Sheffield Hallam University

Faculty of Arts, Computing, Engineering & Sciences

Department of Computing

Final Year Individual Project (SEGM)

[55-6727]
2017/18

Author:	**U. N. Jayawardena**
Date Submitted:	**20th of August 2018**
Supervisor:	**Dr Pradeep Abeygunawardhana**
Degree Course:	**BEng (Hons) in Software Engineering**
Title of Project:	**Bird Recognizing Android Mobile Application Using Image Processing**

Confidentially Required?

☑ **NO**

☐ **YES**

Abstract

Bird Watching becomes more common especially around the bird sanctuaries in most of the countries. It is an awesome job and people doing it as a hobby. Since there are some advantages like, people are the appreciation for nature and birds, it causes quick relax for their busy minds, also increase the human attraction for birds and nature and bird watching can increase the economy of a country. But in bird sanctuaries, there is any number of birds some time even watchers can't identify their names easily. They take photos of the birds but they won't able to get the details about that bird because they even don't know the exact name of that bird. Because of that sometimes it can occur some obstacles for bird watching. This problem can decrease the number of bird watchers, nature lovers, and guides.

This research shows that using new inventions of technologies can overcome these problems. So as a solution can develop mobile applications, web-based applications, desktop applications which can identify the relevant bird by giving some major features, uploading their audio or video file moreover pictures. These functionalities can contribute to identifying birds. The intention of this project was to implement a new Android mobile application which use to identify birds by uploading a bird picture.

The proposed Android application was developed to identify birds by uploading the picture of a bird. The application identifies the bird by analysing the uploaded image and extract features such as contrast, noise, and histogram. The targeted audience of this project is bird watchers (photographers) and people who are interesting on birds. Android studio was used as the development platform to design the mobile application and scripting was done in Java. Various tests were carried out on increasing the accuracy by uploading high-resolution pictures which are of high quality, moreover posture of the bird in the pictures and useful information gathered as a result of the study. Plans are underway to improve the on the design and develop the application further to provide the facility for the users to recognize birds by uploading a video clip of a bird behaviour.

Acknowledgement

This project would not have been successful without the guidance and help of numerous individuals who contribute and spread their valuable assistance in the preparation and completion if this study.

I wish to express my sincere gratitude goes to my supervisor, Dr Pradeep Abeygunawardhana whose expertise and encouraged me to sharpen my ideas regarding the project through this venture. I appreciate his assistance in writing this research report.

I would like to express my deep gratitude to Dr Dharshana Kasthurirathna, for his administration and support at all the levels of the project development.

Finally, I take this opportunity to express my gratitude to my family who taught me that I could do everything and give me strength and my friends for their support and understanding throughout my studies at Sri Lanka Institute of Information Technology.

Table of Contents

List of Figures

List of Tables

List of Tables

List of Abbreviations

API   : Application Programming Interface

QFD   : Quality Function Deployment

SDK   : Software Development Kit

NFC   : Near Field Communication

REST   : Representational State Transfer

AutoML : Auto Machine Learning

SVM   : Support Vector Machine

UX   : User Experience

IDE   : Integrated Development Environment

APK   : Android Package

Chapter 1: Introduction

In the last few years with the development of technology people used technology to build interactive connectivity between nature and human. This research presents an approach for bird classification and identification based on analyzing unconstrained images to provide the easy method for bird identification and through that improve the human interaction with birds and nature. And distribute some knowledge about birds in an interesting manner.

1.1: Aims and Objectives

The intention of the project is to build an interactive and useful bird guide Android mobile application that supports an easy way for users to identify birds online. The objective is to develop an android mobile application that is to retrieve the most accurate matching result of a given picture by a user. It can also increase the interaction between human with birds and nature. And the application can be used for study purposes also. Moreover to examining possibilities of implementing the system on a mobile device.

1.2: Problem Statement

In identifying the intentions of the project works, infrequent inquiries have to be considered;

1. How to provide an easy way of identifying birds in several conditions to users?
2. What kind of approach can be applied to get the results?
3. How to implement it in a user-friendly manner?
4. How to check the accuracy with user input?
5. What are the possible scripting languages and development platform can be used?

These are all essential factors to examine when planning this project.

1.3: Project Scope

The main goal of the project is to identify the birds using image processing approach. Considering easiness of usability the intention is to implement an Android mobile application named EyeBird. The birds may appear in different scenarios as well as may present different poses, sizes and angles of views. Also, the images present strong variations in illuminations and parts of the birds may be occluded by other elements of the scenario. So the identifying approach need do apply color segmentation, eliminate backgrounds, noise filtering, histogram modification, and delimit candidate regions. So those processes are done using Vision API.

The creation of the EyeBird system will be divided into three major parts.

1. Uploading Image.
   Images can be uploaded through browsing the phone gallery but that images need to in high resolution or images can be uploaded by taking using DSLR camera.

2. Analysis of the image and identify the bird.
   The uploaded image request needs to be sent to the Vision API. Then through the API do the color segmentation, eliminate backgrounds, noise filtering, histogram modification, and delimit candidate regions and resend the response to the system with the most accurate result.

3. Retrieve details of birds by name.
   The user can be able to view details of birds by passing the bird name.

1.4: Targeted Audience

The intended audience of this system can be divided into two categories;

1. Beginning and intermediate bird watchers.

Even birdwatchers knowing birds may have different names. So through the application they able to find them easily. Sometimes they work as guides for tourists so the guides also use this application.

2. Learners about birds.

Students or adults can learn about birds through this application.

1.5: Key Benefits

- Users would be able to easily and quickly identify birds.
- Birders don't have to pack paper field guides when they go for bird watching, they can use their mobile phones which they would probably have.
- Can get the detailed description of birds.
- Able to use as the learning resource for students.
- Useful for guiders and birdwatchers.
- Since this is a mobile application can easily meet targeted clients and clients can easily enjoy the features.

Chapter 2: Literature Review

2.1: Review of Related Literature

In earliest research and projects in image recognition of birds, features were extracted using an image processing algorithm where the images process for various aspects and identify the bird.

One of the exceedingly famous birds' image recognition system is **Merlin Bird ID** ("Merlin Bird ID – Free, instant bird ID help for 2,000+ North, Central, and South American, and European birds," n.d.) was built by computer vision researchers at Cornell and the California Institute of Technology, along with Cornell's ornithology department. Merlin Bird ID is a mobile application which has separate APKs that compatible for IOS devices and Android devices. This application can identify over 400 species of birds found in North Africa using a library over 70 million photos. This application has not been studied the birds common to Asia because it mainly focuses on birds which are common in North Africa. It helps the user to recognize bird with a photo of a bird or by asking 5 simple questions from the users. It reveals the list of birds that best match the given description. Moreover, the user can retrieve more photos, sound, details and ID tips of the matched bird and users can search birds by scientific name also. Merlin Bird ID also develop a website named Merlin Bird Photo ID Tool. Merlin's computer vision system was created by the Visipedia research team at Cornell Tech and Caltech, in collaboration with the Cornell Lab of Ornithology. Merlin Bird Photo ID created works through machine learning techniques. For the development of the project Merlin Bird ID application able to give design ideas and flow of the process.

Bird Species Classification Based on Color Features (Marini, Facon, & Koerich, n.d.), paper present bird species classification based on color features. This paper mainly focuses on pattern recognition of birds in various situations, color features of birds, color image segmentation approach and bird species classification. The paper helps to give an idea about the color segmentation process briefly.

An Introduction for Image processing in MatLab (Mcandrew, n.d.), the tutorial contains image processing concepts and different algorithms involved in image processing approaches such as; Image Enhancement, Image Restoration, Image Segmentation. Moreover, it includes MatLab, a data analysis and visualization tool designed with powerful support for matrices and matrix operations. It also includes how Matlab's matrix capabilities allow analyzing images and properties for each type of image.

A Comparison of Image Processing Techniques for Bird Recognition (Nadimpalli, Price, Hall, & Bomma, 2006)**,** the article explains about implementation methodology in bird recognition system. Three object detection algorithm is mention in here; Image Morphology, Artificial Neural Networks, Template matching.

An Overview on Image Processing Techniques (Chitradevi, Srimathi, & Professor, 2007)**,** journal article discusses the advantages of using digital image processing such as repeatability, versatility and preservation of original data precision. So considering these advantages, the project developed under digital image processing and follow the techniques; Image pre-processing, Image enhancement, Image segmentation, Feature extraction, Image classification.

Android Studio Development Essentials developer guide online (*Android Studio Development Essentials*, 2015), the referential website helps in setting up Android Studio development environment and use it as development guidance in the project implementation stage.

2.2: Proposed Project

After considering existing similar systems and researches which have done previously, supposed to implement an Android mobile application named EyeBird, to identify birds using images. To design the application decide to use Android studio as the development platform and the scripting language is Java. For the image identification core of the project is calling Google Vision API. The proposed project has three major components;

1. Can capture a quality photo.
2. Select a picture from the phone gallery.
3. Browse the dictionary of the birds.

Finally user able to see the result with the accuracy percentage. And also user can browse the birds not only but also common in Sri Lanka and get their details. So the intention is to output a reliable, user-friendly and easy use of the deliverable product.

