Faculty of Engineering

A MOBILE APPLICATION FOR BIRD SPECIES RECOGNITION USING DEEP LEARNING TECHNIQUES

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A MOBILE APPLICATION FOR BIRD SPECIES RECOGNITION USING DEEP LEARNING TECHNIQUES

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ABSTRACT

The development of a mobile application for bird species identification has become a significant area of research due to its potential to engage bird enthusiasts, facilitate citizen science initiatives, and contribute to conservation efforts. In this project, we present a comprehensive approach to building a mobile application for bird species identification, encompassing the development of a machine learning model in Jupyter Lab, model optimization using Google Cloud Platform with Vertex AI, then building the API to process the request then send prediction and the creation of an application through Android Studio. The system utilizeses a convolutional neural network (CNN) architecture through transfer learning trained on a dataset of local Sarawak birds. The images were preprocessed to enhance relevant features and remove noise. The CNN transfer learning model chosen was EfficientNet-B4. To validate the robustness of the model, 5 famous transfer learning model (EfficientNet-B4, ResNet-50, InceptionV3, MobileNetV2 and VGG16) were compared through parameters such as training time, training loss, validation loss, training accuracy, validation accuracy, test loss, and test accuracy. The chosen EfficientNet-B4 model achieved an accuracy of 93.06%, test loss of 0.3156, training accuracy of 96.81%, training loss of 0.1081, validation accuracy of 93.87%, validation loss of 0.2853 and average training time of 285 seconds for 1 epoch with a total of 20 epochs, demonstrating its effectiveness in accurately classifying the bird species. The successful completion of this project makes a valuable contribution to the field of bird species identification and conservation. The developed mobile application provides an accessible and user-friendly tool for bird enthusiasts, researchers, and citizen scientists, promoting active engagement in bird conservation efforts and facilitating data collection for monitoring bird populations and habitats. Future directions for this project include expanding the model's dataset to cover a broader range of bird species and environmental conditions, as well as integrating real-time updates and environmental sensor data to enhance the application's functionality and provide users with dynamic and contextually rich bird identification information.

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LIST OF ABBREVIATIONS

CNN	-	Convulutional Neural Network
AI	-	Artificial Inteligence
TV	-	Television
CUB	-	Caltech UCSD Bird
UCSD	-	University of California San Diego
ResNet	-	Residual Network
ProtoPNet	-	Prototypical Part Network
UAV	-	Unmanned Aerial Vehicle
R-CNN	-	Region-based Convolutional Neural Network
YOLO	-	You Only Look Once
IoT	-	Internet of Things
SVM	-	Support Vector Machine
VggNet	-	Visual Geometry Group Network
API	-	Application Programming Interface
DeCaf	-	Deep Convulutional Neural Network Activation Features
RS-DeCaf	-	Reducing and Stretching
MobileNet	-	Mobile Network
CWBF	-	Chinese Wild Bird Federation
ID	-	Identification
POOF	-	Part-based One-vs-One Features
IOS	-	IPhone Operating System
UI	-	User Interface
ONNX	-	Open Neural Network Exchange
CPU	-	Central Processing Unit

GPU	-	Graphics Processing Unit
RAM	-	Random Access Memory
OS	-	Operating System
GDDR	-	Graphics Double Data Rate
HDD	-	Hard Disk Drive
SSD	-	Solid State Drive

CHAPTER 1

INTRODUCTION

1.1 Background

Sarawak, known for its historical association with head-hunters and abundant hornbill population, is the largest state in Malaysia and covers the north western region of the island of Borneo. The rainforests in this area are incredibly diverse and teeming with a wide variety of tropical wildlife [1]. Sarawak is home to a significant number of Borneo's 650 bird species, including many of the island's unique, endemic species such as the Bornean Bristlehead. The state boasts the highest number of national parks and nature reserves in Malaysia, covering over 600,000 hectares of protected areas, providing excellent birdwatching opportunities [2].

National parks in Sarawak still rely on old method using the expertise of ornithologists to identify bird’s species. By old methods means Sarawak government still hired ornithologist or birds’ experts to help them identify and keep count of birds manually in Sarawak every year to obtain their statistics for conservations purposes. Recent advancement of deep learning, provides state of the art solutions to help bird conservation.

