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Comprehensive Study on Orange Disease Detection: A Review

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Abstract: ***This review paper abstract provides an overview of the state - of - the - art research on the detection of diseases in orange crops. In recent years, the agricultural industry has faced significant challenges due to the impact of diseases on orange fruit production. This review highlights the critical importance of early disease detection to mitigate economic losses and improve the overall quality of orange yields. It discusses the various diseases that affect orange crops, their symptoms, and the challenges associated with traditional, manual detection methods. The abstract also explores the promising potential of automated systems and advanced technologies for the early identification and severity assessment of orange diseases. By summarizing the existing research and advancements in this field, the review paper aims to contribute valuable insights into enhancing disease detection methods and ultimately securing the future of orange production in the agricultural sector.***

Keywords: Machine learning, Citrus Disease, CNN, Feature Extraction, Segmentation

1. Introduction

In the field of agribusiness, diseases of fruit products initiate the degradation of the economy, just as large - scale manufacturing affects the economy around the world. Some researchers in the last decade demonstrated the criticality of the quality of fruit products, as it impacts human wellbeing [1]. Fruit products ought to be the basis of a sound eating regimen. Citrus fruits are a significant product in agriculture, and nearly everybody consumes them consistently [2]. Citrus fruits include lemons, oranges, grapes, and tangerines. Various diseases affect citrus fruits, including black spot, greasy spot, canker, and greening, as well as many more. Diseases of citrus fruits are a critical subject that significantly influences the quality and number of yields around the world. The utilization of pesticides by farmers to control various diseases and enhance the production of crops is taking place on a vast scale [3].

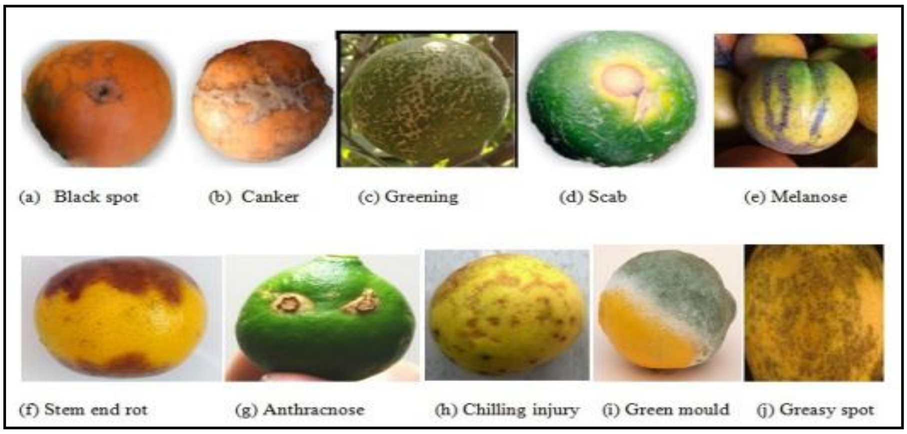

Figure 1: Types of diseases present in citrus fruit.

Diseases of fruit crops cause significant issues, such as low levels of production and monetary misfortunes, for farmers. Therefore, the detection of diseases and the identification of their severity is a primary need in the agricultural world. Generally, symptoms of disease in citrus fruits are identified with regular monitoring using just the naked eye. This procedure is costly in enormous manors and is less precise. In some countries, farmers hire specialists to identify citrus fruit diseases, and again, this is a costly and tedious task. There is a need for high returns in horticultural enterprises, as well as a better - quality yield of fruit products, if automatic systems are developed to help in the early discovery of infection or diseases in citrus fruit [4].

Many systems have been examined and proposed by analysts in the landscape of artificial intelligence, machine learning, digital image processing, and deep learning for the prediction and classification of citrus infections. Machine vision platforms are indeed a commercial tool for the evaluation of food standards. All such systems are used to assess production throughout the domain and are used for robotic post - harvest or the early diagnosis of possibly lethal diseases [5]. They are often used in post - harvest processing for the computer - controlled investigation of the fruits' external quality, including the breakneck speed filtering of them together in commercial sections.