2.3: Research Gap

As above mentioned there is an existing mobile application named Merlin Bird ID. In exploring about Merlin Bird ID, able to gather some specific features that application has not been addressed. The Merlin Bird ID currently includes identifying instant bird ID help for 2,000+ birds in North, Central, and South American, and European birds. But the proposed project EyeBird is to develop a bird identifying the application to use it for beginning and intermediate bird watchers mostly related to Asian countries especially in Sri Lanka and also can use it for study purposes. This mobile application is more realistic and practical to people who are interesting in Sri Lankan birds because the proposed system intend to develop an option to browse Sri Lankan birds and view details of them. The aim of the system is to outcome a product which is more accurate for Sri Lanka and its tourists rather than existing systems.

The existing system just displays the identified bird name and if the user needs to get more details user has to navigate to another page. But in the proposed application users can view bird details clearly and shortly. If the application able to identify the bird it automatically gives details of identified bird in a simple and clear format such as bird name, owned group etc.

Finally, the purpose of this research is, through an application achieve the targeted goals by providing facilities for users.

Chapter 3: Project Management and Tools

Choosing a project management strategy and project management tools very critical because it carries the project successfully. Project management can improve the chances of achieving the desired results and basically provide an easy way to manage project scope, resources, time and cost effective.

For this project;

- Use GitHub as the version controller to record the changes in the source code of the project over time and recall when needed.
- Google Drive use for backups and recovery.
- Use Trello to manage the project tasks and set personal timelines and task trackers. And it provides an ability to set due dates and reminders.
- For manage the referencing in the project report use Mendeley.

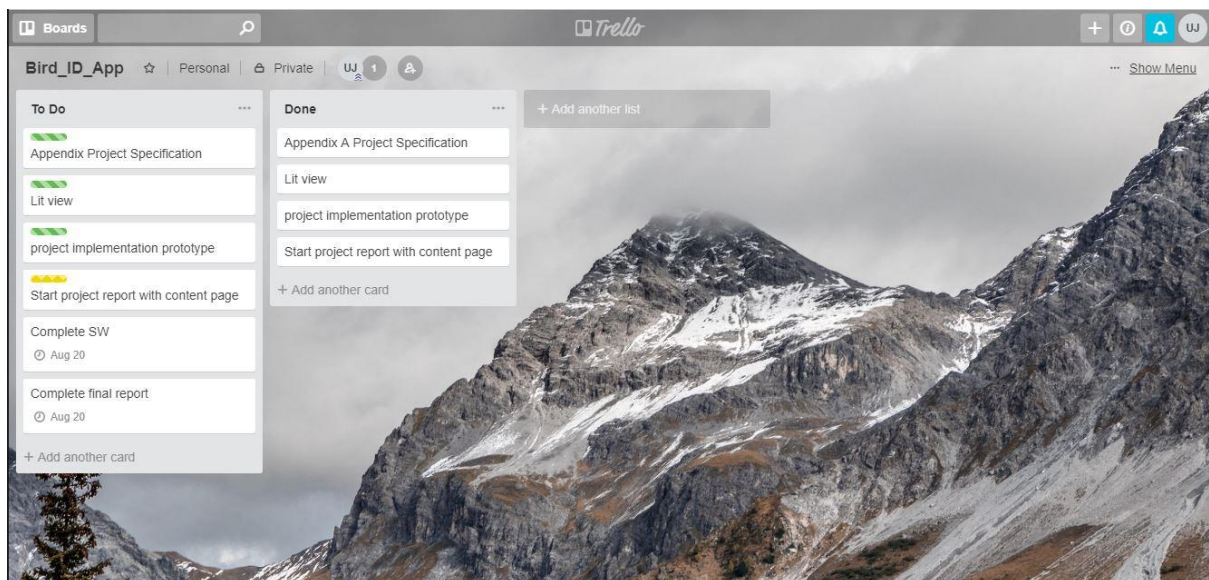Below is a screenshot of the Trello board demonstration.

Figure 3.0.1: Trello

By selecting such project management strategies and tools, support to tackle the challenges from project proposal to the implementation level and the testing level.

Chapter 4: Requirement Gathering and Analysis

4.1: Quality Function Deployment of EyeBird

Quality Function Deployment is a technique that translates the needs of the user into technical requirements for software. It concentrates on maximizing user satisfaction from the Software engineering procedure. With respect to this project, the following requirements are identified by a QFD.

- Normal Requirements
- Expected Requirements
- Exciting Requirements

4.1.1: Normal Requirements

Normal requirements consist of objectives and goals that are stated during the meeting with the application user. Normal requirements of this project are;

- Availability of expected requirements within the mobile configurations.
- Easy to operate.
- High user interaction.
- Lucrative system.
- More accurate and efficient.

4.1.2: Expected Requirements

These requirements are implicit to this application and may be fundamental that the user does not explicitly state them. So these requirements absence will be cause for user dissatisfaction.

- Minimum hardware requirements that relevant for the application.
- Easy to operate.
- The details must be in higher accuracy.
- Higher definition for the system.

4.1.3: Exciting Requirements

These requirements are directly affect for user expectations and user satisfaction.

- Identify Bird.
- Range of information.
- Show accurate results.
- Easy to version updates.

4.2: Required Tools

Project need some hardware and software requirements.

4.2.1: Hardware Interfaces

EyeBird is a mobile application designed specifically for Android platform and is functional on both mobile smartphones and tablets. Almost everyone owns a smartphone, although they are not small, they are suitable to be managed by children with adult supervision. So the best choice would be the smartphone. And the compatible operating system to this application is Android which is developed by Google. Considering the operating system iPhone OS only compatible with Apple devices which are normally expensive and rare than Android. Majority of mobile devices run on Android devices, several phone brand companies have adapted to this operating system. Application data is stored locally on the device and device access the application through the APK. This application has been developed for

Android Lollipop 5.1.1 version with API level of 22 SDK and above android versions with higher SDK versions.

EyeBird is an application which identifies birds by analysing images. So need to upload quality and high-resolution photos. So can reach accurate results by this application. For that need to capture photos using DSLR camera or high-quality mobile camera. The camera should have 24MP with Dual Pixel AF. If using a camera it should have WIFI or NFC connected to share the photo with the mobile device.

4.2.2: Software Interface
Since this is an online mobile application, need the internet connection and for the fast performance need to be a strong connection.
 EyeBird has been developed using some development tools such as;
- Android Software Development Kit (Android SDK): Software development kit for applications on the Android platform.
- Image analysis tool which is Google Cloud Vision API.
- Adobe Photoshop which use for to design the application.

4.3: Data Model
This application uses the Google Cloud Vision API and AutoML Vision API for recognizing birds. The recognition is done through REST API. So the AutoML Vision API provides a service to manage own dataset. The dataset serves as the input for training a model. To create the dataset there are three main tasks;

1. Create a database
2. Import data items to the database
3. Label the items

After creating the database can import dataset which trained using MATLAB. So upload the .csv file that contains the training images. Then need to label the items in the AutoML Vision UI.

There is an optional feature in EyeBird application. It is user able to browse birds by name and view their details. For that option, there is a data set of Sri Lankan birds' images and details which collect from Ceylon Bird Club ("Ceylon Bird Club, Birds of Sri Lanka, sri lankan birds, endemic birds of sri lanka," n.d.). For testing purposes, will be using the Caltech-UCSD-Birds-200-2011("Caltech-UCSD Birds 200," n.d.) dataset. This dataset includes 200 categories of bird species, 11,788 total number of images, and other information.
In data analytics, it can divide into three sections.
1. SQL Query
2. Machine Learning
3. Graph Analytics

In here for the bird image classification and identification Machine Learning involves. The Machine Learning section again divide into two, Traditional Methods which contains Regression, SVM, and Recommender systems and other section are Neural Networks. It contains Machine Learning and Neural Networks approaches.

Chapter 5: Required Techniques and Approaches

5.1: Image Processing

Image processing is the manipulation or modification of a digitized image to enhance its quality. It uses to improve the image, pictorial information for human interpretation or render it more suitable for autonomous machine perception. The basic idea behind the image processing is the processing of a digital image. For an example removing noise irregularities present where creep into the image either during its formation or during transformation using the computer. To analysis mathematically, the image may be defined as a two-dimensional function $f(x, y)$ where x and y are coordinates. When x and y values are finite and discrete quantities it's a digital image. The digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are knowns as pixels. There are various techniques for image processing.

- Image Preprocessing
- Image Enhancement
- Image Segmentation
- Feature Extraction
- Image Classification

5.1.1: Image Preprocessing

In image preprocessing, image data recorded by sensors contain errors related to geometry and brightness values of the pixels. Those errors are corrected by using appropriate mathematical models.

