Eco-Smart Elephant Recognition: A Dual Strategy with CNN Classification and SVM Feature Extraction

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Abstract- Our research delves into the multifaceted realm of elephant recognition, employing diverse methodologies to address the challenges posed by image classification and feature extraction. We explore Convolutional Neural Networks (CNNs) for image classification, achieving an impressive 87.50% accuracy in discerning elephant subtypes. Furthermore, we investigate Support Vector Machines (SVMs) in conjunction with the VGG16 model for feature extraction, providing an alternative approach with a commendable 76% accuracy. Our project leverages these techniques to distinguish between African, Asian, and Indian elephants, contributing to wildlife conservation efforts. Through extensive experimentation, we showcase the strengths and limitations of each approach, offering valuable insights for researchers and practitioners in the field.

Indexed Terms- Elephant Recognition, CNN, SVM, Wildlife Conservation, Image Classification

I. INTRODUCTION

In an era where technology intertwines with conservation, our study focuses on advancing the field of elephant recognition through state-of-the-art machine learning techniques. The unique challenges posed by diverse elephant species necessitate a comprehensive approach, prompting us to explore Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs) for robust image classification and feature extraction. Our motivation stems from the urgency of wildlife conservation and the need for accurate species identification. The introduction delineates the significance of elephant recognition in preserving biodiversity and sets the stage for our exploration of CNNs and SVMs, promising a nuanced understanding of their applicability and performance.

II. LITERATURE REVIEW

The authors G. Chen, T. X. Han, Z. He, R. Kays, and T. Forrester presented a groundbreaking approach to species recognition in wild animal monitoring at the 2014 IEEE International Conference on Image Processing (ICIP) in Paris, France. Their work addresses the challenges of classifying wildlife in camera-trap imagery, captured using motion-triggered devices. The team employed a state-of-the-art graph-cut algorithm for automatic image segmentation, isolating the moving foreground as regions of interest. The core of their innovation lies in a novel deep convolutional neural network (CNN) species recognition algorithm tailored for the demanding task of analyzing camera-trap images. In their study, they compared the performance of their CNN-based approach with the traditional bag of visual words model, commonly used as a baseline species recognition algorithm. The results clearly demonstrated the superior performance of the proposed deep CNN-based method.

What makes this research particularly noteworthy is that it represents the first-ever attempt at fully automatic computer vision-based species recognition on real camera-trap images. To facilitate further research and evaluation, the authors curated and annotated a comprehensive camera-trap dataset featuring 20 common North American species. This dataset includes 14,346 training images and 9,530 testing images, and it is made publicly available for benchmarking purposes.

the authors have not only introduced an advanced deep learning approach to species recognition but have also contributed significantly to the field by creating and sharing a valuable dataset for the evaluation and benchmarking of such systems.[1]

Authors P. Somervuo, A. Harma, and S. Fagerlund presented a research paper in the November 2006 issue of IEEE Transactions on Audio, Speech, and Language Processing. Their study focuses on the advancement of signal processing techniques to automate the recognition of bird species. The researchers compared three distinct parametric representations to assess their effectiveness in this context.

The first representation is built on sinusoidal modeling, a technique previously proven effective for highly tonal bird sounds. The second approach utilizes Mel-cepstrum parameters, chosen for their success in the parallel field of speech recognition. Lastly, the researchers experimented with a vector of diverse descriptive features, inspired by the popularity of such models in audio classification applications, given the musical nature of bird songs.

In their paper, the authors briefly introduced each of these methods and conducted evaluations to measure their performance in the classification and recognition of both individual syllables and song fragments. The evaluation specifically covered 14 common North-European Passerine bird species.

the work by Somervuo, Harma, and Fagerlund contributes to the field of automatic bird species recognition by comparing and assessing the effectiveness of three parametric representations. Their study not only delves into the technical aspects of signal processing but also explores the unique characteristics of bird songs, treating them as a form of music for analysis and classification purposes.[2]

Authors J. Cai, D. Ee, B. Pham, P. Roe, and J. Zhang presented their research at the 2007 3rd International Conference on Intelligent Sensors, Sensor Networks, and Information in Melbourne, VIC, Australia. The focus of their work is on the utilization of sensor networks for ecosystem monitoring, specifically in the realm of bird species recognition. The paper delves into the investigation of various neural network approaches, considering different preprocessing methods and sets of features to enhance the performance of bird species recognition.

