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HIGHWAY TRAFFIC CONGESTION DETECTION AND EVALUATION BASED ON DEEP LEARNING TECHNIQUE

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Abstract- In recent years, the rapid growth of urban population and the increased ownership of private vehicles have led to significant challenges in managing traffic congestion, a pervasive problem in many metropolitan areas around the world. Traffic congestion has become a ubiquitous problem in urban centers across the globe, posing significant challenges to commuters, city planners, and transportation authorities. This research paper aims to delve into the primary factors contributing to this persistent issue, drawing insights from various academic sources. This paper presents Highway Traffic Congestion detection and evaluation based on deep learning technique. The results show the effectiveness of the proposed method.

Keywords: Highway, Traffic Congestion, Deep Learning, Intelligent Technologies.

1. INTRODUCTION

The application of intelligent technologies, particularly deep learning techniques, offers a promising avenue for addressing the problem of urban traffic congestion. Deep learning-based algorithms can be leveraged to analyze large volumes of traffic data, obtained from various sources such as surveillance cameras, vehicle sensors, and GPS-enabled devices, to accurately detect and predict traffic patterns, identify congestion hot spots, and forecast future traffic conditions [1][2]. By harnessing the power of deep neural networks, it is possible to extract complex, nonlinear relationships from this data, enabling more robust and adaptive traffic management strategies[3][4].

1.1 Causes of Traffic Congestion

While various temporary solutions, such as road expansion and vehicle restrictions, have been implemented in an attempt to alleviate traffic congestion, these measures have often produced minimal long-term results[5][6]. Instead, experts recommend that city authorities adopt a more comprehensive and integrated approach, focusing on influencing the behavior of road users and addressing the underlying factors that contribute to the problem[7].

2. SOURCES OF TRAFFIC DATA

Traffic data is essential for understanding and managing transportation systems, and there are various sources of this information, including traffic cameras, sensors, and Global Positioning System (GPS) devices. Traffic cameras are a widely used source of traffic data, as they can provide real-time information on vehicle movement, traffic flow, and congestion levels[8][9][10]. These camera-based systems have the advantage of being able to operate in different weather conditions and at night, unlike some other technologies. Sensor-based systems, such as loop detectors, are another common source of traffic data. These sensors can measure traffic volume, but they can be expensive to install and maintain[11][12].

3. OVERVIEW OF CONVOLUTIONAL NEURAL NETWORKS

CNNs are inspired by the visual cortex of animals and consist of multiple layers that automatically and adaptively learn spatial hierarchies of features from input images[13]. The key components of a CNN include the following

3.1 Convolutional Layers

These layers apply a set of learnable filters (or kernels) to the input image, producing feature maps that capture various visual patterns such as edges, textures, and shapes.

3.2 Pooling Layers

Pooling layers reduce the spatial dimensions of the feature maps, retaining the most salient information while reducing computational complexity and increasing robustness to variations.

3.3 Fully Connected Layers

These layers, typically found towards the end of the network, perform high-level reasoning by combining features extracted by previous layers and outputting predictions.

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3.4 Activation Functions

Non-linear activation functions such as ReLU (Rectified Linear Unit) introduce non-linearity into the model, enabling it to learn complex patterns.

Fig. 3.1 The key components of a CNN

3.5 Application to Traffic Congestion Detection

In the context of highway traffic congestion detection, CNNs can be trained on large datasets of traffic images and videos to automatically identify congested versus non-congested conditions. The process involves the following steps:

Fig. 3.2 Traffic Congestion Detection Process

3.6 Software Implementation Framework

Implementing a Convolutional Neural Network (CNN) model for highway traffic congestion detection and evaluation requires a well-structured software framework. This framework ensures that the model can be efficiently developed, trained, evaluated, and deployed in real-world scenarios. This section outlines the key components and steps involved in the software implementation framework, covering data management, model development, training pipeline, evaluation, and deployment [14][15].

The proposed method involves training two SVM models, SVM-1 and SVM-2, to classify traffic congestion in each input video during the training phase. as medium, heavy, or low. We extract texture features from N frames using the LTR approach, and then we use the training videos and the accompanying ground-truth (GT) findings (actual class label of each video) to construct a compact feature representation to train SVM-1. In order to train SVM-2, we additionally simultaneously collect motion features from training films and merge them. We combine the outputs of SVM-1 and SVM-2 after they have been trained to obtain the final classification results for traffic congestion in input videos. During the testing stage, test videos' texture and motion features are taken out and input into SVM-1[16].