5.1.2: Image Enhancement

Image enhancement is modifying the image by changing the pixel brightness values to improve the visual impact of the image. Image enhancement contains a collection of techniques which are used to improve the visual appearance of an image or to convert to a format that suits for human and machine interpretation. Image enhancement basically uses to feature extraction, image analysis and image display. In the image enhancement process, it does not increase the inherent detail content in the data but emphasizes specific image characteristics. The algorithms of enhancement are generally interactive and application dependent. Also, the enhancement has three main techniques;

- Contrast Stretching
- Noise Filtering
- Histogram Modification

5.1.2.1: Contrast Stretching

Some images are homogeneous, that means the images which are taken of dense forests, clouds, snow, and deserts don't have many changes. So that is characterized as a narrow peak. That images hence

obtained are not easily interpretable due to poor human perceptibility. The contrast stretching methods are used infrequently encountered situations. So the stretching techniques are introduced to stretch the narrow range to available dynamic range.
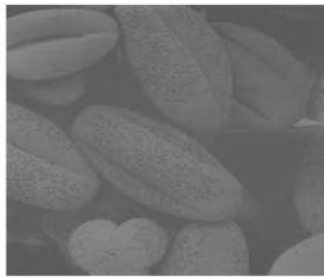
Original Image   Contrast Enhanced Image

Figure 5.0.1: Contrast Stretching

Figure 5.0.2: Contrast Stretching

5.1.2.2: Noise Filtering

Noise filtering is removing unnecessary information from an image. There are various filters like low pass, high pass, median etc.
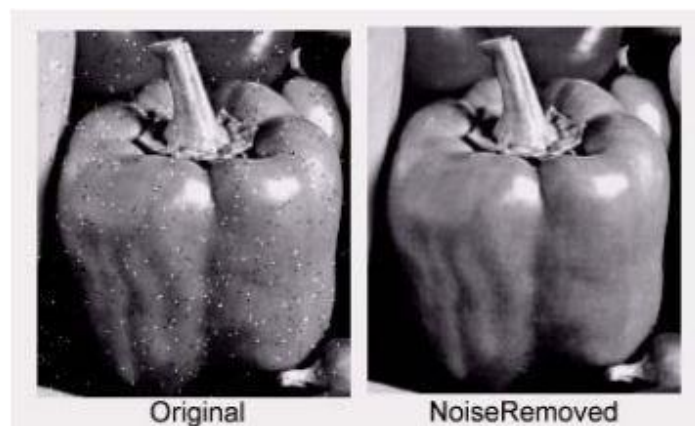

Figure 5.0.3: Noise Filtering

5.1.2.3: Histogram Modification

The histogram is connected with characteristics of an image. By modifying the histogram, image characteristics also can be modified.

5.1.3: Image Segmentation

Image segmentation is the process that divides the image into constituent parts. Image segmentation is defined as a key problem in image processing. The level of division of the image depends on the problem which needs to solve. As an example segmentation should stop when the objects of interest in an application have been isolated. Image thresholding techniques are used for image segmentation. Image segmentation involves discrimination between the object and the background as well as separation between different regions.

5.1.4: Feature Extraction

To extract features in synthetic radar images, feature extraction techniques have been developed. Those techniques extract high-level features to perform classification of targets. Features are items which uniquely describe a target such as a shape, location, size and composition etc. After preprocessing and segmentation level is completed some feature extraction technique is applied to the segments to extract features of them. It is important that focus on feature extraction because it has an observable impact on the efficiency of the recognition system. Feature extraction process is the most essential factor to achieve high recognition performance. The internal process of the feature extraction is, extracting from raw data information which is suitable for classification with minimizing class pattern variability. There are different feature extraction methods and those methods are selecting by considering input.

5.1.5: Image Classification

Image classification is the labelling process of a single pixel or group of pixels based on its grey value. In the information extraction method, the image classification is commonly used.

All these techniques involve a sequence of methods to process an image to improve pictorial information for human interpretation and processing data for storage, transmission and representation for machine perceptions. The principal advantage of this processing method is versatility, repeatability, and the preservation of original data precision. To improve performance and extract important data from a bird image and through that identify the bird and get an accurate result, EyeBird application is using image processing techniques for development.

Chapter 6: System Design and Implementation

6.1: Application Design

In application design, there are two key terms to consider. They are UX (User Experience) and Backend programming. User experience design is any aspects of a user's experience with a given system, including the interface, graphics, physical interaction, industrial design. And the backend is the code that supports the front end. To increase user acceptance both are important in the software industry.

6.1.1: Application Design of EyeBird

EyeBird is a mobile application which is compatible only with android platform. The idea of smartphone application was to port the identification algorithm to a handled device in order to make it practically useful and real-time in several situations.

The main purpose of creating this application was users can able to take a quality photo of a bird using the handheld device then uploading and identify the bird. Once the identification process finished user would be able to see a list of detail of identified bird. The application was drafted to have the following features.

- Choose a photo from gallery.
- Capture a bird by phone camera.
- Upload photo to restricted area.
- Identifying after uploading finished.
- Display identified bird and some related works.
- Browse some Sri Lankan birds and link to further reading about each species.

The user interfaces are designed using Android studio platform. For this project design done under Android studio 3.1.0 version. The user interface is the only thing that the user can see and interact with. So the design should be in user understandable and simple manner. So the EyeBird application user interfaces designed simply. And use popup messages and other notifications to guide the user.

6.2: Development Environment

6.2.1: Android Studio Programming

Android Studio is Integrated Development Environment (IDE) for designing Android applications. The Android application is composed of four main components which are Activities, Services, Content Providers, and Broadcast Receivers.

- Activities: Single screen with the user interface that bridge with the user. Written as a single Java class, with the main activity extending Android's Activity class. Handle user navigation within the app Example: back button.
- Services: General purpose entry point and keeping the app running in the background which doesn't interact with the user.
- Content Provider: Saves data between start-ups and changes.
- Broadcast Receivers: Enable the system to deliver events to the app when currently not running.

It provides a Gradle based flexible compiler system, an emulator and tools for debugging, code checking and version compatibility.
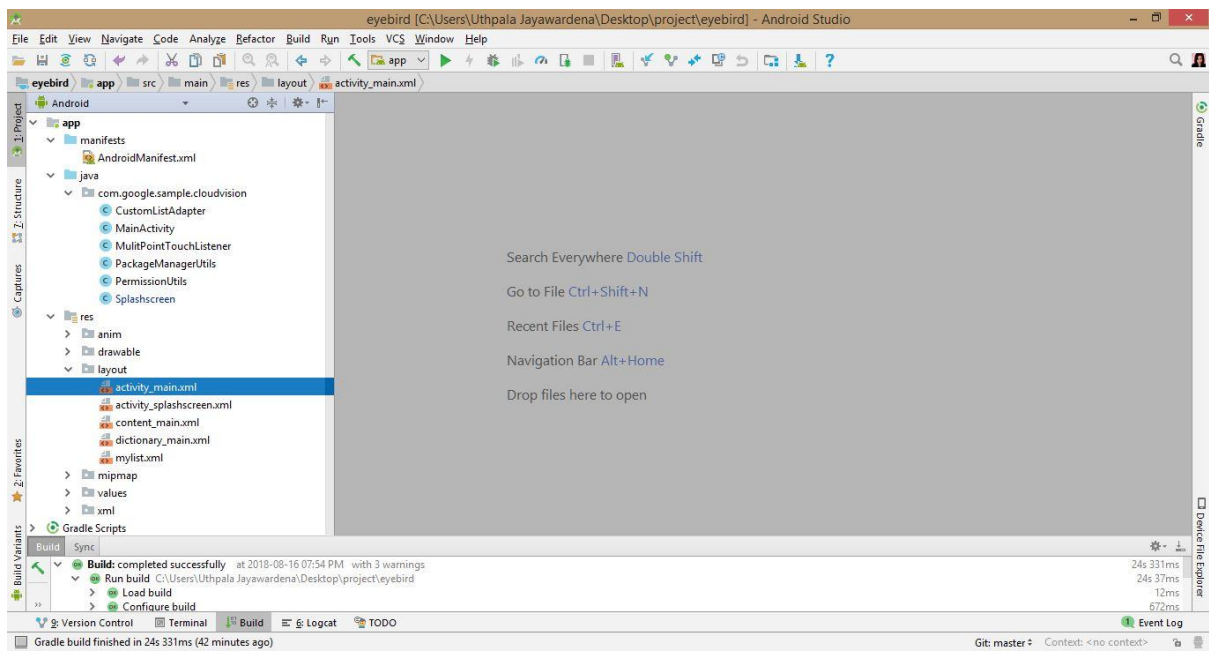
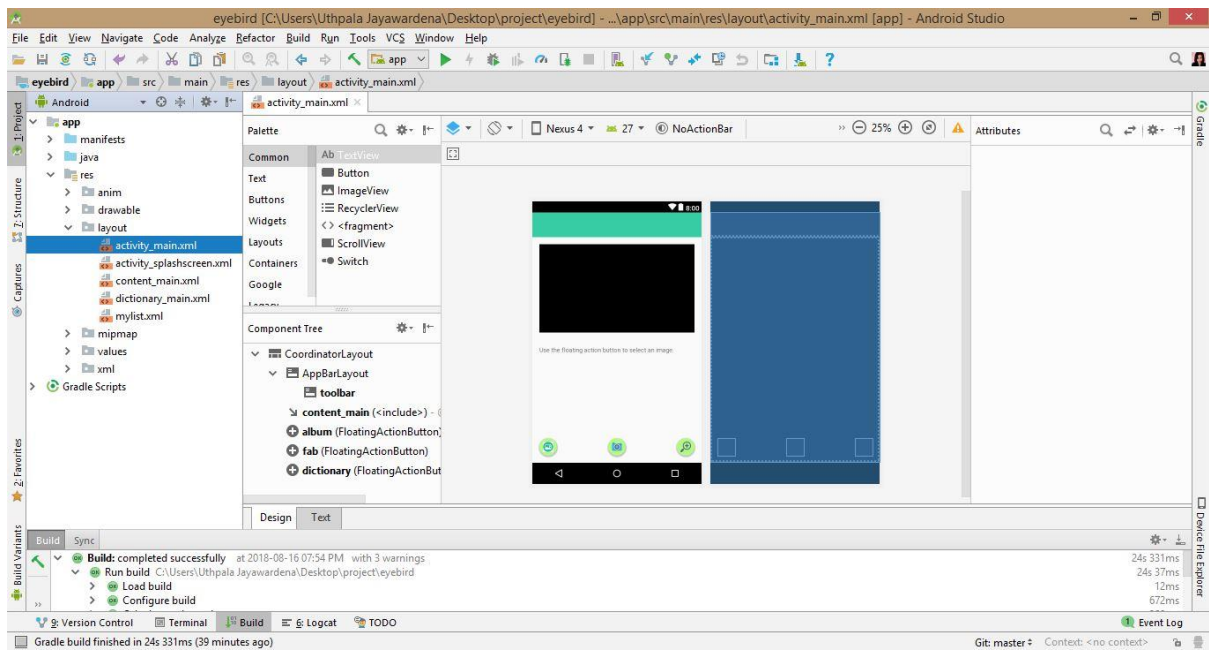*Figure 6.0.1: Android Studio*

6.3: Interface and Control

Figure 6.0.2: Android Studio Interface Design

The system features of the application are

1. Gallery
2. Camera
3. Photo upload grid and display response
4. Browse option

1. Gallery button display on the bottom of the application interface. If the user needs to choose a photo from the gallery, then click on the button. Then the user will able to open up the phone gallery and pick a photo. Then the user automatically navigates to the application main screen and that selected photo is display on the grid.