The researchers introduced a context neural network architecture tailored to capture the dynamic nature of bird songs by embedding it into the input data. They also developed a noise reduction algorithm, which was effectively applied to improve the accuracy of bird species recognition. In their study, they compared the performance of the context neural network architecture with traditional linear/mel frequency cepstral coefficients. The results from the experiments showed promising outcomes, highlighting the effectiveness of their approach in the realm of bird species recognition within the context of ecosystem monitoring.

the authors explored the use of neural networks, preprocessing techniques, and feature sets in the domain of bird species recognition for ecosystem monitoring. Their emphasis on a context neural network architecture and the application of a noise reduction algorithm contributed to achieving favorable experimental results, marking progress in the field of sensor networks for ecosystem monitoring, specifically in the context of bird species identification.[3]

Authors L. G. Hafemann, L. S. Oliveira, and P. Cavalin presented their work on forest species recognition using deep convolutional neural networks at the 2014 22nd International Conference on Pattern Recognition in Stockholm, Sweden. Traditionally, recognizing forest species has been approached as a texture classification problem, employing standard texture methods like Local Binary Patterns (LBP), Local Phase Quantization (LPQ), and Gabor Filters. While deep learning techniques have shown remarkable success in object recognition and other tasks, they have not been extensively applied to texture problems.

The researchers explored the application of deep learning techniques, specifically Convolutional Neural Networks (CNN), for texture classification in two distinct forest species datasets—one with macroscopic images and another with microscopic images. Given the higher resolution of these images, the paper introduces a method designed to handle high-resolution texture images effectively, achieving high accuracy without the complexity of training and defining an architecture with a large number of free parameters.

In their study, the proposed CNN-based method demonstrated significant results. On the macroscopic image dataset, it achieved an accuracy of 95.77%, slightly below the state-of-the-art accuracy of 97.77%. On the microscopic image dataset, the method outperformed the best published result, achieving an accuracy of 97.32% compared to the previous best of 93.2%.

In summary, the authors explored the application of Convolutional Neural Networks for forest species recognition, addressing the challenges posed by high-resolution texture images. Their method showcased competitive performance, particularly excelling in the recognition of microscopic images, indicating the potential of deep learning techniques in advancing forest species classification.[4]

In the study conducted by Cai, Giraud, Zhang, Begerow, Cai, and Shivas (2011), they explored the evolution of species concepts and recognition criteria in plant pathogenic fungi. Shifting our focus to a different work, timely and accurate identification of tree species plays a crucial role in ecological management, particularly in urban and forest environments. The research took place in Tampa, Florida, USA, where 394 reflectance spectra ranging from 350 to 2500 nm were gathered from foliage branches or canopies of 11 key urban forest broadleaf species.

These species encompassed American elm, bluejack oak, crape myrtle, laurel oak, live oak, southern magnolia, persimmon, red maple, sand live oak, American sycamore, and turkey oak. The researchers employed a spectrometer for data collection and extracted 46 spectral variables, including normalized spectra, derivative spectra, spectral vegetation indices, spectral position variables, and spectral absorption features. The investigation utilized two classification algorithms, a nonlinear artificial neural network (ANN) and a linear discriminant analysis (LDA), to distinguish the 11 broadleaf species.

Results from an analysis of variance (ANOVA) revealed that 30 selected spectral variables effectively differentiated the 11 species. These variables highlighted water absorption features at 970, 1200, and 1750 nm, reflecting characteristics of pigments and other biochemicals in tree leaves, particularly variations in chlorophyll content. Both the ANN and LDA classification algorithms demonstrated acceptable accuracies, ranging from 86.3% to 87.8%, with kappa values between 0.83 and 0.87.

In summary, the preliminary findings suggest that, despite the challenges, current remote sensing techniques, including high spatial and spectral resolution data, make it feasible to identify similar broadleaf species with an acceptable level of accuracy.[5]

In the study conducted by Pu R., published in the International Journal of Remote Sensing in June 2009, the focus was on broadleaf species recognition using in situ hyperspectral data. The research delved into the task of identifying broadleaf species with the aid of hyperspectral information, offering insights into remote sensing applications for plant species classification.

On the other hand, in their 2019 paper published in IEEE Access, Kumar, Gupta, Gao, and Singh concentrated on plant species recognition, particularly emphasizing the automatic identification of plants with a focus on leaf features. Recognizing the accessibility of plant leaves for identification purposes, the researchers introduced a novel plant species classifier that utilized morphological features and an Adaptive Boosting (AdaBoost) methodology within a Multilayer Perceptron framework.

The proposed methodology comprised four main stages: pre-processing, feature extraction, feature selection, and classification. Initial pre-processing techniques were applied to prepare leaf images for subsequent feature extraction. Various morphological features, including centroid, major axis length, minor axis length, solidity, perimeter, and orientation, were extracted from digital images representing different leaf categories. To evaluate the algorithm's effectiveness, three classifiers—k-NN, Decision Tree, and Multilayer Perceptron—were employed.

