# Chapter 13
# Application of Fuzzy Logic in Plant Disease Management

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## ABSTRACT

*The timely detection of the infection in plants and its severity is a major concern for the farmers. Although various techniques have been employed to identify and estimate the severity of infection, they generally use a fixed threshold to segment the infected areas from the leaf image. Such methods define the participation of a pixel, as part of the infected area, in the form of a classical or crisp set. Use of fuzzy logic in feature extraction, grading the disease post identification, and estimating the disease severity are seen as rapidly growing techniques. Using fuzzy logic, the infected area is calculated by considering the degree of contribution provided by neighboring pixels to the current pixel. The severity estimation is performed on the basis of the infected area and the number of lesions in the leaf image. Depending on the amount of infection, severity has been classified into early, middle, later, and advanced stage. The proposed technique will help the farmers to identify the disease class at an early stage.*

## INTRODUCTION TO PLANT DISEASE MANAGEMENT

Agriculture is the backbone of majority nations, especially in the Asian and African continent. Not only it caters to the food requirements, but also builds the economy of these countries. However, the agricultural society around the globe is facing a serious threat in the form of loss of production. The Food and Agriculture Organisation (FAO) estimates that pathogens, insects and weeds together are held responsible for this loss as they reduce 20-40% of the total agricultural productivity around the globe (Dangl, Horvath, & Staskawicz, 2013). All plant diseases result from a three-way interaction between the host, the pathogen and the environment. Losses from diseases affects the economy of the region by causing a reduction in the income of crop producers and price rises for consumers. Various studies

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on variations in environmental conditions have been pursued, in different locations, to estimate the losses occur due to different diseases. Various empirical control practices have been discovered for crop protection even before the causal nature of plant diseases. Parts of the world where the daily survival of a large proportion of the population depends on crops, is at risk, since a crop disease leads them to starvation. In 1980, U.S.A suffered a loss of four billion dollars due to plant diseases while in India it was probably even more than that (Rangaswami G and Mahadevan A, 1998). Crop losses due to pre and post-harvest fungal diseases annually exceed $200 billion euros and over $600 million are annually spent on fungicides (González-Fernandez et al. 2010) in the United States alone. In 2007, Georgia faced a loss of about $539.74 million. So resistance to plant disease and managing it are necessary for the consistent supply of food (Bentley et al. 2009; Martinez A, 2007. Less than 25% of Malawi farmers attained self-sufficiency in maize in years (2000–2001) (Devereux S, 2009). In India, the annual estimated losses due to nematodes have been assessed to be about Rs.242.1 billion. In $19^{th}$ century (Biffen, 1905) disease resistant plants were grown and the result was the discovery of variety of plants that were resistant to diseases. Disease management was often based on type of the disease, economic value of the crop and quality or demand of the market because the main objective of plant pathology is to control the disease. However, the term control indicates that the measures are taken only one the disease has affected the crop whereas the word "Management" is about continuous processing and managing the damage such that it does not affect o the economic front. Thus, there is a need to identify any disease in the crop and estimate the quantity of infection so as to curb any potential danger to the life of the plant, thereby contributing towards economical, biological, sociological and ecological losses. Plant disease management firmly stands on the shoulders of two major areas, namely, disease identification (or classification) and severity estimation.

Plant disease identification has come a long way from witnessing proximate detection, immunological (Hampton et al. 1990) and DNA-based methods (Lin et al. 2007), remote sensing technologies (Bock et al. 2010; Mahlein et al. 2012; Zhao et al. 2018) to digital imaging based techniques. In imaging based technique, Segmentation is done to separate the infected region from the entire leaf region based on a threshold value (Fan et al. 2001). Generally thresholding is done to distinguish between healthy and infected area. However, in practice, the healthy and infected region of the leaf are uneven and cannot be distinctly distinguished. Pixels of the infected region do contain some green color in them and vice versa. Fuzzy logic is used to overcome the limitations of crisp thresholding. A fuzzy logic model developed by (Kim et al. 2005) estimates apparent infection rate from the environmental temperature. This infection rate is used to predict the severity of soybean rust. Pang et al. (2011) proposed an adaptive segmentation algorithm by integrating local threshold and seeded region growing. Identification of the disease can however be done by using different feature extraction followed by classification techniques (Dhingra et al. 2018; Parikh et al. 2016).

Severity estimation is also the most critical part of disease management system which primarily aims to quantify the severity with which the plant has been affected. The severity estimation methods should be accurate, precise, reproducible, economical and easy to implement. Different parameters like percentage of infected area (Cui et al. 2010), rust color index (Cui et al. 2010), number of lesions etc. are used to estimate the severity of the infection in a leaf image. The occurrence of the number of spots on the infected leaf area needs to be evaluated under a fuzzy logic system

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