2. The application provides user to open the phone camera through the application. As above mentioned in the document the camera should be in 24MP or above. After open, the camera user can capture a photo and the user gets the confirmation message to "OK" or "Retry". When he clicks "OK" the application automatically navigate to the main screen and the captured photo is available in the grid.

3. After completing 1 or 2 option the application automatically sends the request through the internet and the matching bird will display to the user.

4. As an additional option, there is a button to browse for more bird details. When the user clicks the button, navigate to another user interface which displays some link named bird's names with their picture. By clicking the link user will navigate to another web view which displays descriptive details about the selected bird.

6.4: Used Programming Languages and Libraries

For the Android mobile application, the basic and main programming language is Java. Java is an object-oriented language, platform independent and has many libraries that support to build android developments. The Android SDK includes many standard java libraries as examples data structured libraries, math libraries, graphics libraries, networking libraries and also Android libraries that impact Android application development. When building the project Android application takes JAR files and package deployment on devices as APK (Android Package) files with extension .apk. This file format includes compiled Java code of the project, and strings, images, and all required files that application needs to run and also Application Manifest file as AndroidManifest.xml. This AndroidManifest.xml contain all the configuration details of the application project. GSON is a java library used for serializing and desterilizing Java objects from and into JSON. In this EyeBird project use this GSON library to send client/user request to API to identify the bird and get the response back.

6.4.1: Machine Learning

Differentiation or Identification is not hard for humans. But for computers, it is not a simple task. So the machine learning able to give a solution for that.

Machine learning is an area of artificial intelligence which is focused on computers the ability to learn and understand. Basically, the computer executes tasks which contain a set of strict instructions. By use of machine learning, the computer is programmed to interpret a giving set of data using several mathematical and statistical models and learn to make decisions.

Cloud Vision API provides developers to identify the content of an image by using machine learning models in REST API which easy to use.

6.5: Image Analysis Tool

EyeBird is bird recognition application. In this project for the analyzing process used Google Cloud Vision API. This is an open source library for high-performance computations and specializing in machine learning applications. This API allows developers to analyses content and contextual data associated with images with a trained machine learning model. It is a REST API. So according to this application, can obtain information on a given image of a bird through the API. Also can categories the image into subcategories. To this project, it uses Label detection in Vision API. Label detection is an image annotation feature in Vision API which predicts the most appropriate labels that image describe. So it returns label identifier, label description and accuracy of the suggested result.
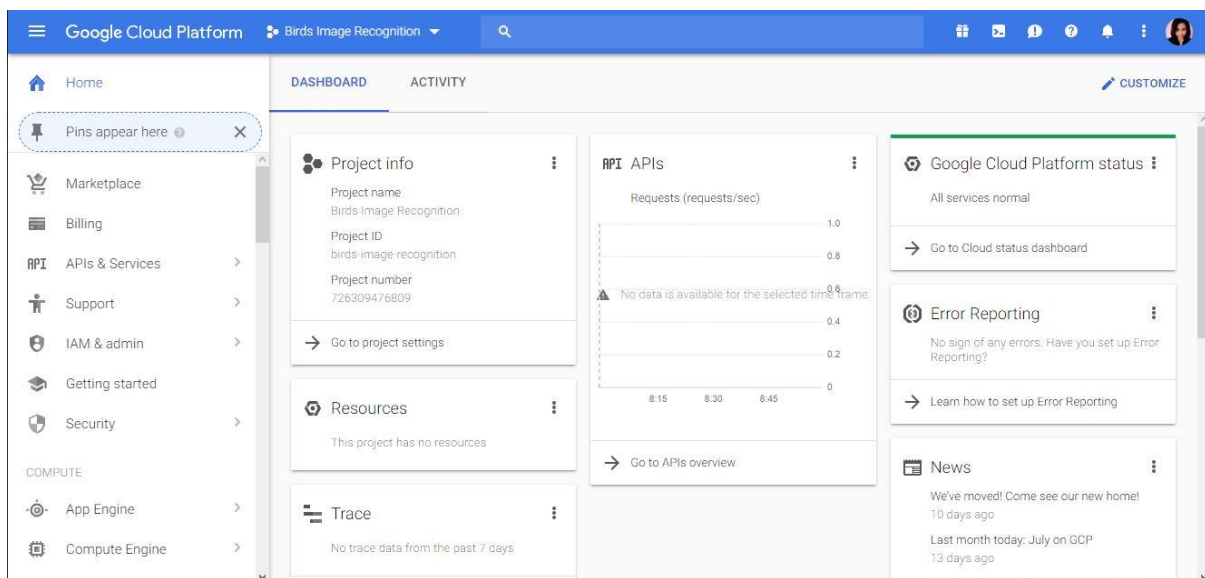

Figure 6.0.3: Google Cloud Vision API Console

6.5.1: Image Labeling with Google Cloud Vision API and AutoML Vision API

Classifying images done under two approaches. Mapping a detected label to a predetermined category and use word vector to find similar category. One method of mapping labels to categories is map Vision API labels to specific categories that each category is associated with one or more Vision API labels (fixed label-to-category mapping). And return the category confidence score for each label.

After detection is done then the detected labels are converted into equal vector representation using Glove. Applying to this project, convert the images labels into individual words like "Bird", "fauna". The combined word vector created by linearly combining the single word vectors for each label accuracy. Vector is calculated for each category considering the sum of the word vectors and represent the category.

6.5.2: Google Cloud Vision API Internal Process

Open up the EyeBird application and upload the captured image and rearrange the photo to set the targeted bird to the restricted area. Then the application automatically sends a JSON request to the Google Cloud Vision API through accessing the Cloud Vision API Key by calling callCloudVision() function. This diagram shows the flow of request send process.
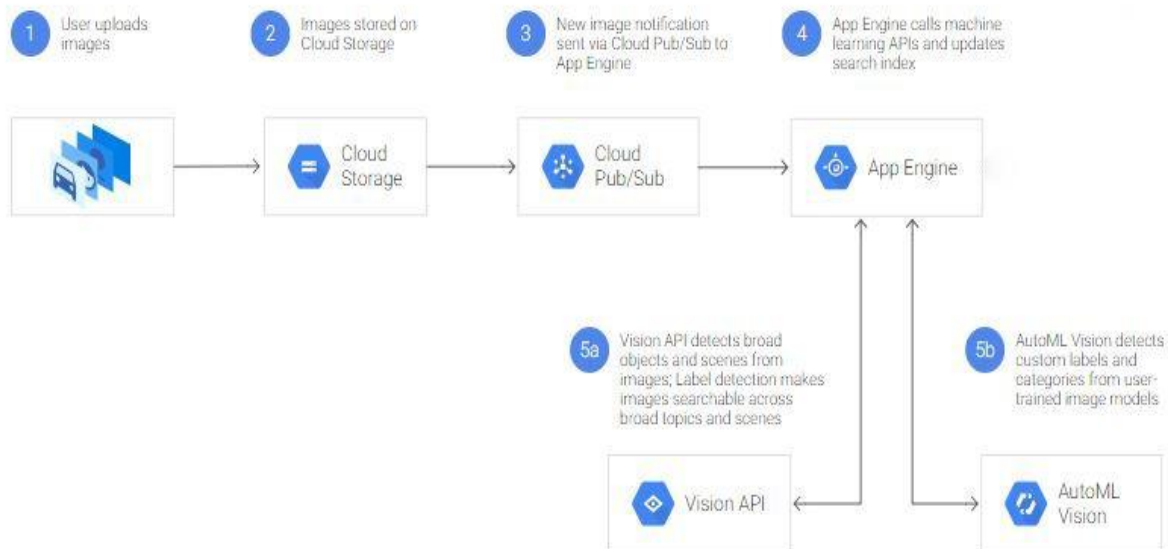

Figure 6.0.3: Google Cloud Vision API Internal Procedure

According to the above diagram;

Step 1: User upload the image of bird from phone internal storage which he want to identify.

Step 2: The uploaded image stored in the cloud database. After some time period cloud database remove that image from their database. So the image is storing therefor temporary.

Step 3: Uploaded image notification send to App Engine through Cloud Pub/Sub. Cloud Pub/Sub is a fully managed real-time messaging service that allows to send and receive messages between independent applications.

