Deep Phenotyping: Disease Detection In Santalum Album

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Abstract- *Phenotyping of plants using the technological tools is not a new concept. Deep learning methodologies have been employed to learn the plants and their interaction. Though many technological advancements have been made to overcome the traditional methods of phenotyping, in the end there is always something that is missed. Convolutional Neural Networks have been very effective in plant phenotyping and classification of plants. Sandalwood is the most valuable tree of India. It is used for its wood and oil. Like most other agriculture crops, Sandalwood is grown and harvested for its wood and its aromatic fragrant oil. In this paper, we discuss about employing DenseNet architecture to predict the health of sandalwood trees and also analyze the root sensor data to predict early diseases in its roots.*

Keywords- Phenotyping, Deep learning, DenseNet, sandalwood trees, Convolutional Neural Network, root sensor data.

I. INTRODUCTION

Phenotyping has been gaining a lot of popularity in the recent times of agriculture. It is a method of observing plants, environment and their interaction with the climate. Before the advancement of computer technology and the image processing algorithms, the plant and their interaction were checked manually. But this was a tedious job and gave inaccurate results. As the technology evolved, the methods of assessing the plant properties turned to computer thereby reducing the human efforts. Technologies such as machine learning and deep learning, with the current supply-demand structure, have proved to be faster, efficient & effective in assessing the plant traits correctly. Now, phenology is not restricted only to agricultural plants but can also be used in agro-forestry. Clonal multiplication of selected phenotypes is a key step in forest tree breeding [1]. Convolutional Neural Network (CNN) has been used from counting the number of trees to assessing their health in the forest. Santalum album also known as Sandalwood tree in common terms, is a tree which is mainly found in the southern parts of India and are harvested majorly for its medicinal properties. Sandalwood tree is the source of highly priced and fragrant heartwood which on steam distillation yields up to 5-7% of high-grade aromatic perfumery oil [2]. Hence, sandalwood is now commercially grown to extract the oil for government legally. But given the changing climatic condition, the trees are prone to insects such as **Indarbelaquardinotata,** abark eating caterpillarand is prone to diseases such as **spike disease** which can start at any stage of growth and can kill the plant if not treated.The sandalwood timber and oil have a greater demand in the market and each tree takes a minimum of 30 years for a full harvest. To supply to the demand a large number of trees have to be grown and taking care of so many trees is a difficult job without any proper technological intervention. Many deep learning methodologies such as deep CNN and dense CNN have been used in many computer vision problems to extract the smallest of feature in the image. This can be extended in plant phenology. Spatio-temporal vegetation classification is a very challenging task [3] since it has to handle: 1) High volumes of temporal data [4]; 2) missing data [4]. Many studies are made and many models are derived to solve the above problems which greatly use deep learning methods but the problem of missing data challenge is yet to be fully resolved.

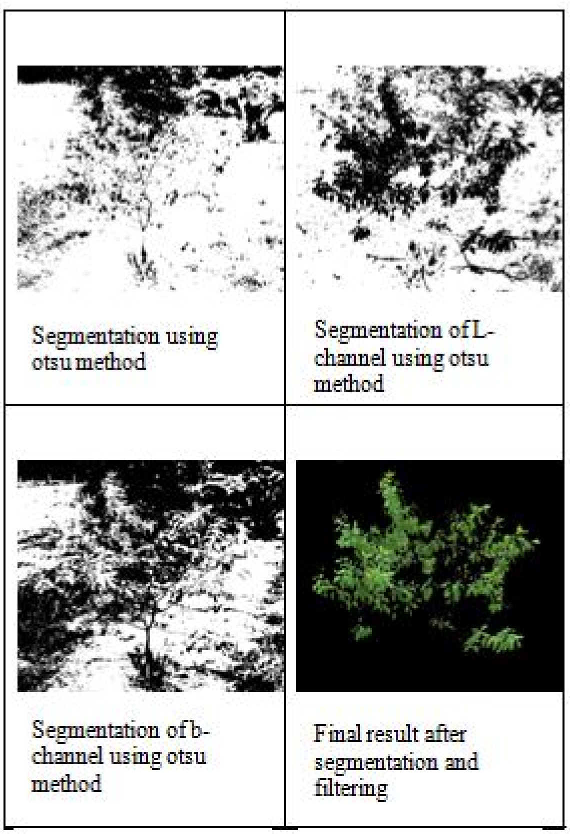
Technically this paper focuses on using **DenseNet,** a CNN model which is a iterative concatenation of previous feature maps [5]. The high-resolution spatio-temporal images of the sandalwood trees which are captured through UAVs are used for semantic segmentation and classification using fully convolutional DenseNets. The DenseNet consists of 4 dense blocks which produces k feature maps on each block, a feature extraction layer i.e. Convolutional layer which is a bottleneck that reduces the total number of feature maps and a transition layer. This makes DenseNet more adaptable to missing data as well. The soil type and water holding capacity determines the health of the roots. Through soil sensors, the plant’s reaction to irrigation [6] and its health. The same model can also be used to determine the health of the soil using the root moisture sensor data. The data from the sensor is recorded and fed to DenseNet prediction model which then determines what is the condition of the roots of the tree.

