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COMPARATIVE ANALYSIS ON MOVING VEHICLE DETECTION: A SURVEY

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Abstract

Vehicle detection through satellite video imagery has witnessed remarkable advancements, revolutionizing remote sensing and Earth observation. In this survey research, we explore the latest methodologies, approaches, and innovations in satellite video-based moving vehicle detection, with a special focus on the Semantic-Embedded Density Adaptive Network (SEDAN) architecture. Satellite videos provide an unparalleled perspective of Earth's surface, enabling us to grasp dynamic events and human activities. However, discerning moving vehicles within these videos presents significant challenges, including low image quality, varying lighting conditions, and diverse backgrounds. Traditional handcrafted features and shallow learning algorithms often fall short in delivering robust results under such circumstances. In response, deep learning-based solutions have emerged, with the SEDAN framework emerging as a promising approach. Drawing insights from a meticulous review of 22 papers, this survey research delivers a comprehensive overview of vehicle detection using satellite video data, highlighting the transformative potential of satellite technology in remote sensing and its crucial applications in various domains, including disaster management, traffic monitoring, and national security.

Keywords: *Vehicle Detection, Review, Deep Learning, Image Processing*

I. INTRODUCTION

Vehicle detection is an important process in intelligent transport management systems, as it allows the collection of data on vehicles' speeds and weights as well as the traffic intensity, which helps to enhance smooth transportation and to reduce road accidents Fig 1 represent moving vehicle system and tracking under complex transportation environments In recent years, satellite technology has seen extraordinary development and innovation, allowing a broad range of applications ranging from environmental monitoring to urban planning and national security [1]. Among these applications, the recognition and tracking of moving vehicles in satellite video has emerged as a critical field [2]. The capacity to monitor automobile activity from space has far-reaching consequences that go beyond sheer curiosity; it aids in disaster management, traffic analysis, border security, and critical infrastructure monitoring [3].

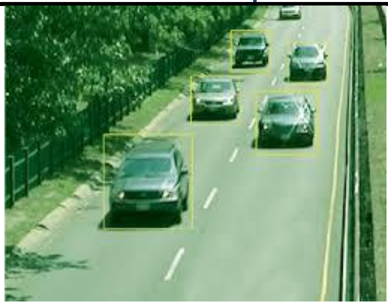

Fig. 1. Moving Vehicle System

The effort to identify moving vehicles among the wide expanse of satellite images, on the other hand, provides a tough set of obstacles [4]. These difficulties include the intrinsic fluctuation of lighting conditions, the limited spatial resolution of satellite pictures, the existence of complex and dynamic backdrops, and the need to deal with variable vehicle numbers across geographical areas [5]. Traditional approaches, which rely on handmade features and traditional machine learning algorithms, have traditionally failed to provide the resilience and accuracy needed for effective vehicle recognition in such challenging circumstances [6].

In response to these problems, advances in deep learning approaches have spurred a remarkable revolution in the area of moving vehicle recognition in satellite movies [7]. The Semantic-Embedded Density Adaptive Network (SEDAN) architecture stands out as a compelling paradigm change among these transformational techniques [8]. SEDAN uses convolutional neural networks (CNNs) to extract spatial and temporal data from satellite videos while also incorporating a density adaptive mechanism to adjust to variable vehicle densities seen in various geographical locations [9]. Furthermore, it uses semantic information to improve detection accuracy and limit the occurrence of false positives [10]. This introduction lays the groundwork for a comprehensive examination of the Semantic-Embedded Density Adaptive Network (SEDAN) architecture for moving vehicle recognition in satellite movies [11-13]. We hope that this review will give a complete overview of the most recent approaches, strategies, and breakthroughs in this sector, with a special emphasis on the SEDAN framework as a possible solution to the inherent problems of satellite-based vehicle identification [14-17]. In the next parts of this study, we will dig into the SEDAN framework's basic components, covering its feature extraction capabilities, the complexities of density adaptation, and the critical function of semantic integration [18-21]. We will also look at how vehicle recognition algorithms have evolved in the setting of satellite data, tracking the move from traditional handcrafted feature-based systems to the deep learning-driven approaches shown by SEDAN. [22-24].