Step 4: Then App Engine calls Machine Learning APIs.

In step 4, API do the image processing technique in order to arrange the image to identify the bird. The algorithm executes these approaches Image Pre-processing, Image Enhancement, Image Segmentation, Feature Extraction, Image Classification respectively. Then send it to APIs.

Step 5a: At this level, two processes are running concurrently. In here Vision API detects broad objects.

Step 5b: Another task is for the image identification through customizing dataset, it uses AutoML Vision API. So as one task AutoML Vision detects customize labels and categories from user trained image model.

23

Then it matching with the relevant dataset and identify the most accurate matching bird image and get the label of the bird. After identifying the bird name API resend the response to the client side as JSON respond. And finally, application convert the response to a string by invoking convertResponseToString () method and display the response to the user with matching bird name and other relevant labels. Additionally user able to browse some birds which are related to Sri Lanka and Asia. After navigating to browse interface user can choose a bird and then navigate to another web view that includes chosen bird's information.

Chapter 7: System Process

Initially user need to install the application APK to the Android mobile device or tablet which has OS with Lollipop 5.1.1 or above.
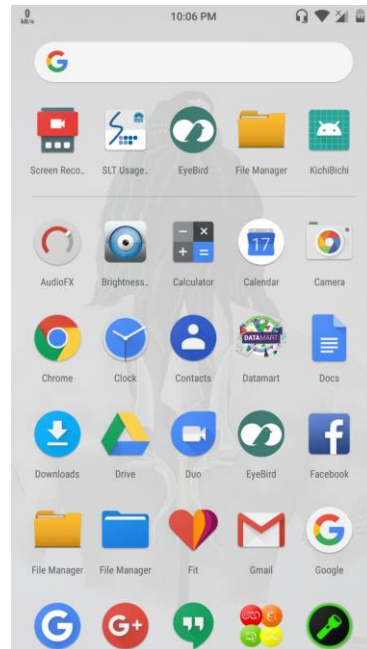
Figure 7.0.1: Application Icon

Then open the application.
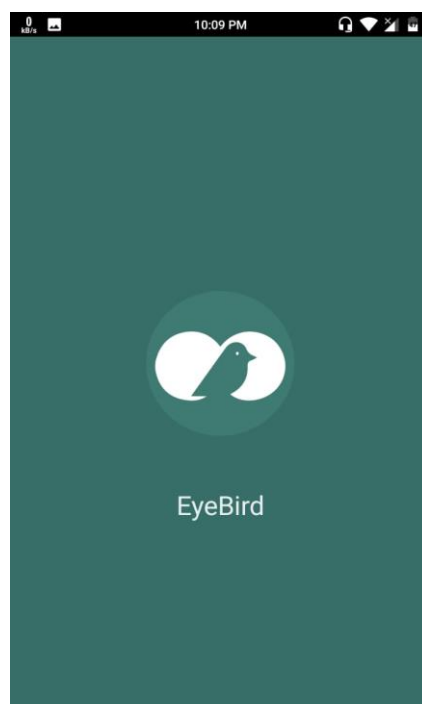
Figure 7.0.2: Loading Application

Then navigate to home screen which contains three options for user.

The three options are

1. Open the phone gallery.
2. Open phone camera.
3. Browse Birds.
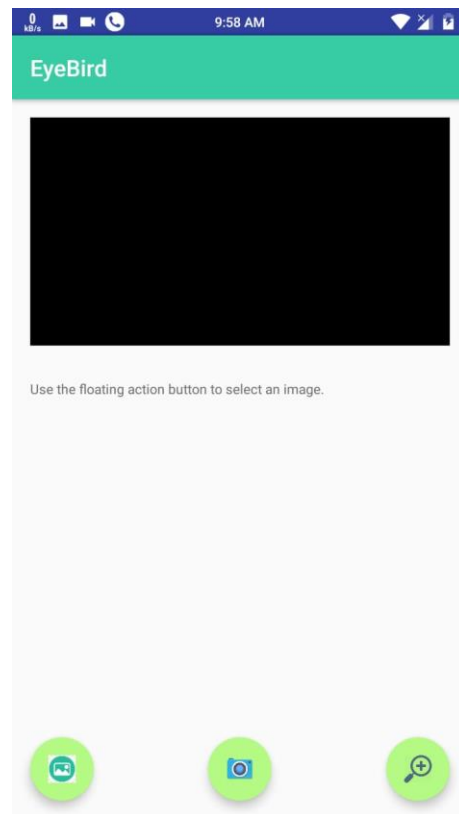
Figure 7.0.3: Application Home Page

To identify a bird user need to upload a photo. If phone storage already have a photo user can select gallery button, then navigate to phone gallery and can choose a photo.
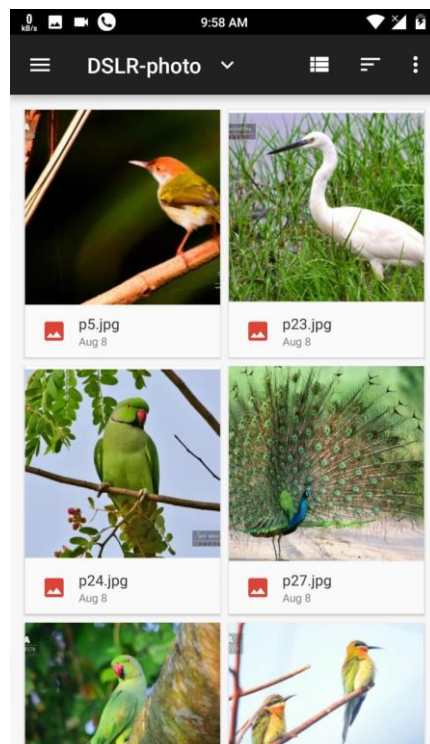
Figure 7.0.4: View gallery

26

Else user can a photo using DSLR camera with Wi-Fi or NFC or high-quality phone camera which is 24MP or above. If he uses a DSLR camera, then need to connect the camera to the phone using a bridge. As an example for Canon cameras, there is a software named Canon Camera Connect App. It provides a Wi-Fi connection with the camera for Image transfer and Bluetooth connection with enabled cameras. It's another software which can interconnect the camera and phone and send the captured photo to the phone memory. The phone can download the image using the bridging software.

If the user selects an option which is a gallery or camera, the selected or captured photo automatically upload to the application. Then the application sends the image request to the API. At that time it displays uploading message and waiting for the respond.
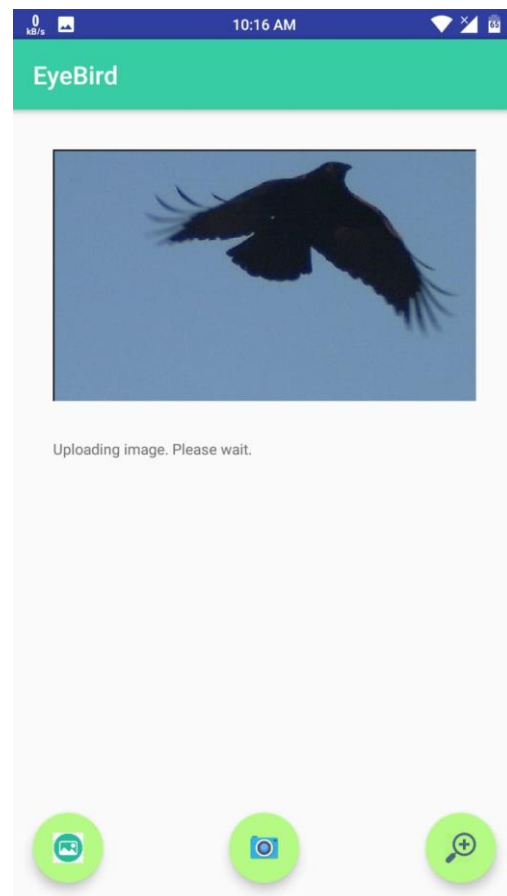
Figure 7.0.5 Waiting for Results

After few seconds application will display the identified bird name with some more adiitional features such as region, family with the relevant accuracy.

