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Enhancing Bird Species Identification using Deep Learning Models

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Abstract: Birds are an amazing creature which lead lovely lives along with humans which are one of the signs of Climatic change. Identification of Bird Species is a Complex Task for humans as there are huge number of species of birds are available. Even it is also more difficult for Ornithologists to identify the correct name of a bird related to a particular specie.

The main importance of identifying the Bird Species includes various applications such as for monitoring wildlife, for the efforts of conservation from becoming extinct, and for some projects which are related to the birds. As the present existing system uses the Random Forest algorithm to identify the bird species from image. In proposed system tried to utilize deep learning algorithm models in order to enhance the overall accuracy of the project to identifying the bird image. We used EfficientnetB4 algorithm in order to increase the Accuracy.

Keywords: Random Forest, Decision Trees (DT), EfficientnetB4.

I. INTRODUCTION

Understanding the dynamics of bird populations is increasingly vital in today's context. Birds serve as essential indicators of ecosystem health, helping us gauge the presence and behaviour of other species, particularly insects, which respond swiftly to environmental changes. Their role in the food chain is also significant, contributing to the delicate balance of ecosystems. However, the identification and classification of certain bird species pose considerable challenges, especially as some become increasingly rare.

From a human perspective, birds present a diverse array of shapes, sizes, colours, and postures, making them intriguing subjects for study. Photographs offer valuable insights into bird species identification, surpassing the capabilities of sound-based methods. Nevertheless, the collection of bird data is resource-intensive and costly. In response to these challenges, there is a pressing need for a robust system capable of processing bird data efficiently on a large scale, benefiting various stakeholders, including researchers and governmental agencies.

Bird species identification from images emerges as a critical aspect in this endeavour. Birds occupy pivotal roles across trophic levels within ecosystems, serving as both predators and prey. Predatory birds like eagles, hawks, and owls play a crucial role in maintaining ecological equilibrium by controlling the populations of smaller birds, rodents, and fish. Additionally, birds contribute significantly to pollination and seed dispersal, facilitating the propagation of numerous plant species.

However, numerous threats jeopardize bird species, including habitat loss, climate change, pollution, hunting, invasive species, and collisions with human structures. Bird photos offer a valuable resource for species identification, capturing key features such as coloration, pattern, size, and morphology. This visual data empowers experts and enthusiasts to effectively identify and monitor bird populations.

While some bird species may pose challenges for identification based solely on physical characteristics, photographs can provide crucial details that aid in species differentiation. Establishing comprehensive datasets of birds is imperative for conservation efforts, biodiversity research, behavioural studies, and citizen science initiatives. These datasets enable a deeper understanding of the natural environment and inform strategies for the preservation and conservation of avian species.

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Central to the endeavour of bird species identification is the development of feature extraction algorithms capable of analysing visual content and extracting meaningful features such as shapes, colours, textures, and edges. While both audio-based and visual classifications involve data analysis for categorization, they necessitate distinct approaches and techniques due to the unique characteristics of the data.

Machine learning algorithms, particularly deep learning models like EfficientNetB4, play a pivotal role in visual classification, offering advanced capabilities for image recognition and species identification. Number of samples, making them suitable for applications with large datasets.

A. Literature Survey

Many works are done about the identification of bird species using a variety of focuses.
The following literature survey focuses on the identification of birds by using different aspects.

Persia Abishal B et. al. [1], demonstrated a way about the identification of bird species using Machine Learning model named Random Forest. This method efficiently worked but the overall accuracy and the dataset they used are somewhat low. In this case they used the Caltech-UCSD dataset which contains
over 100 species of bird's names.

Chandu B et.al. [2], demonstrated that birds species names can be identified by using the audio signals. They used the Deep learning model named Alex Net and also the features of this model are high accuracy, scalability. And there are some flaws in this algorithm, it requires high computational resources for training the datasets. It also demands significant computational power and memory in order to get the better results for different datasets.

