UNDERGRADUATE THESIS

COMPARATIVE ANALYSIS OF ADAPTIVE MINIMAL ENSEMBLE AND EFFICIENTNET V2-L METHODS IN VEHICLE CLASSIFICATION

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APPROVAL SHEET

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ABSTRACT

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Thesis Title:	Comparative Analysis Of Adaptive Minimal Ensemble And Efficientnet V2-l Methods In Vehicle Classification
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Manual classification of heavy vehicles based on the number of axles on highways has a high level of inefficiency; thus, an automated system using a Convolutional Neural Network (CNN) based on side-view images serves as a crucial solution. Although CNN models are highly accurate, architectures with a large number of parameters generally require massive and expensive computational resources. This study aims to conduct an in-depth comparative analysis regarding classification performance, computational resource efficiency, and model decision interpretation between the massive single-architecture EfficientNetV2-L and the Adaptive Minimal Ensemble (AME) approach based on EfficientNetV2-S.

The experiment was conducted using 1,295 vehicle images categorized into five classes (Group 1 to Group 5) and validated using the 5-Fold Stratified Cross-Validation method. Model performance was evaluated through accuracy, precision, recall, and F1-Score metrics, while efficiency was measured by VRAM usage, GPU utilization, power consumption, and inference time. The decision-making process was visually validated utilizing attention heatmaps from the HiResCAM algorithm.

The results showed that both the AME and EfficientNetV2-L End-to-End models successfully achieved perfect classification accuracy, scoring 100% across all evaluation metrics. Nevertheless, the AME architecture proved to be significantly more computationally efficient. During the inference phase, AME only allocated 1,375.8 MB of VRAM with a power consumption of 63.9 W, which is much lighter compared to the EfficientNetV2-L End-to-End, which consumed 2,032.4 MB of VRAM and 70.4 W of power.

Further HiResCAM visualization analysis confirmed that the AME model was able to precisely and logically localize features by highlighting the axle and wheel areas, which are the main parameters for determining vehicle classes. Overall, the adaptive ensemble approach in AME proved to be highly optimal in maintaining the maximal accuracy of a large model while drastically reducing the computational load.

Keywords: *Adaptive Minimal Ensemble, Convolutional Neural Network, EfficientNetV2, HiResCAM, Vehicle Classification*.

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The author realizes that this thesis is far from perfect due to limited knowledge and experience. Therefore, the author greatly appreciates constructive criticism and suggestions from various parties for future improvements. Finally, the author hopes that this thesis will be beneficial for the development of science, particularly in the field of *Computer Vision* and *Machine Learning*, as well as for readers in general.

Surabaya, July 10, 2026

Author

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES