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Animal Footprint Detection and Classification Using Machine Learning and Texture-Based Feature Extraction

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ABSTRACT

Animal footprint identification plays a crucial role in wildlife monitoring, biodiversity conservation, and ecological research. Traditional tracking methods rely heavily on human expertise, which can be time-consuming, subjective, and prone to errors. With advancements in artificial intelligence and image processing, automated systems for footprint detection and classification have emerged as efficient alternatives. This project presents a machine learning-based approach for detecting and classifying animal footprints using texture-based feature extraction and classification algorithms.The proposed system focuses on identifying footprints of animals such as bear, deer, elephant, horse, and tiger. It utilizes image processing techniques to extract meaningful features from footprint images and employs classification algorithms to predict the corresponding animal species. The system integrates both traditional machine learning and deep learning approaches, specifically Support Vector Machine (SVM) and Convolutional Neural Network (CNN), for performance comparison.Feature extraction is performed using the Gray Level Co-occurrence Matrix (GLCM), which captures texture information such as contrast, energy, and homogeneity from grayscale images. These features are highly effective for distinguishing footprint patterns. The extracted features are normalized and used as input for classification models.The SVM classifier is trained using an RBF kernel, which effectively handles non-linear data distributions. Additionally, a lightweight CNN model is implemented to learn feature representations automatically. The dataset is split into training and testing sets to evaluate model performance using metrics such as accuracy.A graphical user interface (GUI) is developed using Tkinter to provide a user-friendly platform. The system allows users to upload datasets, extract features, train models, visualize performance, and predict animal footprints from new images. The predicted result is displayed visually and also announced using a text-to-speech engine.The proposed system demonstrates the potential of combining texture-based feature extraction with machine learning techniques for wildlife monitoring. It offers an efficient, scalable, and cost-effective solution for automated animal footprint classification. Future work may include integrating deep learning models with larger datasets and deploying the system in real-time wildlife tracking applications.

Keywords: Animal Footprint Detection, GLCM, Texture Analysis, Support Vector Machine, Convolutional Neural Network, Image Processing, Wildlife Monitoring, Machine Learning, Pattern Recognition, Computer Vision

I. INTRODUCTION

Wildlife monitoring is essential for understanding animal behavior, tracking endangered species, and maintaining ecological balance. One of the most common methods used by researchers and forest officials is footprint tracking, also known as spoor analysis. Animal footprints provide valuable information about species presence, movement patterns, and population density.However, traditional footprint identification relies heavily on human expertise, which can be subjective and prone to inconsistencies. Environmental factors such as soil type, lighting conditions, and footprint distortion further complicate the process. As a result, there is a growing need for automated systems that can accurately identify animal footprints.Advancements in computer vision and machine learning have opened new possibilities for solving this problem. Image processing techniques allow extraction of meaningful features from footprint images, while machine learning algorithms can classify these features into predefined categories.This project presents a system for animal footprint detection and classification using texture-based feature extraction and classification algorithms. The system uses the Gray Level Co-occurrence Matrix (GLCM) to extract texture features such as contrast, energy, and homogeneity. These features capture the structural patterns of footprints, making them suitable for classification.The extracted features are used to train a Support Vector Machine (SVM) classifier, which is known for its effectiveness in handling high-dimensional data. Additionally, a Convolutional Neural Network (CNN) is implemented to automatically learn features and improve classification performance.The system includes a graphical user interface (GUI) built using Tkinter, allowing users to interact with the system easily. Users can upload datasets, train models, and test new images for prediction.The integration of machine learning with wildlife monitoring offers significant advantages, including improved accuracy, reduced human effort, and scalability. This system can be used by researchers, forest departments, and conservationists to enhance wildlife tracking and management.

