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A REVIEW ON PLANT SPECIES CLASSIFICATION USING DEEP LEARNING

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ABSTRACT

Agriculture is vital for the existence of humans, which stands as a major driver of several economies around the world. It creates opportunities to lift people out of poverty in both developing and under developing nations. Due to the growing global population and the challenges faced by climate changes, there is an increasing need for farm outputs with minimal costs. The weed spread on the farmlands will create crops reduction. There will be able to use the most effective methods to control weeds. In the running world, a great deal of interest in the development of new methods. Machine learning has a great demand in the field of agriculture due to it's high accuracy. This paper discussing about different deep learning approaches that are designed for classifying different plant species from weeds.

KEYWORDS: Deep learning, weeds, Plant Species.

1. INTRODUCTION

Plants are an integral part of ecosystem. Plants continue to serve as a source of food, medicine and oxygen for all life on earth. They are also useful in many industries. Hence without plants it is difficult to think of the existence of human life on earth because plants have an important role in the natural circle of life. Agriculture is predominant in many countries. Proper automation of the farming process should help to optimize crop yield and ensure continuous productivity. The transformation of the agricultural sector by use of smart farming methods can boost the economic growth in many countries. According to this, there is a strong link between increased productivity as well as economic growth. One of the major reason for reduction in crop yield is weed spread on farmlands. Weeds typically don't have any useful worth in terms of food, nutrients or medicines however they need accelerated growth and parasitically compete with actual crops for nutrients and area. Inefficient processes like hand weeding has led to significant losses and increasing prices beacuse of manual labour[2].It is harsh to spot the weeds due to unclear crops boundaries, with varying rocky or sandy backgrounds.

For plant classification trained taxonomist and botanist follows various methods. They follow many methods such as morphological anatomy, cell biology and molecular biological approach [1].These way square measure needed to follow several vital tasks. Performing these tasks is time consuming process and it requires more efforts. Traditional classification methods are likely to fail on this task.

Exploiting recent artificial intelligence methods like Deep learning[4] to automatically classify plants is vital for improvement of the recognition accuracy. Classification is an active research area in pattern recognition which has been used in many applications that involves a decision mechanism that assigns a new observation to a set of classes, based on a training dataset. *The independence of human intervention in training the model is good advantage of deep learning methods.* Traditional methods largely rely on manually crafting descriptors and characteristics. in this paper, a review of Deep Learning (DL) method that can extract features from two-dimensional plant images for plant species classification is proposed.

2. DEEP LEARNING METHODS FOR PLANT SPECIES CLASSIFICATION

A. Probabilistic neural network(PNN)

PNN is a widely used feed-forward neural network [5] for Classification and pattern recognition. In a PNN, the operations are organized into a multi layered feed-forward network with four layers: Input layer, Pattern layer, Summation layer,Output layer.PNN [6] is widely used in classification problems.When an input is present, the first layer computes the distance from the input vector to the training input vectors.This produces a vector where its elements indicate how close its input is to the training input. The second layer sums the contribution for each class of inputs and produces its net output as a vector of

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CODEN: IJESS7

probabilities. Finally, a compete transfer function on the output of the second layer picks the maximum of these probabilities, and produces a 1 (positive identification) for that class and a 0 (negative identification) for non-targeted classes.

Stephen Gang Wu et al. (2007) [7] utilises a leaf recognition approach based on a probabilistic neural network (PNN) for plant classification. Proposed method used many features for recognition purpose such as geometric and digital morphological features. Firstly, they apply a preprocessing step. Secondly, 12 features have been extracted, then Principal Component Analysis (PCA) algorithm [8] was applied for the purpose of dimensionality reduction. Finally, the PNN was applied as a classifier. This approach achieved an accuracy greater than 90%.

B. Convolutional neural network(CNN)

Convolutional Neural Networks(CNN) is a type of artificial neural network architecture designed for specific tasks like image classification.CNN [9,10,11,14] were inspired by the organization of neurons in the visual cortex of the human brain. They provide certain interesting features that are useful for processing certain types of data like images, audios, and videos..A CNN is composed of an input layer, output layer and mutiple hidden layers.For basic image processing, this input is typically a two dimensional array of neurons which correspond to the pixels of an image. It also contains an output layer which is typically a one dimensional set of output neurons. Hidden layers consist of convolution layer, pooling layer and fully connected layer.

Sue Han Lee et al. (2015) [10] utilises convolutional neural networks (CNN) to learn unsupervised feature representations for 44 different plant species[13] and employ a deconvolutional networks (DN) [3] to visualize the learned features.Proposed method gained an accuracy of 99.5%.

Mads Dyrmann et al. (2016) [11] presents a method that is capable of recognising plant species in colour images by using a convolutional neural network.The network is built from scratch trained and tested on a total of 10413 images containing 22 weeds and crops species at early growth stages.A custom architecture of CNN is used in this method rather than a pretrained CNN architecture.For these 22 species, the proposed system achieve a classification accuracy of 86.2%.

Ignacio Heredia et al. (2017)[14] built a a large scale plant classification algorithm based on convolutional neural network architecture[16] such as the ResNet50.This approach uses three set of dataset for plant classification: Google Search Images, Portuguese flora dataset,i Naturalist website.Top1 and Top 5 accuracy of these datasets are increased compared to usual plantnet architecture.

Yu Sun et al. (2017)[17] proposed a 26 layer ResNet architecture for plant identification innatural environment. Firstly, plant image dataset collected by mobile phone in natural scene is presented, which contains 10000 images of 100 ornamental plant species in Beijing Forestry University campus .Secondly, a Flavia leaf dataset is considered. A 26-layer deep learning model consisting of 8 residual building blocks is designed for large-scale plant classification. This approach achieves a recognition rate of 91.78% on the BJFU100 dataset.

