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# Large-scale Urban Pavement Segment Model Reconstruction From Open-source Aerial Images

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## Background

The creation of precise and extensive road maps is crucial in numerous fields. The standard approach for extracting and reconstructing roads from aerial or high-resolution remote sensing images involves the development of two-dimensional semantic segmentation models and the integration of digital elevation models (DEM). However, this process is not very efficient and is further complicated by challenges posed by trees and buildings obstructing the segmentation work. As a result, it is necessary to modify existing three-dimensional road model extraction pipelines.

## Objectives

- Reconstruct 3D road pavement models based on the traditional photogrammetric theory
- Integrate probability distribution field models as unsupervised method for simultaneous road object extraction on a large scale
- Develop multiple output formats for the reconstructed road model, such as vector data, point cloud data, etc..

## Data sources

- GSI aerial image dataset provided by the Geospatial Information Authority of Japan. (Ground sampling distance of 0.6 - 1m)
- Experimental Area: Numazu station in Numazu, Shizuoka, and the surrounding area (Approximately 3km * 4km)
- Training data for shadow removal in GSI images: Aerial image for shadow detection dataset (AISD)

## Methodology

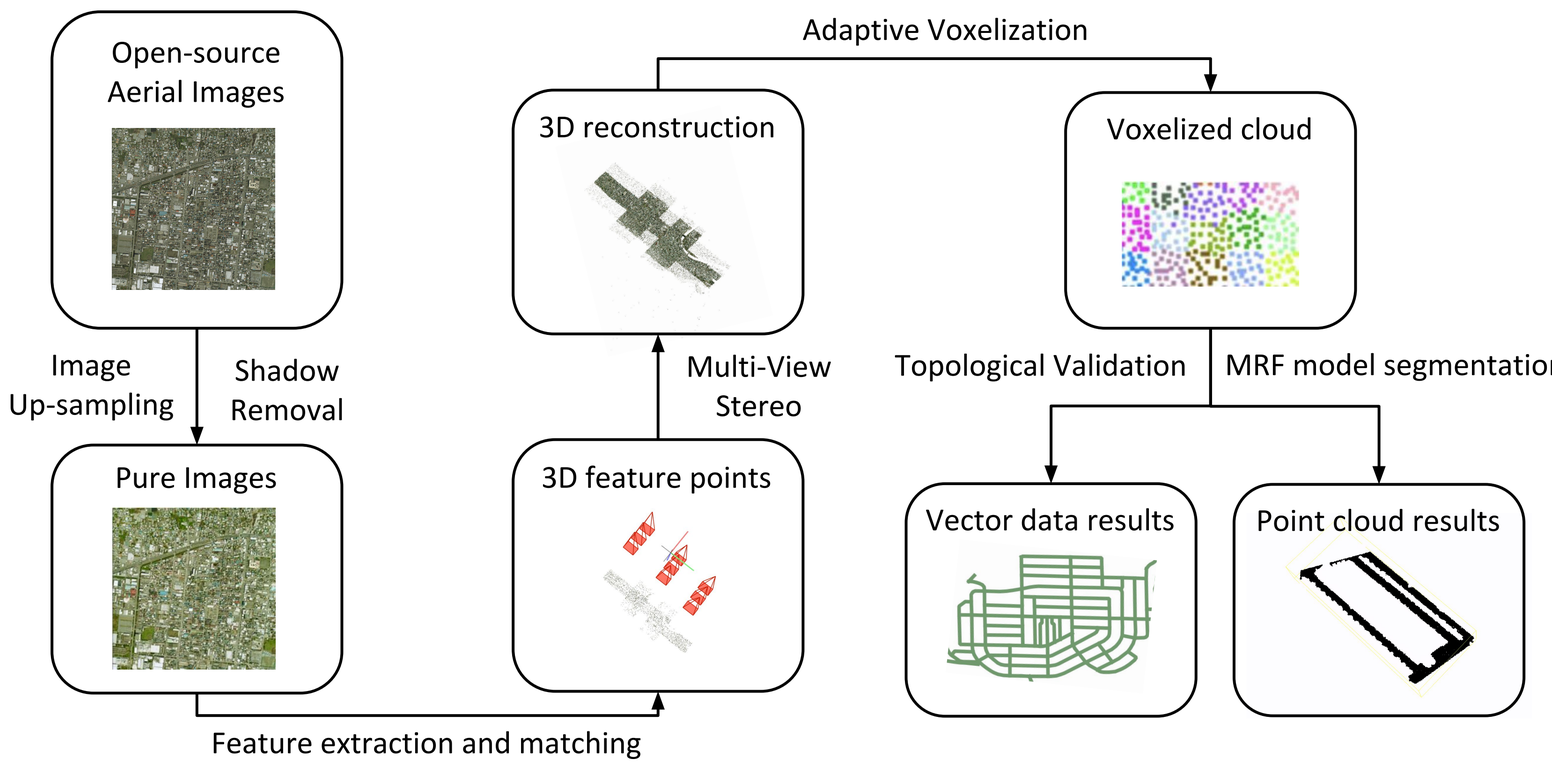
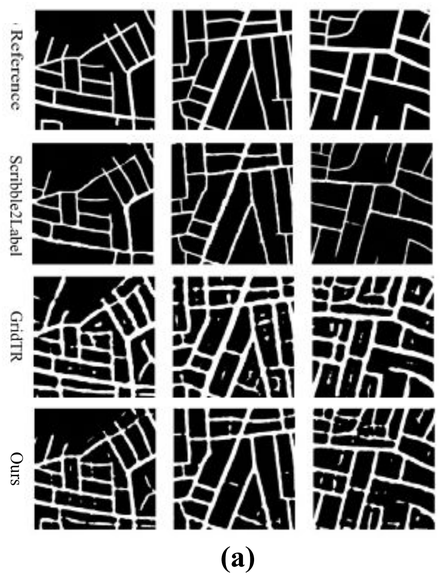