II. LITERATURE SURVEY (WITH EXISTING METHODS)

Animal footprint recognition has been an active area of research in computer vision and wildlife monitoring. Early approaches relied on manual feature extraction techniques such as shape descriptors, edge detection, and statistical texture analysis. While these methods provided basic insights, they lacked robustness and accuracy when dealing with complex environmental conditions.Texture-based methods, particularly those using the Gray Level Co-occurrence Matrix (GLCM), have been widely used for pattern recognition tasks. GLCM captures spatial relationships between pixel intensities, making it effective for analyzing textured patterns such as animal footprints. Studies have shown that features like contrast, energy, and homogeneity are useful for distinguishing between

different classes.With the rise of machine learning, algorithms such as Support Vector Machines (SVM), k-Nearest Neighbors (k-NN), and Decision Trees have been applied to classification tasks. Among these, SVM has gained popularity due to its ability to handle high-dimensional feature spaces and provide high classification accuracy.Recent advancements in deep learning have further improved performance. Convolutional Neural Networks (CNNs) have become the standard for image classification tasks due to their ability to automatically learn hierarchical features. CNN-based approaches eliminate the need for manual feature extraction and provide better generalization.Several studies have compared traditional machine learning methods with deep learning models for image classification. While CNNs generally outperform traditional methods, they require large datasets and higher computational resources.

Hybrid approaches that combine handcrafted features with deep learning models have also been explored. These methods aim to leverage the strengths of both approaches.Despite these advancements, challenges such as limited datasets, variability in footprint patterns, and environmental noise remain. The proposed system addresses these challenges by combining texture-based feature extraction with machine learning and deep learning techniques, providing a balanced and efficient solution.

III. EXISTING SYSTEM

Existing systems for animal footprint detection primarily rely on manual identification or basic image processing techniques. In traditional approaches, experts analyze footprint shapes, sizes, and patterns to identify animal species. While effective, these methods are time-consuming and require significant expertise.Some automated systems use simple image processing techniques such as edge detection, thresholding, and morphological operations. These methods can extract basic features but often fail in complex environments where footprints are unclear or distorted.Machine learning-based systems have been introduced to improve classification accuracy. These systems typically use handcrafted features such as color, shape, and texture. However, their performance depends heavily on the quality of feature extraction.Deep learning-based systems, particularly CNNs, have shown promising results in image classification tasks. However, they require large datasets and high computational resources, making them less accessible for small-scale applications.Another limitation of existing systems is the lack of user-friendly interfaces. Many solutions are designed for research purposes and are not easily usable by non-technical users.The proposed system overcomes these limitations by integrating texture-based feature extraction (GLCM) with machine learning (SVM) and deep learning (CNN). It also includes a GUI for ease of use and supports real-time prediction with visual and audio output, making it a practical and efficient solution for animal footprint classification.

IV. PROPOSED METHOD

The proposed system focuses on **automated animal footprint detection and classification** using a hybrid approach combining texture-based feature extraction and machine learning models. The system is designed to classify footprints of animals such as

bear, deer, elephant, horse, and tiger using image processing techniques.The system pipeline begins with dataset acquisition, where footprint images are collected and organized into labeled categories. The images are preprocessed by resizing and converting them into grayscale to reduce computational complexity. Feature extraction is performed using the **Gray Level Co-occurrence Matrix (GLCM)**, which captures spatial relationships between pixel intensities. Key texture features such as contrast, energy, and homogeneity are extracted, as these are highly effective for distinguishing footprint patterns.For classification, the system employs **Support Vector Machine (SVM)** with an RBF kernel due to its ability to handle non-linear data efficiently. Additionally, a lightweight **Convolutional Neural Network (CNN)** is implemented to automatically learn feature representations and compare performance with traditional methods. Studies show CNN models achieve higher accuracy (up to 97%) compared to SVM in complex image classification tasks .

A user-friendly GUI is developed using Tkinter, allowing users to upload datasets, extract features, train models, and perform predictions. The system also integrates a text-to-speech module to announce predicted animal classes.Recent research highlights the importance of automated footprint recognition for biodiversity monitoring and conservation, especially with emerging datasets like OpenAnimalTracks . The proposed system provides a cost-effective, scalable, and efficient solution for wildlife tracking and ecological studies.

V. IMPLEMENTATION

The implementation of the animal footprint detection system is divided into several stages, ensuring modularity and efficiency.

1. Dataset Collection and Input Handling

The system allows users to upload a dataset containing footprint images organized in class-wise folders. Each folder represents a specific animal class. The dataset is read using Python libraries such as OpenCV and NumPy.

2. Image Preprocessing

Each image undergoes preprocessing steps:

- Resizing to a fixed dimension (64×64 pixels)
- Conversion to grayscale
- Noise reduction

These steps ensure uniformity and improve model performance.

