TABLE V
SUMMARY OF METHODS USED IN HYPERSPECTRAL IMAGING FOR PLANT DISEASE DETECTION

Method Type	Specific Methods	Advantages	Disadvantages	Application Areas
Deep Learning	CNN [264], CNN-SVM [335], DCNN [39], MLP [336], STDA [336], OR-AC-GAN [337]	• The models are deep learning-based models, and they have high accuracy in image detection/recognition [338] • Requires minimum human interference to obtain the important features [338] automatically • The weight of the models are shared [338]	• The position and orientation of data is not encoded [338] • Large number of training data/annotated images are required to obtain accurate results [338]	Disease detection, Disease classification
Machine Learning	RBF [336], SVM [339], kNN [320], QDA [318]	• Machine learning algorithms can automatically identify and extract the most informative features from the data [340]. • The models can handle high dimensional data (hyperspectral imaging) and large datasets, efficiently [340]. • The model performance (accuracy) is better than statistical-based models [340].	• Although certain models have the ability to perform automatic feature extraction, significant manual effort may still be required in the process of feature engineering to create the most relevant and useful features for training [341]. • Accuracy of the model is greatly dependent upon the size and correct labels of the training dataset [341]	Disease detection, Disease classification, Disease severity analysis
Statistical Methods	Multivariate regression [158], PCA [317], PSLR [223], MLR [306], SRR [280]	• The statistical models are less complicated and easy to interpret as it allows to model the mathematical relationships directly [342]. • Dimension reductions and noisy data are can be processed easily [342]. • A Large number of data can be processed in a definite method [342].	• The statistical models are very sensi- tive to data and parameter estimation for a sparse data set is very poor [342]. • The data processing time is very high, which can impact the assessment process [9]	Disease detection, Disease classification, Disease severity analysis, Genetic Resistance of diseases

4) Several researchers have attempted to use machine learning and deep learning algorithms to preprocess the hyperspectral images and then detect and classify the diseases. However, one common challenge for computer-aided algorithms is that it requires good quality and a large amount of data to process the hyperspectral images. If a smaller dataset is used, the results might be biased and unable to detect the diseases well. Therefore, during the data acquisition period, a good-quality camera and a large amount of data (approximately 10k above) should be collected so that the models do not face overfitting issues.
5) The data processing of hyperspectral imaging is also complex and computationally expensive, which can impede timely analysis [316], [317]. Methods such as PCA, used in the feature extraction part, can be computationally demanding to reduce the dimensionality of high-dimensional hyperspectral data [318]. In addition, machine learning techniques for regression and classification (such as SVM or RF) can increase the need for high computational power and time. This reduces the chance of being implemented in real-time/resource-limited settings, such as crop monitoring [319], [320]. One potential solution to overcome these issues could be employing parallel processing to manage computational load and reduce computational time by ensuring the data integrity and accuracy of the results/analysis [321]. Besides, batch processing [322], data sampling [323], and hardware acceleration [324] can be employed to enhance the hyperspectral data processing.

V. Conclusion and Future Prospects

This article extensively reviews plant disease detection using hyperspectral imaging techniques. Hyperspectral imaging is a nondestructive, fast, reliable technique. Hyperspectral imaging is a nondestructive, fast, reliable technique that can be employed to detect plant diseases. With the advent of such technologies, human perceptions are extending further to the visible spectrum [17]. This aids in classifying the infected plants, assessing and analyzing the disease severity, classifying the pathogens, and detecting the early symptoms of plant diseases before the human eyes can detect them.

One of the most pressing issues of the current hyperspectral imaging is the inability to detect plant diseases at their early stages. The current systems are capable of detecting diseases when they are visibly infested. Hence, developing remote sensing platforms that can monitor the disease growth at the emerging stages is crucial. The placement of sensors or the distance between the sensors and the diseased plants is one of the crucial factors for image analysis. This is because the distance of the sensor is directly related to the spatial resolution