MANGROVE TREE RECOGNITION USING DEEP LEARNING

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering.

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APPROVAL

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DECLARATION

I hereby declare that, this thesis has been done by me under the supervision of **Md. Tarek Habib, Assistant Professor,** Daffodil International University. We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

This thesis titled “Mangrove Tree Recognition using Deep Learning” is a very important topic in not only Computer Science and Engineering but also Botany. Recognition of different mangrove trees with high accuracy provides a lot of knowledge to people. However, because of the complex background of mangrove tree, the similarity between the different species of mangrove tree, and the differences among the same species of mangrove tree, there are some challenges in the recognition of mangrove tree images. This mangrove tree recognition is mainly based on the three features: leaf, root and fruit, which requires people to select features for recognition, and the accuracy is not very high. In this project, based on Inception-v3 model of TensorFlow platform, we use the transfer learning technology to retrain the mangrove tree category datasets, which can greatly improve the accuracy of mangrove tree recognition. We have used Google’s Inception-v3 model trained on 3000 images covering 5 different categories. We retrained the Inception model to classify the mangrove tree images, using the Tensorflow Library and achieved an overall accuracy of 99% on the images.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Mangrove Trees are known as concentration of salt enduring trees and shrubs that grow in the seashore regions of the subtropical and tropical coastlines. Mangrove Trees are also home to a large variety of fish, mollusk, shrimp, and crab species. These fisheries form an indispensable origin of food for more than thousands of coastal areas around the world. This helps stagnate the coastline and confine degradation from storms and waves. They are found in the intertidal zones of coastal, marine or estuarine ecosystems of 124 tropical and sub-tropical and areas. Mangroves are an significant residency for sustaining biodiversity. It also provides indirect and direct benefits to human activities.

Non-coastal area people are not familiar with the species of Mangrove Trees. Every mangrove tree has different attributes and appearances. These mangrove trees vary significantly from each other. It is really a problem for non-coastal people to identify mangrove trees. People of non-coastal area tend to identify themselves with their own.

1.2 Motivation

The process of recognizing mangrove trees and the extraction of information from tree image is quite interesting as well as a challenging issue. With the improvement of computer technology and digital image processing technology, many people have started to search the function of automatic mangrove tree recognition using computer. For the purpose, we have decided to do a research on this topic and we think this research knowledge will help us in future to make a better and accurate support system which will help our people and all over the world. The ultimate goal of our research is to develop a new strategy to identify mangrove trees automatically by utilizing new techniques of Computer Vision and Machine Learning and improving accuracy. During this thesis, the key technological innovation is the deep learning-based tree image recognition algorithms.

1.3 Rationale of the Study

In our thesis, the transfer learning technique is used to retrain the method called Inception-v3 [1] of Tensor Flow [2] over the dataset of 5 mangrove tree species, locally known as Shundori, Golpata, Geowa, Keowra, and Khalshi.

1.4 Research Questions

How to choose the best topic that may suits best to one's ability and desire and how to involve students with new research trending topics?

1.5 Expected Outcome

From this research, universities and research institutions can discover the papers most pertinent to their thesis or research projects. So, searching for the exact papers to read becomes a very significant part of their academic studies and introducing with trending and upcoming research topic impacts on their thought. 'A Convolution Neural Network based Classification Approach for Recognizing Mangrove Trees of Bangladesh from Tree Images' help these people to find out the most pertinent papers and saving their valuable time. In addition, it can explore more talked buzz, used the topic in recent times, which motivates them to work with new problems, finding new solutions, and help the students who are confused about their field of interest. In computer vision, there are many algorithms and techniques to extract the best information and knowledge from a massive number of collected data. However, when we conduct them for classification we have to calculate the accurate result. For this research, we are using here one model for our data set and find out the best result but this is the prediction and a continuous process or result totally depends on the data set and the attribute.

1.6 Report Layout

In chapter 1, Introduction is discussed of mangrove trees, rationale of the study, motivation, research questions and the expected result of the thesis. And it is followed by the report layout later on.

The rest of the report arrangement is as follows:

In chapter two, the background of our research topic is discussed. This chapter also deals with the literature review, research summary, scope of the problem and challenges.

In chapter three, we will explain the methodologies that are employed in our study.

In chapter four, we will explain the obtained results and discussion.

Finally, some future work scopes, conclusion and recommendations are explained in chapter five.