Liu-Lei Zhang et.al. [3], identified the birds species using the Convolutional Neural Networks. Used the Deep Learning model named ShuffleNetV2 Model. As it contains many advantages like the improvement of Accuracy, Precision, Recall, F1 score. The model training should be done repeatedly in order to increase the Accuracy.

Srinath P et.al. [4], described the importance of Convolutional Neural Networks and Deep learning in the published paper. It contains the basic idea about the evolution of the CNN models for the Image Classification.

In case of Shyam Krishna et.al. [5], developed a CNN model that aims to identify the different bird species. The created model improved the precision and improved the observation of birds.

Deep Neural Network technique by Vemula Omkarini et.al. [6], proposed a model that works on 253 species of birds by using an approximate of 7000 images of birds. The model was worked efficiently.

II. EXISTING SYSTEM

One of the most important species in the world are the birds. There are over more than 20000 species of birds are there in this world. Sometimes the identification of the correct specie is very difficult for humans. Ornithologists who study about the birds are interested in order to develop a system that should identify the correct name of the species of the birds.

As there are many existing systems for the identification of bird species one of the existing systems that was chosen is "*Bird species identification using a Machine Learning model named Random Forest*".

The Random Forest algorithm works on the decision trees.

Random Forest is an ensemble learning algorithm used for classification and regression tasks. It works on the principle of building multiple decision trees during training and combining their outputs to make predictions.

Working principle

1. Decision Trees: Random Forest utilizes a collection of decision trees. A decision tree is a flowchart-like structure where each internal node represents a "test" on an attribute (e.g., whether a feature is above or below a certain value), each branch represents the outcome of the test, and each leaf node represents a class label (in the case of classification) or a numerical value (in the case of regression).

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2. Randomization: Random Forest introduces randomness in two key ways:

a. Bootstrapping: It randomly selects a subset of the training data with replacement. This means some instances may be repeated in the subset while others may not be included at all. This process is called bootstrapping.

b. Feature Randomization: At each node of each decision tree, a random subset of features is considered for splitting. This helps in decorrelating the trees and reduces overfitting.

3. Growing Trees: Multiple decision trees are grown during the training phase. Each tree is grown to the largest extent possible without pruning. This means that each tree will continue to grow until each leaf node is pure (contains only instances of one class) or until the maximum depth of the tree is reached.

4. Voting: For classification tasks, when making a prediction, each decision tree in the forest independently predicts the class label, and the class that receives the most votes among all the trees is chosen as the final prediction. For regression tasks, the final prediction is often the average of the predictions made by individual trees.

5. Ensemble Learning: The strength of Random Forest lies in its ensemble nature. By combining the predictions of multiple decision trees, it reduces overfitting and improves generalization performance. It tends to be more robust and accurate compared to individual decision trees, especially when dealing with noisy or high-dimensional datasets.

Random Forest builds multiple decision trees using random subsets of the data and random subsets of features. It then combines the predictions of these trees through voting (classification) or averaging (regression) to make final predictions, resulting in a robust and accurate ensemble model. The existing system used the Random Forest algorithm in order to be better from the previous models and it produces the accuracy up to 80 percent. The data set is also limited for this identification.

