Generalizable Road Segmentation in High-Resolution Satellite Images Using Deep Learning

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Abstract

This study evaluates the performance of deep learning for road extraction in high-resolution satellite imagery using the DeepGlobe dataset. A U-Net model was trained to segment road networks from RGB imagery. After 40 epochs, the model achieved a Dice score of 0.6938 and an IoU of 0.5312 on the validation set. Testing on an unseen dataset from Washington further demonstrated the model's generalization capability, confirming U-Net as a reliable tool for automated road detection.

Background

Road extraction supports key tasks like urban planning, navigation, and emergency response. Detecting untarred or dusty roads is especially difficult, as they often blend with surrounding terrain due to similar spectral reflectance. Traditional methods struggle with such low contrast features. Deep learning models like U-Net overcome these limitations by learning spatial and contextual patterns directly from data. This study aims to evaluate the effectiveness and generalizability of U-Net for accurately segmenting roads, both paved and unpaved, in high-resolution satellite imagery.

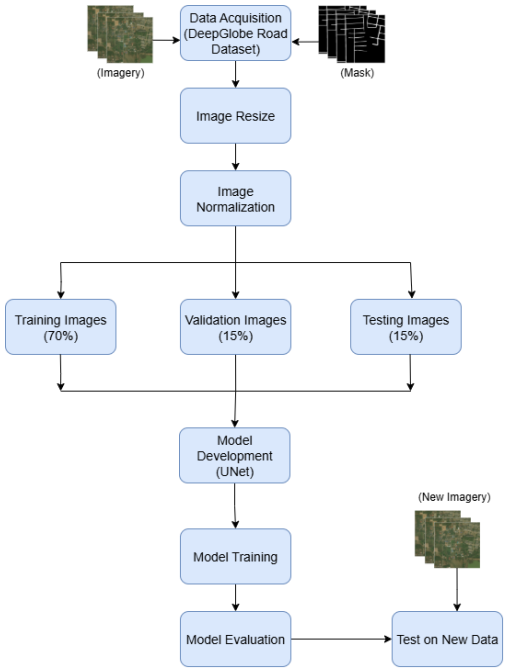
Discussion

The U-Net model trained on the DeepGlobe dataset achieved a Dice score of 0.6938 and an IoU of 0.5312 after 40 epochs. When tested on an unseen Washington dataset, it accurately extracted roads without retraining, showing robustness to domain shifts. Detecting roads, especially unpaved rural paths, is vital for emergency response, humanitarian aid, and peacekeeping missions in remote areas with limited infrastructure. These results confirm deep learning's effectiveness for road segmentation in diverse and socially important settings.

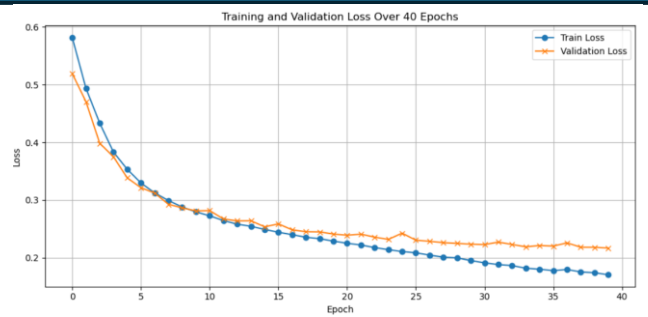
Conclusion

Deep learning demonstrated high effectiveness in extracting roads from satellite imagery, achieving strong accuracy and generalizing well to unseen datasets. Its capability to accurately detect roads across different geographic regions highlights its promise for practical applications in automated mapping and geospatial analysis.

Methodology

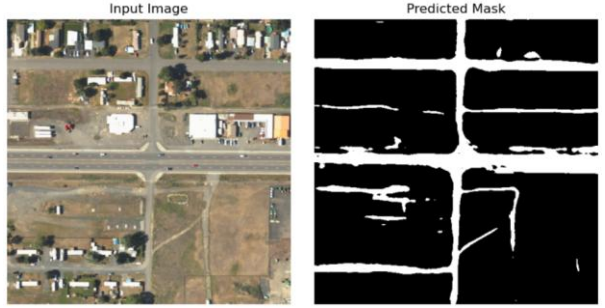


Results



Results (Test Data)

Results(Washington Dataset)



References

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Link to Datset : https://www.kaggle.com/datasets/balraj98/deepglobe-road-extraction-dataset/data