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# 1 Introduction

## 1.1 Introduction To Problem

Plants underpin life on earth, they are fundamental to humankind as most of them carry information necessary for the progress of human society. Majority of the products we utilize today are from plants. Food and oxygen for the entire biosphere, biofuel, essential medicines and the significant role they play in climate regulation. We have till date documented Over 30,000 plant species which provide essential Uses Figure 1. Agricultural yield and its products play a significant role in the economy of various countries.

Approximately 390,900 plants species have been discovered by botanists and 2000 new plant species are discovered each year ( Shreya Dasgupta, 2016). 40% of the plants species today are at the threat of extinction (Open Access Goverment, 2020) due to deforestation, change in climate and loss of habitat. Plant species are described as a “treasure chest” of medicines and food, and they have in the past demonstrated to assist humanity in tackling complex challenges. “The planet may be losing plant species more quickly before we can find, name and study them. This could have severe consequence’s as some food crops are resilient in the face of climate change” (Pavid, 2020). Discovering, defining, classifying and naming a species has so become a critical task, if we do not know a species exist we cannot protect it (Pavid, 2020).

Classifying and documenting them has become critical to progress in sectors of Botany, Pharmaceutical and Agriculture. The pace of species identification needs to be accelerated. If we do not move fast One third of the plant species could be gone in 50 years (University of Arizona, 2020). We are so, in a race against time to find, inspect and document Plant species before they go extinct.

Chart, bar chart

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Figure 1

## 1.2 Motivation And Targeted Audience

Plants vary greatly in diversity, the difficulty to classify plants is greatly enhanced as many species show resemblances in their structure Figure 2. Botanists are the people who study plants, by studying their morphological features (size, shape, margin and colour), they are able to classify the plant to a particular species. It would be a dreadful or even an impossible task to classify all plants, considering the volume of species that could be between 5 - 50 million (Stuart Pimm, 2010).

Encoding pre-defined morphological features of a leaf to a computer vision system by botanist has been applied in the past, but this method isn’t promising as this depends upon the ability of computer vision experts (Karim & Beikmohammadi, 2018, pp. 21-26) and Certain methods that have been used before only perform good on a particular set of datasets to a specific species (Zhang, et al., 2015, pp. 2143 - 2150). Several studies and research have been conducted in this area, but we still haven’t been able to produce a definitive solution and thus plant classification remains a challenging and unsolved question.

Deep learning has demonstrated great potential and produced promising results with its image processing, object detection and speech recognition techniques. It’s been deployed successfully in various areas to solve complex problems and has now entered the agriculture and botany sector. Advancements in deep neural network (DNN) has led to the development of Convolutional neural network (CNN) and transfer learning. CNN offers to extract high level features from images, thus saving time for experts to predefine morphological features or spend time on developing feature extractions methods. CNN does require a large dataset to produce good performance, using a small dataset could result in overfitting (mode heavily relying on training dataset) to overcome this problem, transfer learning is used at times. In transfer learning we use a pre-trained model (Karim & Beikmohammadi, 2018) (features learned during basic model training) .

With the developments of deep neural network and the plant classification problem still un-solved it would be interesting to comprehend what results we obtain when we apply different models of deep neural network to solve this problem.

A plant classification system would accelerate the rate at which species are being identified, it would assist botanist In faster recognition and detection of endangered species. Some regions require our immediate attention which contain multiple species on the verge of extinction, we could so dedicate our resources to such areas and document them before it’s too late.

Such a system could be taken and developed into a web app or a mobile application which would help people who are inquisitive to know about the plants they grow or students who are aspiring to become botanist to know about its species, so the need of for a botanist would be reduced significantly. Agriculture can be made more cost-effective and environment friendly by spraying herbicides only on weeds (Kaya, et al., 2019, pp. 2-3). Controlling deforestation, remote sensing for farming and food safety are other area which would benefit from such a system.