CHAPTER 2
BACKGROUND

2.1 Introduction

We have opened an Inception-v3 [1] method of TensorFlow [2] platform and used CNN [4]. TensorFlow is an open source library, developed by Google Brain Team within Google's Machine Learning Intelligence analysis association, for numerical computation that makes machine learning simpler and faster. TensorFlow joins the computational algebra of compilation optimization techniques, making simple the calculation of many mathematical expressions where the problem is the time needed to accomplish the computation.

Inception-v3 is the 2015 iteration of Google’s Inception artifice and a vastly used image identification network method that has been presented to obtain more than 78.1 percentage accuracy on the ImageNet dataset. Inception is a remarkable architecture and it is the result of multiple cycles of trial and error. The model is the climax of many ideas developed by multiple researchers over the years. The original paper on which Inception-v3 is based on is "Rethinking the Inception Architecture for Computer Vision" by Szegedy, et al. [5].

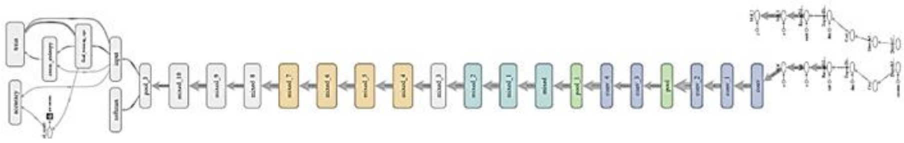

Figure I: Main graph of Inception-v3 model from tensor board

Transfer learning [3] is the application of knowledge obtained from completing one task to help in solving a different but related problem. The development of algorithms that assist transfer learning processes has become a goal of machine learning technicians as they attempt to make machine learning as human-like as possible [3]. For example, the knowledge obtained by a machine learning algorithm to recognize trucks could later be transferred for use in other machine learning model being developed to recognize other types of vehicles, such as buses. Compared with the traditional NN (neural network), it needs to use a minimum amount of data to train Inception V3 model, and gain the highest accuracy with small period of training time.

Convolutional neural networks (CNN) [4] are deep artificial neural network architectures, which are utilized basically to differentiate images, bouquet them according to similarity, and to accomplish object identification within scenes. A Convolutional neural networks (CNN) consists of single or multiple convolutional layers and then it followed by single or multiple completely associated layers as in a standard multiple layer neural network [6]. It gains especially from image data. Neural network can be prepared to do image analysis tasks including object detection, classification, segmentation, and image processing.

Many types of layers are used to build Convolution Network architectures like Non-Linearity Layer, Convolutional Layer, Rectified Linear Units (ReLU), Rectification Layer, Pooling Layer, Dropout Layer, Fully Connected Layer.

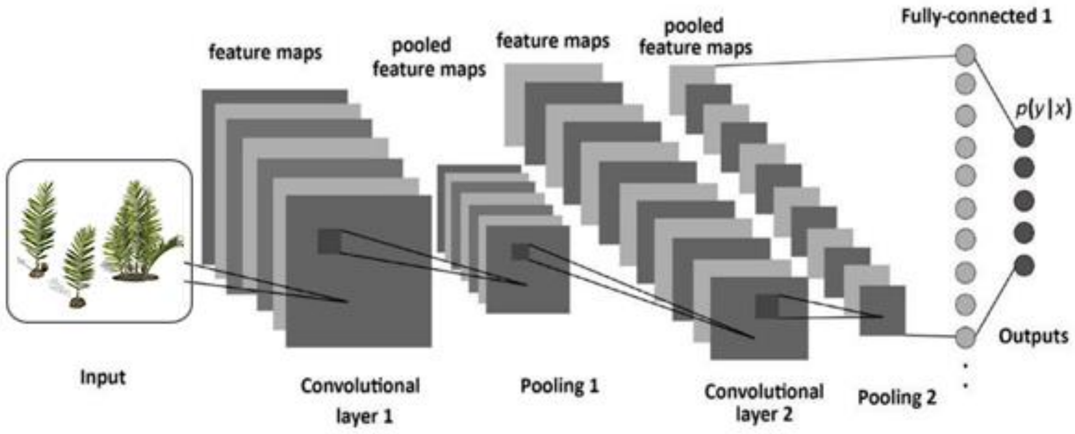

Figure II: The Architecture of Convolutional Neural Network (CNN) [7]

The main task of the convolutional layer is to detect local conjunctions of features from the previous layer and mapping their appearance to a feature map. As a result of convolution in neuronal networks, creating local receptive fields, the image is split into perceptron's and finally compressing the perceptions in feature maps of size $m_2 \times m_3$. So, this map stores the data where the property occurs in the image and how well it meets to the filter. Hence, each of the filter is trained local in consideration to the position in the volume where it is applied to [8].