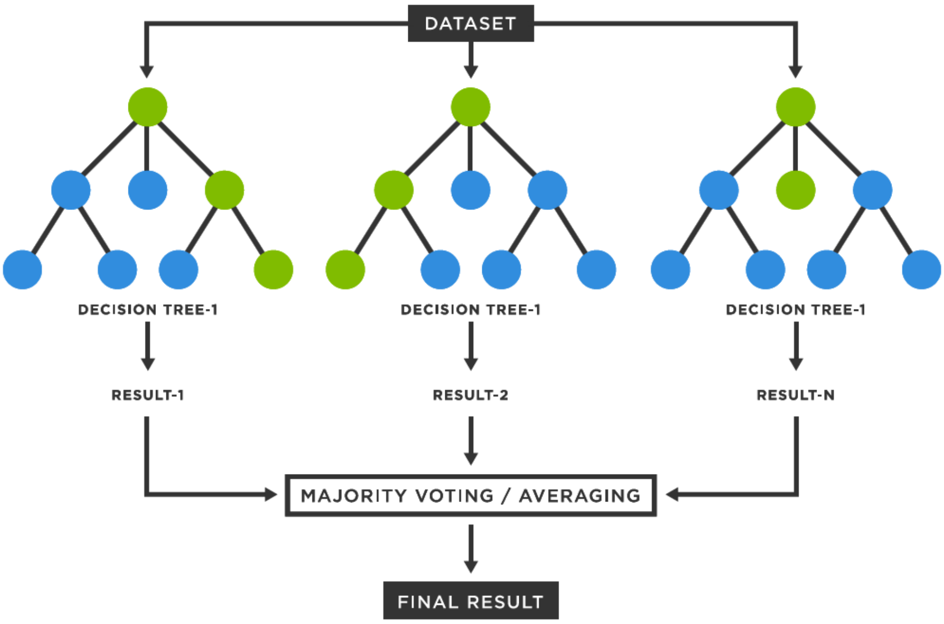

Fig.1: Working of Random Forest.

III. PROPOSED SYSTEM

The Efficient Net B4 model is a convolutional neural network architecture that has demonstrated superior performance in various image classification tasks while maintaining computational efficiency.

Developed by Tan et al. in 2019, the Efficient Net architecture introduces a novel compound scaling method that uniformly scales network depth, width, and resolution, leading to better performance and efficiency compared to traditional CNN architectures.

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The Efficient Net B4 model consists of multiple layers of convolutional and pooling operations followed by fully connected layers for classification. The key characteristics of the Efficient Net B4 architecture include:

Depth: The network architecture consists of multiple stages of convolutional layers, enabling the model to learn hierarchical features from input images.

Width: The width of the network, represented by the number of channels in each convolutional layer, is scaled based on a coefficient to balance model complexity and performance.

Resolution: The input resolution of the images is scaled up or down to match the requirements of the network, allowing the model to handle images of different sizes efficiently.

A. System Architecture

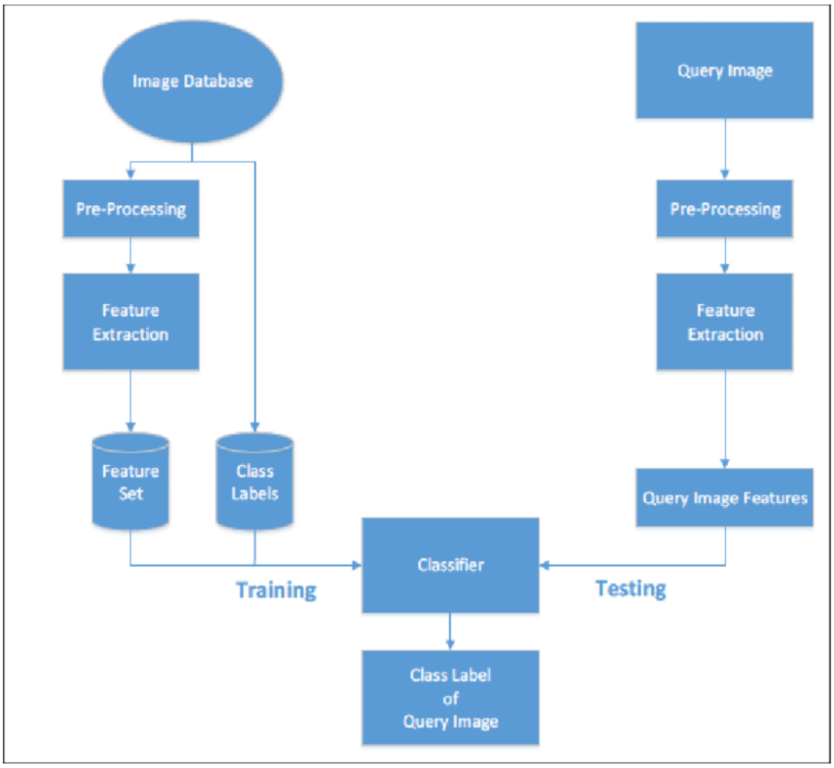

Fig. 2: System Architecture

1. Data Acquisition and Preprocessing Module: Collecting a dataset which contains a vast number of species of birds and also, they are divided into Training, Testing and Validation process. Preprocess the collected images by resizing, normalizing, and augmenting them to enhance the model's robustness to variations in lighting, orientation, and background clutter.