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Figure 2

## 1.3 Aims and Objectives

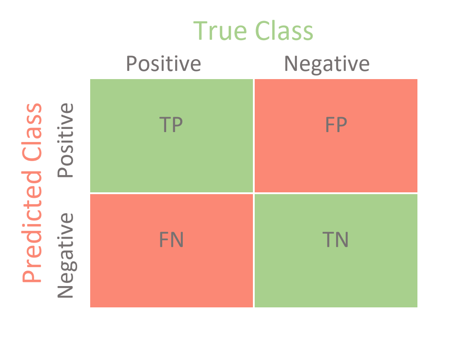
**Primary aim.** My primary aim will be to find the most accurate deep neural network model to classify plants by their species, which could then be used further to develop a plant classification system comprising of a website or mobile application. **Objectives of research.** I would be first developing different models of deep neural network. Once these models are developed I would be training them on a dataset containing images of leaves or features of leaves (shape, margin and texture).I would then be using a testing dataset on these trained models to evaluate how much accuracy they provide in predicting the right plant species. The techniques we would be employing to evaluate the performance of our model is the following : -

* Using a validation dataset, A validation dataset will not be part of our training dataset and so it is held back from the training process. It gives us unbiased estimate of the model’s performance after each epoch Figure 3. Passing the dataset forward and backward once through the neural network is called an Epoch.
* Using Learning curves Figure 6, Learning curves are used as diagnostic tool in machine learning they will demonstrate to us how the error change as the model trains or learns from the trained dataset. I would be using matplotlib pyplot library to draw training and validation learning curve, this well disclose how well the model is learning or help in diagnosing overfit and underfit models.
* A classification report Figure 5 which would assist us in measuring the quality of predictions the model makes when we use it on a testing dataset. For this I would be using sklearn metrics library.
* For summarizing the performance of our model, I would also be using a confusion matrix where applicable Figure 4. A confusion matrix provides a clear idea of what mistakes or errors is the model performing and what is getting correct, In other words a classification report summarizing correct and incorrect predictions. For this I would be using sklearn metrics library.

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Figure 3



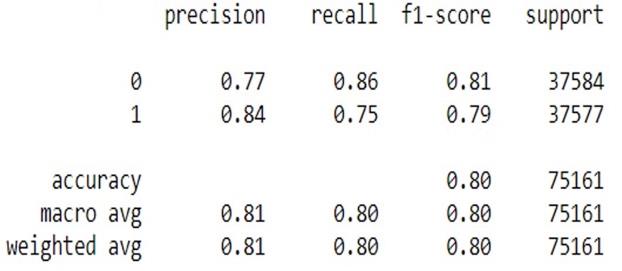


Figure 4

Figure 5

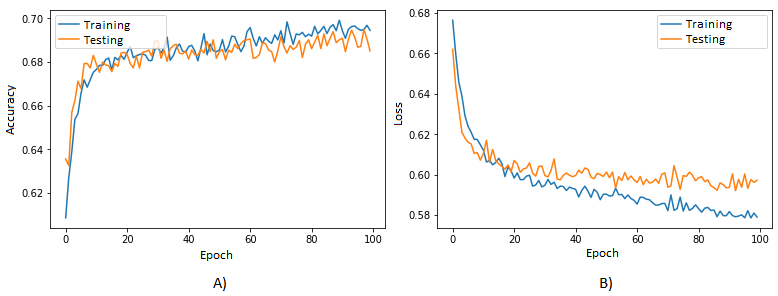


Figure 6

## 1.4 Deep Neural Network

### 1.4.1. Introduction To Deep Neural Network.

The most crucial part of the human body is the brain. If the human body is described as a computer, the brain can be called the CPU of the human body which helps us in performing all the daily functions, consisting about 86 billion neurons. The brain is built of fundamental unit called neurons which is chiefly responsible for receiving sensory input and sending appropriate motor responses to the muscles (Woodruff, 2001). Each Neuron is connected to other neurons, which forms a complex network of interconnected neurons responsible for transmitting information.

Artificial neural network is a system which is designed to mimic the brain, the way we analyse and process information, it is based on the study of artificial intelligence to solve problems that would be difficult for human beings to solve in a short period of time example number crunching. An artificial neural network (ANN) system cannot mimic a human brain completely it can only be programmed to perform certain behaviours or functions the brain performs.

Machine Learning is the branch of artificial intelligence which focuses to program themselves from the input data it receives, it is able to improve its accuracy on its own by working with more input data over time. It provides Artificial intelligence the power to solve problems based on data, and so artificial neural networks are examples of machine learning algorithms (Ciaburro & Venkateswaran, 2017, pp. 1-5).

