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Image-Based Automatic Vehicle Paint Error Detection

H K T P L Sampath¹, D G S P Thilakarathne¹, R R L U I Rajapaksha^{1*}

¹ Faculty of Computing and Technology, University of Kelaniya, Kelaniya, Sri Lanka
*rasikar@kln.ac.lk

A significant gap exists in current literature regarding automated, image-based verification of vehicle paint color originality. This study addresses this gap by developing a machine learning framework that classifies vehicle brands based on paint color features, where the response variable is the vehicle brand label extracted from paint surface images. A cleaned dataset of 6,144 images across fifteen brands was constructed and split into training (80%) and testing (20%) sets. Two feature extraction strategies, HSV color histograms and hybrid deep features from VGG16 and MobileNet were evaluated using ten distinct models, including k-Nearest Neighbors (k-NN), Decision Trees, Support Vector Machine (SVM), and Random Forest. The Random Oversampling and Synthetic Minority Oversampling Technique (SMOTE) applied to mitigate class imbalance. Across the ten models, hybrid deep feature approaches consistently outperformed histogram-based methods. The best performance was achieved by Model 9 (with VGG16 and Random Forest), which reached 84.20% accuracy, 83.80% precision, 84.20% recall, and an F1-score of 83.80% on the testing set. Since the test set exhibited class imbalance, class wise accuracies were also computed. It revealed that the model maintained strong performance across the major classes, with accuracy ranging from moderate levels in minority classes to over 90% in majority classes. These findings demonstrate that combining deep convolutional features with ensemble classifiers significantly enhances paint-based brand classification. The study establishes a practical, cost-effective direction for automated paint originality verification, supporting quality assurance and fraud detection in the automotive sector.

Keywords: Convolutional Neural Network, Feature extraction, VGG16, MobileNet, Decision trees, Support Vector Machine.