2. Training the Model: Choose the Efficient Net B4 model as the backbone architecture for bird species identification due to its superior performance and efficiency. Utilize pre-trained weights of the Efficient Net B4 model trained on large-scale datasets like ImageNet to leverage learned features. Fine-tune the pre-trained Efficient Net B4 model on the collected bird dataset to adapt it to the specific task of species classification.

3.Model Evaluation: Split the dataset into training, validation, and testing subsets. Utilize the validation dataset to monitor the model's performance during training and prevent overfitting.

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B. Algorithm (EfficientNetB4:)

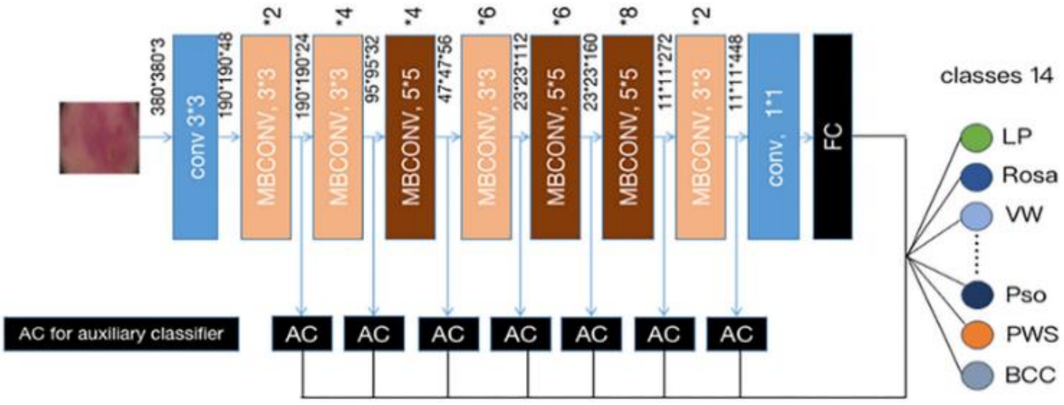

Fig. 3: System Architecture of Efficient net B4

Working Principle:

The Efficient Net B4 model employs a combination of depth wise separable convolutions, batch normalization, and nonlinear activation functions (e.g., ReLU) to extract features from input images. The model learns hierarchical representations of the input data through successive layers, with each layer capturing increasingly abstract features.

a) Compound Scaling: Efficient Net B4 introduces a novel compound scaling method that uniformly scales network depth, width, and resolution to balance model complexity and performance.

C. Dataset:

We used a popular dataset from Kaggle which contains the images of bird species up to 90000 images. The dataset is divided into three parts training, testing and validation.

D. Performance Metrics:

1) *Accuracy:* the proportion of correctly classified instances out of number of instances.

2) *Precision:* the proportion of true positive predictions out of all positive predictions made by the classifier.

3) *Recall:* the proportion of true positive predictions out of all actual positive instances in the dataset.

4) *F1 score:* F1 score is the harmonic mean of precision and recall, providing a balance between the two metrics.

IV. EXPERIMENTAL RESULTS

After the execution of the proposed system, we gained a better accuracy when compared with the existing system random forest algorithm.

Table 1. Performance Metrics

S.NO	METRICS	EFFICIENTNET B4	RANDOM FOREST
1	Accuracy	90%	80%
2	Precision	0.94	0.52
3	Recall	0.90	0.34
4	F1 score	0.88	0.35

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The experimental results are represented using bar graph, Accuracy, Precision, Recall, F1 score are all high for the efficient net model when compared with the random forest model.