Citrus is an important source of nutrients such as vitamin C for plants around the world. Citrus contains numerous economically significant species. Few species are cultivated commercially in India, including grapefruit, lemons, limes, sweet oranges, and mandarins. Citrus is indigenous to Southeast Asia. Several citrus species, such as mandarins, are native to the North East of India. In central India's Vidharbha region, Nagpur Santra is cultivated on a big scale. Similarly, the Brahmaputra Valley and Dibrugarh district are renowned for their production of mandarins in Assam. Khasi mandarin is a notable Nilgiri hills cultivar. In addition to mandarins, limes and lemons are also grown everywhere. India. Pests and illnesses are the two most influential influences on citrus yield. Many citrus pests and illnesses exist in nature. Several of them have a similar look, making it challenging for farmers to identify them in a timely manner. In recent years, advancements in machine learning algorithms have significantly advanced computer vision. These new network topologies have allowed researchers to achieve great precision in picture classification, object detection, and semantic segmentation [6]. Thus, some studies have applied the machine learning approach to determine the disease category based on an image. As a significant contributor to the agricultural economy as a whole, the citrus industry requires proper disease control in citrus groves to prevent losses. Melanoses, greasy patch, and scab are the most destructive citrus diseases [7]. Ensuring fruit quality and safety, and boosting the citrus industry's competitiveness and profitability, would be technologies that easily identify these pathogens. The objective is to examine the viability of pattern classification algorithms for detecting disease lesions on citrus leaf surfaces. Based on the disease, the leaves are divided into four categories: scab, melanoses, greasy patch, and normal leaf [8].

Citrus production: Around 923.2 thousand hectares are devoted to citrus cultivation in India, with an estimated output of 8, 607, 7 thousand metric tons. Agriculture entails substantial production risks, and numerous variables must be taken into account when making decisions [9]. For management strategies and development programs to be effective, it is necessary to have a thorough understanding of the variables that have the most direct impact on output. Comprehending the behavior of variables is challenging due to the complexity of relationships and the number of relevant elements.

Citrus Diseases: Citrus fruits, including lemons, mandarins, oranges, tangerines, grapefruits, and limes, are widely cultivated around the world. Citrus manufacturing enterprises generate a substantial amount of trash annually, with fifty percent of citrus peel being lost to various plant diseases. [10] Currently, citrus exports to international markets are significantly hampered by fruit illnesses. Citrus diseases negatively impact citrus fruit yield and quality.

Table 1: Citrus Fruit Disease Classes

Disease Class	Details	Sample	Ratio
Huanglongbing (HLB)	"It is just a citrus fruit disease that has dramatically affected the dimension and pattern of the nation’s modern agriculture. Its negative impacts are still affecting the economy as the infection progresses all across the world’s largest citrus fruit - producing countries. "		14.4
Blackspot disorder	"A bacteria and fungi disease known as the black spot is characterized by gloomy, gangrenous splodges or patches on the citrus fruit rind. This also causes premature seed size and decreases agricultural output. "		15.3
Melanose disorder	"Melanose can attack any citrus fruit variety. The loss is superficial that has no bearing on the individual’s character of the fruit. "		12.1
Citrus Canker disorder	"The bacterium 'axonopodispv. citri' causes the citrus disorder. Canker has a major negative effect on citrus trees’ health and vitality, having caused leaves and fresh fruit to fall off before their time even though it is not toxic to human beings. "		17.3
Scab disorder	The parasitic fungus “Elsinoe - fawcettii” causes scabs. The scabs are initially grey or pale pink and darken to maturity level. They’re more popular on citrus fruits instead of on leaves.		16.4

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Healthy	Numerous fruit varieties, including lemons, lime, and oranges, are classified as citrus. Citrus fruit grows on annual herb trees and bushes. Individuals have thick skins as well as pulpy flesh that is segmented		27.8

Taxonomy of Citrus Diseases: In the agriculture industry, plant diseases are primarily responsible for the decline in productivity that results in economic losses at the national level. Grapefruit is an important global source of nutrients such as vitamin C. Unfortunately; citrus diseases severely impacted citrus fruit supply and quality. Many citrus lesions, including anthracnose, citrus scab, black spot, melanoses, and canker greening, afflict citrus plants such as lemons, oranges, grapefruits, and limes [11]. Included below are brief descriptions of several citrus illnesses.