II. LITERATURE SURVEY

Tan, D. et al. (2016) all sectors of society, including intelligent manufacturing, rely heavily on network information services. Real-time performance, self-adaptive service, and dynamical coordination were three areas where the existing C/S-based or distributed NMS falls short. An UPnP-NMS framework was presented as a solution to the issues. The suggested framework has the following advantages over alternatives like Metamorph, NetMan, iCAS, PROSA, and CIMOSA: network architecture dynamic response, node configuration PCT transmission method, gateway traversal service for distant stream data transmission, and network node inter-help service for production.

Zhang, J. et al. (2017) the author offer a new method for detecting moving vehicles in high-definition satellite footage by analyzing the motion flow patterns of these items. First, the ViBe background subtraction approach was used to collect potentially moving pixels for detection, and from these pixels, motion flow vectors were created. Second, motion patterns were defined as clusters of similar motion flows over several frames. Detection of motion in high-definition satellite movies has been made possible with the elimination of parallax shifts. Both qualitative and quantitative measures were used to assess the outcomes of the experiments.

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H. -H. Trinh et al. (2017) the author used the Background Model and Histograms of Oriented Gradient (HOG) features to conduct the object detection. The size of the sliding window encompassing the focus area has been drastically reduced according to the modeling history. The SVM classifier built on HOG features was useful for re-evaluating the detection efficiency of moving objects. Vietnam's traffic dataset has been successfully applied using the provided approach. Although cars were the primary target of the research, many other types of moving objects may be detected using the same technique. The suggested approach was now capable of computing crucial data. The suggested approach successfully identified object classes; it may now be used for monitoring and recognizing objects and people's actions to develop into a fully functional intelligent surveillance system.

A.Soin and M. Chahande (2017) the author offers a method for detecting vehicles using deep learning. To further improve identification accuracy and drastically lower the computational cost of operating a CNN, a reformative CNN structure was introduced. These authors system's accuracy has been vastly enhanced when the author used transfer learning. Numerous tests have been conducted, with encouraging outcomes. The recognition accuracy was also improved by presenting a novel fine-tuned CNN structure.

H. Geng et al. (2018) the author present a fully automated neural network-based vehicle recognition model to recognize cars of varying sizes in urban surveillance footage. These authors technique outperformed Faster-RCNN and SSD in urban surveillance footage, with an accuracy rate of 78.6 percent. In addition to vehicle recognition, these authors approach may be used to identify pedestrians in a road scenario. These authors technology for identifying and following illicit cars may be used to create a sophisticated surveillance system in the real world.

J. Zhang et al. (2018) finally, the spatial and temporal grid flow model and bilevel optimization structure of the proposed multiple target tracking technique enhance detection and tracking performance. Successfully reducing the number of endpoints of trajectories due to the missed detection, the spatial and temporal grid flow model produces longer tracklets in the detection association. The tracklet association was able to reassemble broken tracklets from non-overlapping frame batches thanks to the suggested tracklet transition probability.

However, SHDV's absence of appearance information leads to false positives, which negatively impacts tracking effectiveness.

S. JABRI et al. (2018) intelligent transportation systems (ITS) rely heavily on computer vision technology. An object detection system was very portable, since it can be used on both high-performance computers and mobile devices like smartphones. This makes it ideal for supporting cutting-edge ITS applications. In this research, the author evaluates the performance and energy efficiency of two different feature extraction algorithms: the Haar-like feature and the LBP.