In every layer, there is a shaft of m_1 filters. Total filters are applied in one stage is equal to the altitude of the volume of output feature maps. Each filter detects a specific feature at every position on the input [6]. The output $Y_i^{(l)}$ of layer l consists of $m_1^{(l)}$ feature maps of size $m_2^{(l)} \times m_3^{(l)}$. The i^{th} feature map, denoted $Y_i^{(l)}$, is computed as

$$Y_i^{(l)} = B_i^{(l)} + \sum_{j=1}^{m_1^{(l-1)}} K * Y_j^{(l-1)} \quad (1)$$

where $B_i^{(l)}$ is a bias matrix and $K_{i,j}^{(l)}$ is the filter of size $2h_1^{(l)}$ + 1 × $2h_2^{(l)}$ + 1 connecting the j^{th} feature map in layer $(l-1)$ with i^{th} feature map in layer.

The pooling layer is responsible for reducing the spatial size of the activation maps [8]. The pooling layer l has two hyperparameters, the spatial extent of the filter $F^{(l)}$ and the stride $S^{(l)}$. It takes an input volume of size $m_1^{(l-1)}$ × $m_2^{(l-1)}$ × $m_3^{(l-1)}$ and provides an output volume of size $m_1^{(l)}$ × $m_2^{(l)}$ × $m_3^{(l)}$ where;

$$m_1^{(l)} = m_1^{(l-1)} \tag{2}$$

$$m_2^{(l)} = m_2^{(l-1)} - F^{(l)}) / S^{(l)} + 1 \tag{2}$$

$$m_3^{(l)} = (m_3^{(l-1)} - F^{(l)}) / S^{(l)} + 1 \tag{3}$$

The aim of the total fully connected architecture is to tune the weight parameters to create a stochastic likelihood representation of each class based on the activation maps generated by the concatenation of convolutional, non-linearity, rectification and pooling layers [8].

If $l-1$ is a totally connected layer;

$$y_i^{(l)} = f\left(z_i^{(l)}\right) \text{ with } z_i^{(l)} = \sum_{j=1}^{\mathrm{m}_1^{(\mathrm{l}-1)}} w_{i,j}^{(l)} y_i^{(l-1)} \tag{5}$$

Otherwise;

$$y_i^{(l)} = f(z_i^{(l)}\ with\ z_i^{(l)} = \sum_{j=1}^{\mathrm{m}_1^{(\mathrm{l}-1)}} \sum_{r=1}^{\mathrm{m}_2^{(\mathrm{l}-1)}} \sum_{s=1}^{m_3^{(l-1)}} w_{i,j,r,s}^{(l)} \left(Y_i^{(l-1)}\right) r, s$$

2.2 Related Works

A plethora of research and development efforts have been made in the field of computer vision over the last few years to ease the effort of automatic object recognition, among which food image recognition has recently gained much importance. However, none of the work has found recognizing traditional foods.

Inception-v3 [1] model is used in many types of research of different categories. One of the work by Xiaoling Xia and Cui Xu from College of CS, Donghua University used the transfer learning method to retrain the Inception-v3 model of TensorFlow on the flower category datasets [8] of Oxford-I7 and Oxford-102 for Flower Classification in

2017. The classification precision of the model was 95% on Oxford-I7 flower dataset and 94% on Oxford-102 flower dataset [10].

Alwyn Mathew, Jimson Mathew et al. from bVuelogix Technologies Pvt Ltd utilized Google's TensorFlow deep learning a framework to train, validate and test the network for Intrusion Detection in 2017 [11]. The precision was 95.3%. However, the proposed network is found to be harder to train due to vanishing gradient and degradation issues.

Brady Kieffer, Morteza Babaie et al. used CNN and Inception-v3 model for Histopathology Image Classification in 2017 [12]. All experiments were done on Kimia Path24 dataset. The precision was 56.98%.

