Development of Shoreline Detection Module Using Remotely Sensed Imagery By Deep Neural Networks and Geomorphology Techniques

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ABSTRACT: A shoreline is essential for estimating coastal changes and monitoring coastal environments. Use of remote sensing techniques is more efficient than traditional field survey techniques for periodically monitoring the shorelines in wide coastal zones. However, detection of the accurate shorelines from the remotely sensed imagery is difficult due to the misclassification errors. In this study, the shoreline detection module that can automatically detect the shorelines from the imported remotely sensed imagery by the deep neural networks (DNN) and geometry techniques was developed. In the developed shoreline detection module, the areas of water and land were classified in the imported imagery by DNN, and the misclassification errors were eliminated by geomorphology techniques for generating the shorelines. This shoreline detection module was employed to detect the accurate shorelines from the KOMPSAT-3 satellite image acquired in the coast of Gyeongju, Republic of Korea.

INTRODUCTION

Shoreline is a boundary line that separates the sea from the land, and is a marine spatial data that defines the shape of the land. The information obtained from this shoreline location shows information about beach fluctuations, which affects marine monitoring or policy decisions (Hagenaars et al., 2018). Therefore, detecting shoreline is very important economically and socially for marine workers (Toure et al., 2019). However, the GPS technology used in common shoreline surveys is difficult to cover a wide range and takes a huge amount of time (Pugliano et al., 2019). In recent years, high-resolution satellite imaging and geographic information system (GIS) technologies have been actively used to overcome the limitations of GPS (Aedla et al., 2015).
Advances in programming languages such as Python have made it easy for non-majors to conduct Artificial Intelligence (AI) research, allowing them to detect precise coastline from remote sensing images with minimal manual intervention. Using the Python library, this study developed a module that can detect the coastline from KOMSAT-3 images, a high-resolution satellite in Korea. The module introduced in this study classifies water and land by learning RGB from KOMSAT-3 via Deep Neural Network (DNN) (LeCun et al., 1989). Geomorphology techniques have also eliminated errors to provide a more precise shoreline. The module developed in this study was applied to the coast near Gyeongju, Republic of Korea

STUDY AREA AND DATA SETS

The module developed in this study uses satellite images of KOMPSAT-3 developed and operated in Korea. KOMPSAT-3 is a high-resolution earth observation satellite launched in May 2012, with a spatial resolution of 0.7 m in black and white and 2.8 m in color. Gampo-ri and Oryu-ri, Gampo-eup, Gyeongju-si, the study area of this study, are mixed with cities, vegetation, and the sea. As can be seen from the satellite image of Figure 1, it was determined that the target area would be suitable for training the DNN model because the boundary between the sea and the land was clearly distinguished. In this study, KOMPSAT-3 satellite images taken on January 23, 2019, were used in coastal areas of Gampo-ri and Oryu-ri, Gampo-eup, near Gyeongju-si, Gyeongsangbuk-do, Republic of Korea. In this study, images from 2019 and 2014 were used.

METHODOLOGY

First, enough training samples for major land cover (water, land, etc.) were acquired from a given satellite image using QGIS (Figure 1). Based on the training sample, a binary image distinguishing water and land from a given satellite image was produced using an artificial intelligence model provided by Python's keras library. In addition, noise near the boundary between water and land was removed from the binary image by utilizing the morphology operation of computer vision provided by Python's opencv library. Finally, the longest line among the N boundaries located at the boundary of the object was defined as the coastline from the noise-free binary image, which was calculated in the form of a GIS Shapefile using Python's osgeo library.