Z. Luyao and L. Weiyao (2018) based on the dynamic segmentation threshold, the enhanced updating approach, and the counter, this study suggests a new and improved Surendra algorithm. The procedure was easy to use and provides quick results. The experimental findings show that the algorithm was successful in counteracting the effects of camera shaking. The problem of cars that suddenly halt was also addressed, which improves the system's flexibility to changing traffic situations.

Ao, W. et al. (2019) Satellite footage may be used to spy on urban areas in a way no other camera can. The author builds a viable framework for recognizing and tracking small moving vehicles in satellite films, and discusses the corresponding algorithm in this study. To distinguish candidates from sounds, the author use a probabilistic distribution for the first time to capture the pattern of noises in the spatiotemporal domain. To further separate genuine vehicle targets from a small number of sounds, the author present the multi-morphological-cue based discriminating method. There was also the need to present a whole assessment procedure and introduce a set of evaluation measures. Three manually annotated regions of a satellite movie were used to evaluate the suggested algorithms, and the results were compared to those of the baseline methods. These results show that these authors' algorithms function well.

G. Saxena et al. (2019) the author provide an agent for automatic video motion detection and counting. Unlike still pictures, video presents unique challenges for the detection and enumeration of moving objects. The first algorithm may be readily modified to handle traffic on several lanes. A CS and lock pair to be installed in each lane to make this possible. In this situation, the CS may be set to either fixed (vehicles must stay in their designated lanes) or floating (Indore). By employing appropriate locks, these CSs may be secured for the exclusive use of certain cars. Counting was simple since all CSs may use the same global count variable.

V. Rin and C. Nuthong (2019) these authors' research films of metropolitan highways in Thailand were used to analyze vision-based front moving vehicle recognition and tracking method. This research projects the future driving status of the leading car to alert drivers of impending collisions and improve overall road safety. Front-facing moving object identification and object tracking were the two primary use cases in this study. The suggested research employs a mix of the Sobel edge detector method and a shifting three frame difference in its detection procedure. The idea of a moving frame was there to guarantee the system works properly in a real-time environment.

W. Ao et al. (2019) Satellite footage may be used to spy on urban areas in a way no other camera can. The author builds a viable framework for recognizing and tracking small moving vehicles in satellite films, and discusses the corresponding algorithm in this study. To distinguish candidates from sounds, the author use a probabilistic distribution for the first time to capture the pattern of noises in the spatiotemporal domain. To further separate genuine vehicle targets from a small number of sounds, the author present the multi-morphological-cue based discriminating method. There was also the need to present a whole assessment procedure and introduce a set of evaluation measures. The author compares the performance of the proposed algorithms to that of the baseline methods by testing them on three manually annotated regions of a satellite movie.

Z. Charouh et al. (2019) the author provide a machine learning technique for intelligent transportation systems that uses robust background subtraction to recognize moving vehicles. Using data from images and a neural network, the author provide a method to automatically fine-tune the parameters used in morphological procedures. Other intelligent transportation-related activities that might benefit from the suggested machine learning technique were now under study.

Chen, R. et al. (2020) Satellite imagery has potential uses in intelligent traffic management and city planning because to its ability to track moving objects over large metropolitan areas. Because of all the distractions on the roofs of the surrounding buildings, it was difficult to accurately separate tiny moving vehicles from these footage. Using background subtraction models on an adaptively filtered video to get candidates with high recall and then using a lightweight CNN model to suppress erroneous targets, the approach suggested in this paper improves the accuracy of moving vehicle recognition while maintaining brevity. The KNN model was shown to be the most effective in detecting small moving objects from satellite films after being put through a battery of tests and evaluations that compared it to other popular background removal methods. The author developed a lightweight convolutional neural network (CNN) model that can be trained rapidly with modest quantities of data to eliminate erroneous targets. Based on experimental data, it's clear that the suggested CNN model may significantly enhance detection accuracy while just slightly decreasing recall.