Figure 7.0.6: Display Result

The final option is after selecting the browse button, the user will navigate to another screen which contains a list of bird names. When the user clicks on a name then he will navigate to another screen which contains a description about the selected bird.
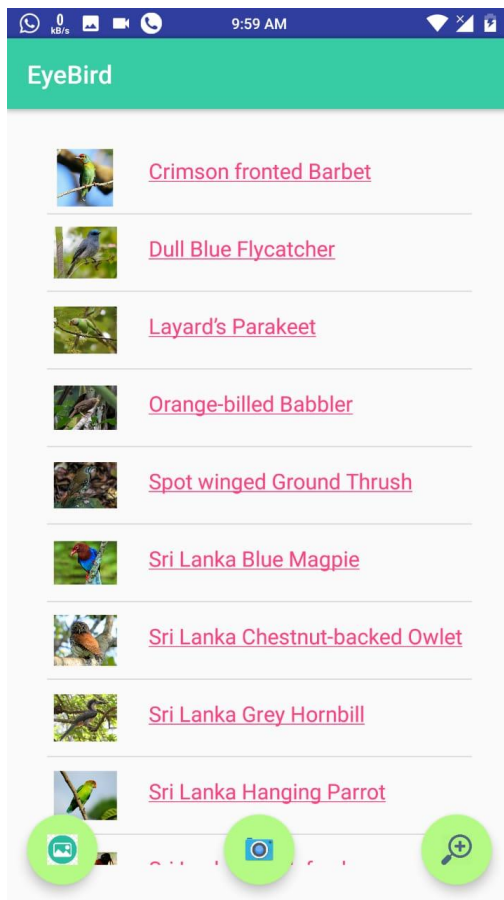
Figure 7.0.7: Browse Birds
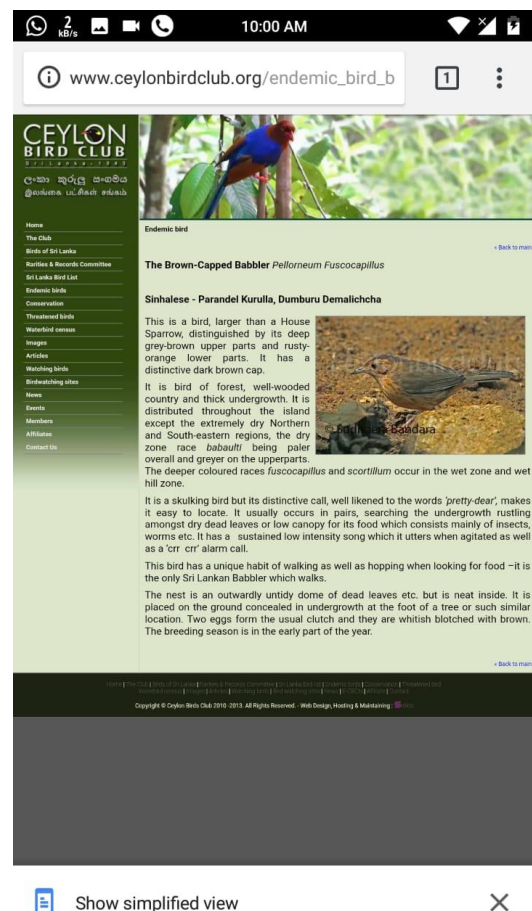
Figure 7.0.8: View Bird Details

Chapter 8: Testing of EyeBird

8.1: Acceptance testing

The EyeBird mobile application is a system that directly can use any person and give reliable service to users, this application needs to be tested as a functioning unit. So the acceptance testing for this application is important. This will check whether the application is ready to be implemented. The users of this application are bird watchers, learners, tourists and any other person. The test plan for the testing is a vital part of acceptance testing. For this, the application will be tested part by part and identify the issues in the application. Then categorize them according to their impact on the overall system. Finally, focus on the issues with the most impact and solve them and retest the application to clarify for more issues. For this set of unit test are used to input data and compare with the expected result.

Test Number	Test Description	Input Data	Output Result	Test Result
1	Execute the application.	Run the application on Android device.	Show the welcome home page.	Successfully executed.
2	Screen navigation.	Touch icon/link for appropriate screen.	Redirect to appropriate screen.	Successfully navigated.
3	Select photo from gallery.	Select a photo.	Navigate to home page and display selected photo in the grid.	Successfully selected the photo.
4	Send the identification request.	Select a bird photo.	Display bird name.	Successfully send the request.
5	Browse bird.	Select a bird name.	Navigate to another screen and display bird details.	Successfully browse.

Table 1: Testing

8.2: Test Cases

These are some test cases for the application to test if the application works properly in several situations.

8.2.1: Test Cases 1

Test Case   : Check if the bird identifying work correctly with a quality image.

Test Procedure : Upload a known bird's photo (Parrot) with high quality from gallery.

Expected Result: Identify the bird as parrot and display.

Actual Result   : Identified correctly.

Comment   : App is running perfectly.

8.2.2: Test Case 2

Test Case   : Check the browse bird list working.

Test Procedure : Click on one bird name link "Sri Lanka Whistling Thrush".

Expected Result: Display the details of "Sri Lanka Whistling Thrush".

Actual Result   : Display information.

Comment   : Feature is working perfectly.

8.2.3: Test Case 3

Test Case   : Check if the bird identifying not working correctly with low quality photo.

Test Procedure : Capture a known bird (Crow) using the phone camera.

Expected Result: Failed to identify the bird.

Actual Result   : Failed to identify the bird correctly.

Comment   : App needs to be improved by training a powerful data set.

Further testing is done with different set of images which contains different resolutions. And calculated the time period that take to receive the result. So by graphing them it shows that if the resolution of an image is low the response time is high. If image has high resolution, the respond time is low. So as a conclusion, the response time is depends on the resolution of an image. The below graph shows the testing result variation.
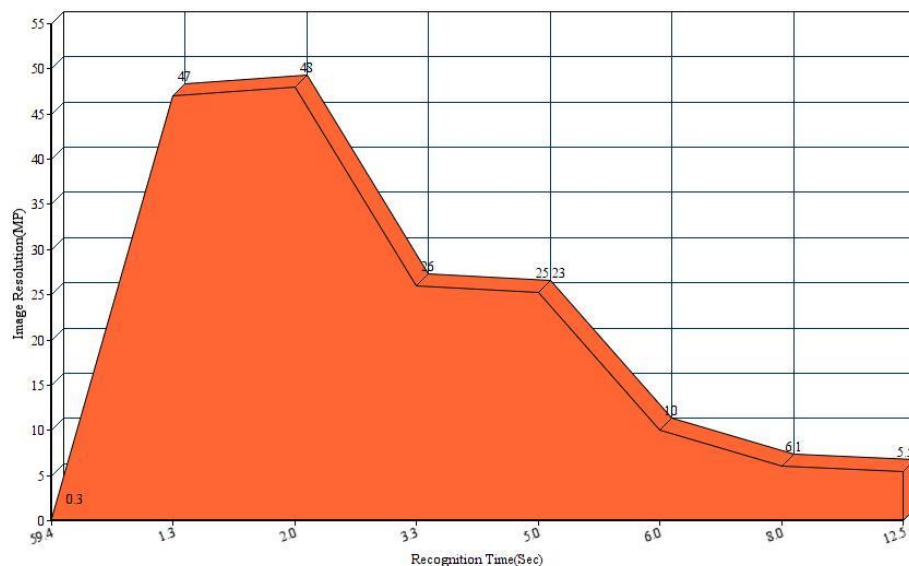

Figure 8.0.1: Image Resolution vs Response Time

Chapter 9: Critical Reflection

9.1: Deviations from the Proposed System

In the beginning, it was proposed to develop a mobile application which is possible to use to identify any bird. When further analysing the research area, it was found that there is some exiting application which targeted the African birds and introducing the same kind of product is useless and also found that those existing applications are not targeted the Asian birds. Therefore this project used to sample data set of Asian birds and mainly focus on Sri Lankan common birds.

In the proposed system there is an additional feature to search birds by name. But after studying about birds realize that there is a different kind of names for each bird. So that might reduce the reliability and efficiency of the application. So as a replacement there is newly added feature of browse the birds by given name. Since this application target the Asian and Sri Lankan birds the browse option filled with Asian and Sri Lankan birds to improve the efficacy and reliability.

Initially, it was proposed to use Firebase database to save uploaded data. But after referencing about image processing algorithm using API, realized that no need to upload it to a separate database because the user uploading the stored photo. So the current system doesn't contain a Firebase database.

These are the deviations from the proposed system.

9.2: Evaluation on Project Planning

It was proposed to develop a bird recognition system using image processing techniques. So the project is going to implement an online Android mobile application. And it was planned to recognize the bird using Google Cloud Vision API Service.

Since the trained dataset is stored on the server side, the advantage is that the application doesn't need any large storage space to install the application APK on the device. And also the identifying speed depends on the quality or the clearness of the photo and the strength of the internet connection.

But considering the usage of the application, it was a disadvantage. Because the EyeBird application is using birdwatcher in rural areas or the inner side of the country which away from town or city areas. So using an online application is not realistic. Because most of the time those areas haven't a strong internet connection.

So as alternatives, it's better to build this as an offline application which doesn't need an internet connection to identify a particular bird through a given photo. Then the birdwatchers or any user can use the application in any location easily.

9.3: Evaluation on Project Design

The design of the project is proposed as a simple mobile application which has main three features. The design of the application has the welcome screen, the main home screen which contains the three navigation buttons to navigate to camera, gallery and browse bird option. In the same screen, it shows the user uploaded a photo of the bird and the result which means the name of the bird. When the user clicks the camera he can capture a photo and that photo will automatically upload. And when the user clicks the gallery button he can choose a photo in the phone storage. And finally, when the user clicks the browse button he will navigate to another screen which displays the names with the photos of the birds in Sri Lanka. By clicking the name user will navigate to a web page which contains descriptive details about the selected bird.

Since the application is simple and easy to use any user can easily manage and get the service efficiently.

The design of the application has some issues. In the browsing feature, the bird's details are shown on a webpage by sending a URL. If the application builds as an offline application this webpage cannot load without internet connectivity. Also when identifying the bird it shows some additional list of details with the name of the bird. Sometimes it's not necessary for some user requests. They might need just the name of the bird.

As alternatives for the above issues, there are some suggestions with the application design. When uploading the photo, the application can display only the name of the identified bird and if the user needs future information, can add a link as view more or set the identified bird name as a link and by clicking the name user able to view more information. And for the browse feature, can use another screen to show the selected bird's details rather than loading a web page. The details can store in a database with some categorization such as colour, size, family group, scientific name, habits, sexual variations, behaviour etc. And retrieve from it and display in the listed format rather than descriptive format.

