

ABSTRAK

EVALUASI KINERJA DEEP LEARNING UNTUK IDENTIFIKASI SPESIES KUPU-KUPU SUMATERA BERBASIS AUGMENTASI DATA

Oleh

RICO ANDRIAN

Kupu-kupu merupakan salah satu indikator penting keanekaragaman hayati yang memiliki peran ekologis dalam proses penyerbukan dan pemantauan kualitas lingkungan. Identifikasi spesies kupu-kupu secara manual memerlukan keahlian taksonomi dan waktu yang relatif lama sehingga diperlukan sistem identifikasi otomatis yang akurat dan efisien. Penelitian ini bertujuan untuk mengevaluasi kinerja berbagai arsitektur *deep learning* dalam mengidentifikasi spesies kupu-kupu Sumatera berbasis citra digital serta menganalisis pengaruh teknik augmentasi data terhadap performa model.

Dataset yang digunakan terdiri atas delapan spesies kupu-kupu Sumatera yang berasal dari Taman Kupu-Kupu Gita Persada, Bandar Lampung. Penelitian membandingkan tujuh arsitektur *deep learning*, yaitu DenseNet201, ResNet50, Xception, MobileNet, InceptionV3, *Vision Transformer* (ViT), dan EfficientNetB0. Selain itu, diterapkan enam teknik augmentasi data, yaitu *Rotation*, *Flip*, *CutMix*, *Mixup*, *AugMix*, dan *LayerMix*. Evaluasi dilakukan menggunakan metrik akurasi klasifikasi, efisiensi komputasi, dan penggunaan memori.

Hasil penelitian menunjukkan bahwa seluruh model mampu melakukan identifikasi spesies kupu-kupu Sumatera dengan tingkat akurasi yang tinggi. DenseNet201 menghasilkan akurasi tertinggi sebesar 99,38% pada data asli, diikuti ResNet50 dan Xception sebesar 98,75%, serta MobileNet sebesar 97,50%. Penerapan augmentasi data terbukti meningkatkan kemampuan generalisasi model dan menghasilkan beberapa kombinasi arsitektur-augmentasi dengan akurasi tertinggi sebesar 99,38%, yaitu DenseNet201–*LayerMix*, MobileNet–*Flip*, MobileNet–*CutMix*, *Vision Transformer–Flip*, *Vision Transformer–CutMix*, Xception–*Flip*, Xception–*CutMix*, Xception–*Mixup*, Xception–*AugMix*, serta EfficientNetB0–*LayerMix*.

Hasil penelitian juga menunjukkan bahwa MobileNet memiliki keseimbangan terbaik antara akurasi, waktu inferensi, ukuran model, dan jumlah parameter sehingga sangat sesuai untuk implementasi pada perangkat bergerak. Penelitian ini berhasil menghasilkan sistem identifikasi otomatis spesies kupu-kupu Sumatera berbasis *deep learning* yang mendukung konservasi biodiversitas dan diimplementasikan dalam aplikasi mobile Butterfly Vision.

Kata kunci: *deep learning*, identifikasi spesies, kupu-kupu Sumatera, augmentasi data, *convolutional neural network*, *vision transformer*, aplikasi mobile.

ABSTRACT

PERFORMANCE EVALUATION OF DEEP LEARNING FOR SUMATRAN BUTTERFLY SPECIES IDENTIFICATION BASED ON DATA AUGMENTATION

By

RICO ANDRIAN

Butterflies are important biodiversity indicators that play significant ecological roles in pollination and environmental monitoring. Manual butterfly species identification requires taxonomic expertise and considerable time, creating a need for an accurate and efficient automated identification system. This study aims to evaluate the performance of various deep learning architectures for identifying Sumatran butterfly species from digital images and to investigate the impact of data augmentation techniques on model performance.

The dataset consisted of eight Sumatran butterfly species collected from the Gita Persada Butterfly Park, Bandar Lampung, Indonesia. Seven deep learning architectures were evaluated, including DenseNet201, ResNet50, Xception, MobileNet, InceptionV3, Vision Transformer (ViT), and EfficientNetB0. In addition, six data augmentation techniques were applied: Rotation, Flip, CutMix, Mixup, AugMix, and LayerMix. Model performance was assessed using classification accuracy, computational efficiency, and memory usage metrics.

The results demonstrated that all models were capable of accurately identifying Sumatran butterfly species. DenseNet201 achieved the highest accuracy of 99.38% on the original dataset, followed by ResNet50 and Xception with 98.75%, and MobileNet with 97.50%. Data augmentation significantly improved model generalization and produced several architecture–augmentation combinations that achieved the highest accuracy of 99.38%, namely DenseNet201–LayerMix, MobileNet–Flip, MobileNet–CutMix, Vision Transformer–Flip, Vision Transformer–CutMix, Xception–Flip, Xception–CutMix, Xception–Mixup, Xception–AugMix, and EfficientNetB0–LayerMix.

Furthermore, MobileNet provided the best balance between classification accuracy, inference time, model size, and parameter count, making it highly suitable for deployment on mobile devices. This study successfully developed an automated deep learning-based system for Sumatran butterfly species identification

and implemented it in the Butterfly Vision mobile application to support biodiversity conservation efforts.

Keywords: *deep learning, species identification, Sumatran butterflies, data augmentation, convolutional neural network, vision transformer, mobile application.*