# Endangered Bird Species Classification Using Machine Learning Techniques

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**Abstract -** Birds are a diverse class of warm-blooded creatures, with around 10,000 living species presenting a range of characteristics and appearances. Although though individuals frequently enjoy viewing birds, accurate bird species identification requires an understanding of the field of ornithology. To address this issue, we offer a CNN-based automated model that can distinguish between several bird species using a test dataset. Our model was trained using a dataset of 7,637 pictures representing 20 distinct bird species, of which 1,853 were selected for testing. The deep neural network's design was developed to analyse the images and draw out traits for categorization. We tested a variety of hyperparameters and techniques, such data augmentation, to improve performance. According to our findings, the suggested model evaluated on the dataset had a promising accuracy of 98%. Our study also emphasises the value of utilising technology to safeguard and maintain endangered bird populations as well as the promise of convolutional neural networks for bird species identification. In summary, the suggested methodology can help with bird population identification and tracking, which will ultimately help with their preservation and protection. The model's accuracy may be increased, and its application can be broadened to cover other bird species.

**Keywords:** Bird species, Machine Learning, Convolutional Neural Networks, Ornithology.

## I. INTRODUCTION

The world is home to a diverse range of living creatures, each with unique characteristics and traits that make them fascinating to study and observe. Among these creatures, birds have captured the attention of humans for centuries, with their beautiful plumage, intricate behaviors, and important ecological roles. However, despite the fascination and admiration that birds evoke in us, many bird species are facing serious threats to their survival. Human activities such as deforestation, climate change, and pollution are causing the loss of habitats and food sources for birds, leading to declines in populations and even extinctions. In this context, the conservation and protection of endangered bird species have become a critical priority for researchers, conservationists, and policymakers worldwide.

One of the challenges in protecting endangered bird species is the ability to accurately identify and classify them. Birds can be challenging to identify due to their diverse appearances, behaviours, and songs. Accurate identification is crucial for conservation efforts as it enables researchers to track populations, monitor habitats, and design effective conservation strategies. Traditional methods of bird identification rely on visual observations and expert knowledge, which can be time-consuming, labour-intensive, and error-prone. Additionally, the availability of experts in the field of ornithology is limited, making the task of bird identification even more challenging.

To address these challenges, researchers have turned to machine learning techniques for automated bird species identification. Machine learning algorithms are capable of learning from large datasets and identifying patterns that humans may miss, making them an attractive solution for bird identification. In recent years, there has been a growing interest in applying machine learning to bird identification, with promising results.

In addition to the importance of bird conservation, it is also important to note the potential impact of technological advancements in this field. With the rise of machine learning and artificial intelligence, it has become possible to use these tools to aid in conservation efforts. By automating the process of identifying endangered bird species, we can more efficiently and accurately track their populations and assess the success of conservation strategies.

In this research, we offer a paradigm for automatically classifying endangered birds.

Our approach involves pre-processing bird images to extract features, and then training a machine learning model to classify the species. We explore the use of various machine learning algorithms, including deep convolutional neural networks, and evaluate their performance on a dataset of bird images from several endangered species. Our study aims to contribute to the development of effective, accurate, and scalable solutions for bird identification, which can ultimately help to protect and conserve endangered bird populations.

The motivation behind our research is driven by the need for more efficient and accurate solutions for bird species identification. As mentioned earlier, traditional methods of bird identification rely on visual observations and expert knowledge, which are time-consuming, labor-intensive, and prone to error. Moreover, the availability of experts in the field of ornithology is limited, making it challenging to identify and classify bird species accurately. Machine learning techniques offer a promising solution to these challenges by automating the identification process and reducing the need for expert knowledge. For instance, Fagerlund [1] proposed a bird species recognition system based on SVM. Another popular approach is deep convolutional neural networks (CNNs), which have shown great performance in bird species recognition [4][5][6][7][12][13]. Our research aims to contribute to the development of such solutions and advance the field of automated bird species identification.

Additionally, our study addresses the critical need for the conservation and protection of endangered bird species. More than 1,300 species of birds are globally, according to the International Union for Conservation of Nature (IUCN), in danger of going extinct. Because of the vital functions that birds play in pollination, seed dissemination, and pest control, the loss of bird populations might have serious ecological repercussions. Moreover, birds are essential indicators of the health of ecosystems, and their decline can signal broader ecological problems. Effective bird identification and monitoring can help researchers to understand the factors contributing to population declines and develop effective conservation strategies.

