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Determination of Traffic Density by Categorizing Different Types of Vehicles Using Machine Learning Techniques

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Background: Urban traffic congestion presents a persistent challenge in modern cities, contributing to increased travel delays, fuel consumption, and environmental pollution. Accurate estimation of vehicle density is essential for effective congestion management and the development of smarter transportation systems.

Objective: This study proposes a real-time traffic density estimation approach using computer vision and machine learning techniques.

Results: Multiple pre-trained models, including You Only Look Once version 12 (YOLOv12), Convolutional Neural Network (CNN), K-Nearest Neighbors (KNN), and Mixture of Gaussians v2 (MOG2), were employed for vehicle detection and classification. A dataset of 9,000 labeled images collected from congested intersections in the northern region of Sri Lanka, representing ten distinct vehicle categories, was utilized. Of these, 8,000 images were used for training and 1,000 for testing. Background subtraction, object extraction, and vehicle counting methods were integrated to estimate traffic density.

The comparative analysis of model performance revealed that YOLOv12 achieved the highest classification accuracy of 98.0%, followed by CNN (95.0%), KNN (86.0%), and MOG2 (65.0%). YOLOv12 consistently demonstrated superior performance across varied traffic conditions and vehicle categories.

Conclusion: The findings confirm the effectiveness of deep learning-based computer vision systems for vehicle detection and density estimation. The proposed approach provides a scalable solution for congestion analysis, offering valuable insights for developing intelligent and efficient urban transportation strategies.

Keywords: Computer Vision, Intelligent Traffic Control, Machine Learning