International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 04 ISSUE 04 Pages: 74-78
SJIF IMPACT FACTOR (2022: 5.636) (2023: 6.741) (2024: 7.874)
OCLC – 1368736135

Journal Website: http://sciencebring.com/index.php/ijasr

Research Article

EVALUATION OF TRANSPORT FLOW USING DEEP LEARNING METHODS OF SATELLITE IMAGES

Submission Date: April 13, 2024, **Accepted Date:** April 18, 2024,
Published Date: April 23, 2024
Crossref doi: https://doi.org/10.37547/ijasr-04-04-13

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ABSTRACT

The exponential growth of urbanization has led to increasing problems in traffic management, which require innovative solutions for efficient estimation of traffic flow. Deep learning methods are emerging as a powerful tool for processing and analyzing satellite images, and are being used for traffic flow estimation. This paper describes deep learning-based methods for traffic flow estimation using satellite imagery.

KEYWORDS

Transport Flow, traffic flow, satellite images, urban traffic.

INTRODUCTION

Today, urban traffic is a common problem affecting the quality of life in modern cities. Accurate estimation of traffic flow is essential for effective traffic management, route planning and infrastructure development. Traditional methods of traffic flow estimation, such as detectors and surveillance cameras, suffer from limitations such as high cost, limited coverage, and maintenance requirements. In contrast, satellite imagery offers a comprehensive and cost-effective alternative to monitoring traffic flow over large spatial areas. With recent advances in deep learning, the ability to automatically learn relevant features and patterns from raw data, analyzing satellite

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imagery for traffic flow estimation, is currently being extensively researched.

Deep learning architectures for traffic flow estimation using satellite imagery.

Several deep learning architectures, including convolutional neural networks (CNNs), recurrent neural networks (RNNs), and their variants, have been used to estimate traffic flow using satellite imagery. CNNs are widely used for feature extraction from satellite imagery due to their ability to efficiently capture spatial hierarchies. RNNs, specifically Long Short-Term Memory (LSTM) networks, have been used to model temporal dependencies in traffic flow data. Hybrid architectures combining CNNs and RNNs also provide superior performance in spatial and temporal data acquisition for more accurate traffic flow estimation.

Figure 1. Satellite image for traffic flow estimation.

In the case above, the purple colored images show the parked cars, the blue ones are moving, and the yellow ones are moving cars.

A comparative analysis of CNN and RNN

Table 1.

Comparative characteristics	Convolutional Neural Networks (CNN)	Recurrent Neural Networks (RNN)
Release features	CNN excels in extracting spatial features from satellite images.	RNNs aim to capture temporal correlation in sequential data.

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Architecture	It usually consists of convolutional layers followed by pooling layers.	Composed of repeating units such as LSTM or GRU cells.
Strengths	- Effective in extracting spatial relationships and visual patterns. Parallel processing for real-time applications.	- The ability to model temporal correlations over time. It is suitable for serial data with long-term correlations.
Disadvantages	- Limited in modeling temporal dynamics and long-term dependencies. It may require additional mechanisms for temporal modeling.	- Complexity increases with longer sequences. Limited in capturing spatial features.
Data requirements	Annotated satellite imagery data sets are relied upon for training.	Requires serial traffic flow data with timestamps for training.
Complexity of training	Usually less complex due to parallel processing of spatial features.	More complex due to sequential processing and acquisition of temporal dependencies.
Ability to interpret	Can visualize learned features in convolutional layers.	Interpretation can be difficult due to complex temporal relationships.
Architectural examples	VGG, ResNet, DenseNet	LSTM, GRU

Datasets and preprocessing methods.

The availability of diverse and annotated datasets is essential for training and evaluating deep learning models for traffic flow estimation. Several public datasets, such as the SpaceNet dataset and the DeepGlobe dataset, provide high-resolution satellite imagery and ground-based annotations for traffic flow. Preprocessing techniques such as image enhancement, normalization, and data augmentation are commonly used to improve the quality and diversity of training data, thereby increasing the robustness and generalizability of deep learning models.

Various evaluation metrics are used to evaluate the performance of deep learning models for traffic flow estimation, including mean absolute error (MAE), root mean square error (RMSE), and intersection by union (IoU). These metrics determine the accuracy, precision, and consistency of predicted traffic flow compared to ground truth data, allowing researchers to effectively evaluate and compare different models.

Despite the promising results achieved by methods based on deep learning, there are a number of problems in the field of traffic flow estimation using satellite images. Challenges include the limited amount of labeled data, the complexity of urban environments, and the interpretability of deep learning models. Future research directions should address these challenges by developing new algorithms, integrating multimodal data sources, and exploring advanced deep learning techniques such as generative adversarial networks (GANs) and reinforcement learning. possible

Conclusion

Deep learning-based methods are emerging as effective tools for traffic flow estimation using satellite imagery, offering advantages such as scalability, automation, and cost-effectiveness. Using the power of deep learning architectures, datasets, processing techniques, and estimation metrics, researchers use the latest advances in traffic flow estimation to contribute to smarter and more manageable transportation systems.

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