9.4: Evaluation on Project Implementation

The implementation of the project is done as separate two components and communication have done by sending a request in JSON file format through the internet. Those two components are the front end which is implemented using the Android studio platform and the backend which is the REST API and according to this EyeBird project, the API is Google Cloud Vision API. API includes the image processing algorithm. When the user uploads the image application automatically send the JSON request to API. After identifying the bird API resend the response to the client side.

Since the API is separately working and in the Google Cloud service, the size of the application is reduced. Also, the matching task is done through the API by invoking the Cloud_Vision_API_Key and so that reliability and accuracy are high in this application because the API do the matching with a large dataset. The code is not complex because the whole application working as separate tiers. It's a disadvantage that user can't use the application without the internet.

So as an alternative idea, it's better to implement a REST API and interconnect those two sides remotely. The REST API can implement using Python. API will send the request to the database and call the query. Then match with the trained model and resend the response. This can use to implement an offline mobile application.

If the project follows those alternatives, the project will be more successful and can output more performance.

9.5: Problems Encountered and the Solutions

There were problems encountered in the planning, design and developing stages in EyeBird project. The biggest issue was, what is image processing? How it applies to this system? And what's internally happen in the image processing approach? So initially started referencing some related projects, existing systems and some references regarding image processing.

Initially, the project was proposed to use the only mobile device for the overall process. While the project was in the prototype level, an obstacle came. That was the quality of the photo. Even though the image processing algorithm is strong but there is a limitation of the photo quality that Machine Learning technique can recognize. So the application can install any mobile device or tablet which OS is Lollipop 5.1.1 or above. But the camera quality issue interrupted. So as a solution decide to overcome the problem with the additional device which is DSLR Wi-Fi/NFC connected camera. The user able to get photos using a camera or smartphone which camera is greater than 24MP.

While doing the implementation with Google Cloud Vision API, able to clarify an issue. That was when identifying the bird it API send the response with unrelated labels. So to prevent that, add a method to filter the labels and hardcoded with wanted labels. The system filters the labels with filter words and displays the output to the user.

9.6: Lessons Learnt

The project was challenging as it included image processing approach and mobile development which was a new area that was studied during the project duration.

The studied theories throughout the research had to be applied to the realistic environment. Since the project development based on the mobile development, the mobile development knowledge was gained as a significant weight of the research.

This project offers an opportunity to establish the project management skills by providing deadlines to meet up and also it enhanced the analysing skills.

It was a valuable experience that will be beneficial in the future path at the industrial level.

9.7: Future Enhancements

It was proposed that the developed mobile application should be identify all the common birds around the world as the current context only identify limited trained birds which are common to Sri Lanka and Asia.

Add new feature of showing locations to user that selected bird commonly living in through loading Google map.

Another main intention was to make the application offline. Which means user able to identify the bird without internet connection. And the DSLR camera and the mobile device or tablet can connect through NFC technology rather than using Wi-Fi.

As another main future invention had been to track and extract features of a bird in a video and identify bird by analyzing video of a bird.

Same as the features in the mobile application, plan to develop a website. So rather than install an application users can browse the website and do the identification.

9.8: Ethical Concern

In EyeBird project there is a feature to access the website called CEYLON BIRD CLUB Sri Lanka-1943 to view more details about the birds. The conductors of that website give the approval to continue the development with the help of this website and use the data which they have published on their website.
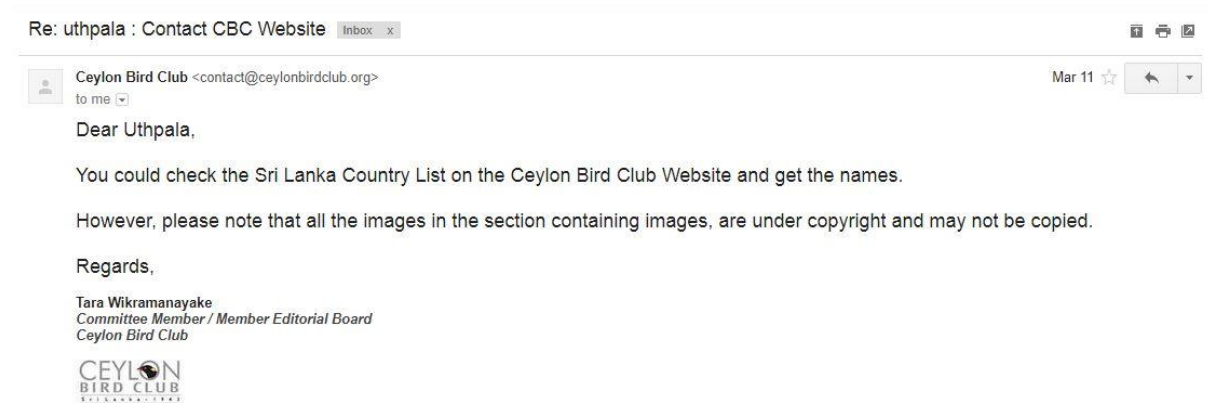

Figure 9.0.1: Ethical Concern

Chapter 10: Conclusion

The main goal of this project is to develop a mobile application which used to identify birds using photos. As mentioned previously, there are related applications and projects have done in this area and they have some unique features for each.

Since almost every person owned a smartphone and the majority of the use of Android devices, the project was planned to develop a mobile application which compatible with Android Lollipop operating system.

So for the development of this application, it included image processing approach which completes the main role of this project. The application was developed by combining two parts which are mobile application design and API which has the algorithm of the application process. The API process the uploaded image and extract features from it and match with a trained dataset and after matched on finding get the label of the image and send back the result to the user interface.

This application allows the users to find birds by uploading a photo. In a practical scenario, the application more useful for birders and bird learners may be students. The success of the application depends on users' satisfaction. The problem of identifying birds try to solve by EyeBird application.

Furthermore, the testing shows the accuracy of the results for each matching. So the user able to understand how correct the results. Through this, it improves the reliability of the user with the application. By further testing with a set of image which has different resolutions prove that the recognizing time is depend on the resolution of the image.

The developed EyeBird application helps to the users efficiently to identify unknown bird within a few seconds and helps to learn more details about birds with interesting and attractive manner while having some interesting.

References

Android Studio Development Essentials. (2015). Retrieved from
    https://www.ebookfrenzy.com/pdf_previews/AndroidStudioEssentialsPreview.pdf

Caltech-UCSD Birds 200. (n.d.). Retrieved August 19, 2018, from
    http://www.vision.caltech.edu/visipedia/CUB-200.html

Ceylon Bird Club, Birds of Sri Lanka, sri lankan birds, endemic birds of sri lanka. (n.d.). Retrieved
    August 19, 2018, from http://www.ceylonbirdclub.org/

Chitradevi, B., Srimathi, P., & Professor, A. (2007). An Overview on Image Processing Techniques.
    *International Journal of Innovative Research in Computer and Communication Engineering (An
    ISO*, *3297*(11). Retrieved from www.ijircce.com

Marini, A., Facon, J., & Koerich, A. L. (n.d.). *Bird Species Classification Based on Color Features*.
    Retrieved from http://www.birding.com

Mcandrew, A. (n.d.). *An Introduction to Digital Image Processing with Matlab Notes for SCM2511
    Image Processing 1*. Retrieved from
    https://eclass.teicrete.gr/modules/document/file.php/TM152/Lab/00_Intro/Matlab-
    Image_Processing_Tutorial.pdf

Merlin Bird ID – Free, instant bird ID help for 2,000+ North, Central, and South American, and
    European birds. (n.d.). Retrieved August 18, 2018, from http://merlin.allaboutbirds.org/

Nadimpalli, U. D., Price, R. R., Hall, S. G., & Bomma, P. (2006). A Comparison of Image Processing
    Techniques for Bird Recognition. https://doi.org/10.1021/bp0500922

Appendix A: Project Specification

PROJECT SPECIFICATION - Project (SEGM) 2017/18

Student:	Uthpala Nilupul Jayawardena
Date:	01/03/2018
Supervisor:	Dr Pradeep Abeygunawardhana
Degree Course:	BEng (Hons) in Software Engineering (SHU)
Title of Project:	Birds recognizing Android mobile application using image processing.

Elaboration

Now a days in the world interaction between nature and human has become very poor because of their complex and busy lifestyle. The purpose of this project is to build a mobile application to acknowledgment about birds. In this application, user has to upload an image of the bird which he has to get to know. The application analysis and match the bird using image processing techniques. Then user can view all the details of the relevant uploaded image.

The target market of the end product would be people who interested in nature or birds and also students for learning purposes. Image recognition software can improve their efficiency.

To further advance this project I aim to create mobile application that can retrieve birds' details using image processing. Future research will focus on testing the recognition algorithms. Applications of such techniques to industrial, agricultural, or related areas are additional future possibilities.

Figure: Project Specification: Page 1

Project Aims

The project aims to achieve following,

- Identify software libraries and tools that can help to develop an analysis of image processing system.
- Design key aspects of the system using UML.
- Learn machine learning.
- Research for methods to analysis images.
- Learn to develop an android applications.
- Develop a prototype that implements the core functionality.
- Create interactive user interfaces.
- Evaluate the feasibility of the product and come up with a completely working application.

Project deliverable(s)

Basic deliverable of the project will be an application which analysis bird's images and give their details. I will deliver a mobile application that will be on android platform.

The deliverable can,

- Upload images.
- Analysis the image and identify the matching bird.
- Search birds by name and category.

