powered by high-performance batteries (LiPo), increasing endurance (approximately 3–20 min) and flight operation capacity. On the other hand, fixed-wing planes operate with fuel and have a higher endurance capacity (1–10 h) [50], [57]. However, the weights of these types of planes increase up to 14 kg, which can induce challenges for flight operation [57]. The main difficulties of UAV are size and weight. In addition, UAVs require a clear or visible view to capture the hyperspectral images. Thus, UAVs are unsuitable for hilly areas, forest areas, or larger land areas [30], [42].

c) Airplane-based hyperspectral imaging: The airplane-based hyperspectral sensor, which was named airborne visible/infrared imaging spectrometer (AVIRIS), was first developed in 1987 [59]. AVIRIS obtained 224 bands of spectral signal in the visible-to-SWIR range. The AVIRIS image data were used to analyze the chlorophyll, water content, yield [60], [61], [62], [63], mapping crop areas [64], [65], pest infections [66], and soil properties [67]. Besides AVIRIS, AISA Eagle, the hyperspectral mapper (HyMap), and compact airborne spectrographic imager (CASI) sensors are used for airplane-based hyperspectral imaging. AISA Eagle is well known to estimate the nitrogen content [68] and biomass of the plants [69]. CASI and HyMap images are used to calculate chlorophyll content [70], crop yield [71], detecting plant stress [72], and biochemical properties [73]. The disadvantage of airplane-based hyperspectral imaging is that the scheduling and flight operation are expensive. The airplanes should fly at 1–20 km to capture medium-to-high spatial resolution of the targets. In addition, the airplanes need to be very steady and stable so that the images are captured and the required resolution is obtained [42], [74], [75]. Some studies show that manned helicopters are used as a platform for hyperspectral imaging as the flight mission is more flexible than airplane-based ones. However, financial constraints for image acquisition with helicopters remain challenging to solve [42], [76].

d) Satellite-based hyperspectral imaging: Over the past few years, some spaceborne hyperspectral sensors, such as PROBA-CHRIS [77], EO-1 Hyperion [78], HJ-1A [79], PRISMA [80], Environmental Mapping and Analysis Program (ENMAP) [81], and HyspIRI [82], have been launched to carry out the satellite-based imaging [71]. PROBA-CHRIS operates in the VNIR region, with a spectral resolution of around 34 nm. EO-1 Hyperion is one of the popular spaceborne hyperspectral image sensors. EO-1 obtains the images in visible, NIR, and SWIR. The spatial resolution of the obtained images is 30 nm, and the spectral resolution is 10 nm. HJ-1A operates within the 0.43–0.90 μm spectral range [83]. The spatial resolution of HJ-1A is 100 m, and the spectral resolution is 5 nm [79]. The temporal resolution for HJ-1A is two days, and the operating distance is 360 km [83]. The PRISMA platform operates in the VNIR region as well as the SWIR region. The spatial resolution is 30 m [84], and the spectral resolution is reported as 12 nm [80]. The temporal resolution is less than 14 days, and the operating distance is 614 km [85]. Similar to PRISMA, the ENMAP operates with the same spectral region of 420–2450 nm. The spatial resolution for ENMAP is around 30 m, and the spectral resolution is 6.5 nm [86]. The temporal resolution for ENMAP is 27 days and the operating distance is 30 km [87]. The HyspIRI has 380–2500 nm of operating spectral region. The spatial resolution can vary from 30 to 60 m, and the spectral resolution is around 10 nm. The temporal resolution of HyspIRI is around 5–16 days [88]. The obtained images through these satellite platforms are used to assess the crop chlorophyll content [89], biomass [90], residues [91], crop disease [92], and soil features [93]. The literature shows that satellite-based hyperspectral image sensors perform satisfactorily for agriculture-based studies. However, the images' data quality and spatial and temporal resolution can affect disease detection in plants [94], [95]. The satellite-based images are also unsuitable for analysis of early pest infestation or disease detection due to their narrow spatial resolution range. The spatial resolution ranges from 17 to 36 m, which is insufficient for detecting minute details of plants for early diagnosis of the diseases. Therefore, this limits the application in precision agriculture [42], [96].

III. Common Plant Diseases

Plant disease and damage occur due to fungal, viral, and bacterial invasions. According to Pimentel et al. [98], around 50 000 parasitic and nonparasitic diseases are reported for plants. When the plants are infected with microbial diseases, the plants start to develop the signs in different areas of plants, which can be different in appearance based on the pathogen infecting the crop [99].

According to plant pathologists, plant disease detection methods include direct and indirect methods [100]. Direct methods are the methods where the pathogens such as bacteria, fungal, or viral diseases are directly identified [101] by using serological methods (such as enzyme-linked, flow cytometry, and immunofluorescence methods) and molecular methods (polymerase chain reaction method, DNA array detection, and fluorescence in situ method) [100]. These methods can provide accurate information about the pathogens causing the diseases [101]. On the contrary, the indirect method detects plant diseases through many other indirect parameters such as a change in transpiration rate, change in temperature, morphological change, or organic components released by the diseased plants [101]. Indirect methods include biomarker-based detection techniques, such as gaseous metabolite profiling, plant metabolite profiling, and plant-property-based disease detection techniques, including both imaging and spectroscopic techniques [100]. Among the imaging techniques, hyperspectral imaging is an emerging technique, as it can capture the spectral profile of plants, which presents the changes in plants' morphological and physiological characteristics. Consequently, hyperspectral imaging is categorized under indirect methods as it identifies the potential symptoms in plants rather than directly identifying the pathogens causing the disease. Hence, this article primarily addresses hyperspectral imaging techniques for plant disease detection, and other methods of plant disease detection are not reviewed.

Diseases commonly start over the small parts in the foliage [7]. Over time, the disease spreads locally and to other plant areas, causing complex symptoms on the plant parts that could be