

Volume 20 | Issue 6

Article 1

OPEN SOURCE REMOTE SENSING:INTROSPECT AND PROSPECT

Sanggoo Kang Department of Information Systems Engineering, Hansung University, Seoul, Korea.

Hee Young Yoo Geoinformatic Engineering Research Institute, Inha University, Incheon, Korea.

Kiwon Lee Department of Information Systems Engineering, Hansung University, Seoul, Korea., kilee@hansung.ac.kr

Follow this and additional works at: https://jmstt.ntou.edu.tw/journal

Part of the Environmental Sciences Commons, and the Oceanography and Atmospheric Sciences and Meteorology Commons

Recommended Citation

Kang, Sanggoo; Yoo, Hee Young; and Lee, Kiwon (2012) "OPEN SOURCE REMOTE SENSING:INTROSPECT AND PROSPECT," *Journal of Marine Science and Technology*: Vol. 20: Iss. 6, Article 1. DOI: 10.6119/JMST-012-0315-1 Available at: https://jmstt.ntou.edu.tw/journal/vol20/iss6/1

This Research Article is brought to you for free and open access by Journal of Marine Science and Technology. It has been accepted for inclusion in Journal of Marine Science and Technology by an authorized editor of Journal of Marine Science and Technology.

OPEN SOURCE REMOTE SENSING: INTROSPECT AND PROSPECT

Acknowledgements

This research was financially supported by Hansung University.

This research article is available in Journal of Marine Science and Technology: https://jmstt.ntou.edu.tw/journal/ vol20/iss6/1

OPEN SOURCE REMOTE SENSING: INTROSPECT AND PROSPECT

Sanggoo Kang¹, Hee Young Yoo², and Kiwon Lee¹

Key words: object-based image analysis, open source, optical image processing, remote sensing software, InSAR processing.

ABSTRACT

It is noteworthy that open source applications have been developed and studied in various fields as well as remote sensing field. Open sources for GIS have long history related to open standards over three decades, but those of remote sensing do relatively short. Moreover, there are still no summary reports for open sources for remote sensing. In this study, we summarized characteristics of open source applications for remotely sensed image processing and discussed their strengths and weaknesses at first. Based on the summary, two open source applications for InSAR Processing and Geographic Object-Based Image Analysis are practically implemented to introspect and prospect open source remote sensing. The developed applications have many advantages compared with existing open source applications because they provide user friendly interface, functions for searching from database and visualizing in mobile devises, concurrent processing of GIS and RS data. The quality of open source software is as good as commercial software. Therefore, OSRS will expand widely and improve continuously due to strengths of open source. We expect this study will be a good guide for users and developers of OSRS.

I. INTRODUCTION

Recently interest in open source software for geo-spatial processing has been increasing. It is closely related to the progress of computing environments such as software as a service, cloud computing, open API accessibility and social networking. In remotely sensed image processing, proprietary software which means commercialized source is widely and intensively used in most of applications. Nevertheless, open source remote sensing is regarded as one of the progressing and advanced fields in remote sensing.

Open source has been mainly developed and integrated in one field till now. Each open source usually works for one module or a target application. Therefore open source mainly provides not several functions but a single function. However several open source modules from various fields will be unified hereafter and we can easily develop software for a specific purpose if open source modules from various field were integrated adequately. Before developing open source software in the integrated user environment for remote sensing, making a list of functions and investigating characteristics should be preceded. Therefore we examined the functions of open source software for remote sensing and compared each other in this study.

In remote sensing area, satellite images including optical images and synthetic aperture radar (SAR) images are widely used. Most of the commercial software offers the functions for processing both optical images and radar images, but it is not easy to find open source software providing processing methods for both types of images. For that reason, we started with the investigation of existing open source programs for optical images and for SAR images separately then compared. At first, OTB, OSSIM and Opticks for optical image processing were compared and then DORIS, ROI_PAC and GMTSAR for SAR image processing were compared. Users can easily choose a suitable open source program via this comparative study. Moreover open source applications can be substituted for the functions in commercial software [1, 7]. In addition, we present practical implementations using open sources and make an attempt to introspect and prospect them for open source applications. One is a case for InSAR processing in the integrated GUI environment, with optical remote sensing image processing modules and another case is for Geographic Object-Based Image Analysis, GEOBIA.

