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RESEARCH ARTICLE OPEN ACCESS

Road Extraction Using Satellite Images

Mrs. M. Khamar, Bandi Pradeep Guru Narayan, Chandavolu Teja, Chavala Dinesh Paul, Gochipathala Harsha Vardhan

Department of IT

KKR & KSR Institute of Technology and Sciences, Guntur

Email: khamar.gousiya539@gmail.com, pgn.bandi@gmail.com, chandavoluteja2202@gmail.com, dineshchavala7@gmail.com, gochipathalaharsha121@gmail.com

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Abstract:

Road Extraction from satellite imagery plays a crucial role in various applications ranging from urban planning to traffic monitoring and infrastructure development. In this project, we propose a method for road extraction using satellite images, aiming to produce clear and accurate representations of road networks. The process begins with acquiring high-resolution satellite images covering the target area. These images are preprocessed to enhance their quality and reduce noise, ensuring optimal input for subsequent analysis. Next, we employ advanced image processing techniques and machine learning algorithms to extract road features from the satellite imagery. One of the key steps in our approach is feature extraction, where we identify distinct characteristics associated with roads such as color, texture, and spatial patterns. By leveraging convolutional neural networks (CNNs) and other deep learning architectures, we train models to recognize these features and distinguish roads from other elements in the images. Once the road features are detected, we employ segmentation algorithms to separate the roads from the surrounding environment effectively. This segmentation process involves delineating the boundaries of road networks, ensuring that the extracted roads align accurately with their real-world counterparts. Furthermore, to enhance the visual representation of the extracted roads, we implement highlighting techniques that emphasize the road features in the satellite images. This enhancement not only improves the visibility of roads but also facilitates their interpretation and analysis by end-users. The effectiveness of our approach is evaluated through extensive experimentation on diverse satellite imagery datasets covering various geographic regions and environmental conditions. Quantitative metrics such as precision, recall, and F1-score are utilized to assess the accuracy of road extraction results. Overall, our project demonstrates a robust and efficient method for road extraction from satellite images, offering valuable insights for urban planning, transportation management, and disaster response. By providing accurate and detailed road maps derived from satellite imagery, our approach contributes to improving decision-making processes and enhancing the efficiency of various applications reliant on spatial data analysis.

***Keywords* —** Satellite imagery, Road detection, Image processing, Machine learning, Feature extraction.

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INTRODUCTION

In today's rapidly evolving world, the availability of high-resolution satellite imagery has revolutionized various fields, ranging from urban planning to environmental monitoring. One of the key challenges in utilizing satellite imagery effectively lies in extracting valuable information from vast amounts of visual data. Among the myriad of features present in satellite images, the identification and extraction of road networks play a crucial role in numerous applications, including

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transportation management, urban development, and disaster response.

Road Extraction from satellite images is a complex task due to the diverse and dynamic nature of road networks, coupled with the presence of various land cover types, environmental conditions, and imaging artifacts. Traditional methods of road extraction often rely on manual interpretation or simplistic image processing techniques, which are time-consuming, labor-intensive, and prone to errors. With the advent of advanced image processing algorithms and machine learning techniques, there has been a growing interest in developing automated approaches for road extraction from satellite imagery.

This project focuses on the development of a robust and efficient method for road extraction using satellite images, aiming to produce accurate and detailed representations of road networks. Leveraging state-of-the-art image processing techniques and machine learning algorithms, our approach seeks to overcome the challenges associated with road extraction by harnessing the rich spatial information embedded in satellite imagery.

The primary objective of this project is to design and implement a comprehensive pipeline for road extraction that encompasses preprocessing, feature extraction, segmentation, and visualization stages. By integrating advanced image processing algorithms with machine learning models, we aim to identify road-like features and delineate road networks accurately from satellite imagery.

Through extensive experimentation and evaluation on diverse satellite image datasets, we seek to assess the performance and efficacy of our proposed method in comparison to existing approaches. Quantitative metrics such as precision, recall, and F1-score will be employed to evaluate the accuracy and reliability of road extraction results.

Ultimately, the outcomes of this project have the potential to significantly impact various domains, including urban planning, transportation management, and disaster response, by providing stakeholders with accurate and up-to-date road maps derived from satellite imagery. By automating the process of road extraction and enhancing the accessibility of spatial information, our approach aims to facilitate informed decision-making and improve the efficiency of resource allocation and infrastructure planning initiatives.

