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Deep Learning in Plant Diseases Detection for Agricultural Crops: A Survey

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ABSTRACT

Deep learning has brought a huge improvement in the area of machine learning in general and most particularly in computer vision. The advancements of deep learning have been applied to various domains leading to tremendous achievements in the areas of machine learning and computer vision. Only recent works have introduced applying deep learning to the field of using computers in agriculture. The need for food production and food plants is of utmost importance for human society to meet the growing demands of an increased population. Automatic plant disease detection using plant images was originally tackled using traditional machine learning and image processing approaches resulting in limited accuracy results and a limited scope. Using deep learning in plant disease detection made it possible to produce higher prediction accuracies as well as broadened the scope of detected diseases and plant species considered. This article presents a survey of research papers that presented the use of deep learning in plant disease detection, and analyzes them in terms of the dataset used, models employed, and overall performance achieved.

KEYWORDS

Computer Vision, Convolutional Neural Networks, Deep Learning, Machine Learning, Plant Disease Detection, Precision Agriculture

1. INTRODUCTION

Agriculture is the first human activity that helped humanity to advance and develop. Nowadays, food industry and farming are the most critical activities worldwide, due to the increasing number of population and the increasing growth of their needs for food in order for their life to continue. Agriculture is also the backbone of any economic system for any given country. Not only providing food and raw material, but also it provides employment opportunities to very large percentage of the population (Gebbers & Adamchuk, 2010; Kitzes et al., 2008; Shalaby et al., 2011; Slavin, 2016).

The global food supply is annually reduced by an average of 40% (Oerke, 2006) demonstrating that our collective battle against diseases and pests of crop plants is not won. Indeed, the emergence and spread of novel and highly virulent crop diseases like the stem rustUG99 that attacks wheat, black pod in Cocoa and viral infections of Cassava suggest that the situation may in fact be worsening.

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This is troubling at a time when the UN FAO recommends we must in fact increase the food supply by 70% to feed the future population.

Plant diseases can be caused by different types of fungi, bacteria, viruses, pests, and other agents. Diseased plant symptoms can include leaf spots, leaf blights, root rots, fruit rots, fruit spots, wilt, dieback, and decline (Riley et al., 2002). The major impact of plant diseases is reducing the food available to humans by ultimately decreasing crop yields. This can result in inadequate food to humans or lead to starvation in some areas (Strange & Scott, 2005).

Plant disease recognition is of utmost importance in order to recommend and choose the proper treatment for diseased plants and also prevent infections of uninfected ones. Plant leaf is the most common way to detect plant disease as it shows different symptoms for different diseases. Discovering and subsequently treating plant diseases was done by the naked eye of an expert by manually examining the plants on site and this process is costly, slow and not affordable. For this reason, the need for partially or fully automated plant disease detection systems is a major growing research area.

Traditional image processing techniques provided reasonable results and performance regarding plant disease detection using leaf images, but those were limited to using small data sets and producing theoretical results. As deep learning has revolutionized the area of computer vision specifically the field of image classification and object detection, it is now considered a promising tool to improve such automated systems to achieve higher results, wide diseases scope, and implement applicable real-time plant disease detection systems.

This paper presents a survey on the current state of the art researches in the area of applying deep learning to plant disease detection using leaf images. It is divided into seven sections. Section 2 explores related surveys and determines the scope of this survey. Section 3 discusses the various types of plant diseases. Section 4 presents the traditional machine learning techniques used in plant disease detection using leaf image. Section 5 discusses deep learning and its impact on computer vision especially in the agriculture field. Section 6 introduces a survey of nearly 22 papers that used deep learning in plant disease detection and compare between them in terms of the dataset, models used, and results achieved. Section 7 presents a brief discussion about the surveyed paper. Finally, section 8 provides conclusions and directions for further research.

2. RELATED REVIEWS AND THE SCOPE OF THIS SURVEY

Almost all previous reviews done on plant disease detection were covering traditional machine learning techniques. Recent developments in deep learning were also reviewed independently. Related reviews could be categorized into 1. overviews of deep learning techniques 2. reviews of using traditional machine learning and image processing techniques in plant disease detection 3. reviews of using deep learning in plant disease detection. The former category was only found in one survey paper that discussed using deep learning in agriculture with plant disease detection as one out of many other application fields. These efforts can be summarized in Table 1, and in this section the most representative publications in each class will be discussed.

2.1. Overviews of Deep Learning Techniques

Authors in Lecun et al. (2015) gave a milestone overview of deep learning, introduced several popular deep learning-based models, and gave insights about the future improvements on using deep learning. Meanwhile, in Schmidhuber (2015) the author dug deep to the origins of deep learning conducting an encyclopedic survey that covered the evolution, methods, applications and future of deep learning. While in Liu et al. (2017) the authors reviewed the latest developments of deep neural networks, and investigated some widely-used architectures and applications such as speech recognition, pattern recognition, and computer vision.

A Study of the Cascading Effects of Ambulance Diversion among Hospitals

Abey Kuruvilla, Suraj M. Alexander and Xiaolin Li (2011). *International Journal of Information Systems in the Service Sector (pp. 60-70).*
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