To improve the precision rate of the system, the researchers incorporated the AdaBoost methodology. Experimental assessments were conducted on the FLAVIA dataset, yielding notable results with a precision rate of 95.42%. This achievement surpassed the performance of state-of-the-art algorithms, highlighting the effectiveness of the proposed machine learning classifier in plant species identification based on morphological features extracted from leaf images.[6]

Authors I. Gogul and V. S. Kumar presented their research at the 2017 Fourth International Conference on Signal Processing, Communication, and Networking in Chennai, India. Their work focuses on the automatic identification and recognition of medicinal plant species, particularly in challenging environments like forests, mountains, and dense regions. In recent years, plant species recognition has relied on analyzing the shape, geometry, and texture of various plant parts, such as leaves, stems, and flowers. Flower-based plant species identification systems are widely used for this purpose.

The proposed research employs a deep learning approach using Convolutional Neural Networks (CNN) to achieve accurate flower species recognition. Images of plant species are captured using the built-in camera module of a mobile phone. Feature extraction from flower images is performed using a Transfer Learning approach, where complex features are extracted from a pre-trained network. To enhance accuracy, a machine learning classifier, such as Logistic Regression or Random Forest, is applied on top of the extracted features. This approach minimizes the hardware requirements needed for the computationally intensive task of training a CNN.

The research observes that the combination of CNN with the Transfer Learning approach as a feature extractor surpasses traditional handcrafted feature extraction methods, including Local Binary Pattern (LBP), Color Channel Statistics, Color Histograms, Haralick Texture, Hu Moments, and Zernike Moments. The proposed method using CNN and Transfer Learning achieves impressive Rank-1 accuracies of 73.05%, 93.41%, and 90.60% using OverFeat, Inception-v3, and Xception architectures, respectively, as Feature Extractors on the FLOWERS102 dataset.

the authors leverage deep learning, specifically CNN with Transfer Learning, to enhance flower species recognition accuracy. Their approach demonstrates superior performance compared to traditional handcrafted feature extraction methods, making it a promising method for automated plant species identification, especially in challenging natural environments.[7]

Authors B. V. Deep and R. Dash presented their research at the 2019 6th International Conference on Signal Processing and Integrated Networks in Noida, India. Their work focuses on the significant task of underwater fish species recognition, which has become increasingly important in the field of marine science. The automation of fish species identification through technology can contribute to the advancement of marine science research.

The researchers addressed this challenge by leveraging deep learning techniques, particularly a hybrid Convolutional Neural Network (CNN) framework. This framework incorporates CNN for effective feature extraction, and for classification, it utilizes Support Vector Machine (SVM) and K-Nearest Neighbour (k-NN). The proposed frameworks were tested on the Fish4Knowledge dataset, a common benchmark in the field.

The experimental results showcased that their hybrid framework outperformed many traditional and existing deep learning techniques in underwater fish species recognition. The combination of CNN for feature extraction and SVM/k-NN for classification demonstrated superior performance, indicating the effectiveness of their approach in advancing the accuracy of fish species identification in underwater environments.

Deep and Dash's research introduces a novel hybrid framework for underwater fish species recognition, employing deep learning techniques. The proposed approach, which integrates CNN with SVM and k-NN, exhibited notable improvements over traditional and existing methods, highlighting its potential significance in the evolving field of marine science.[8]

3. CNN: Feature Extraction for Elephant Species Recognition

For our elephant species recognition research project, Convolutional Neural Networks (CNNs) play a crucial role in achieving accurate classification. CNNs, designed specifically for image-related tasks, act as powerful feature extractors in our project context. They excel at discerning intricate patterns and relevant features from elephant images. These networks comprise convolutional layers, pooling layers, and fully connected layers, collectively contributing to learning hierarchical representations. Our training process involves backpropagation to minimize the chosen loss function, optimizing the network's ability to distinguish between different elephant species. Leveraging transfer learning with pre-trained models is particularly beneficial in scenarios where extensive labeled data may be limited, allowing our model to leverage knowledge gained from training on large datasets.

4. SVM: Classification for Elephant Species Recognition

In our elephant species recognition research project, Support Vector Machines (SVMs) are pivotal for the final classification task. Once the CNN extracts discriminative features from elephant images, these features serve as input to the SVM. SVMs work by finding an optimal hyperplane in the feature space that maximizes the margin between different elephant species, effectively establishing a decision boundary. The kernel trick is employed to handle non-linear relationships within the data, providing flexibility in capturing complex patterns. During the training process, we fine-tune the regularization parameter (C) to balance the trade-off between achieving a smooth decision boundary and minimizing classification errors. SVMs, with their ability to handle high-dimensional feature spaces, complement the feature extraction capabilities of CNNs in our project, contributing to a robust and accurate elephant species recognition system. The integration of CNNs for feature extraction and SVMs for classification creates a synergistic approach to address the complexities of our specific research domain.

