Yellow leaf curl is caused by *Begomovirus*; tomato yellow leaf curl virus (TYLCV). TYLCV is a complex virus disease, and the common symptoms include yellowing of the plant leaf, curled leaves, and stunted plants. The disease is spread through the whiteflies, which carry the virus and infest tomato plants [137]. Gray mold in tomato plants is caused by a fungus named *Botrytis cinerea Pers.: Fr*. It is listed as one of the top plant diseases that can infest many plants. The pathogens develop gray molds and infect the leaves, flowers, stems, and fruit of the plants [138].

Verticillium wilt is a soilborne fungal-based disease. The fungi that is responsible for this disease is commonly known as *Verticillium dahliae*. The fungi attack the plants from the roots and spread through the stems. The vascular tissue of the plants appears brownish-black in color. Common symptoms include foliar chlorosis, stunting plant growth, epinasty, and leaf abscission. These symptoms compromise the food quality and reduce yield [139]. Sour skin is a common bacterial disease that occurs in onion through the bacterium *Burkholderia cepacia*. Sour skin infestation mostly occurs when the onions are stored. Humans can develop pulmonary infections if sour skin-infested onions are consumed [140]. The bacteria survive in the soil and are transferred to the leaves or necks of the onions during irrigation or rain splashing. The water-soaked tissue of the plants and the presence of any openings allows the bacteria to infect. The bacteria grow in warm and high-humidity atmospheres. The initial symptoms include a brown-water-soaked appearance in the first/second layer of onion bulbs. With time, the entire onion bulbs can be contaminated, which can result to the destruction of around 50% of the stored onions [141].

Citrus greening is caused by a pathogen *Huanglongbing*, which is also known as gram-negative bacteria. The citrus greening has different names in different regions. In some places, it is known as yellow shoot, yellow dragon, yellow branch, dieback, decline, blotchy mottle, and greening. They are named according to the symptoms in different regions of the world. The greening occurs on the trees, which causes stunt growth, yellow foliage, dead twigs, and fruit drops. Mottling and chlorosis appear on the leaves. The fruits appear immature, have uneven shapes, and are poor in color. If the fruit is pressed with a finger, grayish–white waxy marks emerge on the surface [142]. Citrus canker is considered one of the dreadful citrus diseases as it can cause severe damage to the citrus fruit growth. The citrus canker is caused by the bacterial pathogen *Xanthomonas campestris pv. citri*. Multiple strains of this bacterial pathogen have been reported to severely destroy citrus plants and fruits. The symptoms include widespread lesions on the foliage, halo, and water-soaked appearance on the fruits [143], reducing the yield.

Hence, understanding and addressing these diseases is not only beneficial to agricultural science but also to global economic stability.

IV. Plant Disease Detection Using Hyperspectral Image Sensors

The hyperspectral imaging is a nondestructive and noncontact plant disease detection technique. The images comprise exorbitant information, and extracting the specific information can be quite challenging [24]. For instance, the information associated with the plant pathogens versus disease can be dispersed into several spectral areas [176]. The infected plants generate spectral characteristics dissimilar to healthy plants, as infected and healthy plants absorb light (in both the visible and NIR regions) differently. Generally, healthier plants contain a higher chlorophyll content to conduct photosynthesis. In the visible spectrum, chlorophyll absorbs the light in red and blue wave bands and reflects the green light [177]. Hence, the healthier plants appear green in color. Alternatively, anthocyanins, another plant pigment, absorb blue, blue-green, and green wavebands [178]. Thus, some specific parts of the plants appear red or purple [179]. However, anthocyanin concentration increases when a plant is infected or stressed, resulting in a decrease in chlorophyll concentration [180]. Consequently, healthier plants exhibit lower reflectance values in the visible spectrum due to the strong absorption abilities of chlorophyll and anthocyanin pigment. Healthy plants show higher reflectance values in the NIR spectrum [181]. This is because NIR light in the healthy leaf is scattered by the air pocket and cell structure, resulting in higher reflection values [182]. The damaged cell structures of infected or diseased plants often cause a decrease in reflectance and an increase in light scattering values [25], [181]. Therefore, certain spectral bands in the hyperspectral images correspond to the diseases of the plants [183]. Many data analysis methods have been recently explored to obtain helpful information for plant disease detection using hyperspectral image sensors. Depending upon the data collection method, different sensors are chosen. For instance, with UAVs, push broom sensors seem better than all other sensors as they can acquire full spectral range in one flight times [184]. Therefore, this section reviews the most common image processing techniques and areas of application of hyperspectral imaging that are used for plant disease detection. This section also highlights the current limitations and provides potential solutions to overcome the current issues.

A. Image Processing Techniques for Hyperspectral Imaging

The hyperspectral image analysis is not straightforward as it contains complicated information. The literature studies show that the most used/common software analysis tool that was employed for image analysis is MATLAB (The MathWorks Inc., Natick, MA, USA), ENVI (Research Systems Inc., Norwalk, CT, USA), R (R Software Foundation, Indianapolis, IN, USA), and Python (Python Software Foundation, Wilmington, DE, USA) [17]. The hyperspectral image analysis can be divided into three main steps. The first step is the data/image acquisition and preprocessing. The second step is the data extraction process, and the last step is data analysis with the extracted information from step 2. Each step is briefly described in the following.

1) Data/Image Acquisition and Preprocessing: In order to obtain a meaningful hyperspectral image analysis, it is very crucial to get high-quality hyperspectral images so that the objectives of the study can be met. The choice of sensors, platforms, resolution setting (spatial and spectral), illumination condition, scan speed, frame frequency, and exposure time is vital in obtaining quality images for analysis [45]. The right combinations of the parameters above depend on the inspection

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