II. OPEN SOURCE REMOTE SENSING (OSRS)

Although there are open source programs for remote sensing, public users, companies and government have some problems to use them as user friendly interface and manuals or documents describing functions are not provided. Moreover

Paper submitted 11/22/11; revised 01/29/12; accepted 03/15/12. Author for correspondence: Kiwon Lee (e-mail: kilee@hansung.ac.kr).

¹Department of Information Systems Engineering, Hansung University, Seoul, Korea.

² Geoinformatic Engineering Research Institute, Inha University, Incheon, Korea.

open source software often has no warranty when a problem happens and it is not easy to find the proper open source among many of them. Even if there are difficulties to use open source, their usage in remote sensing has been increased and the areas using open source have been expanded as there are many efforts to make up for the weak points in OSRS. The difficulties in using open source can be solved as open source code is publicly available. Users are able to customize open source software adding and improving functions.

Other problems which are a few manuals or documents for users and responsibility issues can be solved via the open source user group or community, because most of open source programs support the activities of communities. The developers, public developers and users of open source discuss together and solve the problems through pointing out the bugs and asking the feedback from the community. It provides information as good as manuals or documents. When some problems happen, it can be solved and corrected fast in the community. Developer can download source codes to correct and add a part of codes then upload to the management server again.

The proprietary software is produced for sale so it should be tested in every development environment considering all users before selling it. The test procedure needs a lot of labors and costs. However, in case of open source, users working on different computer environments voluntarily test the programs and report bugs to the community. Consequently, the quality of open source software can be improved saving labors and costs. Another problem, which is a difficulty to find an adequate open source can be solved through comparing various open source applications.

In this study, we selected three open source applications for processing remotely sensed images: OTB, OSSIM and Opticks, and then compared their functions because they are comparable to proprietary software for remotely sensed image processing and continuously updated. This comparison of functions based on the research of Lee and Kang [4] is shown in Table 1. The number of compared functions increased as against the previous study. On the other hand, among open source applications for SAR image processing, DORIS, ROI_PAC and GMTSAR which support the functions like InSAR and DInSAR for monitoring various types of natural disaster such as earthquake, volcano and landslide are selected to compare their functions. The comparison of available functions and the type of supported SAR images based on the researches of Kang and Lee [3] and Simonetto and Follin [6] is presented in Table 2, which release version or patch of each open source is designated with the open source name.

III. INTROSPECT AND PROSPECT

In this section, we attempt to introspect and prospect open source applications for remote sensing via practical cases which are developed using open sources. The first case is the study of Kang and Lee [2] and it is a GUI version of DORIS

