Real-Time Vehicle Damage Classification Based on Accident Detection from CCTV Footage Using Two-Stage Approach

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***Abstract*—Traffic accidents are a significant global issue, causing injuries, property damage, and traffic congestion, which often delay emergency responses. These challenges highlight the need for more efficient and effective real-time traffic management systems that can improve safety, reduce response times, and improve overall traffic flow. This study proposes a two-stage approach using CCTV footage to enable automatic accident detection and vehicle damage classification. In the first stage, the YOLOv8 model is used for real-time accident detection, achieving a mean Average Precision (mAP) of 0.84, indicating its high accuracy in identifying accidents. The second stage incorporates the EfficientNetB0 model to classify vehicle damage into three categories: normal, moderate, and severe, with an overall accuracy of 0.76, while MobileNetV2 achieves an accuracy of 0.7. By integrating these models, the system demonstrates significant potential for accident detection and vehicle damage classification, thereby contributing to a smarter traffic monitoring system, thereby improving emergency response services for evacuation.**

Keywords—accident detection, CCTV, EfficientNet, vehicle damage classification, YOLOv8.

I. Introduction

The World Health Organization (WHO) reports that traffic accidents cause approximately 1.19 million deaths annually, with road injuries being the leading cause of death among children and young adults aged 5-29 years [1]. In Indonesia, as of July 28, 2022, the National Criminal Information Center recorded 62,975 accidents resulting in 12,530 deaths, 6,093 serious injuries, and 75,313 minor injuries [2]. Efforts to mitigate traffic disruptions from accidents include the implementation of the Area Traffic Control System (ATCS), which provides centralized traffic management and emergency responses [3]. However, the current ATCS system still relies on manual public reports and lacks automatic detection capabilities. Integrating Artificial Intelligence (AI) for real-time accident monitoring through CCTV can detect vehicle damage, enabling faster emergency response to speed up accident handling.

Previous studies have addressed accident detection and damage classification. Mane et al. [4] proposed YOLOv8 for rapid accident detection, while Ahmed et al. [5] combined YOLOv5 with ResNet152 and InceptionV3 for post-fire classification. However, these approaches are limited to detecting accidents and do not utilize CCTV footage for vehicle damage analysis. Kyu et al. [6] used machine learning for vehicle damage classification for insurance purposes by relying on a close point of view instead of a remote one such as CCTV footage.

Thus, the main contributions of this research are as follows: (1) development of a real-time accident detection system using YOLOv8, and (2) implementation of a Convolutional Neural Network (CNN)-based vehicle damage classification model for post-accident damage classification. This contribution combines accident detection and vehicle damage classification into a framework that utilizes CCTV footage as the primary data source to address traffic incident challenges. The proposed system is designed to detect traffic accidents in real-time and classify the damage level of the vehicles involved into three categories: normal, moderate, and severe.

The paper is structured as follows: Section 2 reviews related works on accident detection and damage classification. Section 3 outlines the proposed system, including data acquisition and model development. Section 4 presents the experiments and result analysis, and Section 5 concludes with key findings and recommendations for future enhancements.

II. Related Works

In this related work, research results related to incident detection and classification of vehicle damage using Deep Learning methods are summarized. The study conducted by Mane et al. [4] proposed a method that uses YOLOv8 model for efficient detection. Their study used the model trained on an open-source dataset, the Crash Car Detection Dataset, and achieved precision, recall, and mAP of 93.8%, 98%, and 96.1%, respectively, which represents a significant improvement over the previous 91.3%, 87.6%, and 93.8%. They suggested that using YOLO and adopting other methods can further improve the performance in crash detection.

Research conducted by Ahmed et al. [5] aims to improve traffic safety by accelerating emergency response through real-time detection of accident incidents and post-accident fires. One of the models used was YOLOv5 for vehicle detection, which achieved a mAP of 99.2%. In addition, their research used ResNet152 and InceptionV3 architecture for post-fire classification.

The classification of vehicle damage levels in the study conducted by Kyu et al. [6], detection and classification of damage levels to improve the efficiency of insurance claim assessment based on the location of the damage, vehicles were classified into three categories: minor, moderate, and severe. This study compares the performance of VGG16 and VGG19 models. VGG19 has an accuracy of 95.22% and a damage assessment score of 58.44%, while VGG16 has a lower accuracy of 94.56% and a damage assessment score of 54.80.