Josef Haupt et al. (2018) [12] used the Inception, ResNet and DenseNet architectures for large scale plant classification. This method trained on the dataset containing 10000 classes. An ensembleconsisting of aResNet50 and two DenseNet201 with fine-tuned class weights reached a top1-accuracy of 77% on the test set.

Andres Milioto et al. (2018) [18] presents CNN based visual pixel-wise semantic segmentation to identify crops and weeds.CNN-based semantic segmentation of crop fields separating sugar beet plants,weeds,and background solely based on RGB data by proposing a deep encoder-decoder CNN for semantic segmentation that is fed with a 14-channal image storing vegetation indexes and other information that is in the past has been used to solve crop-weed classification.This method attained an accuracy of 89.55% on Zurich dataset and 91.88% on Stuttgart dataset.

C. Recurrent neural network(RNN)

The recurrent neural network (RNN) [20] unlike other neural networks, can operate effectively on sequences of data with variable input length.RNNs uses knowledge of its previous state as an input for its current prediction.RNN work well for applications that involve a sequence of data that changes over time.

Sue Han Lee et al. (2018)[21] proposes a multi organ plant classification based on CNN and RNN. Other approches focus mainly on generic features for plant species classification, disregarding the features representing plant organs[15]. They presents a hybrid generic organ convolutional neural network which takes both organ and generic information under consideration. Combining them for species classification. Also propose a new framework for plant structural learning using RNN.

D. Generative adversarial networks(GAN)

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

The Generative Adversarial Network(GAN) [22] is a combination of two deep learning neural networks: a Generator Network and a Discriminator Network.The Generator Network produces synthetic data, and the Discriminator Network tries to detect if the data seeing is real or synthetic.

Mario Valerio Giuffrida et al. (2017) [23] implemented an alternate solution of dataset augmentation for plant phenotyping, creating artificial images of plants using Adversarial generative networks.Proposed the Arabidopsis Rosette Image Generator through GAN:inspired by DC-GAN(adversarial network model using convolutional layers).It is able to create 128 × 128 RGB images of Arabidopsis plants.That can utilised for plant species classification.\

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3. ANALYSIS AND PERFORMANCE

A. Datasets

Most popular dataset for plant seedlings classification contains a set of 4275 images of approximately 960 unique plants belonging to 12 species[19] like *Black-grass, Charlock, Cleavers, Common Chickweed, Common wheat, Fathen, Loose Silky bent,Maize,Scentless Mayweed, Shepherds Purse,Small-flowered Cranesbill, Sugar beet* is shown in Fig 1.

Fig 1.Random samples of plants in the dataset.

B. Performance

The paper compares the performance of methods mentioned above. Methods listed in Table 1 shows the datasets used and average accuracy.

Each methods have its own merits and shorts. Performance of different methods mainly depends on the type of data and number of avilable data. Performance of CNN mainly depends on type of architecture used. There are several pre trained architecture for CNN like GoogLeNet and VGGNet,ResNet etc.

Table 1. Summary table for plant species classification methods

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Author	Datasets	Methodology	Accuracy
Bao, F. S (2007)[7]	1800 leaves of 32 kinds of plants	Probabilistic Neural Network(PNN)	Above 90%
Sue Han Lee(2015)[10]	MalayaKew (MK) leaf dataset which consists of 44 classes, collected at the Royal BotanicGardens, England.	Both CNN and decovolutional network(DN).	99.5%
Mads Dyrmann(2016)[11]	6 types of datasets are combined.The images contain 22 different plants species.	Custom architecture of CNN is used.	86.2%
Yu Sun(2017)[17]	BJFU100 dataset contain 100 ornamental plant species	ResNet-26 architecture.	91.78%
Ignacio Heredia(2017)[14]	3 types of dataset :Google Search images,Portuguese Flora,iNaturalist images	ResNet-50 architecture	Top1 and top5 accuracy of three sets are 40%&63% and 29%&47% and 33%&49% respectively.
Andres Milioto(2018)[18]	3 types of datasets:Bonn,Zurich, Stuttgart.	CNN based visual pixel-wise semantic segmentation	An accuracy of 89.55% on Zurich dataset and 91.88% on Stuttgart dataset and 94.74%on bonn.
Josef Haupt(2018)[12]	PlantCLEF 2017 dataset.	Inception,ResNet50 and DenseNet201 architectures.	Top1 accuracy of 77%.
Sue Han Lee(2018)[21]	The PlantClef2015 dataset was used. It has 1000 plant species classes.	Hybrid generic-organ convolutional neural network (HGO-CNN) and RNN	Top-1 accuracy of model is 68.5%.
MarioValerio Giuffrida(2017)[23]	CVPPP 2017 dataset.	Generative Adversarial Network	-

4. CONCLUSION

This paper reviewed the popular and successful deep learning approaches between the years of 2005-2018 for plant species classification. Deep learning has gained tremendous progress because it uses big data, powerful computer, and algorithms. An efficient deep learning model for plant classification can help farmers to optimize crop yields and significantly reduce losses in farmlands. One of the prominent method such as the convolutional neural networks achieved high accuracy with significantly reduced error rate compared to the other deep learning approaches in the field of image classification. The CNN models are an extension of artificial neural networks.CNN use little pre-processing when compared to traditional classification algorithms.CNN is a supervised deep learning approach which requires large labeled data for training on the network. After training the model, will learn the weights and the accuracy of the classifier is improved. Thus they have a great value in future in the agriculture sector.

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