A STUDY ON THE BOUNDARY INFORMATION DETECTION OF AQUACULTURE FACILITIES BASED ON KOMPSAT-3 SATELLITE IMAGES

Do-Ryoeng Kim[1], Hyeong-Hun Kim[1], Dong-Ha Ryu[1], Seung-Wook Choi[1], Jang-Bae Lee[1], Hyeong-Sub Kim[1*]
[1]Institute of Spatial Information Technology Research, GEO C&I Co., Ltd, 1119-116 Bangchon-dong, Daegu, Republic of Korea,
Email: {drkim, hhkim, dhryu, swchoi, jblee, hskim}@geocni.com

KEYWORDS: KOMPSAT-3, edge detection, aquaculture facilities, boundary information

ABSTRACT : Marine product aquaculture has been performed for sometime in South Korea as the country is bounded by waters on three sides, and production surveys have been conducted of late for the systematic management of aquaculture facilities. Based on the survey results, marine product pricing has been done to stabilize the local fisheries resources and to secure the livelihood of the fishermen. Such aquaculture facility surveys depend on manual digitizing based on aerial photographs taken yearly. These surveys with manual digitizing using high-resolution aerial photographs can be accurately conducted with the knowledge of experts who are well aware of the characteristics of each aquaculture facility and the deployment of those facilities. The use of aerial photographs, however, has monetary and time limitations in monitoring aquaculture resources with different life cycles, and also requires a number of experts. Therefore, an automatic method for obtaining the boundary information of aquaculture facilities based on satellite images that can broadly monitor these facilities was investigated in this study. The satellite that was used for this study was KOMPSAT-3, a local high-resolution satellite. The edge detection and polygon generation techniques were used for automatic digitizing through image processing. The suggested method can not only overcome the limits of the existing monitoring method using aerial photographs but also assist experts in detecting aquaculture facilities. Aquaculture facility detection systems must be developed in the future through the classification of aquaculture facilities and the application of image processing techniques. Such systems will be of great help in the related decision-making through the monitoring of aquaculture facilities.

1. INTRODUCTION

Marine product aquaculture has been performed for sometime in South Korea as the country is bounded by waters on three sides, and production surveys have been conducted of late for the systematic management of aquaculture facilities. Based on the survey results, marine product pricing has been done to stabilize the local fisheries resources and to secure the livelihood of the fishermen. For this, surveys of aquaculture facilities and resources are conducted every year by surveyors directly visiting local fishing village cooperatives, and vectorizing is performed based on satellite photographs by referring to the information acquired from the field surveys. Field surveys are performed by deploying many personnel, but precise field surveys are impossible due to the insufficient survey personnel. In the case of vectorizing based on satellite photographs, the aquaculture facilities are accurately divided because high-resolution image data are used, but it is difficult to obtain maturation period images for each of the different aquaculture resources with different growth periods because the photographing cost is high and because it is cumbersome to obtain photographing permission. Furthermore, it is difficult to obtain overseas aquaculture resource information with the existing survey method in relation to the monitoring of the operation of overseas aquaculture resources that are being imported in large quantities. In particular, the Chinese aquaculture industry is exporting aquaculture resources acquired through the operation of fish farms in large areas near South Korea, and when these aquaculture resources are exported to South Korea, the livelihood of the fishermen is threatened due to the price slump of the domestic aquaculture resources. The overseas and domestic fish farms thus need to be monitored to solve this problem, but the domestic related technologies provide a management system only for single aquaculture resource types, and monitoring systems for various forms of domestic aquaculture facilities, such as the floating type (sea algae), the long-line type (sea algae, shellfish), and the cage type (fish, shellfish), are insufficient. Therefore, to make up for the shortcomings of the existing methods, a method of extracting contour data to detect and monitor aquaculture facilities using high-resolution satellite images was developed and investigated in this study.

2. STUDY AREA AND DATA

The target areas of this study were Wando-gun and Geoje-si in the South Sea of the Korean Peninsula. Wando-gun is operating many cage-type aquaculture facilities that account for 50% of the domestic abalone production, and they are operating many long-line- or floating-type facilities to produce sea mustards, which are food for abalone. Together with Tongyeong-si, Geoje-si has many long-line-type farms producing shellfish such as oysters, sea squirts, and mussels, as well as cage-type farms producing fish. These two study areas were selected because they have a wide variety and a large number of widely distributed aquaculture facilities. The domestic high-resolution KOMPSAT-3 satellite images were used for this study. The KOMPSAT-3 satellite images allow easier photographing time selection and photograph acquisition compared to aerial photographs, and it is possible to obtain high-resolution submeter-class optical images. To utilize the KOMPSAT-3 satellite images, images of 13 scenes across the study areas were acquired, and a method of extracting the contour data of the aquaculture facilities based on such images was developed.