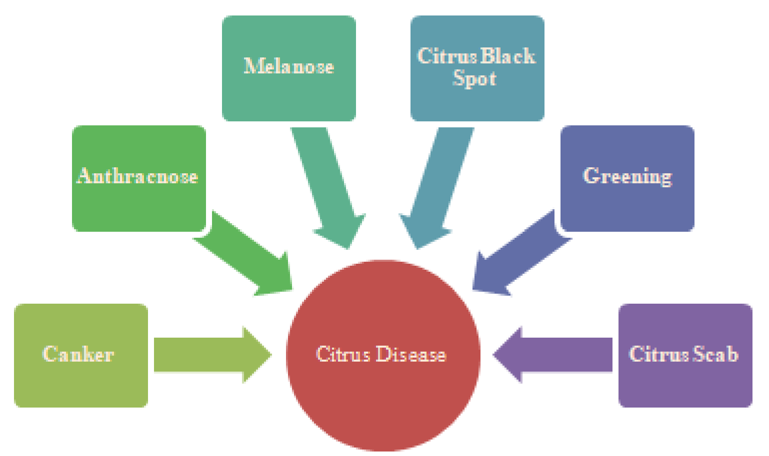

Figure 2: Different types of citrus disease

Anthracnose: Anthracnose is a disease of citrus plants caused by a fungus (Colletotrichum gloeosporioides) and characterized by twig blight of mature tips, leaf spots, and fruit stains, spots, or rots. It can spread rapidly during wet seasons.

Canker: It is a highly serious citrus disease, primarily affecting limes. Sickness manifests itself on leaves, twigs, and fruits. It shows as yellow dots on leaves. Which progressively increase in size, grow rough and brownish, and become elevated on both sides of the leaf? These specks have a yellow halo surrounding them. The sores on the fruit's peel grow tough and corky. Kagji limes and grapefruits are extremely vulnerable.

Citrus Scab: Acne scabs on citrus leaf and fruit are composed of fungal and organism tissue. The color of a scab lesion is dirty grey and yellow - brown. Tiny, dark brown, rough, uneven, elevated lesions appear, predominantly on the undersides of the leaves. Fruits and branches are also infected.

Citrus black spot: Citrus black spot is caused by the fungus Guignardia citricarpa. This ascomycete fungus affects citrus plants in subtropical climates, reducing both the quantity and quality of the fruit. Symptoms consist of both fruit and leaf lesions, with the latter being crucial for inter - tree dispersal.

Melanose: Melanose is caused by Phomopsis citric fungus. On leaves, branches, and fruits, it appears as dark circular depressions with yellow edges. Subsequently, the dots grow rough and elevated, and their light brown and yellow edges vanish. The surfaces of leaves and fruits develop a sandpaper - like roughness.

Greening: It is caused by bacteria and shows as many, rigid, erect branches and buds. The leaves shrink and become speckled. Early defoliation and branch dieback are observed.

2. Methodology

- The purpose of this systematic review is to provide an overview of the various machine - learning and deep learning algorithms employed in the diagnosis of citrus fruit diseases using photographs of sick citrus trees. The review technique consists of the following steps.
- Data Collection
- Searched databases

Science Direct, Scopus, Springer, ACM (Association for Computing Machinery), and IEEE (Institute of Electrical and Electronics Engineers) were utilized to analyze this body of literature (IEEE Explore Digital Library). This survey utilized the years 2000 to 2023 as its time frame.

