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Toward Automated Biodiversity Research on the Tropical Ecosystem Using Artificial Intelligence

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Abstract

Biodiversity plays an important role in the tropical ecosystem. Many forests have been uprooted by the plantations as they promise better and more yields. These conversions have a bad impact on the overall ecosystem as many of the species in the original forest have gone during the process. How much species still exists on the plantation or certain fields? This is a major issue in order to determine the species diversity of the plantation or field. The biodiversity can be measured using different methods, such as counting the number of individuals or even families in a given area. Due to the size of the field, an automated process could be a great help to produce those metrics. This paper presents algorithms for species classification. The algorithms show a positive result, where the precision of 61%, (the system was trained using a sparse dataset) could be improved after increasing the dataset. In the preliminary stage, the systems were trained using a few species only using convolutional neural networks to check the feasibility and challenges. Furthermore, more species may be included in the training sets and the algorithm may be used to detect the species in real-time. For the purpose of getting the species diversity index, having an algorithm that could determine the number of different species on the data-sets would be enough. The system does not need to tell the name of the particular species in detail. The final result is not only available for the tropical ecosystem but also an ecosystem where the species diversity index of the plants needs to be evaluated. Along with this neural network, there have also been algorithms developed using Open CV library in Python to extract the number of individual plants in a picture with an accuracy of above 80%. The algorithm uses hue, saturation, value extraction, and image segmentation from the image to determine the number of plants. The result provides solid findings for further development of the algorithms to be deployed in real-time in integration with drones or field robots.

Keywords: Artificial Intelligence, biodiversity, Computer Vision, Deep Learning, Tropical Ecosystem

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Introduction

A large number of forests and lands are cleared yearly to make more room for plantations (Barlow et al. 2007), specifically in tropical lands such as oil palm plantations in Indonesia. Although they promise to replant the forest, in doing so there has been irreparable damage to the ecosystem. Some species of plants that were present in the original ecosystem may not appear again, even if the forests have been restored. This has an effect on the ecosystem services which in turn has an adverse effect on the climate (Barlow et al. 2007). That's why there has been a need to keep the track of biodiversity in an area specifically at a time like now. So that even when the forest is being restored, one can determine what species needed to be included.

However, to keep track of the species in a forest is very painstaking. To go and individually count each and every plant on the field is not only cumbersome but if it's a large area, it might take days or even months to go through the entire forest, especially if it is a biodiverse hotspot.

Thus there has been a need to get a species estimation, either in the form of numbers of species present or just in any metric that provides value to the species richness within a certain area in the forest (Brooks et al. 2006). The name of the species may not have to be known specifically for this method to work.

A lot of researches in automated plant tracking has been done in the past (Sandbrook, 2015). This includes the use of satellite imagery to keep track of deforestation, the use of drones to make orthomosaic images (Lucieer et al. 2014) and software algorithms to get an estimation of biodiversity. Sensors such as LiDAR (Dubayah & Drake, 2000) and hyperspectral camera (García-Allende et al. 2010) have been used to get the estimation.

The drawback of such a system is that they are expensive and require a lot of effort, for example, the satellite imagery needs to undergo various processing (Nagendra & Doccio, 2008) to make sense of the data, so as creating an orthomosaic image (Lucieer et al. 2014). Furthermore, these are not fully automated but still require human intervention.

Therefore, a system for improving automation in biodiversity research need to be designed. One way of achieving it is by incorporating the novel use of Artificial Intelligence which is discussed in this paper along with real-time application of such a system. This method can be employed in any kind of ecosystem and integrated with drones or field robots to make it fully autonomous system for biodiversity estimation.

This paper presents an application of computer vision and artificial intelligence for tracking and identifying the species of plants and getting a rough estimation of the biodiversity index that might be present in a particular area. At a time where wildlife protection has become a must, these techniques can help researchers to keep an automated track of the biodiversity index while minimizing the manual tasks.

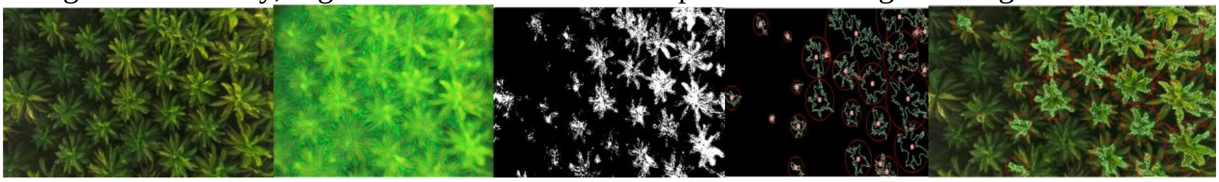
Methodology

Initially, there was an attempt to get information such as the red, green, and blue (RGB) value of an image containing a plant or a particular species of plant. This was done in order to extract the plant out from the background such as soil or other plants. Soon it was found that to properly extract a plant from an image with just considering the RGB colour space is not feasible, especially where other plants are covering the background. Therefore, there is a need to convert the RGB colour space to other colour spaces in an attempt to classify or extract the species. This process proved to be quite useful as a lot of data was extracted and the plants could be more or less determined using this technique. However, the robustness of such a system was extremely limited, that is why there was a need for an alternative algorithm.