3. Feature Extraction using GLCM

The Gray Level Co-occurrence Matrix (GLCM) is used to extract texture features. It computes how often pairs of pixel values occur in an image. Features extracted include:

- Contrast
- Energy
- Homogeneity

GLCM-based feature extraction is widely used in pattern recognition due to its efficiency and high accuracy .

4. Data Splitting

The dataset is split into training and testing sets using an 80:20 ratio. This ensures unbiased evaluation of the model.

5. Model Training (SVM)

The SVM classifier is trained using extracted features:

- Kernel: Radial Basis Function (RBF)
- Handles non-linear separability
- Efficient for small and medium datasets

Performance metrics such as accuracy are calculated after training.

6. CNN Model Implementation

A lightweight CNN is implemented with:

- Convolution layer
- Max-pooling layer
- Fully connected dense layers

CNN automatically extracts features and improves classification performance, especially for complex patterns.

7. GUI Integration

A Tkinter-based GUI is developed with functionalities:

- Upload dataset
- Extract features
- Train SVM and CNN
- Display performance graph
- Predict new images

8. Prediction Module

For prediction:

1. Input image is preprocessed
2. Features are extracted
3. SVM model predicts class
4. Result is displayed with label

The system also uses text-to-speech for audio output.

9. Performance Evaluation

The system evaluates models using:

- Accuracy
- Precision
- Recall
- F1-score

Recent studies emphasize combining machine learning and deep learning for improved classification efficiency .

VI. ALGORITHMS

1. GLCM Feature Extraction Algorithm

1. Convert RGB image to grayscale
2. Compute GLCM matrix for pixel pair relationships
3. Extract features: contrast, energy, homogeneity
4. Normalize feature vector

2. Support Vector Machine (SVM)

1. Input feature vectors
2. Map data into higher-dimensional space
3. Find optimal hyperplane separating classes
4. Use RBF kernel for non-linear classification

3. Convolutional Neural Network (CNN)

1. Input feature map
2. Apply convolution filters
3. Perform pooling for dimensionality reduction

4. Flatten output
5. Apply dense layers
6. Use softmax for classification

4. Prediction Algorithm

1. Load trained SVM model
2. Input test image
3. Extract features
4. Predict class label
5. Display output

VII. SYSTEM DESIGN

The system follows a modular architecture consisting of six major components:

1. Input Module

Handles:

- Dataset upload
- Image selection
- User interaction

2. Preprocessing Module

Performs:

- Image resizing
- Grayscale conversion
- Noise removal

3. Feature Extraction Module

Uses GLCM to extract texture features essential for classification.

4. Model Module

Includes:

- SVM classifier
- CNN model

These models process extracted features and classify footprints.

5. Training Module

Responsible for:

- Model training
- Data splitting
- Performance evaluation

6. Prediction Module

Processes new input images and predicts the animal class.

7. GUI Module

Provides:

- Interactive interface
- Visualization of results
- User control

8. Output Module

Displays:

- Predicted animal class
- Image with label
- Audio output

System Flow

Input → Preprocessing → Feature Extraction → Training → Classification → Output

Advantages

- Low computational cost
- High accuracy with hybrid approach
- User-friendly interface
- Scalable system