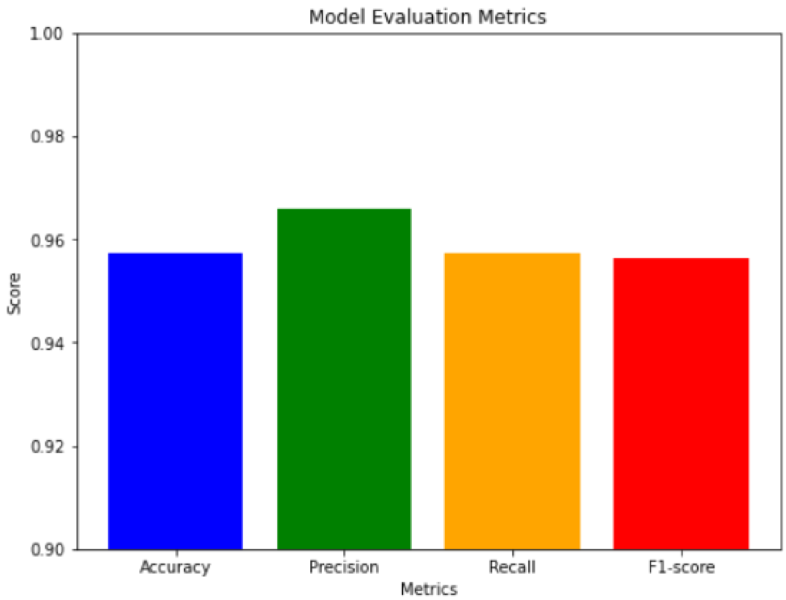

Fig.4: Metrics

From the overall study the results are founded that the random forest machine learning algorithm produces an accuracy of 80% and our proposed system efficient net b4 produced more than 90% accuracy and it is very efficient as it contains the compound scaling.

The testing accuracies of two models are represented in the form of a bar graph and it is shown as below.

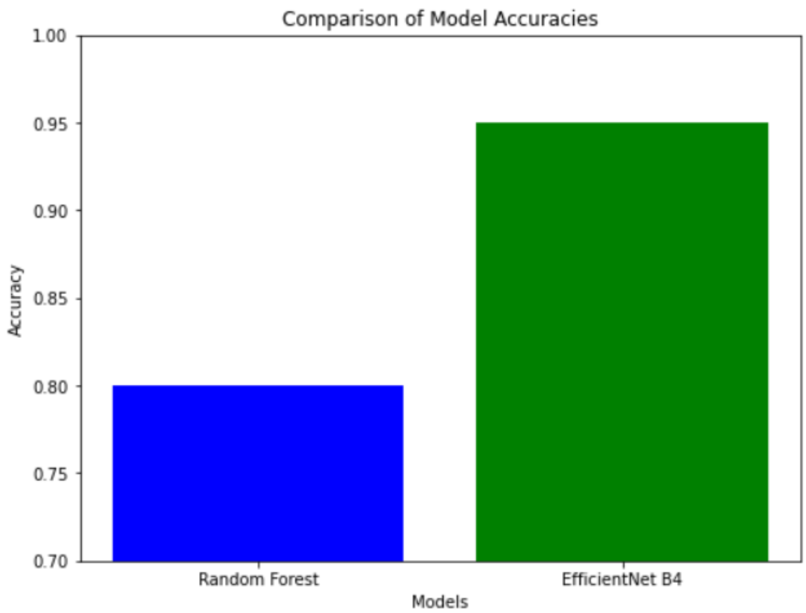

Fig. 5: Accuracy Testing.

The accuracy in the case of Random Forest model is up to 80 % and the efficient net b4 given the accuracy up to 95% as shown in the above figure.

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A. User Interface

In this project there is a user interface which is used for the interaction of the users. The user interface is designed by using stream lit which is a python framework used for the development of web applications. This framework acts a bridge between the user and the data which was analysed after the machine learning or deep learning models are trained.

Fig 6. Represents the user interface for the project which takes the bird image as the input and we can click on the browse file button and upload the image that we wanted to test.