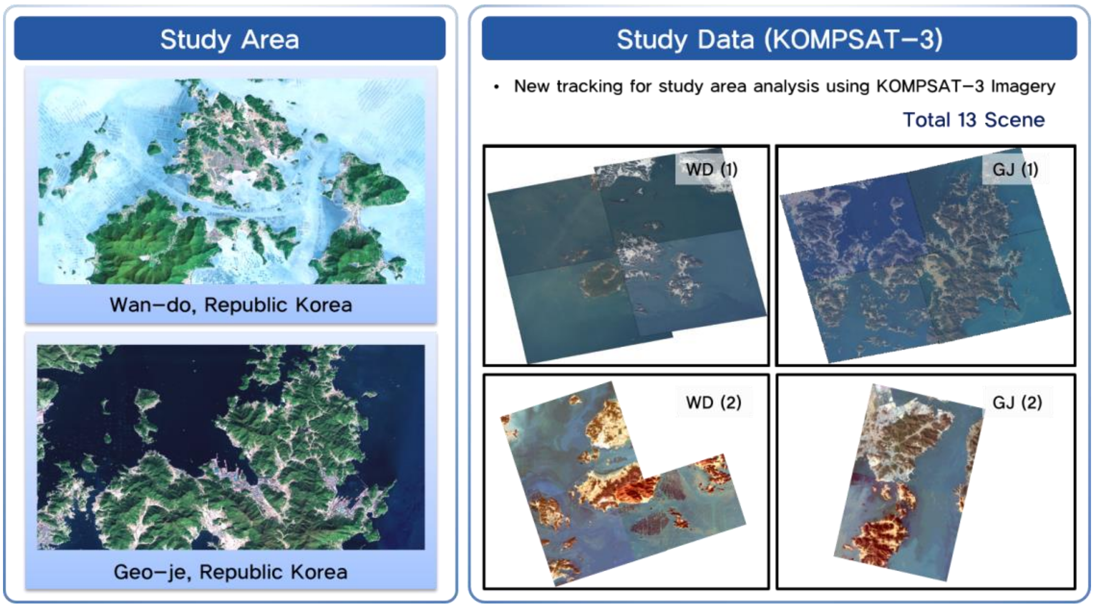

Figure 1. Study Area

3. STUDY METHOD

Aquaculture facilities must be extracted from the images and classified by type to obtain their contour data using the KOMPSAT-3 satellite images. Image emphasis is performed by applying image processing techniques to the satellite images in advance to improve the quality of the extraction and classification results. In this study, the HPF (high-pass filter) and IHS (intensity hue saturation) techniques, which accentuate the emphasis of facilities, were selected and compared before applying the more appropriate technique to the KOMPSAT-3 images. The HPF technique converts and processes the pixel-based image data by frequency. After separating the image data into the high- and low-frequency bands, it emphasizes the high-frequency areas and blocks the low-frequency areas. The high-frequency areas generally have large pixel value differences in the images, and correspond to the boundaries between the aquaculture facilities and the sea in the images and to the parts of the images that have clear color changes. IHS is a method of emphasizing the tone and brightness of multiple band data, and performs direct pixel emphasis. The emphasis data for aquaculture facilities were compared by applying these two techniques to the KOMPSAT-3 satellite images. As a result, the IHS technique generated unnecessary noises in the image even though the boundaries of the aquaculture facilities were clear. Furthermore, in the images to which the HPF technique was applied, the boundaries of the aquaculture facilities were more distinct compared to the other images, and no noises were generated even though the emphasis of the facilities was slightly poorer than that of the images to which IHS was applied. The HPTF technique was applied because noises create unnecessary data when acquiring the contour data of aquaculture facilities.