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SYSTEM DESIGN IMAGES

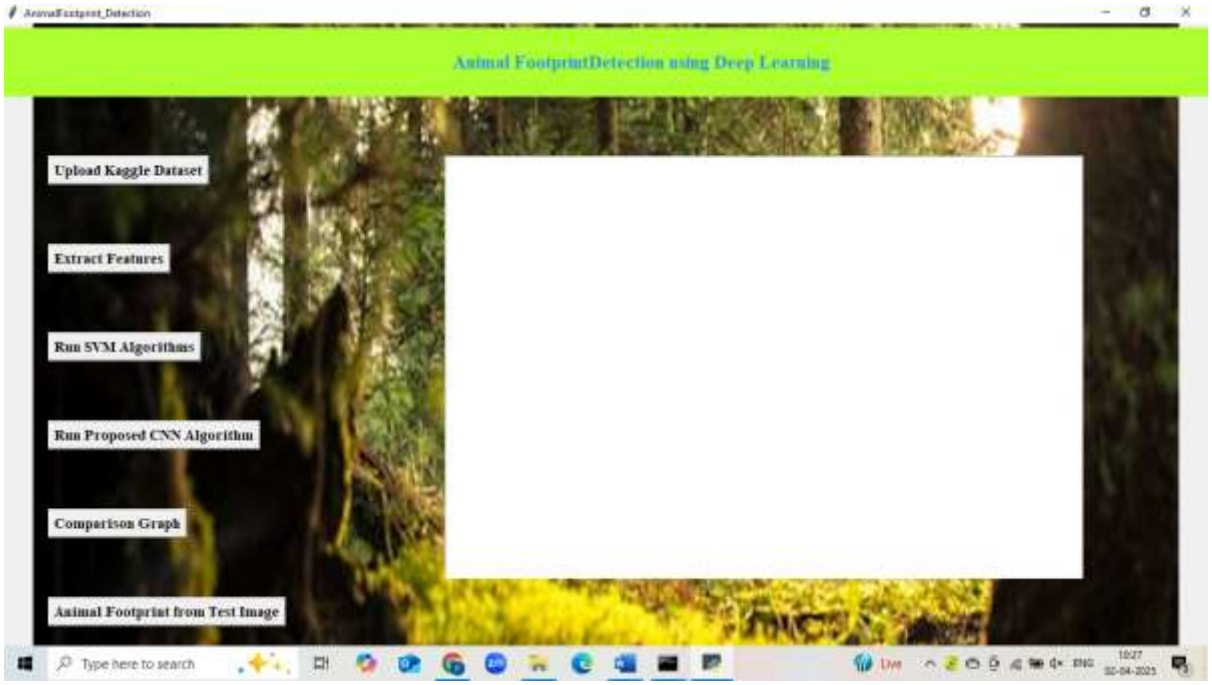


Fig: User Interface for animal footprint detection

This is graphical user interface created by using tkinter library for animal footprint detection. Here we are using SVM(machine learning) and CNN(deep learning) algorithm.

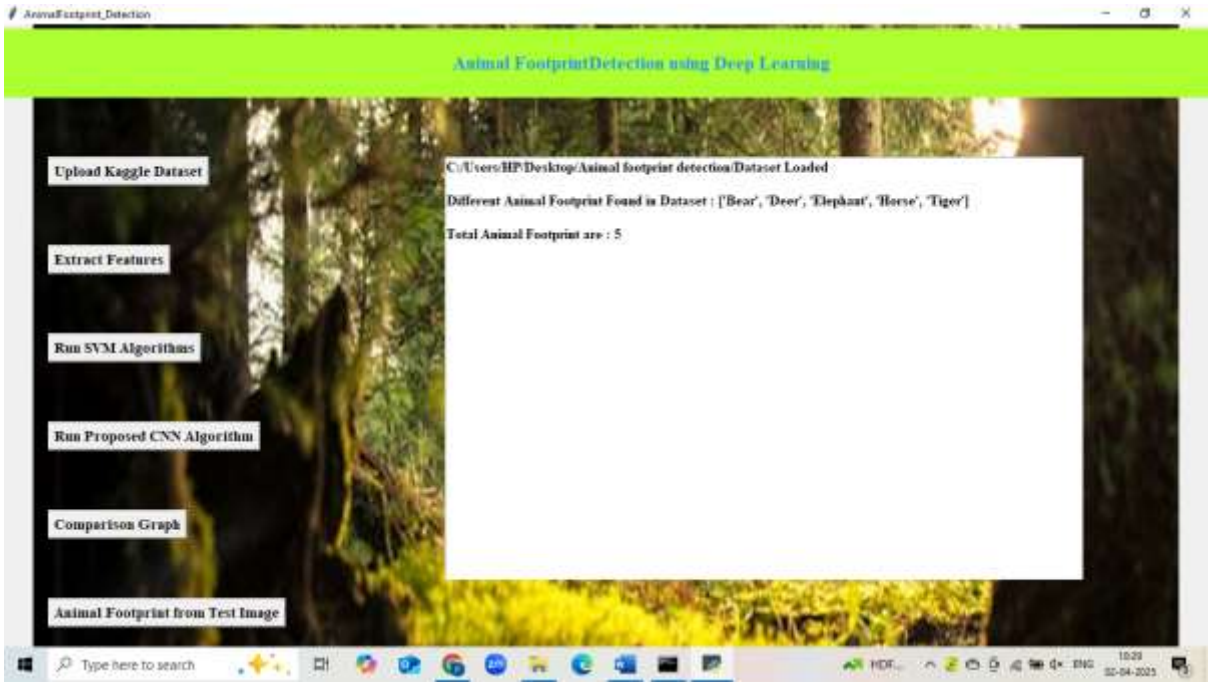


Fig: Loading Dataset

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First step is loading the animal footprint dataset which is taken from Kaggle site. Once dataset is loaded, it will type of animal footprints and number of animal footprint in dataset.