II. PREVAILING SYSTEM

A large consumer of sandalwood oil as perfumes, essential oils and as medicines, the demand for the product keeps increasing. This requires healthy trees to cope with the demand. Deep learning is not a new concept in the field of agro-forestry.

The introduction of deep learning with better classification methodology has transformed the agricultural world. With advanced image detection, classification and semantic segmentation has enhanced the farming capabilities. CNN is the most commonly used deep learning method used for pixel classification.

The basics of phenology start with analyzing the tree content. The prevailing system uses digital image processing technique to give out real time determination of nutritional content which are naturally produced in the trees. The system uses a segmentation algorithm “growth status” and error-in-variable model. The model considered 48 groups of random data modelling and 24 groups for evaluation of sandalwood trees**.**



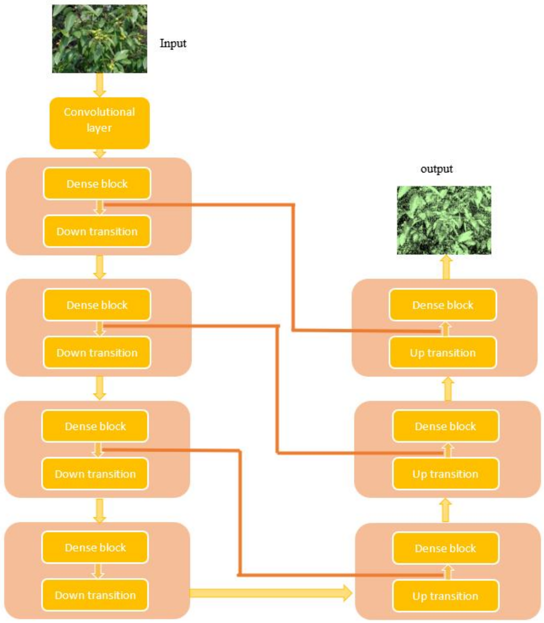
The results show that the exponential function using the Lab color system 1yields the most satisfying accuracy and precision in the regression and validation [7].

The prevailing system only determined the nitrogen content present in the sandalwood trees. But this can be further extended to analyze the interactions of the tree with the environment and also include early detection of probable diseases in the tree. It can also be observed that through deep leaning models such as DenseNet will give out approx. 95-96% accurate results.

III. THE PROPOSEDSYSTEM

Indian sandalwood is found in major regions of Karnataka,Tamil Nadu, Kerala and few states of central India.

The proposed system employs Dense Convolutional Network architecture called DenseNet. In DenseNet, each layer is connected to the next layer in such a way that network can reuse the feature map from the previous step. This method increases variation in the input of subsequent layers and improves the efficiency of the network [8]. But a DenseNet can alone not perform the semantic segmentation of the image set. Hence, this paper approaches the segmentation and classification of images using unsupervised fully convolutional DenseNet. This is a real-time approach which can motion patterns.



