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The Use of Artificial Intelligence in Acoustic and Image Monitoring of Malaysian Wildlife

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Introduction

Artificial intelligence (AI) has revolutionized wildlife conservation in various countries around the world. In the United States, AI-powered systems are being used to automatically analyze vast datasets from camera traps, enabling researchers to track and identify species more efficiently (Norouzzadeh et al., 2018). Similarly, in Australia, AI algorithms have been employed to process acoustic data from rainforests, identifying species through their vocalizations and providing crucial insights into animal distribution and abundance (Garnett et al., 2019). In Africa, AI has enhanced monitoring efforts for large mammals, aiding in real-time population assessments and anti-poaching efforts (Wearn et al., 2019). The integration of AI with physics-based models, such as computational vision systems and acoustic wave analysis, has further enhanced the ability to detect and classify species with greater accuracy. These advancements demonstrate the transformative potential of AI in conservation, offering a more efficient, scalable, and accurate approach to wildlife monitoring. Despite these successes in other nations, Malaysia's use of AI for animal conservation remains underdeveloped, relying heavily on manual processes that are time-consuming and resource-intensive (WWF-Malaysia, 2021).

Malaysia, home to some of the world's most biodiverse ecosystems, is facing an urgent conservation crisis. With 105 animal species categorized as critically endangered and 205 species listed as endangered by the IUCN Red List in 2024, there is an immediate need for more effective monitoring and protection strategies (IUCN, 2024). Current methods, such as manual classification of images and acoustic data, are labor-intensive and limited in scope, making it difficult to keep pace with the growing threats of habitat loss and poaching (Zakaria et al., 2020). Physics-based AI techniques, such as image

recognition algorithms rooted in Fourier analysis and advanced signal processing for acoustic monitoring, could significantly improve the accuracy and speed of species identification. These tools use mathematical and physical principles to model the behavior of sound waves and light, allowing for the automated classification of animal sounds and movements. By adopting these AI technologies, Malaysia could benefit significantly from automated wildlife monitoring, enabling faster data analysis, real-time tracking of species, and deeper insights into their behaviors and habitats. This would not only enhance conservation efforts but also ensure that resources are allocated more efficiently, helping to protect Malaysia's vulnerable species before it's too late (Bennett et al., 2020).

Problem Statement

In 2024, the IUCN Red List categorized 105 animal species in Malaysia as critically endangered, while 205 animal species were endangered. Furthermore, a total of 451 animal species in the country were considered vulnerable (IUCN, 2024). To gauge the health of Malaysian wildlife, scientists are using image and acoustic monitoring to gather valuable information about the presence, distribution, and behavior of species (Burivalova et al., 2019). Recent technological advancements, particularly in artificial intelligence (AI), have driven wildlife monitoring innovations in many countries (Norouzzadeh et al., 2018; Garnett et al., 2019). The integration of AI, coupled with physics-based models such as computational imaging and acoustic signal analysis, offers a powerful new frontier in conservation. However, AI techniques specifically tailored for Malaysian wildlife remain underexplored, and their potential could significantly transform how conservation data is collected and analyzed. This research aims to investigate how far AI algorithms can automate the acoustic and image monitoring of Malaysian wildlife, particularly leveraging physics to enhance data interpretation.

In Malaysia, current manual processes for wildlife monitoring create significant obstacles for researchers aiming to collect comprehensive datasets (WWF-Malaysia, 2021). Manual classification of images and acoustic recordings requires substantial human resources and time, limiting the scale, frequency, and scope of data collection (Wearn et al., 2019). This reliance on traditional techniques often results in delayed data processing and may overlook critical insights regarding species behavior, distribution, and habitat use. Physics-based AI techniques, such as those rooted in Fourier transformations for image processing or wave analysis for sound detection, could revolutionize data classification by significantly accelerating and improving the accuracy of these processes. This research will explore how automating such tasks with AI can reduce manual workloads while increasing precision and timeliness in wildlife monitoring, leading to more efficient conservation efforts in Malaysia.

Additionally, Malaysia's unique biodiversity and ecosystems—such as its dense rainforests and coastal regions—present distinct challenges for wildlife monitoring. These ecosystems harbor a wide range of endemic species, some of which are elusive and difficult to study using traditional methods (Zakaria et al., 2020). Physics-based tools,

such as advanced signal processing for analyzing sound waves and light properties in image recognition algorithms, offer solutions to overcome these challenges. By integrating AI that is specifically designed for the Malaysian environment, researchers can gain deeper insights into the interactions between species and their habitats, filling gaps in knowledge that can improve conservation strategies. This would allow for the identification of subtle behavioral patterns and environmental factors that are critical for understanding and protecting Malaysia's endangered species (Bennett et al., 2020).

Lastly, the applications of AI in wildlife monitoring extend well beyond data analysis; they provide opportunities for proactive conservation management. Physics-based AI models enable real-time analysis of large datasets, offering the potential for continuous wildlife population monitoring and immediate response to emerging threats such as poaching or habitat loss (Norouzzadeh et al., 2018). Moreover, the real-time capabilities of AI can enable conservationists to make timely, data-driven decisions, guiding targeted interventions based on patterns of movement, behavior, and environmental changes. By automating the interpretation of complex datasets, AI can drastically improve the effectiveness of conservation efforts, ensuring that resources are directed where they are most needed and helping to safeguard Malaysia's vulnerable wildlife for the future.

Objectives

1. To develop AI algorithms that utilize advanced image recognition and acoustic signal processing based on principles of computational physics for classification of wildlife images and acoustic data collected in Malaysia.
2. To evaluate the effectiveness of these AI algorithms compared to traditional manual methods in terms of accuracy, speed of processing, and the ability to capture intricate physical properties in wildlife behavior and habitat patterns.

Literature Review

This review encompasses the latest studies on the application of bioacoustics monitoring and AI learning in predicting several ecological outcomes. The results of all the research conducted in this area have been favorable. The AI algorithm assists in ecological studies by analyzing and interpreting a large amount of collected data, providing insights and conclusions based on the findings. The AI method focuses a larger emphasis on prediction than convolutional statistical methods and evaluates species identification and classification with better precision.

Species' vocalization predictions are challenging due to the limited presence of species' sounds and the high proportion of background noise in large-scale bioacoustics libraries, making manual retrieval of vocalizations for analysis difficult. Using AI algorithms can overcome these difficulties, resulting in more accurate identification and analysis of animal vocalizations. AI methods can also be used to analyze large and complex datasets, providing important insights into animal behavior and communication.

Traditional statistical methods have limited precision when dealing with complex datasets. As the number of inputs increases, these methods become less accurate. To address these limitations, AI techniques are utilized to effectively analyze complex data and overcome the challenges posed by traditional statistical models. The application of AI in bioacoustics monitoring has mainly focused on avian and mammalian species, with the highest number of articles published in the year 2021 and the least in 2022. Among the AI learning methods, CNN showed high accuracy and was more frequently used than other methods. The highest F1 score of 99.60% was achieved by combining multi-view features with CNN. However, multi-view features have only been used once in bioacoustics monitoring and more research is recommended to determine their accuracy.