LITERATURE REVIEW

Automating road image analysis is a complex task due to noise in geometry and texture, presenting challenges for traditional algorithms. However, a new semi-automatic approach utilizing multiple descriptors offers an improved solution. This method aims to not only enhance automation but also ensure precise road extraction. It effectively addresses obstacles such as incomplete geometric data and inconsistent road textures. Experimentation on various high-resolution remote sensing images has demonstrated the effectiveness of this approach, achieving an impressive 98% completeness and correctness for roads with specific features. This remarkable result reduced the need for human intervention in comparison to other algorithms. Overall, this innovative method proves to be a valuable solution for overcoming the challenges of road image analysis.[1]

The research paper discusses using Road extraction from satellite images contributes to a better understanding of geological conditions. The method enhances research by utilizing high-quality images for studying road features and optimizing outputs. It has the potential to provide valuable information for large-scale Geographic Information Systems, improving overall accuracy. The process involves image processing to achieve better resolutions, making it applicable for various research applications and providing optimized results.[2]

The abstract highlights the increasing use of the internet Road image analysis encounters challenges due to geometry and texture noise, limiting

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traditional template matching algorithms' automation. A proposed semi-automatic method, utilizing multiple descriptors, aims to enhance automation while ensuring accurate road extraction. The approach addresses issues like incomplete geometric information and poor internal road texture homogeneity. Experiments demonstrate the method's effectiveness, achieving over 98% completeness and correctness for specific road characteristics, significantly reducing human intervention compared to other algorithms.[3]

Automatic road extraction from multisource remote sensing data faces challenges, including shadow occlusion and alignment errors. Traditional deep learning methods struggle with complementarity and redundancy in acquiring road features. The proposed Dual Attention Dilated-LinkNet (DAD-LinkNet) integrates local road features with global dependencies using satellite images and vehicle trajectory data. Experiments on three datasets showcase superior accuracy and connectivity, surpassing state-of-the-art methods. The model combines a joint least-squares feature matching-based trajectory correction and a dual-attention mechanism in the dilated convolutional layer.[4]

This paper presents a Road extraction from satellite images contributes to a better understanding of geological conditions. The method enhances research by utilizing high-quality images for studying road features and optimizing outputs. It has the potential to provide valuable information for large-scale Geographic Information Systems, improving overall accuracy. The process involves image processing to achieve better resolutions, making it applicable for various research applications and providing optimized results.[5]

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PROPOSED METHODOLOGY

The proposed methodology for extracting roads from satellite images is a multi-step process designed to effectively identify and delineate road networks. It begins with acquiring high-resolution satellite imagery of the target area and preprocessing the images to enhance their quality, including removing noise and correcting distortions. Feature extraction techniques are then employed to identify road-related characteristics such as color, texture, and spatial patterns. Machine learning models, particularly convolutional neural networks (CNNs), are trained using labeled data to recognize these features and distinguish roads from other elements in the images. Once the road features are detected, segmentation algorithms are applied to delineate the boundaries of road networks accurately. Post-processing techniques are utilized to refine the extracted road segments, eliminating artifacts and improving the overall accuracy of the results. Finally, the extracted road networks are visualized and evaluated, and the methodology is optimized and documented to ensure reproducibility and comprehensiveness in reporting the findings.

CONCEPTUAL DESIGN:

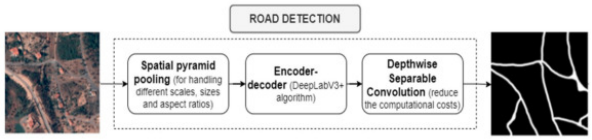

Fig1: System Design

MODULE DESIGN SPECIFICATION

The modules which are used to develop the Road Extraction From Satellite Images
1.User interface module
2. Road Tracking and Postprocessing Module
3.Response Extraction module

USER INTERFACE MODULE

•The User Interface module is responsible for handling the interaction
with the user through a web interface.
•Components used:-

- Streamlit(Streamlit is used to create the web application and user interface)

The Data Acquisition step is responsible for obtaining high-resolution satellite images.
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Fig2: UserInterface

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ROAD TRACKING AND POSTPROCESSING MODULE

•The Road Detection Module identifies road features within the satellite images using classification algorithms.
•Algorithms: Binary Classification, Pixel-wise Classification.
•The Post-processing Module refines the extracted road segments to eliminate artifacts and improve accuracy.

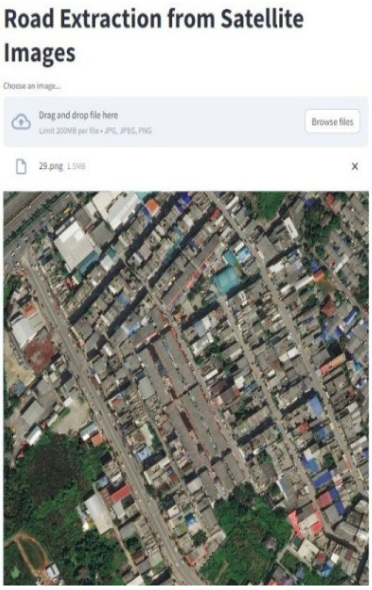

Fig3: Road Tracking and Postprocessing Module

RESPONSE EXTRACTION MODULE

This module could be responsible for generating output files or reports summarizing the results of the road extraction process. This module include generating detailed reports, statistics, or visual of the extracted road networks for further analysis or presentation purposes.

