Inturi Siva Rishitha
me230003026

Change Detection in Satellite Imagery

1. Introduction

Monitoring environmental changes, such as deforestation, urban expansion, and natural disasters, is essential for sustainable planning and effective decision-making. Satellite imagery provides a valuable resource for tracking these changes over time. This project focuses on developing a change detection algorithm to compare two satellite images taken at different times and identify areas of significant change. The emphasis is on simplicity, accuracy, and interpretability to create a robust solution for real-world applications.

2. Data Preprocessing

To ensure consistency and quality, the satellite images were pre-processed through the following steps:

- **Image Resizing**: Both images were resized to a standard resolution to ensure computational efficiency and compatibility during processing.
- **Image Alignment**: Spatial alignment was performed to eliminate discrepancies caused by satellite movement.
- **Noise Reduction**: Filters were applied to reduce noise while preserving meaningful features.
- **Normalization**: Pixel intensities were normalized to ensure comparability across the two images.

These preprocessing steps were critical in preparing the images for subsequent analysis.

3. Methodology

The change detection algorithm employed the following techniques:

- **Image Subtraction**: Initial change areas were identified by calculating the pixel-wise difference between the two images.
- **Otsu's Thresholding**: This method determined an optimal global threshold for binarizing the difference map.
- **Adaptive Thresholding**: To address localized variations, adaptive thresholding was used, dividing the image into smaller regions with localized thresholds.

A step-by-step workflow of the methodology is as follows:

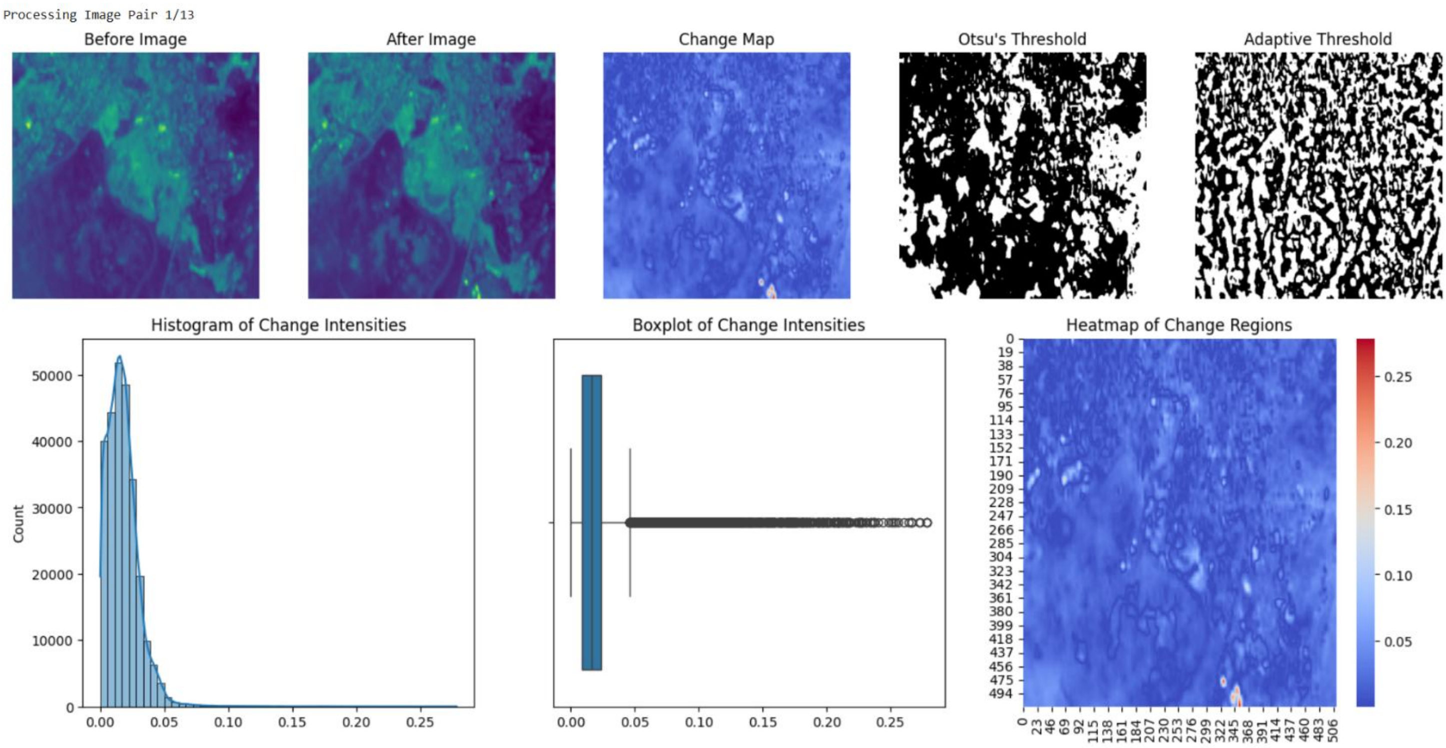
1. Preprocess the images (resize, align, denoise, normalize).
2. Compute the pixel-wise difference between the images.
3. Apply Otsu's thresholding to generate a binary change map.
4. Use adaptive thresholding for finer, localized analysis.

4. Results

The findings of the change detection algorithm are summarized below:

- **Before and After Satellite Images**: These images visually depict the scenes captured at two different times.
- **Binary Change Maps**: Maps generated using Otsu's and adaptive thresholding methods clearly highlight areas of significant change (white for changes, black for unchanged areas).
- **Histograms and Boxplots**: These visualizations illustrate the distribution of pixel intensities in the difference images and quantify change patterns.
- **Heatmaps**: Heatmaps provide a spatial overview of the regions that experienced significant changes.

The change detection algorithm effectively differentiated between areas with and without significant changes, with each technique contributing unique insights.



5. Discussion

The results offer meaningful insights into the changes captured between the two satellite images:

- Significant changes were observed in regions indicative of urbanization and environmental shifts.
- **Otsu's Thresholding**: While globally effective, it encountered challenges in detecting changes in areas with high local variability.
- **Adaptive Thresholding**: This method excelled in identifying localized changes but was computationally more intensive.

Strengths of the approach:

- **Simplicity**: The algorithm was easy to implement and computationally efficient.
- **Interpretability**: Visualizations, such as heatmaps and binary maps, made the results accessible and understandable.

Limitations and Future Improvements:

- Small boundary changes were sometimes missed. Future work could integrate machine learning models to enhance boundary detection.
- The approach relied on high-quality data. Incorporating advanced preprocessing methods, such as super-resolution techniques, could improve results.

6. Conclusion

This project successfully developed and implemented a change detection algorithm for satellite imagery, effectively identifying significant changes between two time-stamped images. The methodology emphasized simplicity, accuracy, and interpretability, making it suitable for various real-world applications, such as environmental monitoring, urban planning, and disaster response. Future improvements, including machine learning integration, could enhance the robustness of the algorithm.

7. Tools and Libraries

- Tools and libraries used in the project are Ostu's thresholding in OpenCV, Rasterio, Matplotlib, Seaborn.