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Review JoAIRA

Birdwatcher's Assistant: AI-Based Bird Species Classification

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Abstract

Many bird species have gone extinct because of human activities and changes in the climate. The loss of habitats is a significant danger to global biodiversity. Therefore, it is important to monitor species distribution and identify the components of biodiversity in an area to develop conservation strategies. The ultimate objective is to build a machine learning model that can accurately differentiate between various bird species based solely on visual cues. The core of this project is a rigorous process involving complete data processing, robust model architecture development, rigorous training, and thorough evaluation. The ultimate desire is to engineer a stable classification system that can identify a broad spectrum of bird species. Distinguishing between different types of birds is no easy feat. It can be quite perplexing, resulting in uncertain categorization and even sparking debates among bird experts and enthusiasts, as well as anteaters, on the exact species being observed. This difficulty presents a formidable test for both human and artificial vision. Despite the presence of shared characteristics among various bird species, their shapes and appearances can differ significantly. In addition to identifying key species, the project provides a comprehensive portrait of each bird theme, delving into important ecological nuances such as suitable habitat and food preferences. These fundamental insights help us gain a deeper understanding of these incredible creatures and provide invaluable knowledge for conservation efforts.

Keywords: Bird species identification, machine learning model, preferred habitats, conservation knowledge, avian biodiversity

INTRODUCTION

The Bird Watcher Assistant project is dedicated to the accurate classification of bird species using advanced artificial intelligence. The main goal is to create a machine learning model capable of distinguishing different bird species with high accuracy based on visual input [1]. The core of the project is a complex process that includes data processing, model architecture creation, rigorous preparation, and thoughtful evaluation [2].

The main goal is to engineer a consistent classification system capable of distinguishing multiple bird species [3]. TensorFlow, the deep learning framework essential to this effort, serves as the backbone, helping models to be implemented and trained seamlessly [4]. In addition to simple species identification, the project provides a comprehensive profile of each bird species, learning important ecological details such as preferred habitat and feeding characteristics [5].

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Such comprehensive insights help provide a deeper appreciation of these magnificent creatures and provide invaluable conservation knowledge [6].

More Detailed Projects

- Building a powerful machine learning model that can accurately identify bird species from images.
- Develop a comprehensive classification system that can distinguish many species of birds.
- Provides information on the ecological details of bird species, including preferred habitats and feeding habits.
- Enhance understanding of bird species and aid in conservation efforts.

We have a project ahead of us, filled with important steps that we must go through [7]. These steps involve processing data, developing models, training them, and assessing their performance [8]. Our primary objective is to create a reliable system capable of visually identifying most bird species [9]. If successful, this project has the potential to greatly contribute to the fields of bird observation and conservation [10]. By providing birders with powerful tools for identifying bird species and understanding their ecology, it can help deepen the appreciation of these magnificent creatures and support conservation efforts [11].

DATA ACQUISITION AND AUGMENTATION

We accessed a variety of online platforms to gather data for this study [12]. By including images from the internet, they were able to make the database more diverse. However, it is important to consider that images from the public domain may not be perfect and could contain flaws like noise, false pixels, artifacts, or rough surfaces [13].