According to Sarawak Forestry, as of 2019 statistics, there are 47,349 visitors 1/3 are foreigners came to Sarawak for birdwatching and as of 2021 annual shorebird count by ornithologist detected that an increase of 6.7% bird in Sarawak from the previous year and 2.4% among detected were endangered bird species [3]. Figure 1.1 shows some of the rarest birds that can only be found in Sarawak are Pink-necked Green Pigeon, Ashy Tailorbird, Mangrove Blue Flycatcher and Common Flameback [4].

(a) (b) (c) (d)

Figure 1.1 Pink-necked Green Pigeon (a), Ashy Tailorbird (b), Mangrove Blue Flycatcher (c) and Common Flameback (d) [6].

Past research in using deep learning technique such as [5], [6], [7], [8] and [9] stated that deep learning technique achieved a high accuracy and faster time in identifying and classifying bird species. This shows that deep learning is proven to be the ideal and effectives way to help identifies and classifying the bird's species. Therefore, it is a need to create a mobile application that integrate deep learning model for identifying and classifying bird species to help Sarawak Government as well as Sarawak Tourism for conservations and tourists.

1.2 Problem Statement

National parks in Sarawak still rely on old method using the expertists of ornithologists to identify bird species where current methods for bird species identification rely heavily on expert knowledge and manual observation, which can be time-consuming and subject to observer bias. This can limit the accuracy and reliability of bird species identification, and can also make it difficult to collect and analyse data on a large scale. In addition, current methods may not be practical or feasible in remote and difficult-to-access areas, where expert knowledge may not be readily available and manual observation may be challenging.

Birdwatching is a popular activity for tourists visiting Sarawak, however, many visitors have a hard time identifying the different bird species in real-time. This is due to a lack of resources available for tourists to reference, such as local guidebooks on birds found in Sarawak. With over 600 species of birds found in Sarawak, many of which are endemic to Borneo, identifying the birds can be a challenging task for visitors who are not familiar with the local avifauna. Even for experienced birders, it can be difficult to find detailed and accurate information about the birds found in the area. As a result, tourists often have to rely on their eyes and the knowledge of local guides to identify the birds they encounter in the national parks. This can make the experience of birdwatching less enjoyable and informative for tourists, as it can be difficult to learn about the different bird species and their behaviours without proper resources. In addition, it also limits the potential for tourists to contribute to citizen science or bird monitoring programs.

Deep learning has been used in recent years as a method for identifying birds, however, it is not without its limitations. One of the main limitations is that it is not a real-time process. These methods typically involve the use of pre-trained models that require a large amount of data to be fed into them in order to accurately identify birds. This process of feeding the data and running the models can take a significant amount of time, making it difficult to identify birds in real-time while observing them in the wild.

1.3 Objectives

The main objective of this research is to develop a mobile application for bird species recognition using image processing techniques and deep learning, with the goal of providing an accurate and convenient tool for birdwatchers and ornithologists to identify and classify different species of birds in real time.

The specific research objectives are to:

1. Develop a deep learning model that can classify bird species based on images.
2. Design a user-friendly mobile application that can utilised the trained deep learning model to classify birds in real time.
3. Evaluate the accuracy of the mobile application in term of its accuracy.

1.4 Summary

In summary, this research aims to develop a mobile application that uses image processing techniques and deep learning to accurately recognize and identify different bird species from photographs, and provide identification and information about the species. The application is intended to make it easier for non-experts to identify and learn about birds, and has the potential to be a valuable tool for birdwatchers, conservationists, and anyone interested in birds. The development of this application is motivated by the importance of birds in biodiversity and the need for a tool that facilitates the identification and monitoring of bird species, and has the potential to make a significant contribution to the field of ornithology and conservation.

Chapter 2

LITERATURE REVIEW

2.1 Overview

This chapter will discuss on old or traditional method in identifying bird and compare it with existing researches on bird identification using deep learning technique (CNN or Transfer Learning) and also the existing mobile application in Appstore and Google Play store. This research also discusses the research gap of the current deep learning technique as well as the existing mobile application for bird identification.

