Chapter 14

Optimized Deep Learning System for Crop Health Classification Strategically Using Spatial and Temporal Data

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ABSTRACT

Deep learning opens up a plethora of opportunities for academia and industry to invent new techniques to come up with modified or enhanced versions of standardized neural networks so that the customized technique is suitable for any specialized situations where the problem is about learning a complex mapping from the input to the output space. One such situation lies in a farm with huge cultivation area, where examining each of the plant for any anomalies is highly complex that it is impractical, if not impossible, for humans. In this chapter, the authors propose an optimized deep learning architectural model, combining various techniques in neural networks for a real-world application of deep learning in computer vision in precision farming. More precisely, thousands of crops are examined automatically and classified as healthy or unhealthy. The highlight of this architecture is the strategic usage of spatial and temporal features selectively so as to reduce the inference time.

INTRODUCTION

There are numerous types of neural networks being invented and introduced on a daily basis. While such new neural network models can be designed and evaluated quickly, configuring them in a way to get the best out of them is quite challenging. That is why “configuring neural network models” is often termed as a “dark art.” The reasons for the lack of guidance can be attributed partly to the fact that many of the

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techniques in machine learning space quickly lose relevance as faster and higher power hardware with superior architecture replace older hardware at a rapid rate. Another prime reason is that there can never be one best algorithm that works best for all cases as it is not possible to analytically evaluate the optimal configuration for a given problem and data set. It is always possible to tweak the configurations to make improvements to speed of learning, right-fitting of the model, accuracy of inference, etc.

Moreover, data for neural networks will be from several different sources. For example, in precision farming, data will come from multiple sensors, cameras, etc. Some of these might be complex data like multispectral images. Many neural network models can’t handle highly complex data. Others may not accurately capture the relationships between different variables. Hence there is a need to create a neural network system that would take simple and complex data as input and the system should be capable of working around the missing variables.

There are also some newer neural network architectures that can take multiple, heterogeneous inputs and extract features on their own and share the “learnings” with downstream sub-systems, thereby facilitating creation of an optimal learning system. Developing such deep learning systems working on heterogeneous data is very challenging since each data type may need distinct pre-processing steps and feature engineering. Hence it is still very much an open area of research and is very often heavily dependent on the specific problem on hand.

BACKGROUND

As evidenced by the detailed survey captured in (Radhakrishnan & Vijayarajan V., 2019), even as there are various researches happening in Deep Learning in the context of Farming 4.0, the economic viability of its application is still very less. The literature survey further provides research direction to optimize deep learning applications for monitoring crop health so as to make this technology useful to farmers. Hence the domain considered for this research work of optimizing deep learning system is “Precision Floriculture” in Green House cultivation where the produce is cut flowers.

That said, there are various researches being carried out to employ Deep Learning to classify plants based on their botanical parts like leaf, flower, etc. Han et al. (Han, Seng, Joseph, & Remagnino, 2017) investigated the use of deep learning to extract discriminatory features from images of leaves by learning and use them as classifiers to identify plant species. Their results demonstrate that compared to using hand crafted features of leaf images, learning the features using CNNs do provide better feature representations.

Gurnani et al. (Gurnani, n.d.) developed a deep learning framework to categorize flowers by doing transfer learning from two famous CNN architectures called GoogleNet which was pre-trained on ILSVRC2014 dataset and AlexNet which was pre-trained on ILSVRC2012 dataset and found their accuracies to be 47% and 43% respectively. By the way, ILSVRC stands for ImageNet Large Scale Visual Recognition Competition. In this study they confirmed the popular claim by researchers that the performance of the neural network will be commensurate with the depth of the network. This claim is further ascertained by Liu et al. (Liu, Yang, Cheng, & Song, 2018) who designed a very deep leaf classification model using a ten-layer CNN based on LeNet architecture to classify 32 species of plants and achieved an accuracy rate of 87.92%.