Xiao-Ling Xia, Cui Xu et al. worked for Facial Expression Recognition based on the Inception-v3 model of TensorFlow platform in 2017. They used CK+ dataset [13] and selected 1004 images of facial expression. The precision was 97% but it was not based on dynamic sequences.

Bat-Erdene.B and Ganbat.Ts worked on Effective Computer Model for Recognizing Nationality from the Frontal Image in 2016 [14]. They used SVM [15], AAM [16], ASM [17]. The precision was 86.4%. The analysis was worked manually and images must be the frontal face image that has smooth lighting and does not have any rotation angle.

The aim of our research is to provide a suitable methodology for accurate automation of Identification of Mangrove Trees as the first work of its kind.

2.3 Research Summary

For doing our research, we studied several research papers, articles, book, and conference paper. In this section, we explained on the forethought of other research and their outcome. Also, we discussed about the scope of the problem and challenges and an overview of the background. In computer vision, many researchers applied the same algorithms on the same dataset. Sometimes the same dataset and same algorithms can give different types of result. Therefore, it is very confusing. Many researchers used Inception-v3 model on distinct datasets.

Some authors, in paper they did not write enough information about their method and algorithm they used. It creates a critical situation for re-implement or re-used the algorithm. Later, different embodiments are used in the same method that might create varieties in output. A little change in datasets, methods or user inputs prophesies creates a bigger change in the representation of the methods. Therefore, selecting the perfect approaches is a significant task.

2.4 Scope of the Problem

While doing our research, we found that selecting the actual research field from the huge ocean of knowledge fields for an unacquainted individual person is quite difficult. There are many knowledge fields where a researcher wants to do research. However, the could not able to choose most of the cases. Therefore, in colleges, universities and research institutions, professors, graduate students, and other researchers got to find the papers that are most pertinent to their research projects. In their academic lives, looking for the exact papers to read becomes a very significant part. This research paper 'A Convolution Neural Network (CNN) based Classification Approach for Recognizing Mangrove trees of Bangladesh from Tree Images' will help these people in utilizing their precious time and the most pertinent papers. There are many related works. However, no works have taken enough pertinent information about research papers into the solicitation. In addition, most of the researcher research on the data set that are same.

2.5 Challenges

Identification of Mangrove Trees from images is an interesting challenge for Computer Vision researchers with applications in different domains. In particular, mangrove tree recognition is becoming more and more significant because of the key role that it plays in the field of Botany. In this paper, we address the study of mangrove tree image processing from the perspective of Computer Vision. The mangrove tree identification is a challenging task since the mangrove tree presents high variableness and an intrinsic deformability. The image representation used to automatically understand mangrove tree images plays the most significant role. To find a suitable representation of mangrove tree images it is significant to have representative datasets with a high variety of species. Practically a research paper/field like identification system has to use a big dataset.

Many mangrove tree datasets are composed of images collected through the Internet (e.g., downloaded from Social Networks) have usually a low resolution and have been processed by the users with artistic or enhancement filters. The big challenges for this research are collecting data from the internet. Most of the raw data is noisy. And there are also some unusable data.

After collecting the data, the main challenge is processing the data.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

Models are the most significant fact for classification. Choosing the appropriate model is very difficult. In this chapter, we are going to describe the models used for this project in the implementation requirements part. We will also discuss the phases of our working process and data collection method. In addition, the chapter elaborates the statistical analysis. Research subject and instrumentation are also included in this chapter. The working method of the two models is shown with simple block diagrams.

3.2 Research Subject and Instrumentation

This research is based on computer vision on the Inception-v3 [1] method of Tensor Flow [2] platform.

Computer vision has some advantages:

- Simpler and faster processes
- Reliable
- Higher accuracy
- Wide range of use
- Reduction of costs

Efficiency and scalability of computer vision models-

They are:

- insanely small
- insanely fast
- remarkably accurate
- easy to tune for resources vs. accuracy

Tools or instrument-

For this research, we are using 2GHz Intel i3 processor, 4GB memory, 1600MHz DDR3, 64-bit Operating System and x-64 based processor.