Chen, X. et al. (2020) However, the tiny sizes of targets provide a barrier to vehicle recognition when using satellite films for traffic monitoring. The spurious motion induced by parallax and illumination variation was addressed in this letter by proposing a detection approach based on AMS and DAT. The moving trajectories were formed by accumulating the difference from the weighted moving variance and were used as a requirement for screening out vehicles in motion. The experimental results show that these authors strategy significantly decreases the number of false positives while keeping the recall rate high. In addition, the suggested approach may be used for real-time processing in space without the need for complex calculations.

G. Ding et al. (2020) the author offer a technique for detecting moving vehicles using vision-based edge-line assistance. This approach has three basic components: lane-line detection, background removal, and target identification. The LaneNet and H-Net components work together to form the lane detecting algorithm. Once you have the formula for the edge lines, you can use it to crop out the unnecessary parts of the picture, leaving just the information between the lanes. After the picture was rearranged, YOLOV3 was used to locate the target, and the original backdrop was added back in. The whole system for detecting moving targets runs on Ubuntu 16.04, and the FPS reaches 15 with a laptop version of the NVIDIA 1060 graphics card.

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Feng, J. et al. (2021) these authors research proposes a unique deep learning architecture that combines CKDNet and SMTNet to recognize and track moving vehicles in satellite movies. CKDNet enhances the memory of hazy moving cars by combining temporal and appearance information extracted from successive frames. In addition, the use of a harsh or soft penalty feature to effectively discourage improper corner matching enhances accuracy. SMTNet uses CKDNet's detection findings as input and uses two-branch LSTMs to make associations between those results and the tracked targets. Spatial LSTM was meant to aid the motion LSTM in keeping track of packed and similar cars by taking into account the relative spatial connection with surrounding vehicles. The SMTNet predicts the validity of the hypothetical trajectory and regresses a new virtual location for each tracked vehicle concurrently based on the motion and spatial data. Re-identifying cars that were previously overlooked or obscured allows for more reliable tracking.

J. Zhang et al. (2022) the mobility of satellite platforms poses a significant barrier to the MOD performance of matrix decomposition algorithms when used to satellite movies. In this study, the author address the hitherto unresolved problem of false alarms brought on by the orbital motion of satellites. To this end, the author use dense optical flow to introduce a moving-confidence matrix and design a foreground regularization technique that uses this matrix to punish the portions in the foreground that have low moving confidences. A new low-rank decomposition model, Moving Confidence-AssistedMatrix Decomposition (MCMD), was created by imposing such regularization on the foreground. The suggested model was optimized for both batch processing (B-MCMD) and real-time processing (O-MCMD). As predicted, B-MCMD improves detection performance.

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C. Xiao et al. (2023 the author extend the model-based approach to MOD in satellite videos by include a deep background prior. A background reconstruction network, trained unsupervised with the use of a custom-built loss, was responsible for obtaining the deep background prior. The proposed approach combines the strengths of both the model-based iterative optimization and the learnt deep background prior. Extensive trials have shown the suggested framework's efficacy and efficiency.

V. Pandilwar and N. Kaur (2023) detecting moving vehicles with real-time speed estimation and number plate detection using OpenCV and YOLO was a challenging problem that calls for the coordination of a number of computer vision methods and machine learning algorithms. YOLO was a well-known object identification system that can recognize and categorize cars in moving video in near-real time. OpenCV offers a suite of strong algorithms for assessing the speed of moving cars based on their location and motion across time, tracking the detected vehicles across frames, and extracting the number plate area from the bounding box of each vehicle. Using optical character recognition (OCR) methods, the author can decipher the characters on the license plate and get relevant data about the car. Traffic management, parking management, and security monitoring were just some of the many uses for this integrated set of approaches. The YOLO model and the tracking and OCR algorithms may be optimized, however, to increase the system's accuracy. The following table 1 shows that the existing author's methods of vehicle detection and accuracy mentioned.