The system employs 4 layers of Dense block. The system consists of a 1x1 convolution layer is a bottleneck layer which reduces the total number of feature maps in the system. This reduces the computational cost and memory.

taken to evaluate the image set. The transition layer is added in every dense layer which also acts as a bottleneck and reduces the total feature maps. This will also further compact the system architecture. Before every dense block, the feature maps are concatenated and rejoined to the next layer. Each layer will give out a set of features extracted from the image ie 4 feature maps. These features are concatenated and passed to next dense layer where 4+1 feature maps are extracted. In the last l^{th} layer will receive feature maps of all the preceding layers as inputs:

$$x_l= H_l([x_0, x_1, \ldots, x_{l-1}]) \text{ ------------------[9]}$$

The result of the final image should be able to extract the specified disease features out from the image. Similarly, the root sensor data can also be used to derive the health of the roots in a similar fashion.

IV. RESULTS AND CONCLUSION

4.1 Comparison of results from existing system and ours

Model	Training time (in hrs)	Accuracy(%)	
		Spike disease	Root
Digital image processing	3	—	—
Multi-temporal ConvNet	16	100%	100%
DenseNet	0.13*	100%	100%

4.2 Error and accuracy for different pixel resolution

Resolution of the image	Error(%)	Accuracy
384x384	5	98.12
512x512	3.83	99.06

In this paper it was observed that the unsupervised fully conventional DenseNet achieves better accuracy results and also the runtime is shorter. Since it can work on real-time motion patterns, it can be able to classify and detect the diseases with running UAVs. The roots sensor data is continuously collected and stored in the server and is evaluated using the model. This system gives an insight to how to assess the environment of Sandalwood trees. Though the system has better performance capability, the errors in the layers can be further minimized by reconstructing the feature maps. This greatly reduces the errors that occur in each layer on DenseNet.

V. CONCLUSION

In this paper, I would like to conclude that the proposed system is an approach to detect the possible disease in Santalum album trees. It was also observed that the presented approach has been a better and faster solution in phenotyping than the previous systems. The system can also be further improved to complete phenotyping and also to reduce the errors in the model. The proposed system does contain few errors that can be reduced with appropriate layer added to the model or with a better future model.

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REFERENCES

[1] V.A bapat,1979. “Somatic Embryogenesis and Plantlet Formation in Tissue Cultures of Sandalwood (Santalum album L.)”. *Annals of Botany* Vol. 44, No. 5 pp. 629-630
[2] Babita Mishra,2018. “SANDALWOOD FARMING IN INDIA: PROBLEMS AND PROSPECTS”. Indian Journal of Tropical Biodiversity26(1): 1-12
[3] K. Anderson,2013. “lightweight unmanned aerial vehicles will revolutionize spatial ecology”. Frontiers Ecology Environ.,vol 11, pp 138-146
[4] Keiller Nogueira, Jefersson A. dos Santos,2019. “Spatio-temporal vegetation pixel classification by using Convolutional networks”. IEEE, 1545-598X
[5] Simon Jegou,2016. “The one hundred layers Tiramisu: Fully Convolutional DenseNets for sematic segmentation”. Arxiv. 1611.09326v2
[6] Manuel Figueroa and Christopher Pope,2017. “Root System Water Consumption Pattern Identification on Time Series Data”. MDPI,sensors.
[7] Zhulin Chen, 2018. “Preliminary research on total nitrogen content prediction of sandalwood using the error-in-variable models based on digital image processing”. Journal pone. 0202649
[8] Gao Huang, 2016. “Densely connected convolutional networks”. Arxiv. 1608.06993v3
[9] Yi Zhu, 2017. “DenseNet for Dense Flow”. Arxiv. 1707.06316v1
[10] Jordan R Ubbens, 2017. “Deep plant phenomics: A deep learning platform for complex phenotyping tasks”. Front. Plant. Sci. 8:1190
[11] H S Baweja,2018. “StalkNet: a Deep learning pipeline for high-throughput measurement of plant stalk count and stalk width”. Springer proceedings in advanced robotics .10.1007
[12] Roland Pieruschka,2012. “Phenotyping plants: genes, Phenes and machines”. Functional plant biology.813-820
[13] Ji Yoon Kim,2019. “Deep Dense Convolutional networks for repayment prediction in peer-to-peer lending”. Advances in Intelligent Systems and Computing, 771-2194-5357.