FEATURE EXTRACTION AND ANALYSIS OF RIVER CHANGE DETECTION BASED ON REMOTE SENSING IMAGES

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ABSTRACT:

The characteristics of rivers in Taiwan are the steep slope with high sediment concentration. The distribution of the precipitation is non-uniform due to the mountain region and the typhoon. The dynamics of channel meandering, therefore, become complicate and not easy to simulate with numerical modelling because of the geographic environment and extreme events. To understand the morphology of the river channel, the field measurements and remote sensing methods for channel detection are necessary. However, there is no efficient method to delineate the channel from remote sensing images. This study conducted edge detection concepts to automatically capture the river bank based on remote sensing images. The images of the river channel were obtained from different seasons at the same location to test the capability of our concepts. This study shows that the river channel can be extracted automatically and the morph-dynamics of the channel can be detected from multi-temporal remote sensing images for change detection.

1. INTRODUCTION

1.1 Motivation and purpose of research

With the rapid development of remote sensing, it has been widely used in various fields of study including land cover change monitoring, disaster management and so on. Remote sensing images are utilized in many pieces of research to predict natural disasters so that essential precautions can be taken to protect the environment. Besides the other, water resource analysis plays a vital role in these researches (Venu Shah et al., 2011). Therefore, it's worthwhile using multi-temporal of remote sensing images for river change detection and monitoring the stability of the river.

For shoreline extraction, traditional manual digitalization requires a lot of time and manpower (Liang et al., 2012). Many studies have been carried out on coastline detection from high-resolution satellite images: unsupervised and supervised classification, segmentation, NDVI (Normalized Difference Vegetation Index) and NDWI (Normalized Difference Water Index) are only some of the methodological aspects that have been already considered and experimented (Massimiliano Basile Giannini et al., 2015).

Based on the factors mentioned above, this study intends to propose an automatic method to achieve river feature extraction. With the multi-temporal of remote sensing images, the morph-dynamics of the channel can be detected for river change detection.

2. LITERATURE REVIEW

2.1 Object-Based Classification

Referring to Kung et al. (2014), traditional pixel-based classification techniques cause to “salt and pepper effect”, often resulting in less satisfactory outcome when applied to high-resolution aerial image data. In recent years, it has gradually developed to object-based classification.

Comparing to pixel-based classification, object-based classification groups pixels into objects according to the spatial relation with surrounding pixels. Image Segmentation is the first step of object-based classification. Pixels are segmented into representative objects based on spectral similarity, and then each object is regarded as the smallest unit for image classification which will effectively reduce the noise caused by pixel-based classification. Segmentation has been done, each object is classified by color, size, shape and texture, achieving higher accuracy results (Humboldt State University Geospatial Online).

In the past, many studies have compared with pixel-based classification and object-based classification. Cheng et al. (2008) applied different classification algorithms to high spatial resolution satellite imagery. In the area of complicated land cover and texture, the object-based classification provided a better result than pixel-based classification. Huang et al. (2010) used object-oriented analysis method to extract landslide and flood disasters with a classification accuracy of 81.6%. Kung et al. (2014) applied the object-based classification for detecting landslides using high-resolution aerial images. The overall accuracy was improved from 87.05%(pixel-based classification) to 99.41%(object-based classification). As a result, this study use object-based classification method to detect waterbody and further extract the river channel from remote sensing images.

2.2 Edge Detection

In the process of river change detection, the ultimate goal is to extract the river channel. The edge line refers that there is a sudden change of the grayscale value of the pixel, reflecting the discontinuity of grayscale value in the image. There are many methods for edge extraction including calculating the maximum value of the gradient, detecting the zero-crossing point of the second derivative, statistical method and wavelet edge detection (Chou et al., 2005). The line features are extracted by calculating the first or second derivative of grayscale value in the image. There are many ways to detect the line features including Robert, Prewitt, Sobel, LoG, Canny and so on.

Canny proposed the Canny edge detector in 1986, which is one of the most commonly used methods for edge detection. There are three criteria when designing a computational approach to edge detection. The first is to have good detection capability. That is, to find the maximum of edge features. For this reason, the value of the signal to noise ratio (SNR) is as large as possible. The second is that the detective must have good positioning capabilities. That is, to find the edge pixel whose position is close to the true edge line. The third is to suppress the problem of multiple responses on a single edge, avoiding the situation where a single edge is considered to be multiple edges (Tsao et al., 2009).

Paravolidakis V., et al., (2016) used aerial imagery to automatically extract the coastline with a combination of a four-step algorithm. Noise distortion is firstly reduced and then the image is segmented into two regions. The result is further processed by morphological operators and finally perform the Canny edge detection method to extract and model the coastline (Paravolidakis V., et al., 2016). As shown in Figure 1, the blue line represents the extracted coastline. Zhang et al., (2013) presented an object-based region growing integrating Canny edge detection to automatically extract the coastline from satellite image and compared it with the artificially digitized coastline. The outcome showed that it has higher accuracy than the artificially digitized coastline. In summary, to extract the edge of the coast or river, Canny edge detection method is a tool to achieve this goal.