Table 1: Comparative Analysis of Various Authors

Author	Year	Methodology	Advantage	Limitation	Accuracy	Dataset
H. -H. Trinh	2017	Histograms of Oriented Gradient	The use of a geometrical model that includes road boundaries and background modeling helps optimize the detection process.	The method may struggle in extreme environmental conditions, such as heavy rain, snow, or fog, where visibility is significantly reduced.	96.87%	Vietnam traffic dataset
Z. Charouh et al.	2019	Machine learning	One of the primary advantages is the enhanced robustness of object detection in AVS systems.	Implementing and fine-tuning the machine learning-based system may require expertise in computer vision and machine learning, which can be challenging and time-consuming.	98.%	video recordings of road traffic on highways in Morocco
A.J. M, S. Nandini and A. T	2022	YOLO	The YOLO algorithm is known for its accuracy and speed in object detection.	The effectiveness of the model relies on the coverage of surveillance cameras.	93.53%	Trash Annotations in Context for Litter Detection dataset
V. Pandilwar	2023	YOLO	The use of the YOLO algorithm	The accuracy of the system can be affected	98.3%	benchmarks, including the COCO

and N. Kaur			for vehicle detection allows for efficient and accurate identification of vehicles in video streams.	by factors such as camera quality, lighting conditions, and the size and clarity of number plates.		dataset

III. DISCUSSION

Existing satellite video data often presents significant challenges for accurate vehicle detection due to its inherent limitations, including low image quality and the difficulty in discerning vehicle density and types. In response to these challenges, our research takes a multi-faceted approach to improve vehicle detection accuracy and advance the state of the art in this field. To address the limitations of satellite video data, we have shifted our focus towards traffic video datasets, which are specifically gathered to provide higher quality and more relevant information for vehicle detection tasks. This transition allows us to work with data that is not only of superior quality but also more conducive to extracting meaningful insights about vehicle density and types. Our research methodology encompasses a series of crucial steps in image processing. We begin by tackling noise removal to enhance the clarity of the video frames, thus reducing interference that might affect subsequent analysis. Following this, segmentation techniques are employed to isolate vehicles from their surroundings, enabling precise delineation. Feature extraction plays a pivotal role in understanding vehicle characteristics, such as size, shape, and motion patterns. These features serve as valuable inputs for our classification algorithms. Leveraging machine learning and deep learning techniques, we employ classification models to categorize detected vehicles into different types. Furthermore, our research incorporates a variety of neural network architectures and algorithms to predict vehicle types accurately. By systematically experimenting with different approaches, we aim to identify the most effective combination of methods that yield the highest accuracy for vehicle detection. This iterative process allows us to continually refine and improve our vehicle detection models.

IV. CONCLUSION

In conclusion, this survey paper has provided a comprehensive overview of the state-of-the-art in vehicle detection using satellite and traffic video data. We have explored the challenges posed by low-quality satellite video data, which often hinder accurate vehicle detection, especially in terms of discerning vehicle density and types. To address these challenges, our survey has outlined a multifaceted approach that leverages traffic video datasets and employs a sophisticated image processing pipeline, classification algorithms, and neural network architectures. The transition from satellite to traffic video data represents a significant improvement in data quality and relevance, enabling more precise and reliable vehicle detection. Our discussion of noise removal, segmentation, feature extraction, and classification techniques highlights the importance of each step in enhancing the accuracy of vehicle detection. Furthermore, our survey has underscored the value of machine learning and deep learning methodologies in the vehicle detection domain. We have explored the application of diverse neural network architectures and algorithms to predict vehicle types with high accuracy. This systematic experimentation is critical for identifying the most effective combination of methods. In closing, this survey paper serves as a valuable resource for researchers, practitioners, and policymakers seeking to understand the current landscape and potential advancements in vehicle detection technology. It highlights the critical importance of accurate vehicle detection in various domains and underscores the continuous efforts to refine and improve the methodologies employed in this crucial field.

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