3.3 Steps of Working Process

We used to retrain model named Inception-v3 in a specific way. The following diagrammatic representation explains the methodology of our proposed models:

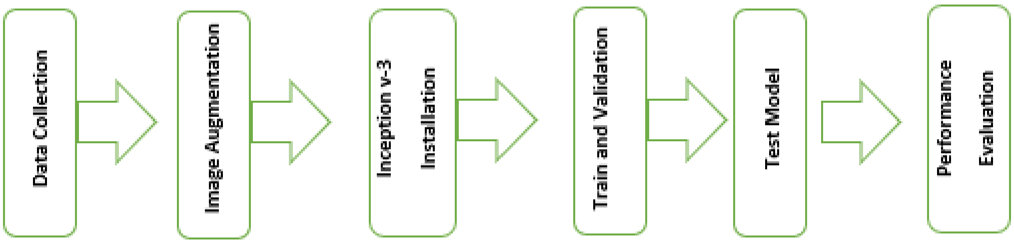

Figure III: Flowchart of the proposed models

The whole working method is something like this, we cropped images according to the specific parts of the tree that we want to train, then we resized images 500x500px and separated dataset with same label.

3.4 Data Collection Procedure

Dataset

Bangladesh has several species of mangrove trees. Our dataset is composed of five most known mangrove trees. They are locally known as Shundori, Keowra, Geowa, Golpata and Khalshi. We collected the data from the internet. The following images represent a portion of our dataset.

Geowa

Golpata

Keowra

Khalshi

Shundori

Figure IV: A portion of our dataset of Mangrove Tree Identification

Data pre-processing

Image pre-processing is a significant stage to promote the effect of image classification. The learning method of CNN directs the execution of our activity in transfer learning, thus in the image pre-processing move we have labeled and resized the images for training and testing from selected clear images.

3.5 Statistical Analysis

Statistical analysis is a component of data analytics. For recognizing different mangrove tree, we gathered 600 images of 5 mangrove trees. Each of the items contains around 120 images. We have extended those images into 3000 image by image augmentation.

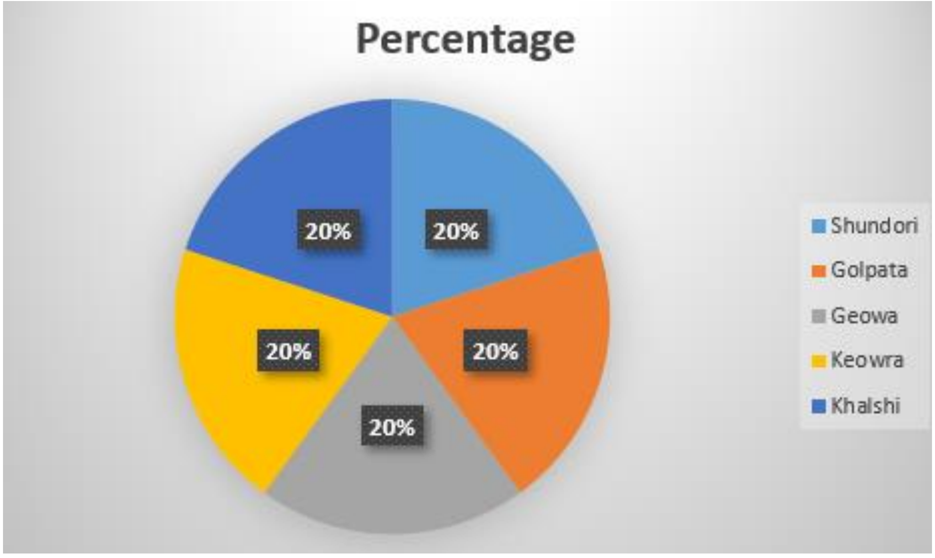

Figure V: Image percentage per label

3.6 Implementation Requirements

Model installation

For the implementation, firstly we have downloaded and installed TensorFlow. Hence, we have downloaded Inception-v3 model and installed it. We have also used the transfer learning model that keeps the framework of the earlier layer and have expelled the final flake of the Inception-v3 model, then retrain a final layer.

Model Dissection

To build and run the models we need to use some Library and modules of “Python” with “Tensorflow” Framework such as “numpy”,” hashlib”, “OS”, “datetime”, “sys” etc.

The use of those library and module on the python code are shown on the figure given below:

```
from __future__ import absolute_import
from __future__ import division
from __future__ import print_function

import argparse
import collections
from datetime import datetime
import hashlib
import os.path
import random
import re
import sys
import tarfile

import numpy as np
from six.moves import urllib
import tensorflow as tf

from tensorflow.python.framework import graph_util
from tensorflow.python.framework import tensor_shape
from tensorflow.python.platform import gfile
from tensorflow.python.util import compat
```

Figure VI: Used libraries and modules

To separate “training” “testing” and “validation” data from our dataset used a function named “create_image_list()”. It analyzes the subfolders in the provided image directory, separates them into stable testing, training, and validation sets, and gives back data structure explaining the numbers of images for each tag and their ways.

