AUTOMATED BIRD SPECIES RECOGNITION USING DEEP CONVOLUTIONAL NEURAL NETWORKS (CNN)

Samruddhi Jayant Aloni
Student, Department of Computer Science, College of Management and Computer Science, Yavatmal
samruddhialoni@gmail.com

Abstract
Bird identification plays an important role in ecological studies, wildlife protection, and biodiversity conservation. Traditional bird identification methods require expert knowledge and manual observation, which are both time-consuming and prone to human error. With the rapid advancement of deep learning techniques, automated image-based classification has become an effective alternative. This research focuses on developing a Convolutional Neural Network (CNN)-based model that can predict the species of a bird from an image. The model is trained on a dataset containing 525 bird species and more than 84,000 training images. A web application is also developed to allow users to upload bird images and receive predictions in real-time. The proposed system achieves an accuracy rate above 90%, demonstrating that CNNs are highly efficient in classifying bird species. This work contributes to the field of image recognition by providing a user-friendly, accurate, and practical solution for bird identification.
Keywords: *Convolutional Neural Network, Deep Learning, Image Classification, Bird Species Prediction, Computer Vision*

Introduction

Birds are one of the most diverse animal groups, and studying them provides valuable insights into ecosystems and climate change. Identifying bird species accurately is crucial for biodiversity monitoring, wildlife conservation, and ecological research. However, manual classification of bird species is complex because of high inter-species similarity, color variations, and differing postures.

To overcome these challenges, Deep Learning, particularly Convolutional Neural Networks (CNNs), offers an automated and accurate approach to image recognition. CNNs have the capability to learn complex visual patterns from large datasets without manual feature extraction. This project aims to design a CNN-based image classifier that predicts bird species from images and integrate it into a web-based interface for public use.

The main motivation behind this research is to combine artificial intelligence and environmental science for creating a tool that can help both researchers and ordinary users in identifying bird species efficiently.

Literature Review

Over the past decade, deep learning has transformed computer vision applications. Early methods relied on handcrafted feature extraction techniques such as SIFT (Scale-Invariant Feature Transform) and HOG (Histogram of Oriented Gradients). These traditional methods performed poorly when dealing with large and complex image datasets.

The introduction of Convolutional Neural Networks marked a significant improvement in image recognition accuracy. Krizhevsky et al. (2012) introduced AlexNet, which achieved remarkable performance on the ImageNet dataset, leading to a revolution in image classification. Later, deeper networks like VGGNet, ResNet, and InceptionNet further enhanced accuracy through better architectural designs.

Several studies have applied CNNs for bird identification. For example, the Caltech-UCSD Birds (CUB-200) dataset has been widely used to train CNN models for fine-grained bird classification. Models trained with transfer learning techniques using pretrained architectures (e.g., ResNet50, InceptionV3) have achieved over 90% accuracy on clean datasets.

Building upon these advancements, this research focuses on creating a deployable web-based bird species prediction system, using CNN to provide real-time, user-friendly results with high accuracy.

Research Objectives

1. To develop a CNN model for accurate bird species prediction.
2. To use a high-quality, preprocessed dataset containing multiple bird species.
3. To implement a web-based interface for uploading and classifying bird images.
4. To evaluate the model's accuracy, precision, and efficiency.
5. To create a system useful for research, education, and biodiversity monitoring.

Research Work

4.1 Dataset

The dataset used in this project includes 525 bird species. It contains:

84,635 training images

2,625 test images (5 per species)
2,625 validation images (5 per species)
Each image is 224 × 224 × 3 (RGB) and stored in species-specific subfolders. The dataset also includes a birds.csv file containing five columns:
Filepath: relative image file location

Label: bird species name
Scientific Label: Latin name of the species
Dataset: type (train/test/validation)
Class ID: numeric label of the species
Low-quality, duplicate, and defective images were removed to ensure data cleanliness and prevent overfitting. All images were standardized for consistent model training.

4.2 Model Architecture

The model employs a Convolutional Neural Network (CNN) architecture designed for multi-class image classification.
Architecture outline:
Input Layer: 224×224×3 image input
Convolution Layers: Extract features such as edges, textures, and patterns
ReLU Activation: Introduces non-linearity
Pooling Layers: Reduces spatial dimensions while retaining features
Flatten Layer: Converts feature maps to a 1D vector
Dense Layers: Perform high-level reasoning
Output Layer: Uses Softmax activation for 525 class probabilities
This architecture was implemented using TensorFlow and Keras libraries.

4.3 Model Training

Training was performed using:
python train.py
Key parameters:
Batch size: 32
Epochs: 50
Optimizer: Adam
Loss function: Categorical Cross-Entropy
Data augmentation techniques such as rotation, horizontal flip, and zoom were used to increase dataset diversity and reduce overfitting.
The dataset was divided into training, validation, and testing subsets in an 80:10:10 ratio. The training process achieved a steady convergence, with both training and validation accuracy exceeding 90%.

4.4 Web Application Development

A Flask-based web application was created to deploy the model.
Working process:
1. The user uploads an image of a bird via the browser interface.
2. The image is preprocessed (resized, normalized).
3. The trained CNN model predicts the species of the bird.
4. The predicted species name and probability score are displayed.

The interface is designed for simplicity, allowing even non-technical users to operate it easily.

4.5 Results and Evaluation

The CNN model achieved the following results:
Training Accuracy: 95.4%
Validation Accuracy: 93.7%
Testing Accuracy: 92.8%
The model's confusion matrix shows that most misclassifications occur among visually similar species, such as sparrows and finches.
The high accuracy indicates that the dataset quality and CNN architecture are well-optimized. Even without transfer learning, the model performs competitively compared to other state-of-the-art methods.

4.6 Discussion

This system demonstrates how deep learning can effectively solve real-world image recognition problems. Compared to traditional machine learning techniques, CNNs provide automatic feature extraction and high scalability.
The system's web-based design makes it practical for educational, research, and field use. Users can upload any bird image and receive a quick prediction. In future work, the model can be extended with transfer learning, mobile deployment, or real-time detection using video input.

Conclusion

The proposed system successfully implements a Convolutional Neural Network (CNN) model to predict bird species from images. The use of a large, clean dataset and an efficient CNN architecture enables high prediction accuracy. The integration of this model into a web application makes it accessible to users for educational and research purposes.
This research proves that CNN-based image classification can significantly simplify and enhance the process of bird identification. Future work may focus on including more bird species, using pretrained deep architectures, and developing mobile-based versions for broader accessibility.

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