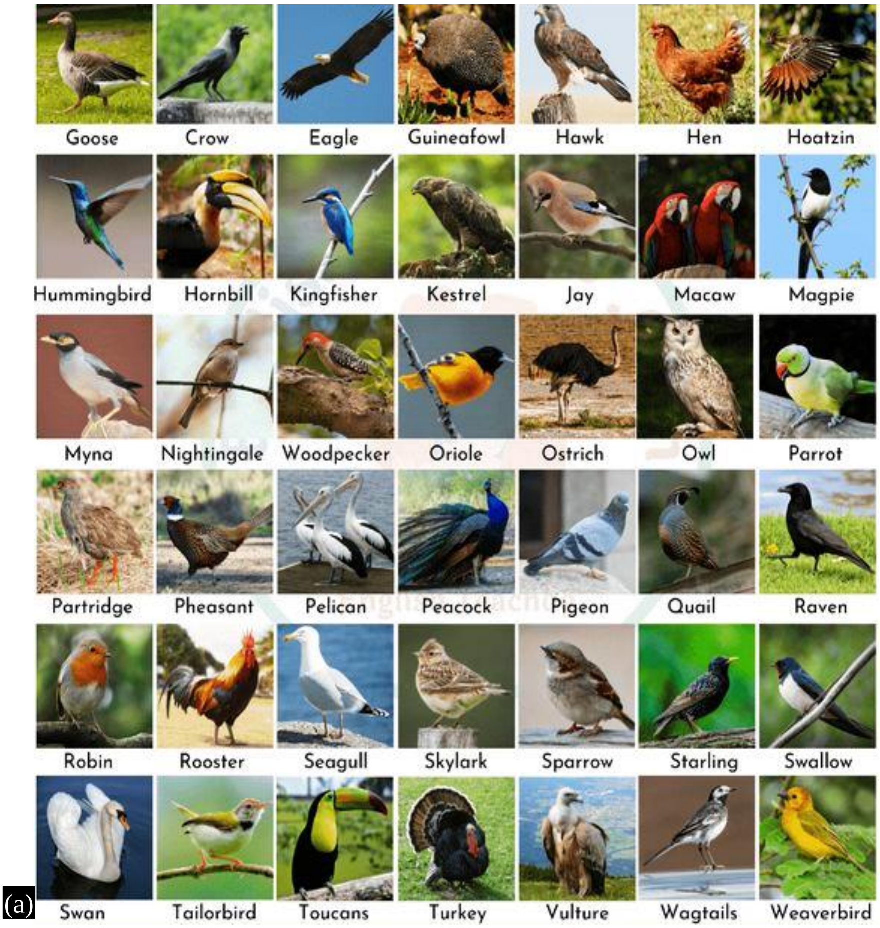

Figure 1. (a and b) Collection of bird species.

Additionally, these images might be blurry or distorted [14]. To deal with these challenges and minimize any loss in image quality, we stored the collective dataset at an average resolution ranging from 1,024×768 to 3,008×2,000 pixels [15]. Overall, they collected a total of 3,892 images representing 29 species of endemic birds (Figure 1).

The deep learning approach uses a multi-layer neural network for training the most complex features and improve its ability in prediction or complex classification [16]. The algorithm clusters many training samples in multiple concealed layers that exist between the input and output layer information. However, a lack of data and limited resources can lead to redundancy, and important data features can be easily missed, that may impact accuracy of classification [17]. In order to avoid copying and deal with discrepancies in information, we have put into action methods of duplicating data for different types of bird pictures [18]. These methods consider the various features that come with each species. The image of each bird goes through a comprehensive process that involves scaling it ten times [19]. This process includes rotating the original image, adding Gaussian noise, shifting it horizontally or vertically, enhancing the contrast, making the image sharper, adjusting the zoom range, and magnifying it to improve its quality [20].

PROPOSED WORK

The proposed solution for the model involves a user taking a picture and uploading it to the system. If the picture is not in the database, the user can save the picture in the database. The system will then extract features such as angle, expression, face, nose, etc. from the picture and use a classifier to make predictions using the training database. The researcher has created a platform that utilizes deep learning to detect and differentiate uploaded images of birds.

The project can be divided into several main modules that serve a specific purpose in the bird species classification system as shown in Figures 2 and 3:

- *Data collection:* Collect different data sets of bird images, including different species, to train and test classification models.
- *Data processing:* prepare the collected data for model training. Features include resizing, tagging, and cropping images to improve the look and quality of the database (Figure 4).
- *Model building:* Building a deep learning model for bird species classification. Use transfer training and pre-built InceptionV2 models from TensorFlow Hub.
- *Model training:* Train the model generated on a subset of the database. Monitor its performance and adjust hyperparameters as needed.
- *Model evaluation:* Evaluate the accuracy and performance of the developed model using a test database. Metrics such as accuracy, precision, and recall are taken into account.
- *Model conversion:* Convert the trained model to TensorFlow Lite (TFLite) format, suitable for deployment on resource-constrained devices (Figure 5).
- *Real-time inference (future scope):* Explore the possibility of implementing real-time bird species classification on edge devices for practical applications.
- *Model Deployment (Future Boundaries):* Deploy TFLite models to edge devices such as smartphones or embedded systems for real-world use.