Code of separating directories and Image formats for reading images are given below:

```
def create_image_lists(image_dir, testing_percentage, validation_percentage):
  if not gfile.Exists(image_dir):
    tf.logging.error("Image directory '" + image_dir + "' not found.")
    return None
  result = collections.OrderedDict()
  sub_dirs = [
    os.path.join(image_dir,item)
    for item in gfile.ListDirectory(image_dir)]
  sub_dirs = sorted(item for item in sub_dirs
                    if gfile.IsDirectory(item))
  for sub_dir in sub_dirs:
    extensions = ['jpg', 'jpeg', 'JPG', 'JPEG']
    file_list = []
    dir_name = os.path.basename(sub_dir)
    if dir_name == image_dir:
      continue
    tf.logging.info("Looking for images in '" + dir_name + "'")
    for extension in extensions:
      file_glob = os.path.join(image_dir, dir_name, '*.' + extension)
      file_list.extend(gfile.Glob(file_glob))
    if not file_list:
      tf.logging.warning('No files found')
      continue
    if len(file_list) < 20:
      tf.logging.warning('WARNING: Folder has less than 20 images, which may cause issues.')
    elif len(file_list) > MAX_NUM_IMAGES_PER_CLASS:
      tf.logging.warning('WARNING: Folder {} has more than {} images. Some images will '
          'never be selected.'.format(dir_name, MAX_NUM_IMAGES_PER_CLASS))
    label_name = re.sub(r'[^a-z0-9]+', ' ', dir_name.lower())
    training_images = []
    testing_images = []
    validation_images = []
    for file_name in file_list:
      base_name = os.path.basename(file_name)

      hash_name = re.sub(r'_nohash_.*$', '', file_name)
      hash_name_hashed = hashlib.sha1(compat.as_bytes(hash_name)).hexdigest()
      percentage_hash = ((int(hash_name_hashed, 16) %
                          (MAX_NUM_IMAGES_PER_CLASS + 1)) *
                         (100.0 / MAX_NUM_IMAGES_PER_CLASS))
      if percentage_hash < validation_percentage:
        validation_images.append(base_name)
      elif percentage_hash < (testing_percentage + validation_percentage):
        testing_images.append(base_name)
      else:
        training_images.append(base_name)
    result[label_name] = {
        'dir': dir_name,
        'training': training_images,
        'testing': testing_images,
        'validation': validation_images,
    }
  return result
```

Figure VII: Dataset splitting and Image format defining

“create_image_lists(image_dir, testing_percentage, validation_percentage)” this function reflect the following scenario.

Arguments:

Image dir: String path to a folder containing subfolders of images.

Testing percentage: Integer percentage of the images to reserve for tests.

Validation percentage: Integer percentage of images reserved for validation.

Returns:

A dictionary containing an entry for each label subfolder, with images split into training, testing, and validation sets within each label.

Train model

In this progression, we should keep the parameters of the past layer, then expel the final layer and input our dataset to retrain the new last layer. The last layer of the model is trained by backpropagation algorithm [18], and the cross-entropy cost function [19] is utilized to integrate the weight parameter by calculating the error between the output of the softmax layer, and the label vector of the given test category [10] [13].

CHAPTER 4
EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction

We have implemented an efficient tree species recognition model by a little training period and achieved the maximum accuracy. In the end of this chapter, one will understand the reason behind choosing the proposed model and its function to this project. We can find out the best model with the best accurate result by using different types of datasets. Hope next researchers will follow it and research on new data.

4.2 Experimental Results

The variations in accuracy based on cross-entropy in our training dataset for Inception-v3 model are shown in Figure VIII and Figure IV respectively.