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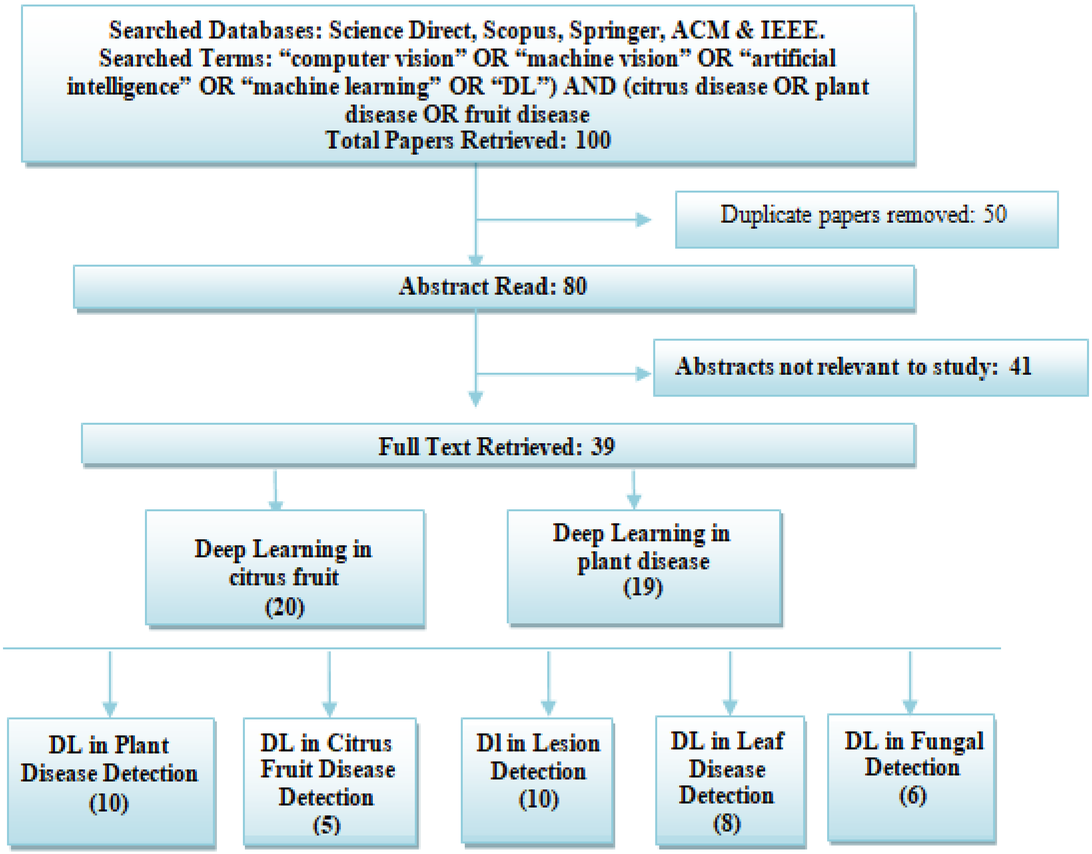

Figure 3: Research Methodology Flow diagram

Searched Terms: For the survey of papers, the following search expression was defined: ("Convolutional Neural Network" OR "Machine Learning" OR "Artificial Neural Network" OR "Deep Learning") AND ("citrus Plant Diseases" OR "Crop Diseases Detection & Classification "OR" citrus fruit disease Classification" orange/

Inclusion criteria: To find the paper meeting desired criteria Titles and Abstract represented the first selection step, and then duplicate papers were removed.

Exclusion criteria

The study omitted articles that did not particularly deal with citrus fruit or other plant disease detection and classification using deep learning/CNN.

Data Analysis: After choosing more than 107 papers deemed eligible for the evaluation, data analysis was conducted with the following factors in mind:

Year of Publication: Researchers' interest in CNN/Deep learning for citrus disease diagnosis has increased over the past few decades. So, knowing the publishing year is essential for determining when this interest has increased.