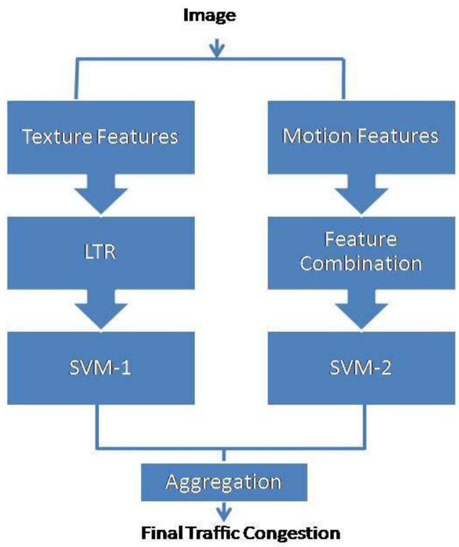

Fig. 3.3 Software Implementation Framework

Given that the primary goal of the suggested approach is to produce accurate traffic congestion classification findings, above figure describes the proposed method's framework[16].

4. RESULT & DISCUSSION

Recent advancements in machine vision algorithms have demonstrated the potential of closed-circuit television cameras as an important data source for determining the state of traffic congestion. Two deep learning techniques, You Only Look Once and Deep Convolutional Neural Network, have been employed to detect traffic congestion from camera images, achieving impressive accuracy rates of 94% and 95%, respectively. In contrast, without CNN, a shallow algorithm, attained a lower accuracy of 89%, highlighting the improvements offered by deep learning approaches.
Based on highway recordings, the total and category number of vehicles as well as information on traffic flow were approximated. According to vehicle types and directions (both incoming and leaving), the approximate number of small vehicle and heavy vehicles are as demonstrated in Table 4.1. The bar graph of the vehicle count is shown in figure 4.1. The comparison between the proposed method using CNN and without CNN is shown in figure 4.1.

Table-4.1 Total number of Vehicles, Estimated Categorical

	Small Vehicle		Heavy Vehicle	
	Incoming	Outgoing	Incoming	Outgoing
Without CNN	128	144	92	80
Using CNN	134	153	95	89

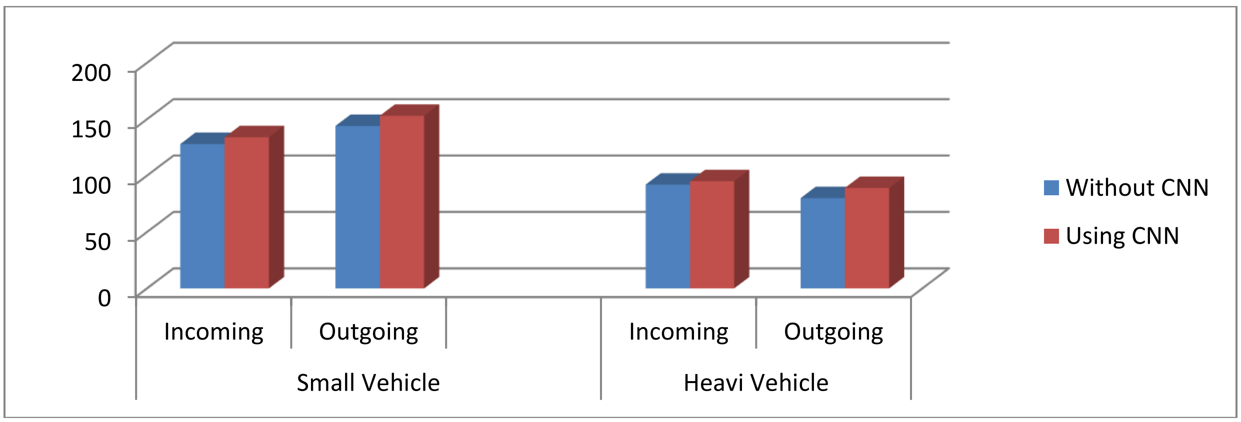

Fig. 4.1 Total number of Vehicles Estimated Categorical

CONCLUSION

The development of intelligent transportation systems has been significantly accelerated by advancements in machine vision and deep learning algorithms. Recent studies have demonstrated the effectiveness of deep learning techniques, such as You Only Look Once and Deep Convolutional Neural Networks, in detecting traffic congestion from camera images with high accuracy. These sophisticated models have outperformed traditional shallow algorithms like Support Vector Machines, showcasing the potential of deep learning in this domain.

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