Working on image processing in model is shown in Figure 6.

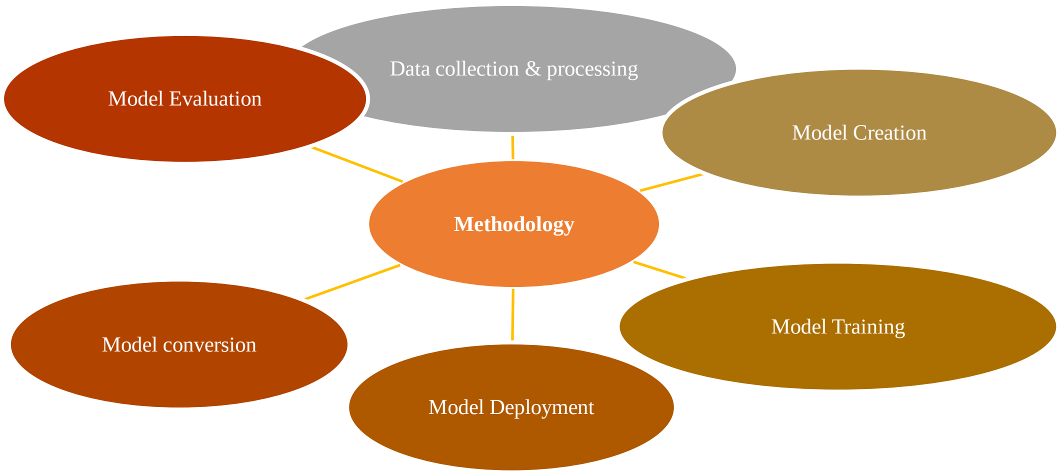

Figure 2. Framework of architectural design of the modules.

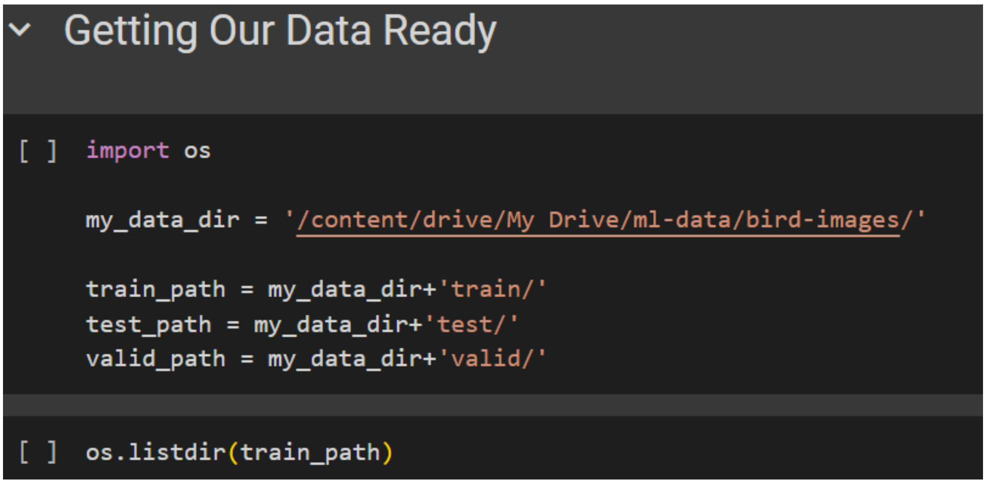

Figure 3. Getting our data ready.