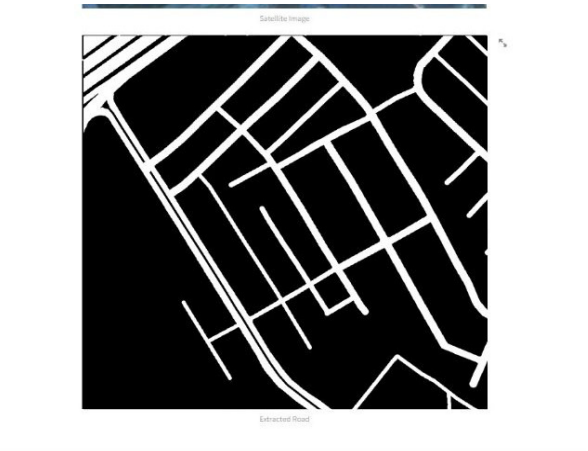

Fig4: Response Extraction Module

ALGORITHM DESIGN STEPS

Steps:

Step 1: Start

Step 2: Open the Road Extraction Application

Step 3: Select Area of Interest
a. Use map interface or input geographical coordinates to define the area for road extraction
b. Provide additional details if necessary (e.g., image resolution, date range)

Step 4: Initiate Road Extraction Process
a. Select road extraction algorithm or method
b. Adjust parameters if applicable
c. Start the extraction process

Step 5: View Results
a. Visualize extracted road features on the map interface
b. Explore additional data layers or analysis options

Step 6: Analyze and Interpret Results
a. Interpret the extracted road features based on visual representation
b. Analyze road network connectivity, density, or other relevant metrics

Step 7: Download or Export Results (Optional)

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a. If required, download extracted road data in a suitable format (e.g., shapefile, GeoJSON)

Step 8: Close the Application

Step 9: Stop

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Together, we charted unexplored territories, harnessing collective expertise to unveil the hidden highways amidst digital wilderness.

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In the saga of "Road Extraction Using Satellite Images," every voice, every gesture of support, has woven a tapestry of triumph. To each contributor, we extend our sincerest gratitude, for together, we have authored a chapter of discovery and achievement that shall resonate through the annals of time.

REFERENCES

[1]V. Mnih and G. E. Hinton, “Learning to detect roads in high-resolution aerial images,” in Proc. European Conference on Computer Vision (ECCV) 2010, pp. 215–236.

[2] Z. Zhang, Q. Liu, and Y. Wang, “Road extraction by deep residual U-Net,” IEEE Geosci. Remote Sens. Lett., vol. 15, no. 5, pp. 749–753, May 2018.

[3] Chaudhuri, D., Kushwaha, N. K., & Samal, A. (2012). "Semi-automated road extraction from high-resolution satellite images using directional morphological enhancement and segmentation techniques." Road Extraction Using Satellite Images, 5(5), 1538–1544.

[4] Z. Chen, C. Wang, J. Li, N. Xie, Y. Han, and J. Du, “Reconstruction bias U-Net for road extraction from optical remote sensing images,” IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., vol. 14, pp. 2284–2294, Jan. 2021.

[5] X. Hu, Y. Li, J. Shan, J. Zhang, and Y. Zhang, “Road centerline extraction in complex urban scenes from Lidar data based on multiple features,” IEEE Trans. Geosci. Remote Sens., vol. 52, no. 11, pp. 7448–7456, Nov. 2014.

[6] Y. Liu, J. Yao, X. Lu, M. Xia, X. Wang, and Y. Liu, “RoadNet: Learning to comprehensively analyze road networks in complex urban scenes from high-resolution remotely sensed images,” IEEE Trans. Geosci. Remote Sens., vol. 57, no. 4, pp. 2043–2056, Apr. 2019.

[7] Leninisha, S., & Vani, K. (2015). "Water flow-based geometric active deformable model for road network extraction." Road Extraction Using Satellite Images, 102, 140–147.

[8] Rajeswari, M., Gurumurthy, K. S., Omkar, S., Senthilnath, J., & Reddy, L. P. (2014). "Automatic road extraction from high-resolution satellite images using level set and mean shift methods." Road Extraction Using Satellite Images, Proceedings of the International Conference on Computer Vision, 1-7.

[9] Dai, J., Li, Z., Jinwei, L. I., & Fang, X. (2017). "A method for road line extraction using chain code tracking with phase verification." Road Extraction Using Satellite Images, 46, 218–227.

[10] L. Xu, C. Lu, Y. Xu, and J. Jia, “Image smoothing via l0 gradient minimization,” ACM Trans. Graph., vol. 30, no. 6, pp. 1–12, 2011.

[11] C. Wiedemann and H. Ebner, “Automatic completion and evaluation of road networks,” Int. Arch. Photogrammetry Remote Sens., vol. 33, pp. 979–986, 2000.

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