In order to improve the classification result, a feature extraction algorithm using Artificial Intelligence was used. For this purpose, a test rack was created which features different plants such as leaves and stems were captured and analysed. This was done in order to observe how the algorithm performed under a fully controlled environment where just selected individual features are exposed to the algorithm. The result should provide the knowledge of whether the developed A.I. algorithm is able to differentiate these features or generalize them as leaves or stems. This step gave us a benchmark for the next A.I algorithm that was developed which were trained on the whole plant where other plants also coexist on the images. The dataset comprises of 200 images with 3 different species. Knowing species name was not necessary, but differentiating the species from the others was crucial for the algorithm for successful classification. This algorithm was developed using a deep neural network and trained for two weeks with these image datasets.

Results and Discussion

The results obtained from two different algorithms were very promising. Figure 1 depicts an example of the image processing steps done by the algorithm to count the number of palm trees. Figure 1.a. shows an aerial image of oil palms as input for the algorithm. Figure 1.b. presents the HSV colour space from the image and Figure1. c. shows the binary image after the segmentation. The final contour extraction after the image has been segmented based on different hues is shown in Figure 1.d. Finally, Figure 1.e shows the detected palms in the original image.



a b c d e

Figure 1: Processing of an oil palm plantation aerial image using open CV in python.

The algorithm is simple but performed well. With just using the hue information, the algorithm was able to detect the number of oil palms with an accuracy of above 80%.

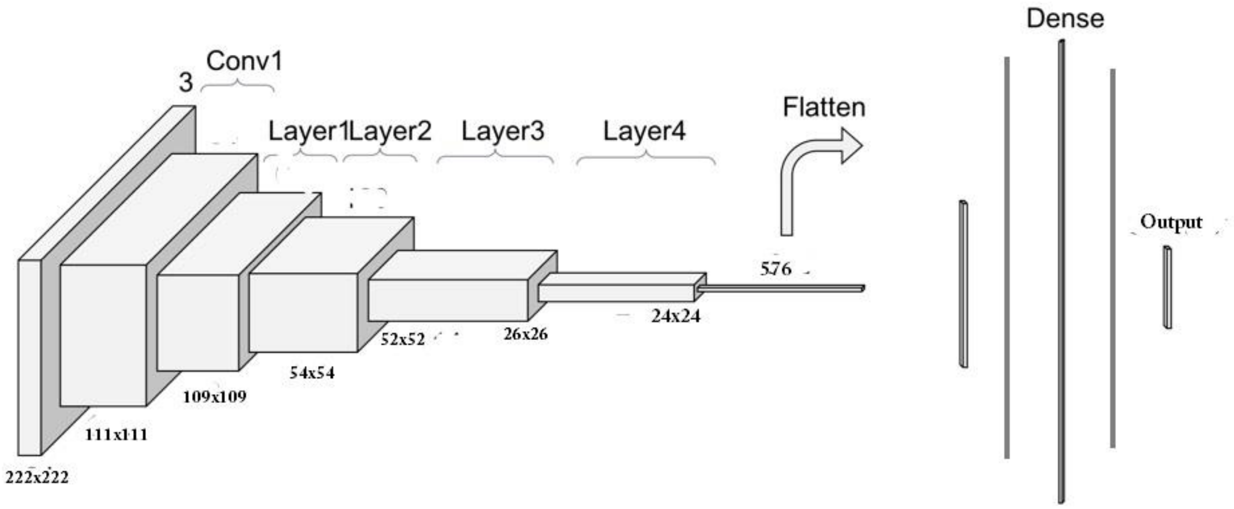


Figure 2: Convolutional Neural Network (CNN)

Six different convolutional models were created and tested, out which this was chosen as it outperformed the others. This consist of five convolutional layers and with a fully connected recurrent network with three hidden dense layers; the model as shown in Figure 2. was chosen for final evaluation. In this model, an image size of 222x222 pixels was convolved to extract important features and reduce the size to a mere 24x24 image which was fed into the recurrent neural network to produce the output as the three species of plants. To train one such a model takes a long duration of time especially when it is done on a regular Central Processing Unit (CPU). After two weeks of parameter and hyperparameter tuning the accuracy of the model was increased from 35% to about 61%. This can be further improved by extending the dataset and increasing the number of species to be classified. Figure 3 shows the prediction sample of the model. The left-most column represents the true labels and the plants while the other three represent the output shown as the confidence level of each species. The model gets almost three of the 4 predictions correct.

True results		**Species A**	**Species B**	**Species C**
Species B		9.9 %	**61.5 %**	28.5 %
Species C		6.3 %	69.2 %	**24.5 %**
Species B		3.0 %	**78.0 %**	19.0 %
Species A		**41.1 %**	16.0 %	42.9 %

Figure 3: Prediction of the trained model

Conclusions and Outlook

As shown in the results, the deep neural network gives a promising result towards classifying plants with reasonable accuracy of 61%. This has encouraged the formulation of better deep neural algorithms that can be deployed in real-time such as the “You Only Look Once” algorithm and the “Single Shot Detection” algorithm (Liu.W et al. 2016). Both algorithms can be used for robust real-time deployment towards automated biodiversity research. However, the initial training of the species depends on the datasets of images fed into it. Therefore, a good collection of datasets is crucial. Once a dataset is created, new species can be added into it and trained. Moreover, the software can be upgraded further to improve the accuracy. These trained models can also be integrated with drones for automated classification and biodiversity estimation.

With the promising results obtained in the experiment, further development can be done using special cameras such as multispectral or hyperspectral. The main challenge is the deployment of the software and integration with drones or other autonomous rovers which can open up a whole new area of research on its own.

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