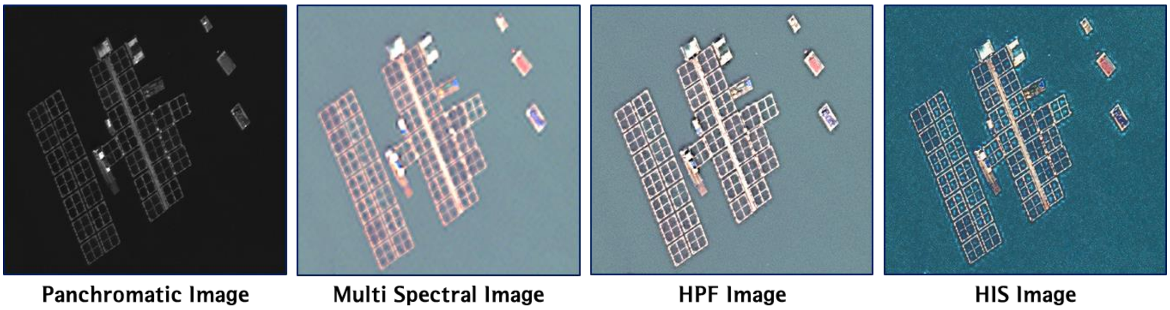

Figure 2. Image Enhancement Method

The aquaculture facilities were classified based on the images to which the HPF technique was applied. A learning-based classifier was used to classify the aquaculture facilities, and the features were extracted for the classifier's learning. For the features, the pixel data of each band of the satellite images consisting of red, green, blue, and near infrared, and the pixel data of the images created through band calculation, such as NDVI and NDWI, were used. After the classifier's learning based on these data, the facilities were classified. The Harris corner and convex hull algorithms were used to extract the contour data of the aquaculture facilities from the classified images. The Harris corner algorithm detects the corner points by calculating the DN difference between the pixels, and uses the pixel differences between the aquaculture facilities and the seawater. Once the corner data are created, a list of points is prepared for each corner, and point connections are performed according to the list. Errors are generated in the contour data if the contour data are directly extracted from the point list, and the convex hull algorithm was used to address this problem. The convex hull algorithm selects the connection points by calculating the angles between the selected coordinate and all the other coordinates, starting from a coordinate with a skewed direction in an oversampled group; sets the connection direction along the direction of this angle; and connects the points until the starting coordinate is reached.

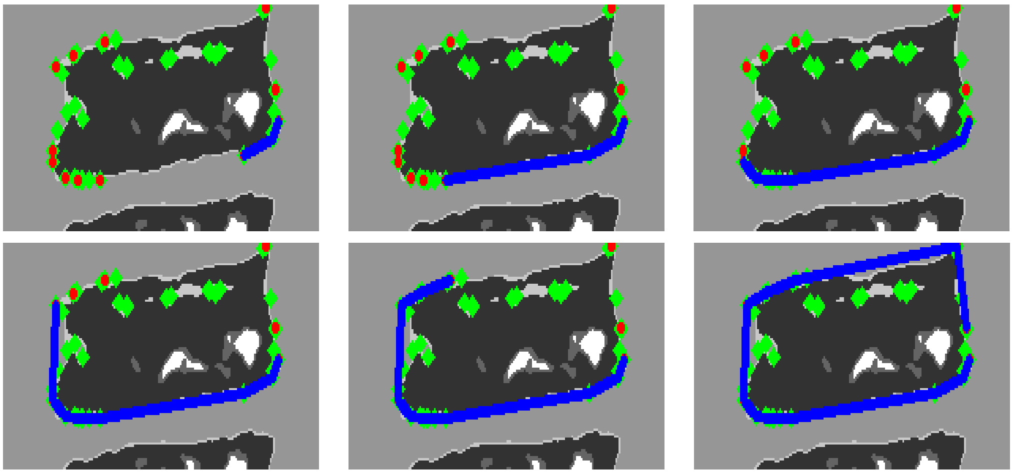

Figure 3. Boundary Information Detection Method

The standard production method provided by ESRI was applied to extract the contour data based on the convex hull algorithm, and to create a shape file based on the extracted data. The shape file was created to allow commercial GIS programs to use the information, and the properties data, such as the contour figure data and the forms of aquaculture facilities, were inputted simultaneously.

