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Role of Artificial Intelligence in Nematode Identification and Management

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Nematodes are microscopic, worm-like organisms with applications in monitoring the environment for potential ecosystem damage or recovery. Nematodes are an extremely abundant and diverse organism, with millions of different species estimated to exist. This trait leads to the task of identifying nematodes, at a species level, being complicated and time-consuming. Their morphological identification process is fundamentally one of pattern matching, using sketches in a standard taxonomic key as a comparison to the nematode image under a microscope. As Deep Learning has shown vast improvements, in particular, for image classification, we explore the effectiveness of Nematode Identification using Convolutional Neural Networks.

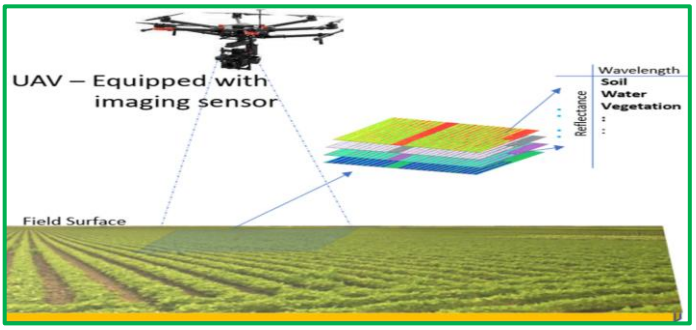
The field of agriculture has seen significant advancements in recent years, with technology playing a crucial role in improving efficiency and productivity. One area that has particularly benefited from technological innovations is nematode identification and management. Nematodes, microscopic worms that can cause extensive damage to crops, have long been a challenge for farmers. However, with the rise of artificial intelligence (AI), there is newfound hope in effectively combating these pests. Furthermore, AI has also proven to be a valuable tool in nematode management. Once nematodes are identified, farmers can use AI-powered systems to develop targeted management strategies. These systems analyze various factors such as soil conditions, crop type, and nematode species to recommend the most effective control measures. This level of precision allows farmers to minimize the use of chemical pesticides, reducing environmental impact and promoting sustainable farming practices.

Existing Approaches for Nematode Identification

Nematode identification can be achieved using their morphological, biochemical and molecular features.

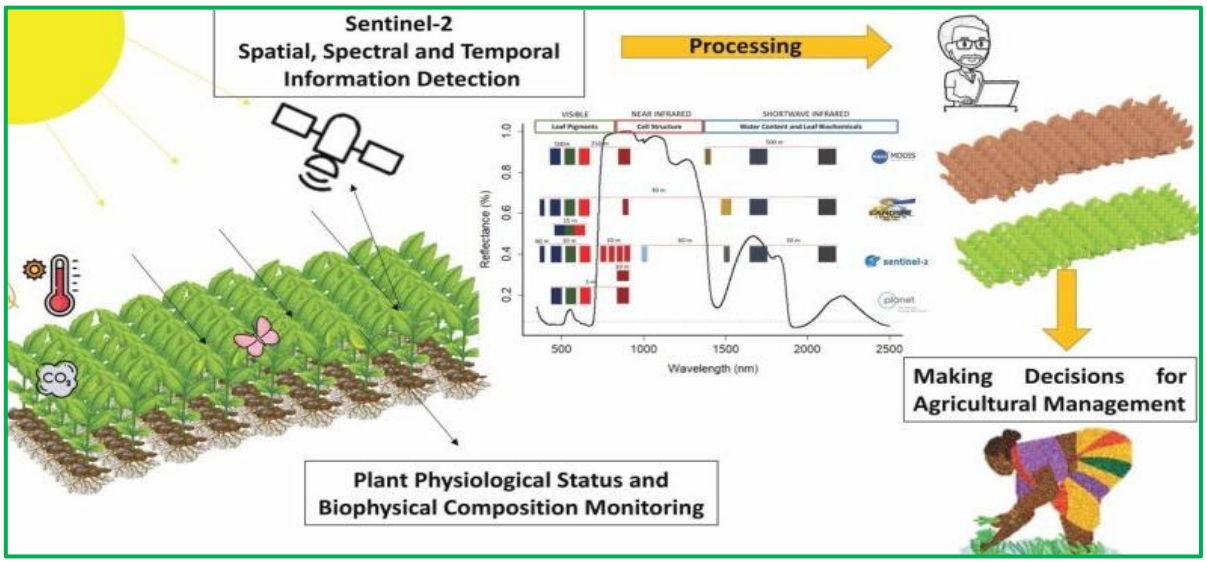
Computer-Aided Approaches: Using technology to aid in nematode identification goes back to the 1980. An overview, presented by (Diederich *et al*., 2000), shows many different approaches to computer identification aids. These approaches include using cluster analysis, similarity coefficient and expert systems. An attempt to improve the system of the printed taxonomic key led to the creation of a web application, NEMIDSOFT, using the genus *Merlinius*, plant-parasitic nematodes (Bouket, 2012). NEMIDSOFT allows the user to enter in morphological measurements that get compared to a database for the closest match. These algorithms have been successfully deployed to detect and count the eggs of soybean cyst nematodes using a convolutional autoencoder (Kalwa *et al*., 2019). Other examples include identifying different strains of the nematode species *Caenorhabditis elegans* based on video recordings of their behaviour and movements (Javer *et al*., 2018).