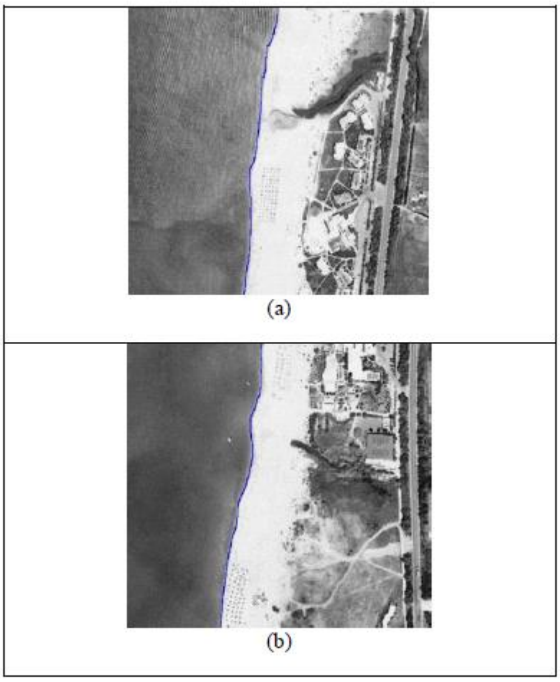

Figure 1 (a), (b) Close-up of the initial image in two different locations. Blue line reflects the estimated coastline (Paravolidakis V., et al., 2016)

2.3 Application of Remote Sensing Images on River Extraction

There have been many pieces of research about river extraction, and the dataset is mostly based on satellite imagery. Khurshid, M. et al., (2012) used an iterative multi-resolution decomposition of textural features to extract river from high-resolution SPOT 5 satellite images. Jiang et al., (2014) combined water index and digital image processing techniques to extract lakes and rivers from Landsat imagery. Komeil et al., (2014) applied different satellite-derived indexes including Normalized Difference Water Index (NDWI), Modified NDWI (MNDWI), Normalized Difference Moisture Index (NDMI), Water Ratio Index (WRI), Normalized Difference Vegetation Index (NDVI), and Automated Water Extraction Index (AWEI) for the extraction of surface water from Landsat data. Overall, the NDWI was found superior to other indexes and hence it was used to model the spatiotemporal changes of the lake. Besides, a new approach based on Principal Components of multi-temporal NDWI (NDWI-PCs) was proposed and evaluated for surface water change detection.

3. DATA AND METHOD

3.1 Data

The vast amount of satellite imagery collected every day across the globe is huge. Frequent global coverage of the earth and high-resolution data with readily available data to the public makes it helpful in monitoring the earth and its environment (Abdishakur, 2019). As a result, this study used sentinel-2 optical satellite images acquired from USGS Earth Explorer as a dataset. Mission Sentinel-2 consists of two satellites: Sentinel-2A (lunched in 2015) and Sentinel-2B (launched in 2017), which will operate at an altitude of 705 km in the same orbit, phased at 180° to each other and the orbit inclination 98.5°. The satellites are equipped with modern multi-spectral high-resolution scanners, 13 spectral channels, resolution 10, 20 and 60 m and a swath width of 290 km. The revisit time is 10 days for one satellite and 5 days for two satellites (Marta Szostak et al.,2017). Table 1 shows the spectral bands for Sentinel-2 sensors.

Table 1 spectral bands for Sentinel-2 sensors(https://en.wikipedia.org/wiki/Sentinel-2)

Sentinel-2 bands	Sentinel-2A		Sentinel-2B		
	Central wavelength (nm)	Bandwidth (nm)	Central wavelength (nm)	Bandwidth (nm)	Spatial resolution (m)

Band 1 – Coastal aerosol	442.7	21	442.2	21	60
Band 2 – Blue	492.4	66	492.1	66	10
Band 3 – Green	559.8	36	559.0	36	10
Band 4 – Red	664.6	31	664.9	31	10
Band 5 – Vegetation red edge	704.1	15	703.8	16	20
Band 6 – Vegetation red edge	740.5	15	739.1	15	20
Band 7 – Vegetation red edge	782.8	20	779.7	20	20
Band 8 – NIR	832.8	106	832.9	106	10
Band 8A – Narrow NIR	864.7	21	864.0	22	20
Band 9 – Water vapour	945.1	20	943.2	21	60
Band 10 – SWIR – Cirrus	1373.5	31	1376.9	30	60
Band 11 – SWIR	1613.7	91	1610.4	94	20
Band 12 – SWIR	2202.4	175	2185.7	185	20

3.2 Method

The data in this study is Sentinel-2 Level-1C product acquired from USGS Earth Explorer. Atmospheric correction of optical satellite imagery is an essential pre-processing for modelling biophysical variables, multi-temporal analysis, and digital classification processes. To obtain Bottom of Atmosphere reflectance images (Level-2A product) derived from this Level-1C products, ESA provides the SEN2COR module, which is implemented in the Sentinel Application Platform (Ion Sola et al.,2018). After that, image segmentation is implemented by determining the segmentation parameters of scale, shape and compactness. Since the result of segmentation influences the accuracy of image classification, segmentation parameters must be optimally determined. The second step is object-based classification and there is much commercial software dedicated to object-based image classification. The image processing software used in this study is PCI Geomatica 2018. The object-based classification technology uses to classify objects and establish rules for computer interpretation. Eventually, the river channel is extracted by edge extraction. Figure 3 shows a diagram of the proposed methodology.