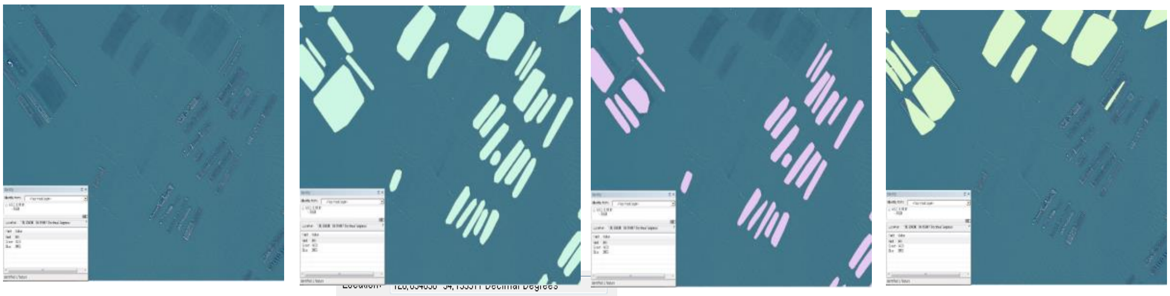

Figure 4. Boundary Information Detection Result

4. STUDY RESULTS

In this study, the contour data of aquaculture facilities were extracted by applying the facility emphasis technique based on the KOMPSAT-3 satellite images to detect aquaculture facilities. The extracted contour data were contrasted with the photograph images of the aquaculture facilities to verify their accuracy. The accuracy of the created data was verified by comparing them with the photograph images of the aquaculture facilities. For the accuracy verification of the created data, the contour data that were digitized manually were compared with the results obtained through the use of the technique. The position data for 13,200 points of the manual segregation sample agreed with the position data of the 12,332 points extracted using the same technique, and the average distance between the divergent points was 1.95 m, showing about 93.4% accuracy.

5. CONCLUSION

The automatic contour data detection of aquaculture facilities using satellite images will make up for the limitations of the detection method based on manual digitizing, which is currently being used in South Korea, and can be used to support decision-making for proper pricing by policymakers using the information of aquaculture facilities. It can also be used to monitor the operation status of domestic and overseas aquaculture facilities.

Monitoring based on aerial photographs has a limited photographing period and range, and overseas monitoring is impossible. The domestic KOMPSAT-3 satellite images were used to overcome these limitations, but it was found that it takes more time to supply the images compared to the overseas satellite images due to the security examination of the satellite images owing to the current situation of South Korea. More active aquaculture monitoring will become possible if these problems will be addressed in the future.

6. ACKNOWLEDGEMENT

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT & Future Planning(2014M1A3A3A03067386)

7. REFERENCES

- NOBUYUKI OTSU., 1979. A Threshold Selection Method from Gray-Level Histograms. Electro technical Laboratory, Chiyoda-ku, Tokyo
- JOHN CANNY., 1986. A Computational Approach to Edge Detection. Artificial Intelligence Laboratory, MIT
- Kim, B.S., 2001. A Study on Artificial Reef Suitability using Satellite Remote Sensing and GIS. Kyungil University
- Park, K., Jang, E.M., 2004. A Study of Marine Aquaculture Management Strategies Using Remotely-sensed Satellite Data - A Case Study on Hallyeo Marine National Park and Tasmania -. Journal of environmental impact assessment / v.13 no.5 pp.231-241
- Yang, C.S., Park, S.W., 2006. Facilities Analysis of Laver Cultivation Grounds in Korean Coastal Waters Using SPOT-5. Journal of Korean Society dor Marine Encironmental Engineering/ v.9 no.3 pp.168-175
- Yang, C.S., Moon, J.E., Park, J.K., 2007. Detection Approach of Laver Cultivation Grounds Using Optical Satellite Imagery. KSRI2007, pp167-170
- Park, J.H., Suh, Y.C., 2013. GIS-Based Suitable Site Selection for Aquaculture Using Scope for Growth of Styela Clava. Journal of the Korean Association of Geographic Information Studies, 16(3), pp.87-90
- Jo, Y.S., Hong, S.J., Kim, H.C., Choi, W.J., Lee, W.C., Lee, S.M., 2010. Development of Bivalve Culture Management System based on GIS for Oyster Aquaculture in Geoje Hansan Bay. Journal of the Korean Society of Marine Environment & Safety
- Yang, C.S., 2010. Prototype Development for Management System of Coastal Farm Facility Using Satellite Data. IPET Final Report