Fig: Feature extraction

Feature extraction needs to be done from images and data is split into training and testing. There are total 342 images in dataset. 273 images will go for training and 69 will be for testing.

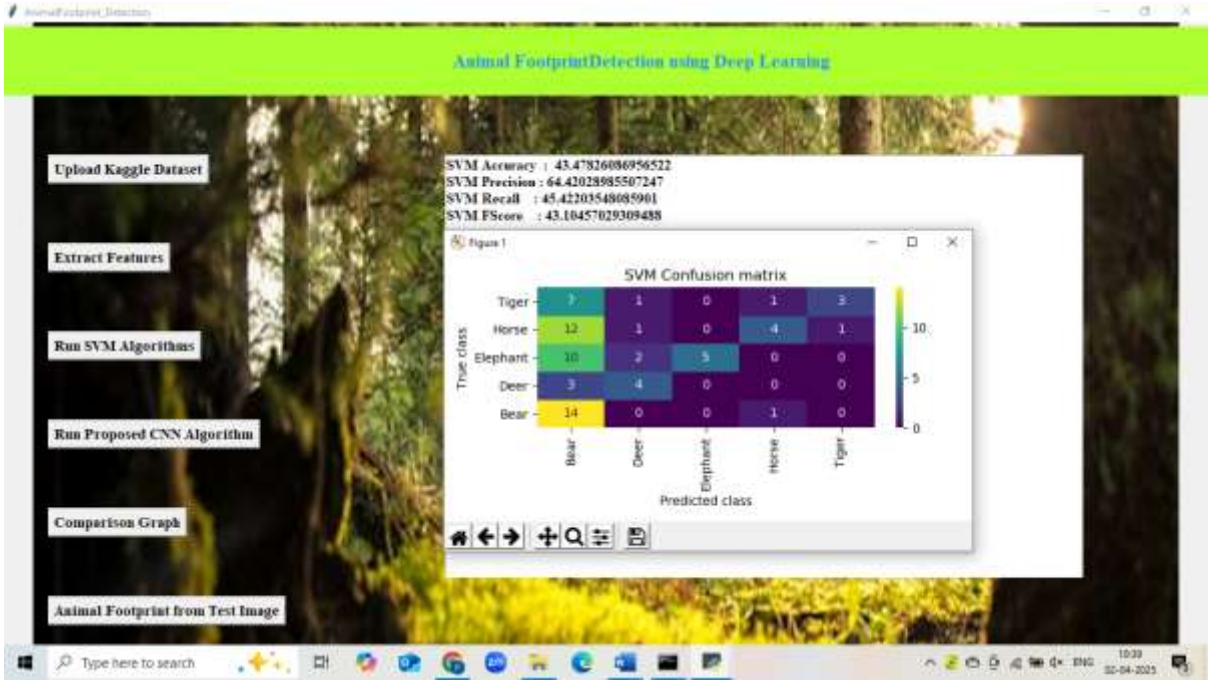


Fig: SVM algorithm performance

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After training with SVM algorithm , accuracy is getting approx. 44% only which is very for prediction animal footprint detection. So further we used CNN algorithm for better performance.