Figure 1: Overall pipeline of the proposed methodology.

In the workflow, original GSI images are preprocessed with the shadow removal and up-sampling modules. Scale-Invariant Feature Transform(SIFT) feature extractor is integrated for feature extraction and matching. After densifying the sparse matching model by Voxel Cloud Connectivity Segmentation(VCCS), an adaptive voxelization method would be applied to extract the ground points. Finally, the topological examination and Markov Random Fields(MRF) model would generate at least two different output formats, respectively.

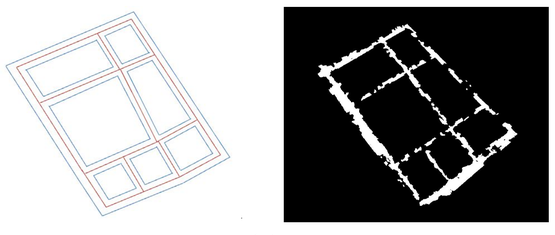
## Results




(a)

| | IoU | F1-score |
|---|---|---|
| SOC-Road Net | 60.21 | 75.16 |
| GridTR | 36.35 | 53.32 |
| Ours | 55.16 | 68.19 |

(b)



(c)

Figure 2: (a) Visual comparison with State-of-the-art 2D segmentation publication. (b) The quantitative version of (a). (c) 3D output of a sample area in vector data(left) and point cloud(right).

## Conclusion

An innovative pipeline for creating a road segmentation model and road network mapping was proposed for an overview of the research. The pipeline applied existing 3D reconstruction methods, including SIFT feature extraction and matching and Multi-View Stereo(MVS) densification, with some optimization of feature bias, to build an integrated framework for both 2D and 3D road model creation experience using mostly open-source aerial image as the input source. Besides, extracting road networks in vector data with topological validation from a 3D reconstructed model further expands the proposed methodology to realize a diverse output performance.