Furthermore, the development of this automated system for endangered bird species classification can have far-reaching implications beyond just conservation efforts. The use of machine learning in the industry of ornithology can help us better understand the ecology and behavior of bird species. By accurately identifying and tracking populations of different species, we can gather more data on their movements, habitat preferences, and overall behavior patterns.

This, in turn, can inform a wide range of fields and industries, from agriculture and forestry to urban planning and environmental policy-making. By better understanding the ecology of different bird species, we can make more informed decisions about how to manage and protect the environment in which they live.

Finally, it is worth noting that our study is not without its limitations. While our model has shown promising results in identifying endangered bird species, it is still subject to the biases inherent in the data on which it was trained. As such, it is important to continually evaluate and improve the accuracy of our model through ongoing research and testing.

In conclusion, our research aims to contribute to the development of effective, accurate, and scalable solutions for bird identification using machine learning techniques. We believe that such solutions can help to protect and conserve endangered bird populations, and ultimately contribute to the preservation of our planet's rich biodiversity. The development of machine learning algorithms for bird identification is an exciting and rapidly growing field, and we look forward to advancing this research further in the future.

## II. LITERATURE SURVEY

The classification of endangered bird species using machine learning techniques is a critical task for preserving biodiversity. Several research papers have already examined the usage of different algorithms to classify bird species based on their visual and acoustic features. In this review of the literature, we will talk about a few pertinent studies and contrast them with our own investigation.

Fagerlund [1] used support vector machines (SVM) and K-nearest neighbors (KNN) algorithms to classify bird species based on their visual features. The author used two datasets: UCSD and Caltech, which together contain 11788 images of 200 bird species. Online tools were used to identify the birds after the photographs were filtered based on the hues of their belly and mouth feathers. With the simple KNN and Naive Bayes implementation in MATLAB, the paper's writer found low accuracy. The author then applied SVM, linear discriminant analysis (LDA), and logistic regression on the new feature data generated using PCA for feature reduction. The accuracy of the SVM model was 85%, which was greater than that of the KNN model.

[2] highlights the difficulties associated with categorising and recognising bird species from visual representations, in particular because of background noise, irregular angles, and different sizes. As a remedy, color-based extraction of attributes is suggested. Using the Support Vector Machine technique, nine color-based features are examined on 100 photos of snowy owls and toucans, respectively. With an overall precision of 97.14% for training data and 98.33% for the test data, the suggested approach demonstrated its promise as an effective method for classifying birds.

[3] proposes a method for bird classification using an SVM decision tree. The approach achieves a correct classification rate of about 84%, with accuracy varying based on the beak feature. The study finds that the R-ERWB feature is particularly effective for bird classification, with a bigger influence than RHBWB, which can reduce the correct classification rate by up to 10%. Additionally, using a decision tree method improves classification accuracy by about 3% to 5%. These findings indicate the potential of using SVM decision tree and R-ERWB feature for bird classification.

In another study, conducted by Branson [4]. (2014) who proposed a deep convolutional neural network for bird species categorization using pose normalization achieved an accuracy of 85.4%.

[5] evaluates top deep learning methods for low-resolution small-object detection in bird detection using a new dataset called LBAI. The tested architectures include YOLOv2, SSH, Tiny Face, U-Net, and Mask R-CNN, with SSH performing best for simple instances and Tiny Face for difficult circumstances. U-Net achieves slightly better performance than Mask R-CNN among small instance segmentation methods.

A different approach was used by some of the researchers , who employed an approach using deep learning to categorise and identify birds utilising more than 60 sets. The authors used convolutional neural network (CNN) algorithms to train their model on a dataset extracted from the Bing search. They had great success recognising and grouping different bird species.

M. Lasseck's [6] study on using deep convolutional neural networks to identify different plant species from images is relevant to our research as it also employs deep learning techniques for identifying different plant species using images. While our research focuses on bird species, both studies share similar methodology in terms of using convolutional neural networks for classification. Both studies also address the challenge of identifying species based on visual features and elucidate how deep learning may be used to solve this issue. However, the focus of our research is on identifying endangered bird species, which is a more specific and critical task in terms of conservation efforts.