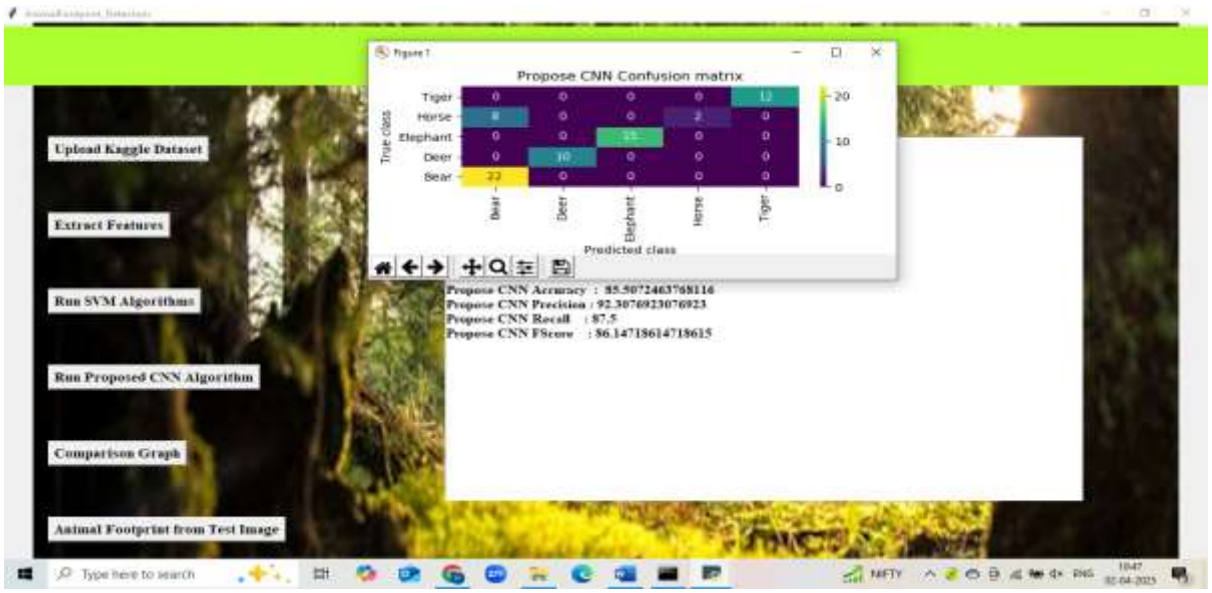


Fig: CNN Performance

CNN algorithm is giving better accuracy than SVM. That's why we will use CNN for prediction of animal footprint prediction.



Fig: Footprint prediction

VIII. CONCLUSION

The proposed system demonstrates an efficient and practical approach for automated animal footprint classification using machine learning and image processing techniques. By combining GLCM-based feature extraction with SVM and CNN models, the system achieves reliable classification performance.Texture-based features play a crucial role in distinguishing footprint patterns, while machine learning algorithms provide accurate classification. The inclusion of CNN enhances the system's ability to learn complex patterns automatically, improving overall performance.The system also provides a user-friendly GUI, making it accessible for researchers, forest officials, and conservationists. The integration of text-to-speech further enhances usability.Recent research highlights the growing importance of AI in wildlife monitoring and biodiversity conservation . Automated footprint recognition systems can significantly reduce manual effort and improve accuracy in species identification.However, the system has some limitations, such as dependency on dataset quality and limited scalability for large datasets. Overall, the system provides a cost-effective, scalable, and efficient solution for animal footprint classification and contributes to advancements in intelligent wildlife monitoring systems.

REFERENCES

1. Ramadan, K., "CNN vs SVM for Animal Classification," *AJAPAS*, 2025
2. RatnaSri et al., "Animal Footprint Classification using Deep Learning," *IARJSET*, 2024
3. Shinoda & Shiohara, "OpenAnimalTracks Dataset," *arXiv*, 2024
4. Kurniati et al., "GLCM-Based Feature Optimization," *arXiv*, 2024
5. Kumar & Singh, "Hybrid ML & DL Models with GLCM," *MGV Journal*, 2025
6. Wen et al., "Deep Learning for Animal Detection," *Scientific Reports*, 2025
7. Shrivastava et al., "Footprint Classification using PNN," *IJIRT*, 2024
8. Fathima & Dhanalakshmi, "Deep Learning for Animal Footprints," *IJNIET*, 2023
9. ScienceDirect, "Deep Learning for Animal Detection Review," 2024
10. Mahendra et al., "Animal Detection using CNN," 2024
11. Khan et al., "ML & DL in Image Classification," *CMC*, 2024
12. Ibraheam et al., "R-CNN Animal Detection Models," 2021
13. Perez & Toler-Franklin, "CNN-based Animal Behavior Classification," 2023
14. Suessle et al., "CNN Animal Classification Study," 2024
15. Zuo et al., "Advances in Food & Image Recognition Models," 2025