Purpose of the study: Several sorts of tasks, such as discoloration & lesion detection, classification, segmentation, etc., were done for various citrus illnesses in the study for diverse reasons, including discoloration & lesion detection.

Deep Learning Architecture: Deep learning architectures such as Deep Neural Network, Convolution Neural Network, and Recurrent Neural Network have been applied to the identification of a variety of crop diseases.

Process of Article Selection: This study's article search and selection procedure consists of the four phases listed below. Figure 3 illustrates this process. This collection of publications is the result of a search of common internet databases. Among the applied electronic databases are Scopus, IEEE Explore, Springer Link, Google Scholar, ACM, Elsevier, Emerald Insight, MDPI, Taylor and Francis, Wiley, Peerj, JSTOR, Dblp, DOAJ, and ProQuest. Also discovered are periodicals, conference papers, books, chapters, notes, technical studies, and special issues. Stage 1 produced 200 documents.

3. Literature Review

Citrus fruit analysis, i. e., fruit quality, disease identification, and classification are hot areas of research. This section covers the comparative analysis of various existing works in the field of citrus fruit disease classification.

Edge Computing is a hot topic that the research community is closely associated with because of its implications for science, technology, and industry. The incorporation of the ETSI guidelines has significantly strengthened the case for edge computing. However, many of the present MEC biological studies fall short, which prevents and invalidates their implementation [12]. A wide range of innovative rapid prototyping, functionalities, and implementation seems to be critical to overcome this discrepancy. Early initiatives can prove the functionality, restrictions, connected techniques, and application frameworks for multi - edge factors affecting the adoption of edge computing [13].

A large amount of IoT statistics is forwarded to the cloud through the cloud - based architecture for strategic decision, research, and data processing. It could cause not just limited availability on the data center but also increased communication overhead, possibly negating the benefits of the cloud. To deal with these challenges, investigators are looking for new distributed network models for IoT - based computing devices and networks, and technology. One such method that is receiving a lot of attention among both academia and industry experts is edge computing. The fundamental idea behind the edge computing technique is to shift the processing of digital information from remote servers to relatively close machines. It is encouraging to see the advancement of more massively parallel, low - latency, and efficient edge computing devices and IoT - edge systems [14]. To determine an optimal technique to determine image imperfections on the citrus fruit skin, an associated with advanced PCA with B - Spline illumination clarification assessment was incorporated. Machine learning and computer vision methods carry out image processing. The proposed model helps to estimate and retrieve useful information for fruit disease images concerning [15].

Various IoT - based devices and sensors are widely used to collect fruit images. Typically, hyperspectral functionality provided obtained 2D statistics at a period and checked all over three - dimensional. Premised on the filtering method multispectral imagers as well as imaging systems are classified into two types: optical filtration and digitally configurable filters [6]. The most frequently used image transmission process is a 3 - CD webcam with illumination gray walls accented with gray files [16]. Numerous image fusion strategies, such as pixel level, quantitatively, and metaphorical level, were formed in recent decades. Image enhancement is being used by investigators to recognize orange fruit disease [17]. The terms near - infrared spectrograph and spatial frequency acquisition refer to two distinct edge devices, namely the segments, and sub - FT - spectrometer. A multivariate regression prototype was utilized to evaluate these two small and medium companies and FT - spectrometers [18]. Image enhancement can be employed to detect and classify diseases at a lower cost. In the proposed model an enhanced Image principal component analysis is implemented to apply reduction on orange images. The Edge detection module in the proposed model mainly extracts seven attributes from the orange fruit image dataset. Next, then, a method of deep learning is employed to detect orange fruit conditions at their earliest stages of growth [10]. The study suggested an image processing technology for evaluating the various imperfections in citrus fruits and detecting malformations in fruit. A failure mark's symptoms reveal the character of the disorder and suggest the ideal treatment regimen [19]. To find the desired diseased region, segmentation is conducted using DE color change. In addition, color statistics and texture analysis were used to classify the disorder [20].