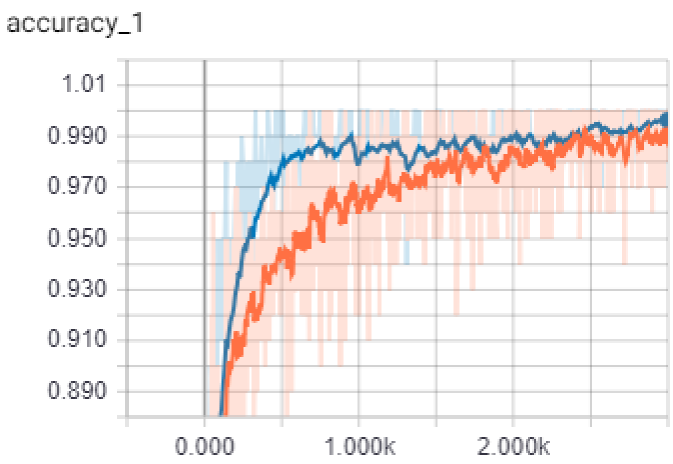

Figure VIII: The variation of accuracy on training and validation set for Inception-v3

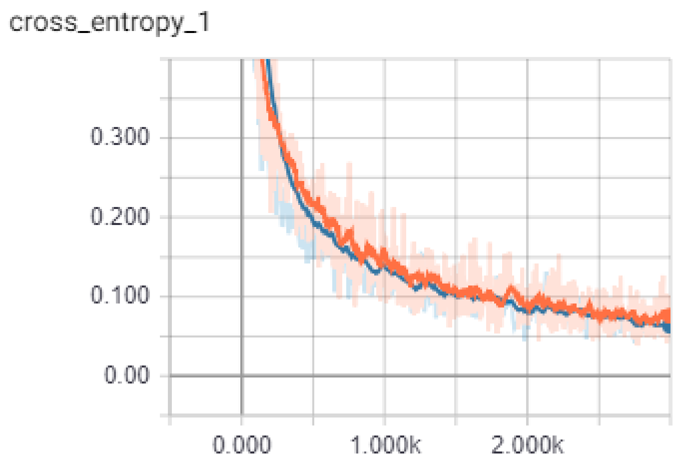

Figure IX: The variation of cross-entropy for Inception-v3

The training set is represented by the orange line, and the validation set is represented by the blue line.

The description of the figures is shown in the following table:

TABLE I: DESCRIPTION OF THE FIGURES

Dataset	Index	Performance of Inception-v3
Dataset	The accuracy of the training set	99%
	The accuracy of the validation set	92% to 95%
	The cross entropy of the training set	0.06
	The cross-entropy of the validation set	22

4.3 Descriptive Analysis

For our dataset, the training accuracy for Inception-v3 reached 99%, and the validation accuracy maintained between 92% to 95%. The cross entropy of the training was 0.06. The cross entropy of the validation set is 22.

4.4 Summary

At the end of the experiment, we can decide that the Inception-v3 model performing better. And hopefully, this research paper will help the student and the researcher who wants to research more on this topic.

CHAPTER 5

SUMMARY, RECOMMENDATION, CONCLUSION AND IMPLICATION FOR FURTHER RESEARCH

5.1 Summary of the Study

In this paper, we studied how to apply a convolutional neural network to the task of detecting and recognizing mangrove tree images. We focussed on classification models of computer vision used in data recognition. Different classification techniques of computer vision have merits and demerits for data classification and knowledge extraction. Furthermore, Inception-v3 model was helpful in classification.

5.2 Recommendations

It is recommended:

- that appropriate model selection is an significant part of any classification;
- that a fresh and healthy image should be used;
- that an increase of data diversity will help to predict more accurately;
- that the creation of bottleneck is significant.

5.3 Conclusions

We have demonstrated a comprehensive pathway to identify mangrove trees of Bangladesh from tree images, which is so far the first work of its kind. As a first research work on this domain, the result is quite satisfactory as well as encouraging. We also believe this work will inspire researchers from various countries to work on their traditional items.

5.4 Implication for Further Study

We proposed the classification model based on the Inception-v3 model for five different mangrove tree species. Hopefully, in the future, we could extend the work with a larger dataset having more varieties of items. We also have the plan to implement some other CNN based models to compare the accuracy on the same dataset.

Appendices

Appendix A: Research Reflection

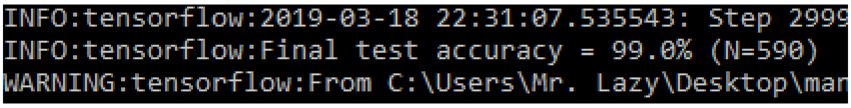

Figure A1: Screenshot of Final test accuracy

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