Drones: Recently, unmanned ground-based or air-based vehicle UAV, equipped with sophisticated cameras have become increasingly relevant and available. These platforms are able to screen a field site automatically, with little human intervention The main advantage of UAV applications compared to satellites is a comparatively higher spatial resolution. Due to the low distance between the object and the camera. UAVs may be so-called fixed wing or copters. Fixed-wing UAVs are able to fly over a higher area in short time. UAVs may be so-called fixed wing or copters. Fixed-wing UAVs are able to fly over a higher area in short time. Using drone remote sensing to monitor pine wilt nematode trees promptly is an effective way to control the spread of pine wilt nematode disease. used drones to collect high-resolution images in pine wilt nematode endemic areas and used artificial neural network ANN and support vector machine technology to monitor pine trees that were killed and withered by pine wilt nematode disease. Drone sensors can also be reconfigured from flight to flight and can capture images through small atmospheric columns.



(Khan, *et al.*, 2018)

Remote sensing method for PPNs: Remote sensing is a method of observing and acquiring information about the properties of the studied entity without physically coming in contact with it (Kundu *et al*., 2022). The method could determine the presence of a nematode species by the change of symptoms in the above ground parts of a plant. It avoids damage to the host and saves time and cost of diagnosis. Remote sensing is a fast, non-invasive, and highly effective process of acquiring information that has a wide coverage. Various spectroscopic and imaging approaches have been performed for the detection of PPNs, such as visible, multiband, infrared, and fluorescence spectroscopy, fluorescence imaging, multispectral. The first to use infrared sensors for pre-sign detection of *R. similis* in citrus trees. *R. reniformis* was detected by Heald using airborne infrared imaging methods in cotton fields. (Heath *et al*., 2000) predicted the amount of the nematodes *G. rostochiensis* and *G. pallida* on potatoes based on non-destructive hyperspectral measurements with a combination of GIS and RS technologies. Remote sensing coupled with GIS technologies was employed to identify and quantify an *H. glycines* population.



(Segarra *et al*., 2020)

Machine learning for PPNs identification: Machine Learning or Artificial intelligence (AI) is a novel technology for nematode identification and quantitation based on image analysis (Bogale *et al*., 2020). Biological image datasets for multiple genera of PPNs were established and used to identify them based on the deep convolutional neural networks (CNNs) method. Convolutional Neural Networks (CNNs) are state-of the-art algorithms that have made significant advances in computer vision tasks, especially in Image Classification. A convolutional CNNs model for identification of nematodes in soybean crop. In this research, we explore the feasibility of designing a CNN suitable for classifying microscope photographs of nematodes. "Detection and Classification of Banana Diseases Using Machine Learning Techniques." This study proposes a machine learning-based strategy for detecting and classifying banana diseases. The objective of this study was to distinguish cyst nematodes belonging to the species *Globodera pallida*, *Globodera rostochiensis*, and *Heterodera schachtii* based on image parameters using artificial neural networks (ANN). The application of image analysis can result in the determination of many textural and geometric parameters of images. The image features can be analyzed using artificial intelligence (Pereira and Barbon 2018).

Conclusion

Artificial Intelligence (AI) plays a significant role in nematode identification and management, offering innovative solutions to improve efficiency and accuracy in agricultural practices. The rise of AI in nematode identification and management has revolutionized the field of agriculture. By automating the identification process and providing targeted management strategies, AI has significantly improved efficiency and accuracy.

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