Chapter 7
Deep Learning-Based Vehicle Detection and Classification in Traffic Management for Intelligent Transportation Systems

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ABSTRACT

For intelligent transportation systems (ITSs) and planning that makes use of exact location intelligence, accurate vehicle classification and detection are topics that are becoming more vital. Although computer vision and deep learning (DL) are smart techniques, there remain issues with effective real-time detection and categorization. The requirement for a large training dataset and the domain-shift problem are two prevalent issues in this area. This research proposes the use of the YOLOv3 (you only look once) algorithm to provide an effective and efficient framework for vehicle recognition and classification from traffic video surveillance data. Along with the other deep learning-based algorithms like faster RCNN and VGG16 pre-trained model, a machine learning model using bag of features (BoF) + support vector machine (SVM) is also compared and analyzed for detecting and classifying vehicles.

INTRODUCTION

The number of automobiles that are legally allowed to drive on the roads today is in the millions, and it's growing (Anastasiu et al., 2020). As a result, improving traffic efficiency and minimizing congestion, as well as the harm caused by accidents to people and property has become a key concern in urban

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areas (Alzubi et al., 2022). However, during the past ten years, this has steadily improved because of ITS (Intelligent Transport Systems) (ITS). As a result, the way we travel today has undergone a considerable transformation because of the integration of new technologies for information and communication into automobile interiors and transport networks (El-Bouziady et al., 2018). These tools decrease travel times and congestion, enhance traffic flow by spotting traffic violations, assist drivers, lower the probability of accidents, and lessen the damage brought on by unavoidable collisions (Hadi et al., 2014). These applications place demands as well, necessitating trustworthy specialized hardware as well as dependable and quick communications (Alzubi et al., 2023). Additionally, because they are inexpensive, simple to maintain, and capable of taking high-quality pictures of the traffic scene, the majority of traffic management systems are built on camera-based video surveillance (Kim & Cho, 2012). In order to assist drivers in travelling securely and comfortably, this enables the exchange and gathering of relevant information between vehicles, as well as between vehicles and the transportation infrastructure (Piedad et al., 2019).

Vehicle statistics and detection in highway monitoring video scenarios are extremely important for effective traffic management and highway control (Alajmi et al., 2013). A sizable library of traffic video material has been gathered for analysis thanks to the widely used deployment of traffic surveillance cameras (Akbar et al., 2023). High viewing angles typically allow for consideration of a further away road surface (Abukharis et al., 2014). At this viewing angle, the vehicle's object size varies significantly, making it difficult to spot a small object distant from the road (Chakrabarti & Goswami, 2008). It can be challenging to precisely detect and classify automobiles in traffic flows in complicated scenarios with a wide range of vehicle models and a high vehicle density (Liu et al., 2021).

Additionally, environmental changes, various vehicle attributes, and relatively slow detection speeds all contribute to limitations in vehicle detection (Huang et al., 2020). As a result, an algorithm must be created for a real-time traffic surveillance system with accurate vehicle detection and real-time computing capabilities (Batool et al., 2023). Consequently, there are theoretical and practical implications for the speedy and precise recognition of automobiles in traffic photos or films (Ahmed Chhipa et al., 2021).

Object identification techniques based on deep learning have been extensively studied due to the quick advancement of computer vision and artificial intelligence techniques (Priyadarshi et al., 2020). Such algorithms contain a potent picture abstraction ability as well as an automated high-level feature representation ability because they can retrieve features autonomously through machine learning (Khan et al., 2023). Although conventional machine vision can identify the vehicle faster, it struggles in complicated environments, pictures with changing lighting or periodic background motion, or when cars are going slowly (Boina et al., 2023). Deep convolutional networks have achieved remarkable success in the field of automotive object detection. Classification and bounding box regression are just two of the many related tasks that CNNs can do well, and they also learn image features quite well (Zhao et al., 2019). It is possible to classify the detection methods into two main groups (Ganesh et al., 2016). First, a candidate box is constructed for the item using many methods; second, a convolutional neural network is employed for object classification in the two-stage process (Khan, 2020). The one-stage approach skips making a candidate box and goes straight to analysing regression solutions for the object bounding box placement challenge (Yang et al., 2022).

Currently, the gold standard for intelligent ITS automation is video feeds collected from a network of security cameras being processed by deep learning (DL) for the purpose of vehicle recognition and classification (Kalake et al., 2021). For the purpose of traffic scene video identification and classifica-