Deep Learning is a branch of machine learning which is primarily focused on algorithms centred around artificial neural networks. It consists of complex set of layers of neurons interconnected to each other. Each layer of these neurons provides us with more processing. We can apply deep learning to difficult tasks such as image identification, classification and handwriting detection.

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### 1.4.2. Inspiration for neural networks.

The manner in which our brain processes information or its overall functioning served as an inspiration for the foundation of neural networking. Our brains are constantly processing enormous amounts of data which it receives from different sensory organs predominantly the eyes. Information is carried by neurons and transmitted from one neuron to another applying a flip-flop logic. when a certain threshold mark is surpassed the neurons fire and the information is transmitted to the other neuron or they do not fire at all; it is either 1 or 0.

**Similarities**

Structure of a neuron Figure 7 : -

* Dendrites : Branching out from the cell body they are the fibrous root like structure. They form the entry or receiving point for the electrical signals that are received from adjacent neurons.
* Axon terminals : Outgoing part of the neuron, which transmits electrical impulses to the next neuron.
* Cell body : also called the soma, upon receiving electrical inputs from the dendrite it decides what action to take.

Diagram

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Figure 7

Structure of an artificial neural network (ANN) Figure 8 : - A neuron is the basic structure of an ANN.

* Input Layer : it brings in the initial or input data into the system and passes it on to the other layer for processing.
* Hidden layers : this layer consists of the linear calculations and activation functions which decide whether to activate the neuron, fire or not.
* Output Layers : after the computation in the hidden layers, the final result is then passed on to the output layer so the user can view them and make a decision.

Chart, diagram, bubble chart

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Figure 8

Computers have been surpassing humans in various domains, such as huge numerical calculations, classification and problem solving but there are some areas where brains have been outperforming machine’s. A toddler can recognize his/her mother in a huge crowd, but a computer wouldn’t be able to do this, hence serving as an inspiration to develop a loosely decentralized architecture which functions like a brain (Ciaburro & Venkateswaran, 2017).

### 1.4.3. How do Neural Network Learn?

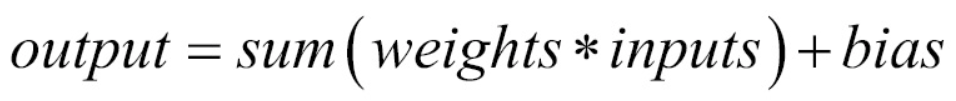
The Neurons in neural network function like a CPU, on receiving an input they perform mathematical operations on it generating an output which is then passed on to the next layer of neuron. By computing the output from all the neurons, the network is able to make a deterministic calculation, which is passed on to the final output layer for the end user to view.

Neurons are interconnected with each other by a weight (a number). Weights are the most essential part of a neuron, as the value they hold effects the output that the neuron will pass to the next one. If the input we receive are x1,x2 and x3 then the weights that will be applied to them will be represented as w1,w2 and w3  (Ciaburro & Venkateswaran, 2017). When we train our model for the first time these weights are set randomly.

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Where ‘I’ will be the number of inputs the neuron receives. A Bias value is also added which allow us to shift the activation function either to the left or to the right. The entire processing done by a neuron can be expressed as : -



The activation function is applied on this output which decides whether the neuron should be fired or not.

Diagram

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This flow of information from input layer to hidden layers and finally to the output layer is called forward propagation.

Just like human beings learn from mistakes or by receiving feedback deep neural network learn the same way by a process called backpropagation. Once the output reaches the final layer, the error is calculated ( predicted output - original output ). The error is then used to re-calculate the weights and biases that was used in forward propagation. To calculate the new weight amount neural network, apply gradient descent.

Gradient descent is an optimization algorithm which is used to find the values of a function’s parameters, that minimizes the cost function as far as possible (Donges, 2019).Backpropagation is performed after each dataset iteration.

By moving forward and backward considerable number of times, readjusting the weights and biases, the neural network is able to reduce the difference between predicted output and actual intended output, and so the model will now have a good fit for the data and could provide us with better accurate results.

### 1.4.4. Different Types of Deep neural network.

### 1.4.5. Neural Network For classification.

# 2 Literature Review

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