Lime and orange citrus fruit with pharmacological decays have lower economic potential. The investigator proposes a method of image handling to recognize types of diseases on X - ray image data of lemons and oranges fruit. The image sequence was automatically classified using K - means and Naive Bayes similar techniques [21]. The researchers utilized the partial least squares analysis to look into the connection between granulation psychological disorder incidence and quality characteristics [22]. The categorization of infectious illnesses affecting citrus fruits has been incorporated using heuristic methods that combine Deep Convolutional neural networks& random forest methodologies [23].

A modern AlexNet infrastructure that utilized deep learning has been used to detect diseases successfully. This method was divided into four major steps: pre - processing, edge detection, object recognition, and categorization [24]. The characteristics of the input object were first improved through pre - processing. After that, the images and videos were categorized using the Based segmentation method. An Alex - Net framework was initially presented as just a filtration feature. A random forest method was finally utilized for the categorization of citrus fruit diseases. Ten independent factors were employed as the neural network's feedback to identify the feature set [25].

RNNs are a type of Neural Network model that uses the immediately preceding step in the process outcome is utilized as direct input within the initial stage. The most popular uses of RNNs include the classification of sequences, emotions, images, and videos [26]. RNNs are a type of network wherein node links establish a sequentially ordered graph. It resembles a linked sequence of items from a deep network. Each one is communicating with the individual ahead of them in sequence. An RNN is trained to recognize patterns and behaviors, whereas a CNN is trained to recognize patterns throughout space [27].

SVM classifiers [20] were utilized to classify citrus fruit after modifying the existing CNN method for the classification procedure. Feature values were accumulated utilizing k - mean cluster analysis. The multi - class problems damage the overall system effectiveness even though they decreased the rate of false positives. The researchers [28] developed a segmentation technique to incorporate prediction models. It has enhanced the segmentation algorithm in identification for sensing the three separate types of disorders. Images of lemon fruits with softness and bacterial blight were used in the testing. In order to categorize the binary classification diseases, backpropagation architectures were used. Although this remedied the multi - class problem, the data processing is extremely complex. Table 1 represents the comparative analysis of the performances of different detection model using various kind of pruning techniques.

Mayen Uddin Mojumdar et. al. (2021): Discusses the significance of automated disease detection for orange trees in Bangladesh. Utilizes image processing techniques, K - means clustering, and SVM for disease detection. Achieves an overall classification accuracy of up to 82.3%. [29]

Thilagavathi K et. al. (2023): Highlights the economic impact of fruit diseases on agriculture globally. Explores the use of machine learning techniques (KNN, CNN, SVM) for detecting six different orange fruit diseases. The CNN approach achieves an accuracy of 90%, outperforming SVM and KNN. [30]

Ruhika Sharma et. al. (2019): Addresses the problem of citrus canker infection in orange trees. Discusses various techniques, including CNN, for detecting and classifying orange leaf disease. Emphasizes the importance of early disease detection for improved plant productivity. [31]

Gendlal Vaidya et. al. (2023): Focuses on the detection and categorization of diseases in citrus plants. Investigates image pre - processing, segmentation, feature extraction, and machine learning. Proposes a machine learning - based image recognition approach for citrus diseases. [32]

Nishant Garg et. al. (2023): Addresses the categorization of six common disorders in oranges using a hybrid model. Combines Support Vector Machine (SVM) and Convolutional Neural Network (CNN) for disease detection. Achieves an accuracy of 88.14% and outperforms other classification models. [33]

Wilfrido Gómez - Flores et. al. (2022): Focuses on detecting Huanglongbing (HLB) disease in citrus fruits. Evaluates pre - trained CNN architectures and transfer learning for HLB detection. Achieves high sensitivity for HLB detection using pre - trained CNNs. [34]

Nidhi Prashar (2021): Provides a broader overview of disease detection in various plants and vegetables. Discusses machine learning approaches for disease detection in crops like potatoes, tomatoes, and oranges. [35]

