote sensing can be integrated with other precision agriculture technologies, such as GPS-guided equipment and crop modeling software, to optimize farming practices and maximize productivity while minimizing inputs and environmental impacts.

Future Directions: Researchers continue to explore new applications and improve the accuracy of remote

sensing techniques in agriculture. Satellite- and drone-based remote sensing technologies offer complementary approaches for monitoring and managing crops in agriculture. While satellites provide broad-scale coverage and systematic monitoring, drones offer high spatial resolution, flexibility, and real-time monitoring capabilities.

Conclusion

Remote sensing technologies provide valuable tools for early detection, monitoring, and management of crop diseases and pest infestations. By leveraging these technologies, farmers can make informed decisions to mitigate the impact of pests and diseases on crop yields, ultimately improving agricultural

productivity and sustainability. In summary, remote sensing plays a critical role in modern agricultural management, providing valuable insights for sustainable and efficient farming practices.

References

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