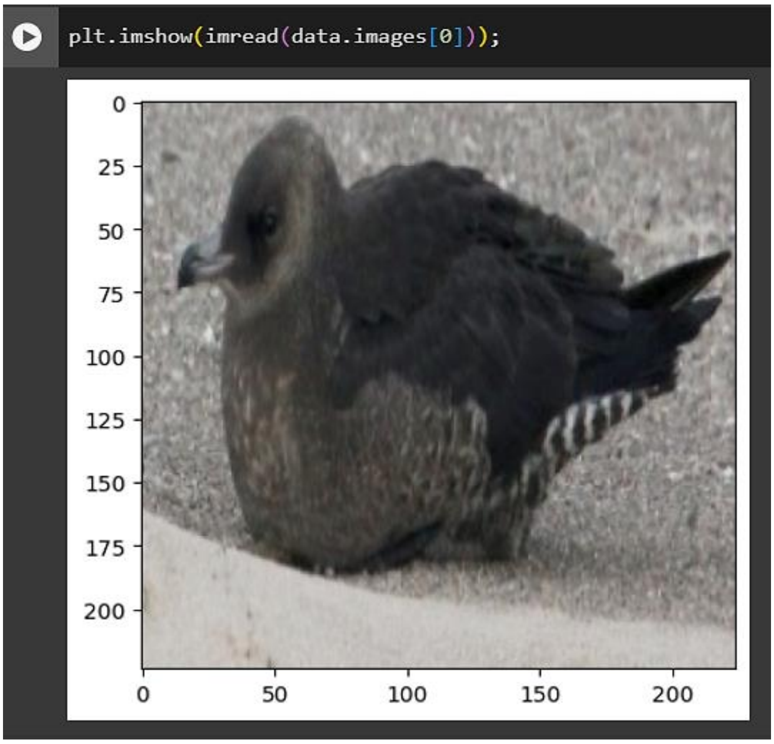

Figure 4. Image normalization.

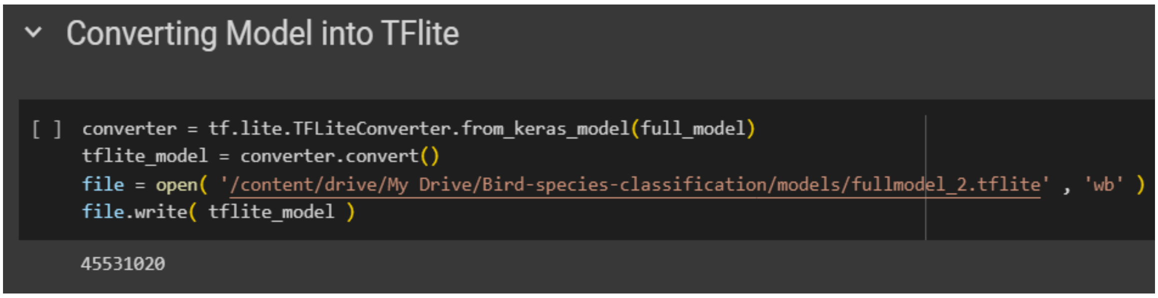

Figure 5. converting model into TFLITE using tensor flow.

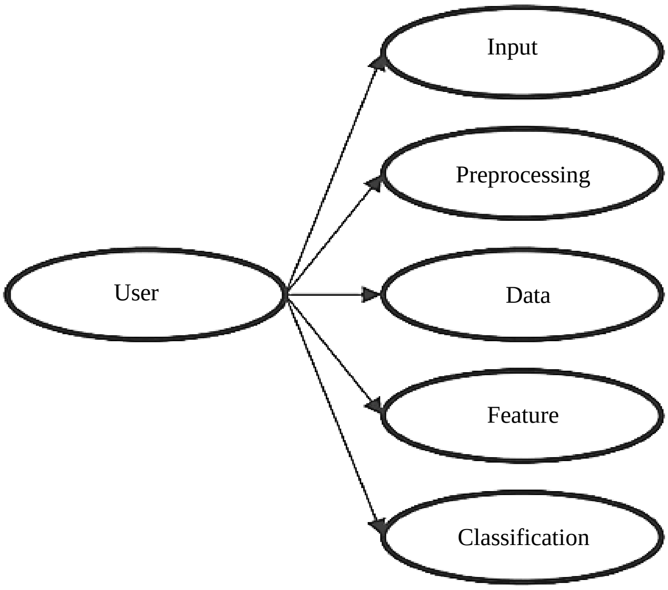

Figure 6. Processing of working image case diagram.