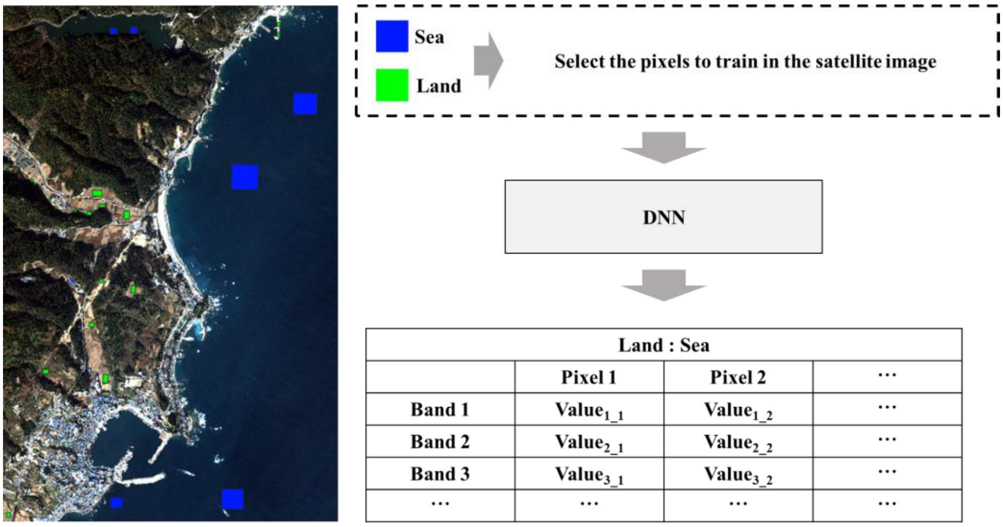

Figure 1. Example of specifying land cover training samples and classifying data

RESULTS AND DISCUSSION

The land cover diagram provided from the Python module developed in this study can be confirmed in Figure 2. The keras artificial intelligence applied in this study classified water and land relatively well, but some pixels in inland areas were classified as water. An example of an image in which noise is removed with the opencv library to remove the coastline can be confirmed in Figure 3. However, when image processing is performed by a general method, inland errors can be eliminated as shown in Figure 3, but detailed parts of the coastline cannot be detected. Therefore, this study compares the land cover that solves the error problem by adjusting the parameters suitable for the Figure 2 image. By performing the previous process, it was possible to detect a change in the coastline as shown in Figure 4. From the results of Figure 4, it was confirmed that the Python module developed in this study could detect a change in the coastline.

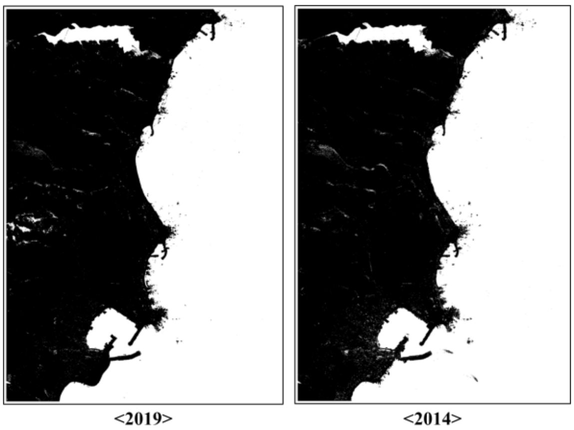

Figure 2. Land Coverage Using DNN

Figure 3. Error removal results from the Opencv

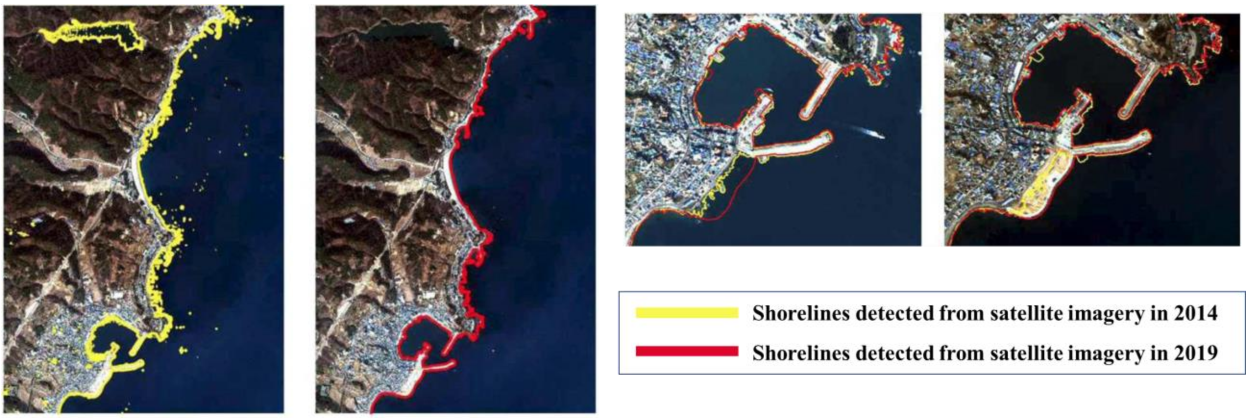

Figure 4. Shoreline ratio detected via developed module

CONCLUSIONS

In this study, a module was developed to detect coastline from high-resolution satellite images using artificial intelligence, computer vision, and spatial information libraries provided by Python such as keras, opencv, and osgeo. In future studies, a module for detecting time series coastline from multi-timer satellite images will be developed using Python. In addition, it is necessary to apply and compare various deep learning techniques such as Convolution Neural Network (CNN) (Simard et al., 2003) and U-Net (Ronneberger et al., 2015), which are more effectively known for image processing than DNN.

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