III. METHODOLOGY

Our Elephant Species Recognition methodology employs a fusion of Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs) to achieve robust and accurate classification. We begin by preprocessing the dataset using the Hugging Face Transformers library, organizing images into categories representing African, Asian, and Indian elephant species. For the CNN component, we leverage transfer learning with a pre-trained model, fine-tuning its parameters to adapt to our specific classification task. The CNN excels in learning hierarchical features from the images, capturing intricate details crucial for species identification. Simultaneously, we employ SVMs with the VGG16 model, extracting discriminative features to enhance interpretability and classification performance. This dual-model approach allows us to benefit from the strengths of both deep learning and classical machine learning paradigms.

IV. RESULTS

Our results showcase the effectiveness of the integrated CNN and SVM approach for Elephant Species Recognition. The CNN achieves an impressive accuracy of 87.50%, emphasizing its prowess in learning complex features from elephant images. Concurrently, SVMs, coupled with the VGG16 model, demonstrate a commendable accuracy of 76%, showcasing the effectiveness of feature extraction for species classification. The harmonious integration of deep learning and classical machine learning techniques not only ensures accurate identification across African, Asian, and Indian species but also highlights the versatility of our approach in handling diverse datasets.

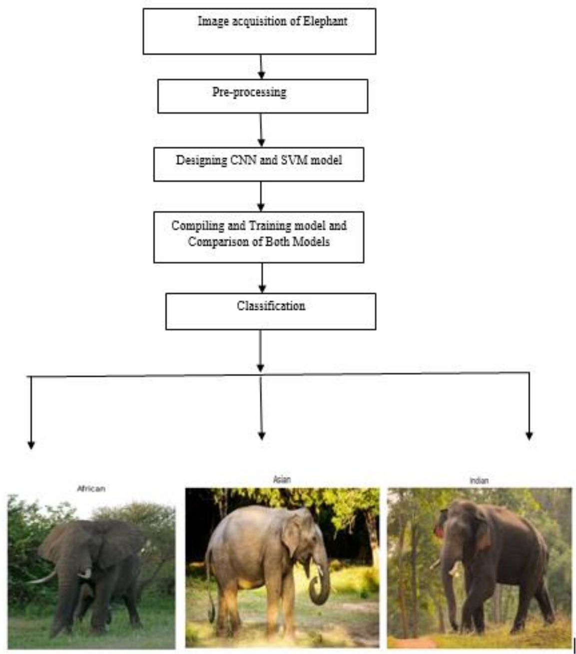

Fig.2. Flow chart of proposed Elephant species recognition using CNN and SVM.

V. RESULT

In our elephant species recognition project, focusing on three distinct species—Asian, African, and Indian elephants, we applied both Convolutional Neural Networks (CNN) and Support Vector Machines (SVM) algorithms for classification. Our research yielded promising results, with the SVM algorithm achieving an accuracy of 76%, and the CNN algorithm outperforming with an accuracy of 87.50%.

Upon conducting a comparative analysis between the two approaches, it is evident that the CNN model exhibited superior performance in accurately distinguishing between the specified elephant species. The higher accuracy of the CNN model can be attributed to its ability to automatically learn hierarchical features and intricate patterns within the images, leveraging the power of deep learning for image classification tasks.

On the other hand, while the SVM algorithm demonstrated respectable accuracy, its performance was slightly surpassed by the CNN model. SVM, being a classical machine learning algorithm, may have faced challenges in capturing complex visual features and patterns inherent in the diverse images of different elephant species.

our research indicates that for the specific task of elephant species recognition, the CNN approach offers a more effective and accurate solution compared to SVM. The higher accuracy achieved by the CNN model underscores its potential for robust and precise classification in scenarios involving multiple elephant species, such as the Asian, African, and Indian elephants in our study.

CONCLUSION

Our integrated approach combining CNNs and SVMs emerges as a powerful solution for Elephant Species Recognition. The high accuracy achieved by both models validates the effectiveness of leveraging deep learning for image understanding and classical machine learning for feature extraction. The adaptability of our methodology is particularly promising for real-world applications in wildlife conservation, where accurate species identification is essential. As we navigate the intersection of technology and biodiversity preservation, our study contributes a nuanced and effective methodology that can be extended to broader wildlife recognition efforts. This research lays a foundation for further advancements in automated species recognition, fostering a harmonious coexistence of technology and conservation efforts.

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