2.2 Related Studies

Many researches have been worked on deep learning specifically using transfer learning but few has applied the deep learning model into mobile applications with local Sarawak's bird dataset. Many researchers have worked on only bird recognition with many traditional diverse solutions. Table 2.1 will discuss on some of the related works on bird identification by researchers.

2.2.1 Traditional Bird Identification Method

(a) (b)

Figure 2.1 (a) Bird tagging [10] and (b) Local Guidebook for Bird [11].

Traditional bird identification methods have been used for centuries by ornithologists and birdwatchers to identify and study bird species. These methods include using field guides, plumage, behavior, and habitat to identify birds [12].

Figure 2.1 shows bird tagging that involves attaching a small tag to a bird, typically on the leg, that contains identifying information such as a unique number or code. This allows researchers to track the movements and migrations of individual birds, which can provide valuable information about the ecology and behaviour of different species. Local book guides, on the other hand, are physical or digital guidebooks that contain detailed information about different bird species, including illustrations, descriptions, and information about their distribution, habitat, and behavior. These guides are typically focused on a specific region and can be used by birdwatchers and researchers to identify different bird species in the field.

Both of these methods have their own advantages and disadvantages. Bird tagging provides a way to track individual birds over time and can provide detailed information about their movements and habits, but it requires capturing and handling the birds. Local book guides are an efficient and easy way to identify birds in the wild, but it requires an expert to use them, and the information provided may not be as detailed as the information provided by tagging.

One of also the most common methods for identifying birds is to rely on memory and prior knowledge. Birdwatchers or birders must familiarize themselves with different species by studying birding books, magazines, and guides in order to recognize a species when they see it in the wild. This can require a significant amount of time and effort to review and learn about different birds. In the field, birds may not always be clearly visible and may only be seen briefly, which can make identification difficult.

One way for a birdwatcher to determine the identity of a bird is to ask someone who is knowledgeable about birds and is nearby or easily accessible. Another option is to take a picture of the bird and then refer to resources such as books or online guides, or seek out an expert for assistance. Alternatively, the birdwatcher can make notes and possibly draw the bird and then seek expert help at a later time.

Field guides are books that contain illustrations, photographs, and descriptions of different bird species. These guides are often organized by region, and they provide information on the size, shape, color, and markings of different bird species, as well as information on their habitat, behavior, and distribution. Field guides are a popular and widely used tool for bird identification, and they are considered to be the foundation of traditional bird identification methods.

Plumage, or the feathers of a bird, is another important aspect of traditional bird identification method. The color, pattern, and shape of a bird's feathers can provide important clues as to its identity. Birds also have different feather patterns and colors depending on their age and sex, so ornithologists and birdwatchers must take these factors into account when identifying birds by their plumage.

Behavior and habitat are also important factors in traditional bird identification methods. Birds have different behaviors and habitats depending on their species, and these can provide important clues as to their identity. For example, some birds are more active during the day, while others are more active at night. Some birds live in forests, while others live in grasslands or wetlands.

