Improving Shoreline Extraction Accuracy with Super-Resolution: A Comparison of Landsat-8, Sentinel-2 and PlanetScope Imagery

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Introduction

1. Background

- Optical satellite imagery is essential for coastal monitoring due to its long-term historical data, global coverage, and repetitive observation.
- Landsat satellite series has a low-resolution limitation (30m/pixel).
- Machine learning based super-resolution(SR) techniques can potentially improve shoreline extraction from Landsat imagery.

2. Objective

- Enhance spatial resolution of Landsat-8 image using Super Resolution Generative Adversarial Network(SRGAN) model and compare the shoreline extraction accuracy across multiple datasets.

Study Site

1. Study Site

- The study site is Wonpyeong-Chogok beach, located in the east coast of South Korea.

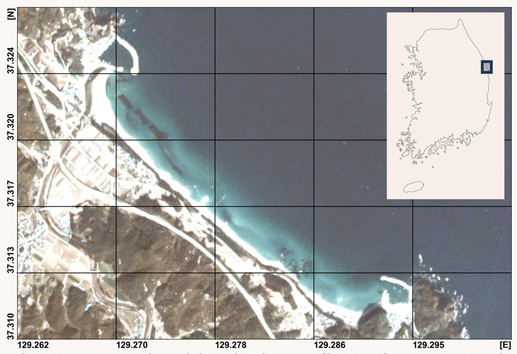

Figure 1. Study site Wonpyeong-Chogok beach. The coordinate reference system is WGS84.

2. Data Acquisition

Table 1. Name, resolution, acquisition date of the satellite used to validate shorelines.

Satellite	Resolution	Date	Time Gap (mm:ss)
PlanetScope	3m/pixel	2019-11-06 10:49:48	Reference Shoreline
Sentinel-2	10m/pixel	2019-11-06 11:17:11	+ 00:27:23
Landsat-8	30m/pixel	2019-11-06 10:59:04	+ 00:09:16

- PlanetScope data is acquired from its own platform[1] and Google Earth Engine is used for Landsat-8, Sentinel-2 data[2].

References

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Methodology

1. Spatial Resolution Enhancement

- Landsat-8 images are super resolved to Sentinel-2 resolution (10m/pixel), using a trained SRGAN model[3].
- The SRGAN model is trained with Setninel-2 images of coastal areas along the east coast of South Korea.

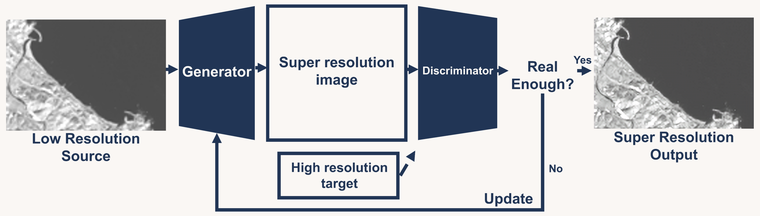

Figure 2. Diagram of the SRGAN process for Landsat-8. The Near-Infrared (NIR) band is shown for example.

2. Panchromatic Sharpening

- Panchromatic sharpened (15m/pixel) Landsat-8 data is used for accuracy comparison.

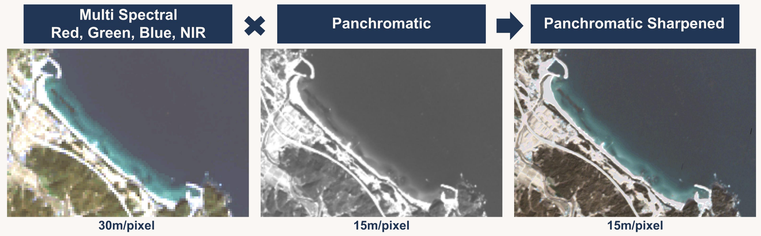

Figure 3. Visualization of the process of panchromatic sharpening.

3. Phase Cross Correlation

- To overcome the difference in georeferencing accuracy, every data is aligned and spatial registered using the phase cross correlation method[4].

4. Shoreline Extraction

- The shoreline is extracted by using the Normalized Difference Water Index(NDWI), Otsu's thresholding algorithm[5]. The NDWI[6] is calculated as follows:
- $$\text{NDWI} = \frac{(\text{Green} - \text{NIR})}{(\text{Green} + \text{NIR})} \quad (1)$$
- The extraction is performed at sub-pixel resolution by applying the Marching Squares algorithm[7].

Figure 4. Visualization of the process of shoreline extraction.

Results

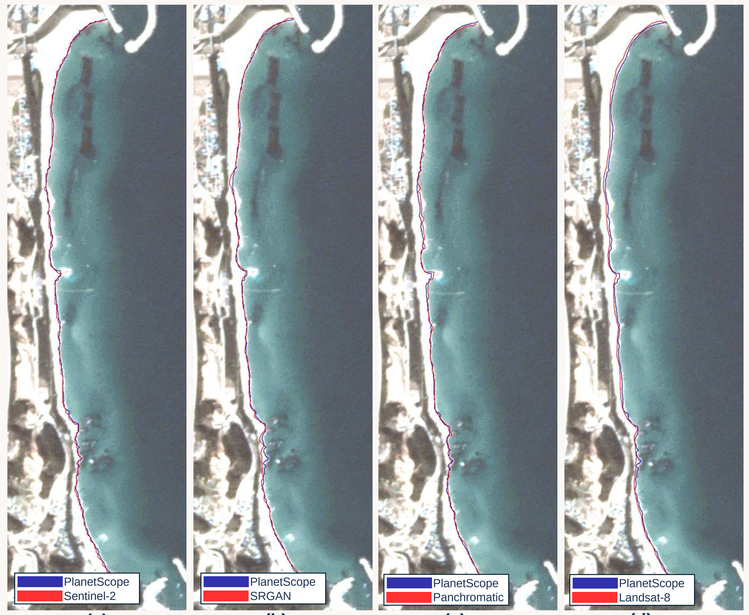

Figure 5. Shoreline extracted from (a) Sentnel-2, (b) SRGAN super resolved Landsat-8, (c) Panchromatic enhanced Landsat-8, (d) low resolution Landsat-8, overlayed with PlanetScope reference shoreline.

Table 2. Accuracy metrics for all methods against the PlanetScope reference shoreline

Method	STD (m)	Bias (m)	RMSE (m)	MAE (m)
Sentinel-2	2.505	-1.309	4.903	2.714
SRGAN	3.713	-1.246	6.072	3.086
Panchromatic	2.916	+1.140	6.247	3.534
Landsat-8	4.233	-4.757	11.761	6.872

- Sentinel-2 provides the most accurate shoreline with the lowest RMSE and MAE.
- SRGAN-upscaled Landsat-8 performed better than panchromatic enhancement, with lower RMSE and MAE.

Conclusion

- Machine learning based SR is a viable method for enhancing Landsat imagery for shoreline extraction.
- Since Landsat-5,7 lacks a panchromatic band, SR provides an alternative for improving its spatial resolution.
- Further improvements in SR techniques are needed to achieve Sentinel-2-level accuracy.
- Enhancing SR methods will enable more reliable long-term shoreline monitoring using historical satellite data.

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