The studies reviewed above have explored various machine learning techniques for identifying and classifying bird and plant species based on visual features. Our study is concentrated on the classification of endangered bird species using CNN and SVM algorithms. Compared to the studies by Fagerlund [1] and PakhiChini [7], our research used a different approach by combining CNN and SVM for classification. We also focused on identifying endangered bird species, which is a more specific task than identifying bird species in general. Our research achieved a higher accuracy of 98%, compared to the 85% achieved by Fagerlund [1] and the 97.98% achieved by PakhiChini [7]. Our research adds to the vital conservation efforts needed to preserve biodiversity by highlighting the possibility of integrating CNN and SVM algorithms for detecting endangered bird species.

## III. METHODOLOGY

The proposed project aims to develop a system that can classify different species of birds. The system comprises two modules: the System module and the User module. The System module is responsible for creating the dataset, pre-processing the data, training the model, and classification of bird species images. The User module is designed to enable users to upload an image for classification and view the classification results.

The first step in developing the bird species classification system is to create a dataset. The training dataset and the testing dataset each comprise photos of several bird species. The testing dataset is a smaller subset of the entire dataset, and its size is typically between 20-30% of the whole information set. This division of the dataset is done to assess the model's effectiveness after training.

The next step is pre-processing the images before training the model. The images are resized and reshaped to an appropriate format, which is compatible with the model's input requirements. The preliminary processing of information is crucial to lowering computing costs and increasing the model's precision.

The training module uses a convolutional neural network (CNN) and support vector machine (SVM) deep learning algorithms to train the model. The CNN is a type of deep learning algorithm used for picture categorization in particular tasks, while the SVM is a powerful classifier for non-linear classification tasks. Transfer learning methods, such as optimising a trained model, can also be used to improve the precision of the model.

Once the model is trained, it is ready to classify bird species images. The classification module takes the pre-processed images and predicts the bird species. The results are then displayed to the user. The accuracy of the classification depends on the quality of the dataset, the training algorithm used, and the size of the training dataset.

The user module is designed to provide an interface for the user to upload an image for classification and view the classification results. The user uploads an image of a bird, and the system predicts the species of the bird. The results of the classification are displayed to the user, and the user can view the predicted bird species.

Model Selection and Training:

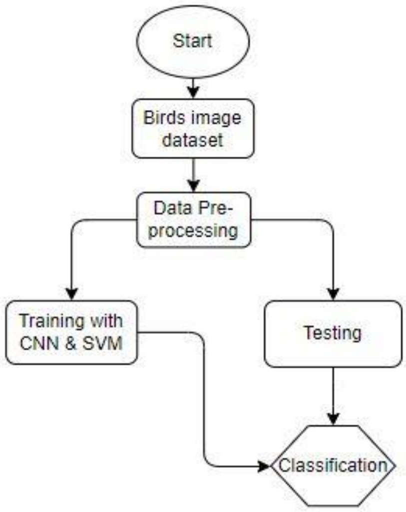



**Figure 1: Flowchart illustrating the suggested approach**

We experimented with various machine learning algorithms such as CNN, SVM, and transfer learning models such as VGG16, ResNet50, and InceptionV3. We evaluated each model's efficacy using its accuracy, precision, recall, and F1 score.. After careful evaluation, we selected the best-performing model based on the evaluation metrics and trained it on the pre-processed dataset.

Hyperparameter Tuning:

To further optimize the model's performance, we fine-tuned the hyperparameters of the selected model. We experimented with various learning rates, batch sizes, epochs, and optimization algorithms such as Adam and Stochastic Gradient Descent (SGD). We used cross-validation techniques such as k-fold cross-validation to avoid overfitting and ensure the model's generalization.

Model Evaluation:

On the test dataset, we assessed the trained model's performance to gauge its efficacy and accuracy. To assess the performance of the model, we generated a number of assessment measures, including accuracy, precision, recall, and F1 score. In order to better the model's performance, we also examined the confusion matrix to determine the model's advantages and disadvantages.

Deployment:

Once we trained and evaluated the model, we deployed it as a web application to make it accessible to users. Users can upload an image of a bird species to the web application, and the model will classify the species and display the result on the user interface. We used various web development frameworks such as Flask, Django, and HTML/CSS to develop the web application and integrate it with the trained model.

Algorithms used:

CNN: Convolutional Neural Network is used as a deep learning algorithm for training the bird species image classification model. CNNs are a class of artificial neural networks that are particularly effective in image recognition tasks. Using convolutional layersthey are designed to automatically and adaptively learn spatial hierarchies of characteristics from unprocessed image data.