Five main types of image processing can be identified as:

- *Visualisation:* The process of visualization serves the purpose of identifying objects that cannot be perceived in the given image. This technique finds its frequent application in the field of medical imaging, where it aids in detecting tumours or any other irregularities that remain hidden from the naked eye.
- *Recognition:* This method detects objects in an image and classifies them based on their features. It is frequently utilized in computer vision applications such as facial recognition, object detection, and self-driving cars.
- *Focus and Restore:* This technique is used to generate an enhanced image from the original image. It is frequently employed to enhance the quality of blurry or out-of-focus images.
- *Pattern Recognition:* This amazing technique is employed to discern various intricate patterns that may be present in the vicinity of an object within an image. It finds its usefulness in a myriad of applications, including but not limited to the recognition of fingerprints, deciphering handwritten text, and comprehending spoken words.
- *Retrieval:* This technique is used to scrape and detect the images from a large database of digital image data like the original image. It is commonly utilized in applications like reverse image search and content-based image retrieval (Figure 7).

Fundamentals and Advanced Concepts in Image Processing:

1. *Image Acquisition:* This foundational step involves capturing the image, often using digital cameras or scanners. Basic adjustments, like converting colour images to grayscale or vice versa, can be applied at this stage.
2. *Image Enhancement:* This technique aims to accentuate visual clarity and bring out concealed details within an image. It is often considered the most aesthetically pleasing aspect of image processing, as it can reveal unseen aspects of an image.
3. *Image Restoration:* This process focuses on mathematically correcting distortions or imperfections that have marred an image. It utilizes models and algorithms to restore the image to its intended or ideal state.
4. *Colour Image Processing:* Includes false colour and full colour image processing.
5. *Waves and multi-dimensional:* the basis for showing different images.
6. *Image Compression:* This involves creating multiple functions to perform that function. There are usually large images or dimensions.
7. *Morphological processing:* includes tools to extract useful image objects in rendering and describing images.
8. *Segmentation:* This meticulous process divides an image into distinct components, like carefully separating ingredients for a recipe. It is considered as one of the most challenging tasks in image processing, especially when done without human guidance.
9. *Representation and Interpretation:* Segmentation is just the start. To truly understand an image, we need to represent the segmented components effectively and interpret their meaning. This transformation of raw image data into usable insights is like crafting a masterpiece from carefully chosen ingredients (Figure 8).
10. *Finding and identifying items:* This is the process of assigning tags to items based on their description.

TOOLS AND TECHNOLOGY USED

- *Data:* Kaggle's Bird Species dataset, containing images of 180 different bird species.
- *Programming Languages:* Python for machine learning and backend development, and Flutter for mobile app development.
- *Machine Learning Libraries:* TensorFlow for developing the Bird Species Classification model.
- *Mobile App Development:* Flutter for building the mobile application.
- *Image Processing:* OpenCV for image preprocessing.

- *Development Environment:* IDEs such as Jupyter Notebook, Visual Studio Code, and Android Studio for app development.
- *Cloud Computing:* Firebase or Google Cloud for model deployment.
- *User Interface (UI) Design:* Figma for designing the app's user interface.
- *Testing and Evaluation:* Diverse testing tools and frameworks are used to assess app performance and gather user feedback.