2.2.2 Deep Learning for Bird Species Identification

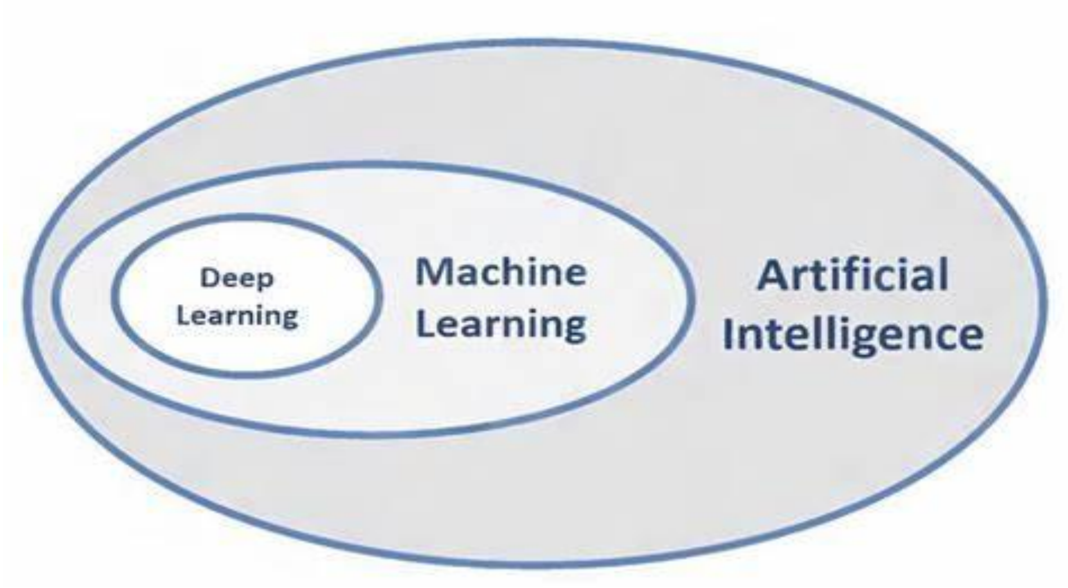

Figure 2.2 Deep Learning Subsets [13].

Based on Figure 2.2, deep learning is a type of machine learning that utilizes neural networks with three or more layers, which aim to mimic the functioning of the human brain, allowing it to learn from large amounts of data. While a neural network with a single layer can still make rough predictions, extra hidden layers can improve and refine accuracy. Deep learning is the driving force behind many AI applications and services that increase automation, enabling the execution of analytical and physical tasks without human intervention. It is the underlying technology for everyday products and services like digital assistants, voice-enabled TV remotes, and credit card fraud detection, as well as emerging technologies such as self-driving cars.

Deep learning is a branch of machine learning that stands out due to the type of data it can handle and the methods it employs for learning. Machine learning algorithms generally use structured, labelled data to make predictions, while deep learning skips pre-processing steps and can handle unstructured data such as text and images, automatically extracting features [13]. For instance, deep learning algorithms can identify which features, such as ears, are crucial to distinguish different animals, whereas in machine learning, this hierarchy of features is established manually by human experts. Through the process of gradient descent and backpropagation, the deep learning algorithm adapts and improves itself for greater accuracy, allowing it to make predictions with more precision.

2.2.2.1 Convolutional Neural Network

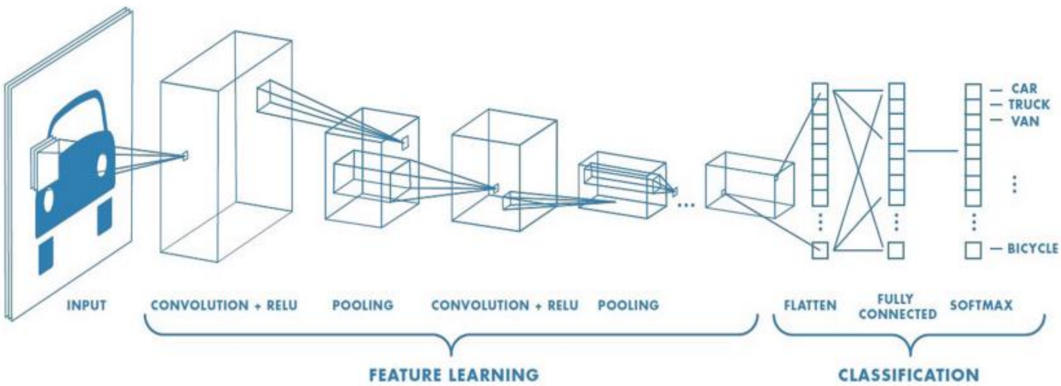

Figure 2.3 Typical CNN Architecture [14].

A standard CNN architecture comprises several layers that work in tandem to extract features from an input image. Figure 2.3 shows that these layers can be broadly divided into two categories: convolutional and fully connected layers.

The convolutional layers extract features from the input image by applying a set of filters, which are small matrices that scan the image to identify specific patterns. The output of the convolutional layer is a feature map, which is a condensed representation of the input image that highlights the features detected by the filters. The pooling layers are used to reduce the number of pixels in the image by taking the maximum or average value of a small region of the feature map, this reduces computational burden and improves the robustness of the network.

The fully connected layers are used to analyze the features extracted by the convolutional layers. There are a large number of neurons composed together that are connected to all the neurons in the previous layer. The output of the fully connected layers is a set of class scores, which are used to classify the input image into one of several