Figure: Project Specification: Page 2

Action plan

Task	Deadline Date
Finding a Supervisor	26th February 2018
Project Specification and Ethics Form	2nd March 2018
Background Research and Literature Review	
Mid Review	10th April 2018
Provisional Contents Page	18th May 2018
Submit Draft of critical evaluation and Sections of draft report	18th June 2018
Submit project report to Turnitin	19th July 2018
Project Demonstration	27th August 2018

Figure: Project Specification: Page 3

Appendix B: Ethic and Risk Form

Project (SEGM) [55-604708] Ethics and Risk Checklist

If the answer to any question is 'yes' the issue MUST be discussed with your project supervisor.

Ethics Checklist

Question		Yes/No
1.	Does the project involve human participants? This includes surveys, questionnaires, observing behaviour, testing etc.	No
2.	Does the project involve the use of live animals?	No
3.	Does the project involve an external organisation? If yes, please write the name of the organisation here:	No
4.	Does the project require access to any private or otherwise sensitive material?	No
5.	Does the project require the reproduction (beyond normal academic quotations) of materials authored by a source other than yourself?	No

Risk Assessment

Question		Yes/No
1.	Does the project take any physical risks (such as electrical, lifting, travel)? If any risk is identified it must be discussed further with the project supervisor.	No

Adherence to SHU policy & procedures

Declaration

I can confirm that:
- I have read the Sheffield Hallam University Research Ethics Policy (available at http://www.shu.ac.uk/_assets/pdf/research-ethics-policy.pdf)
- I agree to abide by its principles.

Signature * .... Print Name Uthpala Nilupul Jayawardena
Date 01/03/2016

* If you have an electronic version of your signature you could include it here. Otherwise, sign a printed out copy and scan it back in.

Figure: Ethics Form

Appendix C: Information Review

Reference: An Introduction for Image processing in MatLab

McAndrew, A. (2016). An Introduction for Image processing in MatLab. [online] Available at: https://eclass.teicrete.gr/modules/document/file.php/TM152/Lab/00_Intro/Matlab-Image_Processing_Tutorial.pdf [Accessed 2016].

This tutorial contains basic concepts of image processing such as enhancing the edges of an image to make it appear sharper, Removing "noise" from an image; noise being random errors in the image, removing motion blur from an image, obtaining the edges of an image. It contains what is the functionalities which a digital image differ from a photo.

There are some small list of application which give some indication of the range of image processing applications in different industry.

The tutorial give some explanation about different algorithms for different tasks and problems like

- Image enhancement
- Image restoration
- Image segmentation

Also it contains basic types of image processing and the efficiency of each type. According to the tutorial the types are Binary, Greyscale, True colour, or RGB, Indexed.

Then it focus on basics in MatLab which is a data analysis and visualization tool which has been designed with powerful support for matrices and matrix operations. Also it includes how the matrix capabilities of Matlab allow us to investigate images and the properties for each image type.

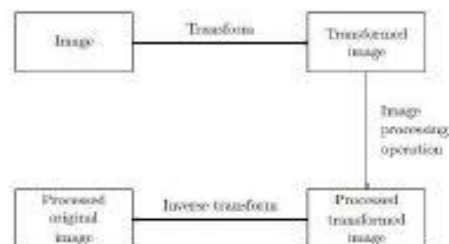Then the document share the process of an image. They have clearly describe in as a diagram.

Figure: Information Review: Page 1

Reference: Bird Species Classification Based on Color Features

Marini, A., Facon, J. and L. Koerich, A. (2013). Bird Species Classification Based on Color Features. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.725.3604&rep=rep1&type=pdf [Accessed Oct. 2013].

This paper presents the bird species classification based on color features extracted from unconstrained images. In here the first approach applies for a color segmentation algorithm in an attempt to eliminate background elements. Then the image is split into component planes and from each plane, normalized color histograms are computed. After aggregation processing is employed to reduce the number of the intervals of the histograms to a fixed number of bins.

In this article it's mainly focus on pattern recognition of birds in various situations, color features of birds, color image segmentation approach and bird species classification.
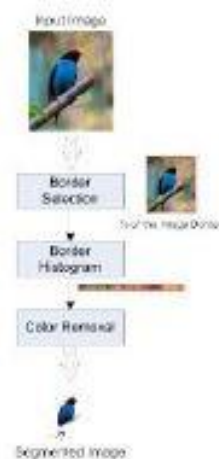
This is a graphical explanation of color segmentation.

Figure: Information Review: Page 2

Reference: A Comparison of Image Processing Techniques for Bird Recognition

Nadimpalli, U. D., Price, R. R., Hall, S. G., & Bomma, P. (2006). A comparison of image processing techniques for bird recognition. *Biotechnology progress, 22*(1), 9-13.

This document is basically focus in implementation methodology in bird recognition system. Image processing and neural network toolboxes of MATLAB were used for developing and testing all the algorithms. The three object recognition algorithms that they have describe are,

1. Image Morphology (Extracting useful information or removing useless information from a picture also known as removing noise)

2. Artificial Neural Networks (An error back propagation neural network)

3. Template matching (method of comparing an input image with a standard set of images known as templates)
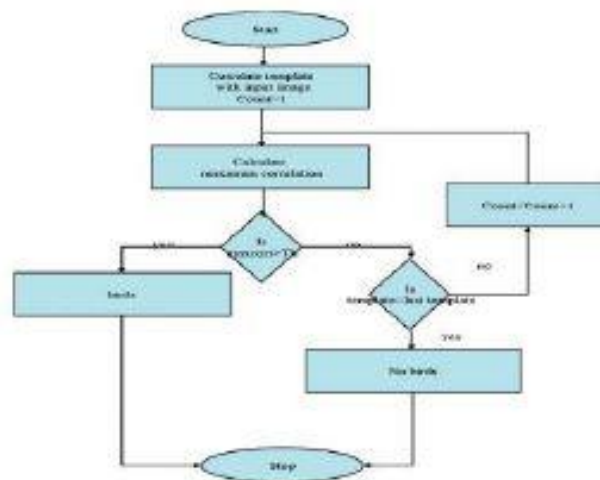
This graph is show working of this technique.

Figure: Information Review: Page 3

Reference: An Overview on Image Processing Techniques

Chitradevi: and Srimathi, P. (2014). An Overview on Image Processing Techniques. [online] Available at: http://www.rroij.com/open-access/an-overview-on-image-processing-techniques.pdf [Accessed Nov. 2014].

In this journal paper they have clearly mentioned about digital image processing and image processing techniques.

According to the paper the principle advantage of Digital Image Processing methods is its versatility, repeatability and the preservation of original data precision. And digital image processing techniques are,

- Image pre-processing
- Image enhancement
- Image segmentation
- Feature extraction
- Image classification

In image processing how the data is recorded and about image enhancement are mentioned here. And usage of image enhancement such as feature extraction, image analysis and an image display. Then the article provide introduction about enhancement techniques. Some of them are,

- Contrast Stretching
- Noise Filtering
- Histogram modification

Also the journal article is about another key problem which is Segmentation. Then move to Image Classification which is one of the most often used methods of information extraction.

Figure: Information Review: Page 4

Reference: Image Recognition and object Detection

MALLICK, S. (2016). Image Recognition and object Detection. [online] Available at: https://www.learnopencv.com/image-recognition-and-object-detection-part1/ [Accessed 14 Nov. 2016].

In this reference, briefly explain image recognition using traditional computer vision techniques and some defects of them. And then they mentioned about reasonable method that needs only two-class (binary) classifiers.

Reference: Android Studio Development Essentials

Smyth, N. (2015). *Android Studio Development Essentials*. [online] Available at: https://www.ebookfrenzy.com/pdf_previews/AndroidStudioEssentialsPreview.pdf [Accessed 2015].

This reference is a tutorial about how to develop an android application using android studio. First they describe about how to setting up an android studio development environment. This involves a number of steps consisting of installing the Java Development Kit (JDK) and the Android Studio Integrated Development Environment (IDE) which also includes the Android Software Development Kit (SDK). It contains how to making the Android SDK Tools Command-line Accessible.

Then they explain creation of a simple Android application project using Android Studio. Also they include how to modifying the Application and reviewing the Layout and Resource Files. Then explain about android studio user interfaces. Provide an initial overview of the various areas and components that make up the Android Studio environment.

One of major task of a developing an application is testing. In here also they describe how to test android studio application on a physical android device and briefly about android debug bridge (ADB).

Figure: Information Review: Page 5

Reference: MATLAB Data Import and Export

Works, M. (2011). MATLAB Data Import and Export. [online] Available at: https://aae.wisc.edu/aae637/matlab/documentation/import_export.pdf [Accessed Sep. 2011].

This book includes importing and exporting different file types. Since I am developing an image processing application I refer how import and export image file.

In importing image file they describe it as two sub topics, Getting Information about Image Files and Reading Image Data and Metadata from TIFF Files.

Reference: Deep Image: Scaling up Image Recognition

Wu, R., Yan, S., Shan, Y., Dang, Q., & Sun, G. (2015). Deep Image: Scaling up Image recognition. arXiv preprint arXiv:1501.02876, 7(8).

Reference: Machine Learning in Image Processing

Lézoray, O., Charrier, C., Cardot, H., & Lefèvre, S. (2008). Machine learning in image processing.

Reference: Algorithms for image processing and computer vision

Parker, J. R. (2010). Algorithms for image processing and computer vision. John Wiley & Sons.

I hope the survey and suggestions made in this paper is more useful for my Birds Recognition Mobile Application.

Figure: Information Review: Page 6