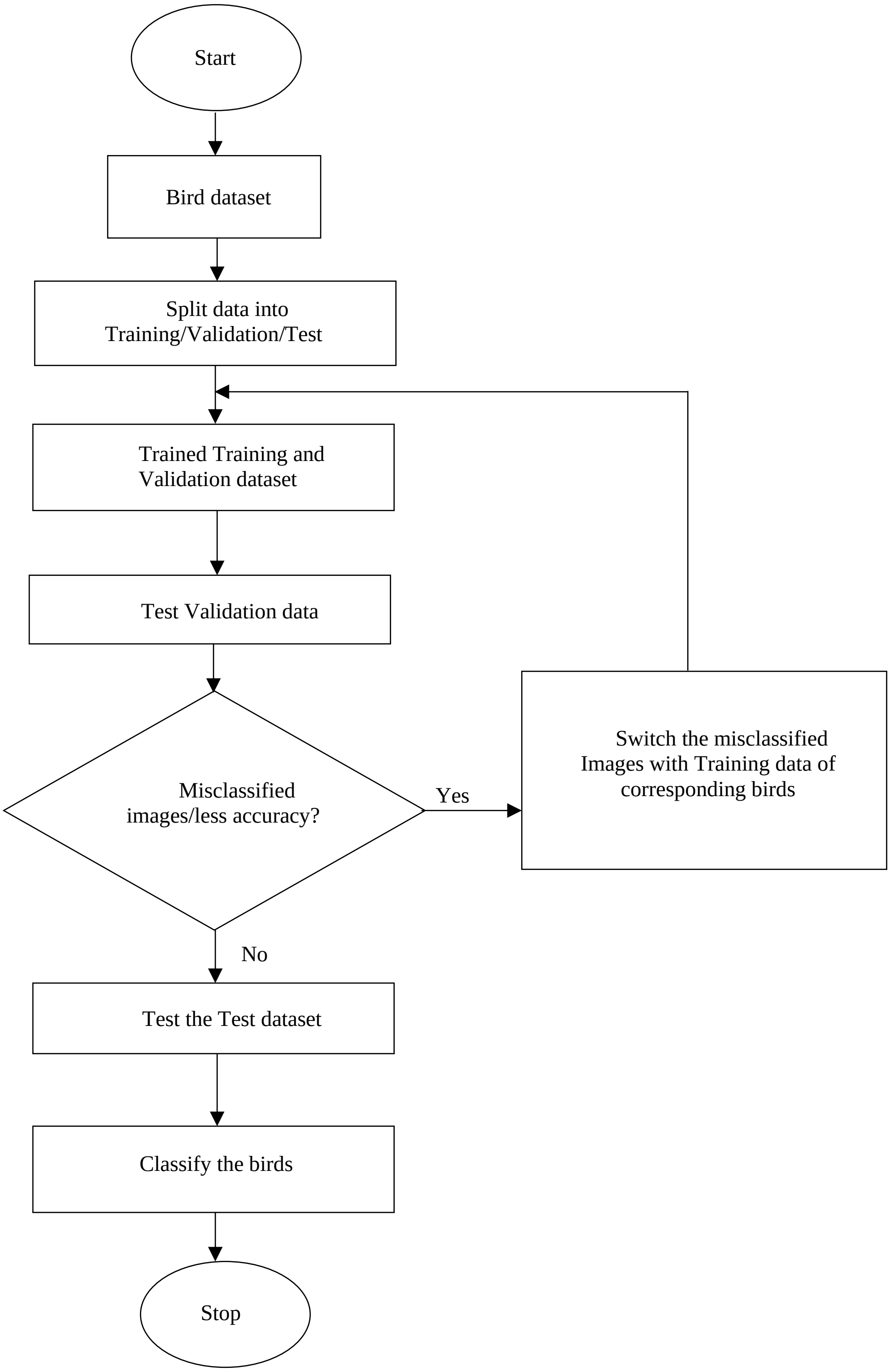

Figure 7. Flowchart of model validation.