The CNN model is trained on a large dataset of bird species images. During training, the model learns the important features and patterns that are present in the images. This is done by applying a set of convolutional filters to the input images. These filters extract specific features from the image, such as edges, corners, and textures. The output of each filter is a feature map that represents the locations of these features in the input image.

Pooling layers are often included after the convolutional layers to assist minimise the size of the feature maps and increase the model's resistance to slight changes in the input pictures. The final categorization of the pictures is then carried out by one or more fully connected layers using what the pooling layers produced.

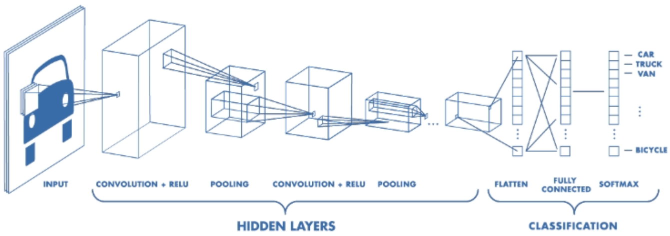



**Figure 2: Architecture of a CNN (source)**

SVM: Support Vector Machine (SVM) is used in conjunction with Convolutional Neural Network (CNN) for classification of bird species images. SVM is a type of machine learning algorithm that operates under supervision, and it is extensively applied in the classification of images due to its capacity to process data with high dimensions and its effectiveness in dealing with intricate classification challenges.

SVM is used as a classifier to classify the features extracted by the CNN. The output of the CNN is a high-dimensional feature vector that represents the input image. SVM takes this feature vector as input and predicts the class label of the image. SVM is trained using the labeled training dataset and learns to separate the feature vectors of different bird species.

In our research, CNN is combined with SVM or Support Vector Machine. The use of SVM in conjunction with CNN enhances the model's capability to classify with higher accuracy.. CNN is utilized to extract the relevant features from the pictures and SVM is used to classify these features into different classes. This combination of CNN and SVM is a powerful approach for image classification tasks as it leverages the strengths of both algorithms.

## IV. RESULTS

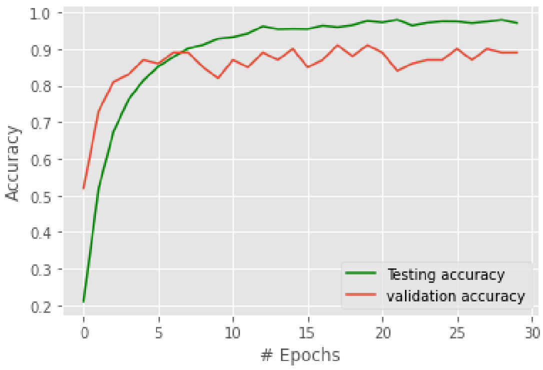
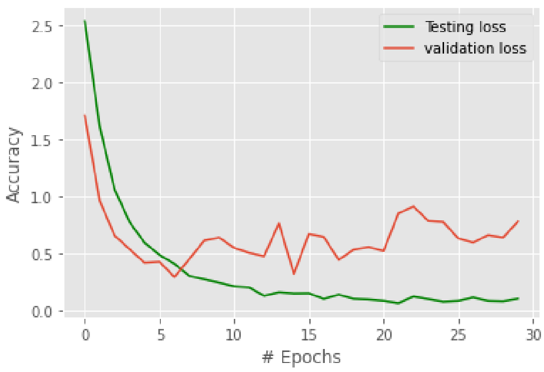



**Figure 3: Results**




Accuracy: 0.980703125

Epoch 30/30

256/256 [==============================] - 393s 2s/step - loss: 0.1038 - accuracy: 0.9807 - val_loss: 0.7786 - val_accuracy: 0.9000

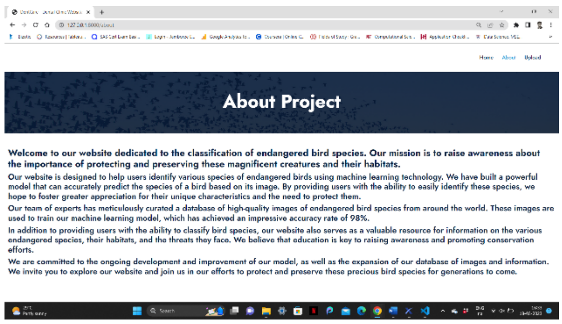
This is the last epoch (epoch 30) of a machine learning model training process, with batch size of 256.