Fig. 6: User Interface to enter the photo of bird.

After the input image is taken the result will be displayed as shown in the figure 7. And the extra information about the bird and the metrics will also display in that.

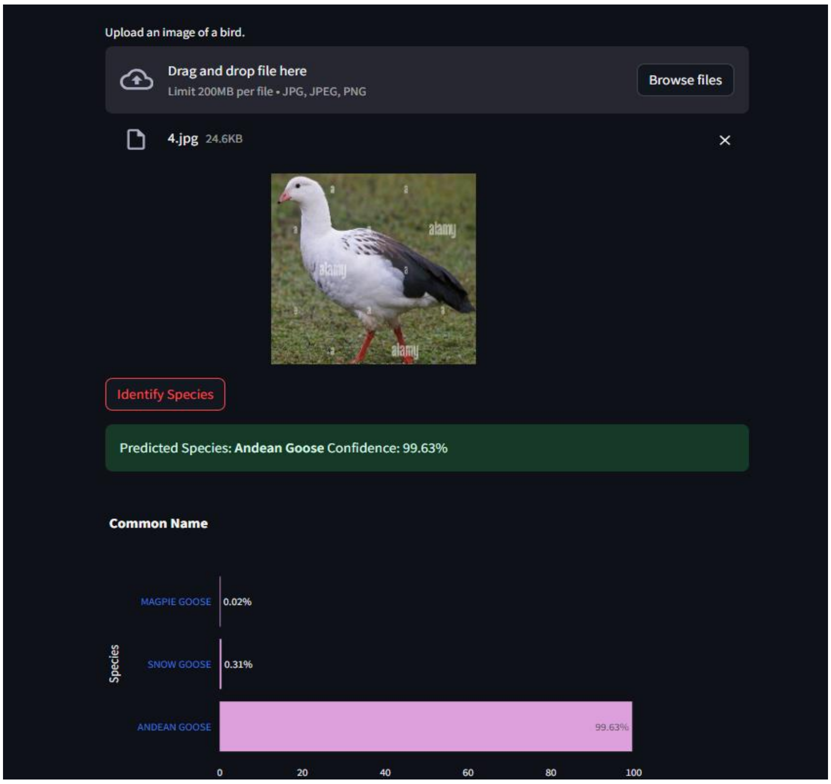

Fig.7: Output of the Project.

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V. CONCLUSION

Bird species identification using a deep learning models are very crucial now a days due to the efficient impact of the CNN architecture in the image classification. In conclusion, the utilization of deep learning models, such as Efficient Net B4, for bird species identification through image analysis represents a significant advancement in the field of ornithology and computer vision. This innovative approach offers a promising solution to the challenges of accurately and efficiently identifying bird species, contributing to biodiversity monitoring, conservation efforts, and ecological research. By harnessing the power of deep learning, researchers and conservationists can now process large volumes of bird images with greater accuracy and speed, facilitating a deeper understanding of avian populations and ecosystems. As technology continues to evolve, further refinements and advancements in deep learning algorithms hold the potential to revolutionize our ability to study and protect avian biodiversity on a global scale.

VI. FUTURE SCOPE

Bird species identification using deep learning models, particularly Efficient Net B4, appears promising and expansive. Continued research and development in this area hold the potential to enhance the accuracy, efficiency, and scalability of bird identification systems. Further advancements may involve the integration of additional data sources, such as audio recordings and environmental variables, to improve the robustness and versatility of these models across different habitats and conditions. Moreover, the application of transfer learning and ensemble techniques could enable the adaptation of existing models to new regions and species, facilitating broader ecological monitoring initiatives worldwide. Additionally, collaborations between ornithologists, data scientists, and conservation organizations may foster the development of user-friendly tools and platforms that empower citizen scientists and stakeholders to contribute to bird conservation efforts effectively. Overall, the ongoing evolution of deep learning technologies offers exciting opportunities to revolutionize our understanding and conservation of avian biodiversity in the years to come.

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