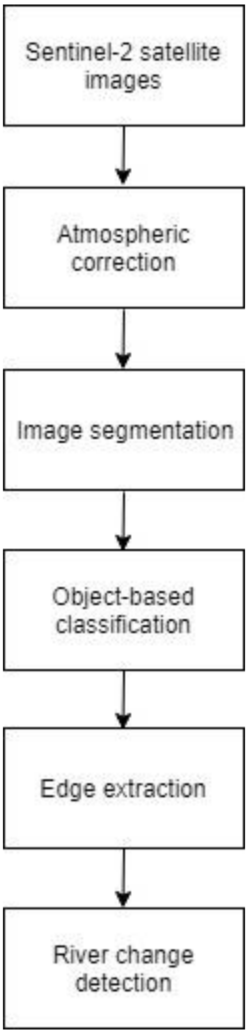

Figure 3 Diagram of the proposed methodology

4. PRELIMINARY RESULTS

Sentinel-2 satellite imageries used is a period from 2017 to 2019. We took advantages of the multispectral data and used the Red and NIR band to compute the Normalized Difference Vegetation Index(NDVI) before implement object-based classification. The result from 2017 to 2019 is shown in Figure 4 to Figure 6.

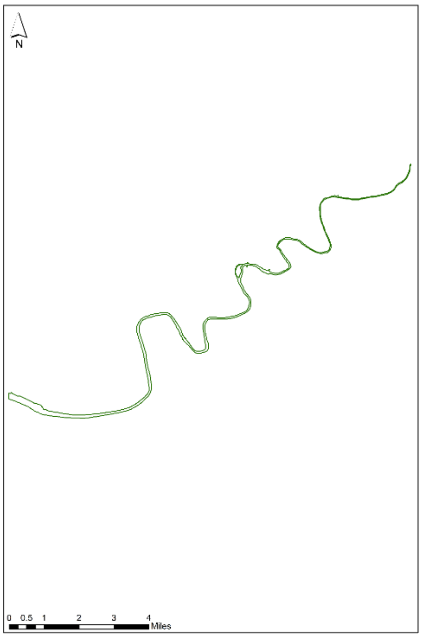

Figure 4 The extraction of river channel in 2017

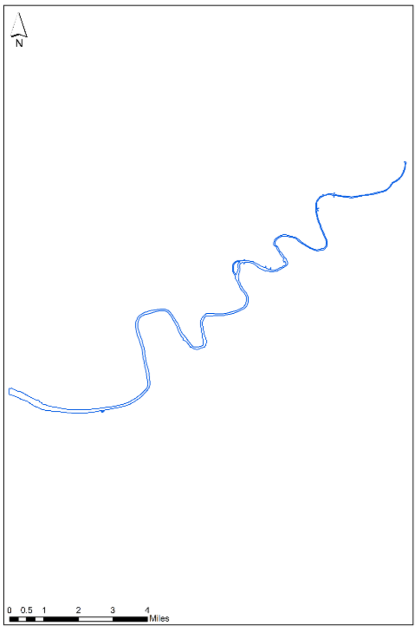

Figure 5 The extraction of river channel in 2018

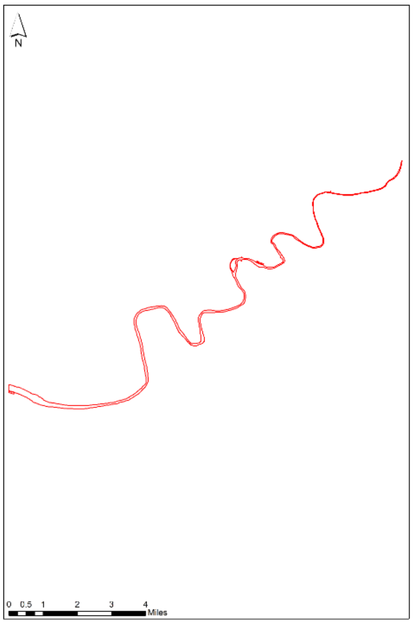

Figure 6 The extraction of river channel in 2019

5. FUTURE WORK

As the preliminary result shows, we use PCI Geomatica commercial software to achieve the extraction of the river channel. In the future, we will also perform MATLAB to process remote sensing images for river extraction. Also, we will compare the river channel extracted from different years for analysis.

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