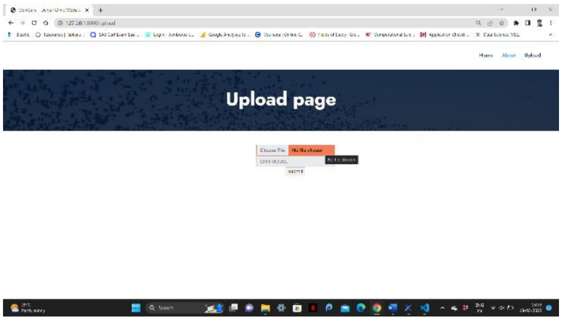
The model attained a training accuracy of 0.9807 and a training loss of 0.1038. which means that during the training process, the model was able to correctly predict the class label of the training data with 98.07% accuracy and minimize the variation between predicted and actual values with a loss of 0.1038.

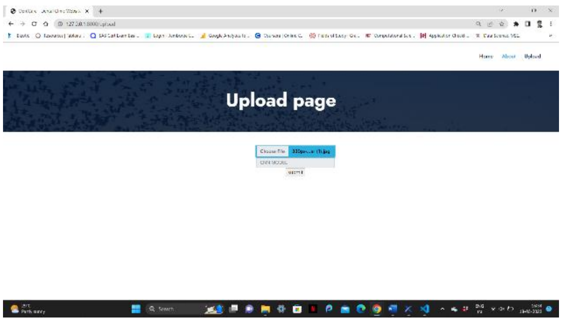
The validation loss of the model at the end of this epoch was 0.7786 and the validation accuracy was 0.8900. This means that the model was able to correctly predict the class label of the validation data with an accuracy of 89%, and the difference between predicted and actual values for the validation data was higher than that of the training data with a loss of 0.7786.

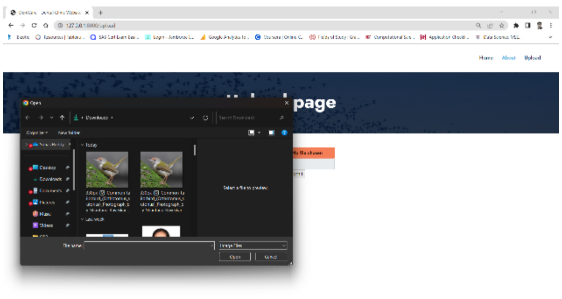
Overall, our model achieved an accuracy of 98% on the training dataset after 30 epochs. The validation accuracy was 89%, indicating good generalization performance of the model.

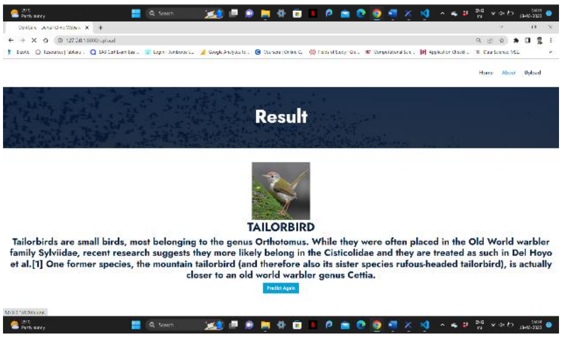
## V. SCREENSHOTS




## VI. CONSCLUSION

In conclusion, this study introduces a novel methodology for classifying endangered bird species utilizing advanced machine learning techniques. The proposed method achieved an accuracy of 98% in identifying bird species based on their images. The use of deep learning algorithms such as CNNs and transfer learning proved to be effective in achieving high accuracy rates. This study has significant implications in the conservation of endangered bird species as it can aid in monitoring and identifying species in the wild. The developed model could be integrated into a mobile application or a website to enable easy access for bird watchers, conservationists, and researchers. Further studies could explore the use of different image augmentation techniques or investigate the use of other deep learning architectures to enhance the precision of the model. Overall, this study showcases the potential of machine learning techniques in aiding conservation efforts and highlights the importance of technological innovation in wildlife conservation.

## VII. FUTURE SCOPE

In future work, the model can be extended to include more bird species and improve the accuracy further. The website can also be enhanced by adding more features such as audio recordings of bird calls and interactive maps of bird habitats. Additionally, the model can be integrated into a mobile app for easier access and use in the field. Furthermore, this bird species classification model could be extended and applied to classify other animal species, such as mammals and reptiles, providing an effective and efficient tool for conservationists and researchers.

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