HongJun Wang et. al. (2020): Presents a model based on Mask R - CNN for detecting disease spots on fruits (apples, peaches, oranges, pears). Improves feature fusion in Mask R - CNN for enhanced detection performance. Achieves accurate detection and robustness in disease spot identification. [36]

Hsin - Chun Tsai et. al. (2022): Introduces a YOLOv5 model for rib fracture detection in chest X - rays. Evaluates detection performance on frontal and oblique chest X - rays. Highlights the importance of using oblique views for rib fracture detection. [37]

Sadhana T S et. al. (2022): Discusses the detection and classification of citrus plant diseases. Utilizes CNN models for disease recognition based on citrus images. Emphasizes the significance of early disease diagnosis in plant growth. [38]

Chai C. Foong et. al. (2021): Addresses the importance of fruit inspection in the food industry. Proposes the use of CNNs for feature extraction and classification of rotten fruits.

Achieves a high validation accuracy of 98.89% for classifying banana, apple, and orange. [39]

Author & Year	Methods Used	Advantages	Disadvantages
Mayen Uddin Mojumdar et al. (2021)	Image processing, K - means clustering, SVM	Automated disease detection. Achieved 82.3% classification accuracy.	Relies on image quality. Limited to orange trees.
Thilagavathi K et al. (2023)	KNN, CNN, SVM	CNN achieved 90% accuracy. Detects six orange diseases.	KNN and SVM less accurate. Model complexity.
Ruhika Sharma et al. (2019)	CNN, GLCM, Multi - SVM	Early detection of orange leaf disease Utilizes CNN.	Complexity of CNN training Dataset size.
Gendlal Vaidya et al. (2023)	Image pre - processing, ML algorithms	Covers multiple citrus diseases Utilizes machine learning.	Image quality dependency. Dataset limitations.
Nishant Garg et al. (2023)	Hybrid model (SVM + CNN)	Achieved 88.14% accuracy Outperforms other models.	Complex hybrid model. - Data requirements.
Wilfrido Gómez - Flores et al. (2022)	Transfer learning (CNN architectures)	Accurate HLB detection Suitable for small datasets.	Impact of network depth. Limited HLB cases.
Nidhi Prashar (2021)	Various ML approaches	Addresses disease detection in various crops.	No specific model evaluated. Dataset - dependent.
HongJun Wang et al. (2020)	Mask R - CNN with feature enhancement	Accurate fruit disease spot detection Improved feature fusion.	Requires GPU for real - time processing Complexity.
Hsin - Chun Tsai et al. (2022)	YOLOv5 for rib fracture detection	Detects rib fractures in chest X - rays Oblique view utilization.	Limited to rib fracture detection. Model depth.
Sadhana T S et al. (2022)	CNN models for citrus disease recognition	Automated disease identification Use of CNN.	Dataset dependency. CNN training complexity.
Chai C. Foong et al. (2021)	CNN for fruit image classification	High classification accuracy (98.89%) Fast processing.	Limited to fruit classification Training time.

4. Conclusion

"In conclusion, the agricultural industry, particularly the cultivation of orange crops, faces significant challenges related to disease outbreaks. The impact of diseases on orange fruit production, both in terms of economic losses and compromised fruit quality, underscores the urgency of effective disease detection methods. This review has provided an overview of the current state of research and developments in the field of orange disease detection. It is evident that traditional manual monitoring methods are often inefficient, costly, and less precise, necessitating the exploration of innovative technologies and automated systems. Advances in remote sensing, image processing, machine learning, and molecular techniques offer promising avenues for the early and accurate detection of diseases in orange crops. By harnessing these technologies and interdisciplinary approaches, the agricultural sector can substantially improve disease management, increase yields, and ensure the long - term sustainability of orange production. However, it is crucial to continue collaborative efforts among researchers, policymakers, and the farming community to further develop and implement these technologies in real - world agricultural practices. As the demand for high - quality fruit products and sustainable agricultural practices grows, the future of orange disease detection holds immense potential for ensuring food security and economic prosperity. "

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