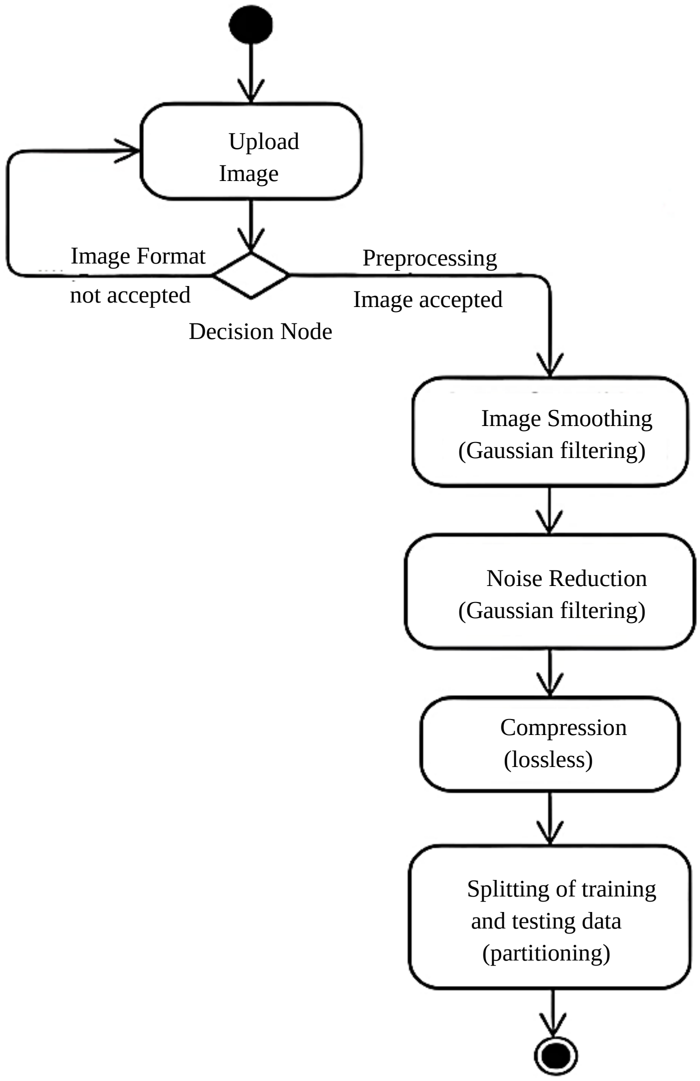

Figure 8. Working of image processing.

Hardware

- A machine equipped with a GPU (Graphics Processing Unit) for efficient model training (e.g., NVIDIA GeForce GTX 10 series or higher), along with sufficient disk space for storing datasets and model files.

Software

- Python 3.x, TensorFlow (with GPU version recommended for accelerated training), Jupyter Notebook (for coding), essential Python libraries (like NumPy, Matplotlib, Pandas), and Flutter for app development are necessary components.

RESULT AND DISCUSSION

Figure 9 shows the various design components of User Interface, Navigation Panel, Home Page which is the main page, Interface for the upload of the images so as to search for the respective species of the bird on the go, and Page for checking the interesting facts.

The tips-giving page for the sake of techniques related with that of the birdwatching, together with recommendations for the concerned equipment. It also provides facility for accessing the additional content required (if any).

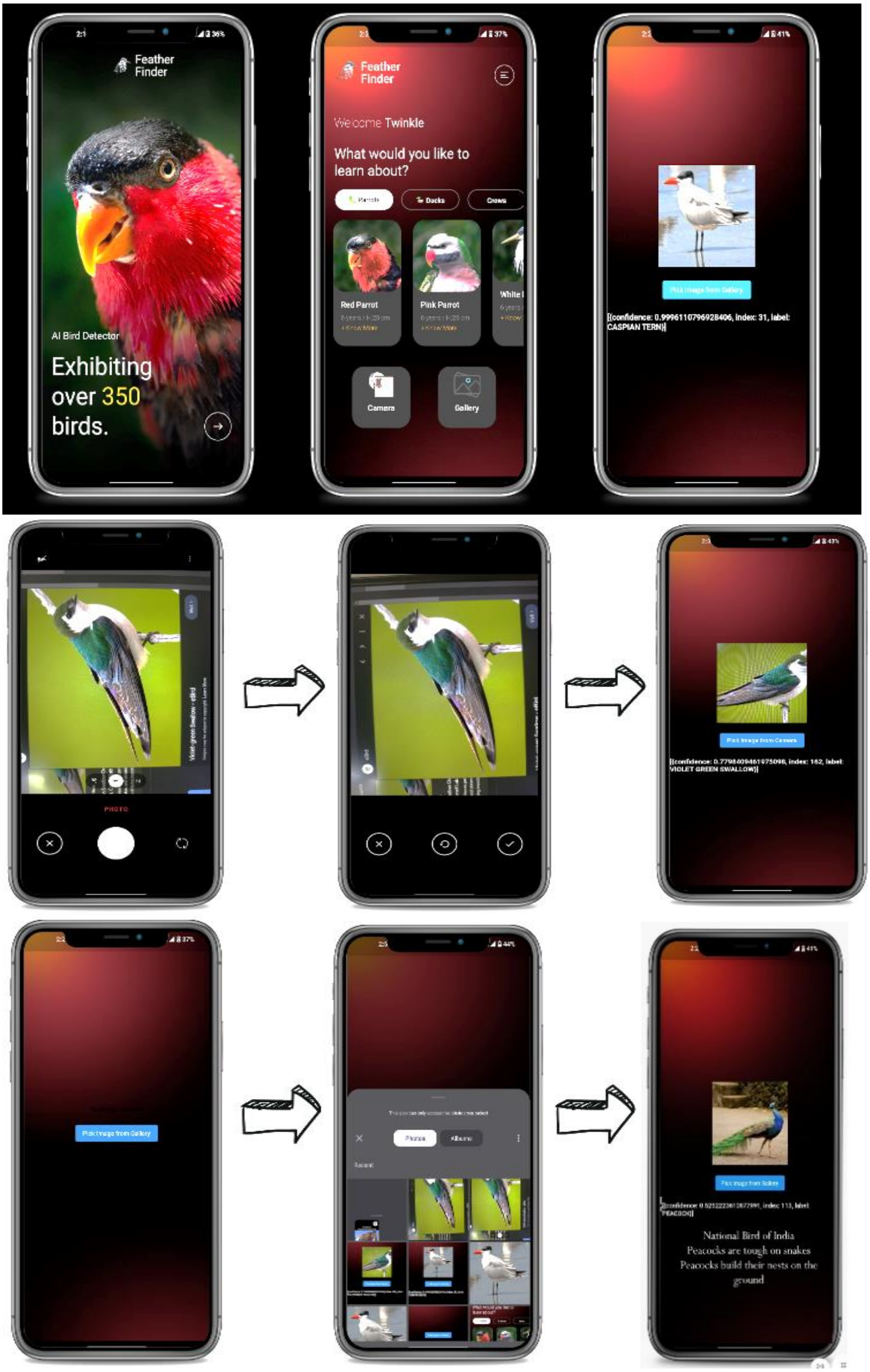

Figure 9. The overview of the project (Working of the app).

CONCLUSION

The project effectively created and implemented a deep learning-based system for classifying bird species. The model, trained with transfer learning and data processing techniques, achieves high accuracy in identifying different bird species from images. To ensure ongoing improvement, the system incorporates a feedback mechanism for users to report on its accuracy. This feedback loop drives continuous system enhancement.

Key Challenges

Imbalanced Data

The number of training samples varied significantly between species, impacting model performance on less represented ones.

Real-World Limitations

The system's performance was impacted by camera quality and perspective, and some species were challenging to differentiate even in optimal conditions. Nevertheless, the project demonstrates the potential of deep learning in image classification tasks that extend beyond bird identification. Its impact can extend to fields like image processing, industrial error detection, and medical image segmentation.

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