Gradients \bullet \blacktriangle Edge Detection \blacktriangle \land Basic FilteringSmoothing Filter \bullet \checkmark Basic FilteringSmoothing Filter \bullet \land Basic Filtering \bigcirc \bigcirc \bigcirc Convolution Filter \bullet \bullet \bigcirc Convolution Filter \bullet \bullet \bigcirc Convolution Filter \bullet \bullet \bigcirc Rasterization \bullet \circ \bigcirc Interest Points \bullet \bullet \bullet Alignments \bullet \bullet \bullet Lines \bullet \circ \bullet Density Features \bullet \circ \bullet Read Extraction \bullet \circ \bullet Region growing \bullet \bullet \bullet Mage SegmentationRegion growing \bullet \bullet ClassificationSVM \bullet \circ \bullet Statistical Detectors \bullet \circ \bullet Multi-Scale \circ \circ \bullet Detectors \bullet \circ \bullet Adiometry A \bullet \bullet Adiometry A \bullet \bullet Adiometry \bullet \bullet \bullet Adiometry <th>Main Category</th> <th>Sub Category</th> <th>OTB 3.10</th> <th>OSSIM 1.8.4</th> <th>Opticks 4.7.1</th>	Main Category	Sub Category	OTB 3.10	OSSIM 1.8.4	Opticks 4.7.1
Threshold••Gradients••Edge Detection••Neighborhood Filter••Smoothing Filter••Distance Map••Convolution Filter••Rasterization••Rasterization••Interest Points••Alignments••Lines••Density Features••Concertin Moments••Condection••Principal Component Analysis••Analysis••Road Extraction••ClassificationSOM••SomSOM••Change Detection••Multi-Scale••Principal Detectors••Multi-Scale••Orthorectification••Mage Registration••Multi-Scale••Orthorectification••Map Projection••Image Registration••CorrectionRadiometry••Alignments•••Alignments•••Change Detectors•••Multi-Scale•••Orthorectification•••Alignments•••Alignments <td>ading and</td> <td>Data</td> <td>•</td> <td>•</td> <td>•</td>	ading and	Data	•	•	•
Gradients \bullet \blacktriangle Edge Detection \blacktriangle \land Basic FilteringSmoothing Filter \bullet \land Basic FilteringSmoothing Filter \bullet \land Distance Map \bullet \circ \circ Convolution Filter \bullet \bullet \circ Convolution Filter \bullet \bullet \circ Rasterization \bullet \circ \circ Interest Points \bullet \bullet \bullet Alignments \bullet \circ \bullet Interest Points \bullet \bullet \bullet Alignments \bullet \circ \bullet Principal Component \bullet \circ \bullet Analysis \circ \circ \bullet Region growing \bullet \bullet \bullet Image SegmentationLevel Set \circ \circ Level Set \circ \circ \bullet \bullet Change DetectionSimple Detectors \bullet \circ Multi-Scale \circ \circ \bullet Detectors \bullet \circ \bullet RadiometryARVI \bullet \bullet Alignerity \bullet \bullet \bullet Multi-Scale \bullet \bullet \bullet Detectors \bullet \bullet \bullet And ap Projection \bullet \bullet \bullet Image RegistrationFusion Algorithms \bullet \bullet Change ProjectionFusion Algorithms \bullet \bullet And ap Projections \bullet \bullet \bullet Image Registration \bullet \bullet \bullet Trans		771 1 1 1	-	-	
Edge Detection \blacktriangle \land \land Basic FilteringSmoothing Filter \bullet \bullet \bullet Basic FilteringDistance Map \bullet \bullet \bullet Distance Map \bullet \bullet \bullet \bullet Convolution Filter \bigstar \bullet \bullet \bullet Convolution Filter \bigstar \bullet \bullet \bullet Convolution Filter \bigstar \bullet \bullet \bullet Rasterization \bullet \bullet \bullet \bullet Rasterization \bullet \bullet \bullet \bullet Interest Points \bullet \bullet \bullet \bullet Alignments \bullet \bullet \bullet \bullet Density Features \bullet \bullet \bullet \bullet Feature Extraction \bullet \bullet \bullet \bullet Manage SegmentationRegion growing \bullet \bullet \bullet Image SegmentationStatistical Detectors \bullet \bullet \bullet ClassificationSVM \bullet \bullet \bullet \bullet Change DetectionStatistical Detectors \bullet \bullet \bullet Multi-Scale \bullet \bullet \bullet \bullet \bullet Detectors \bullet \bullet \bullet \bullet \bullet Multi-Scale \bullet \bullet \bullet \bullet \bullet Detectors \bullet \bullet \bullet \bullet \bullet Multi-Scale \bullet \bullet \bullet \bullet \bullet Detectors \bullet \bullet \bullet \bullet \bullet Map Projection \bullet \bullet	-		•	-	
Neighborhood Filter ● ● ● Basic Filtering Smoothing Filter ●			-		
Basic Filtering Smoothing Filter A A A Distance Map O					
Distance Map \circ \circ Convolution Filter \bullet \bullet Convert \blacktriangle \bullet Rasterization \circ \circ Textures \circ \circ Interest Points \bullet \bullet Alignments \bullet \circ Lines \circ \circ Density Features \circ \circ Geometric Moments \circ \circ Road Extraction \bullet \circ Cloud Detection \bullet \circ Cloud Detection \bullet \circ Urban Area Extract ion \circ \circ ClassificationSVM \circ \circ SOM \circ \circ \circ Change DetectorioSimple Detectors \circ \circ Multi-Scale \circ \circ \circ Detectors \circ \circ \circ Map Projection \bullet \circ \circ OrthorectificationSensor Models \bullet \circ Map Projection \bullet \circ \circ Image Registration \circ \circ \circ Change PublichRadiometry \bullet \circ Aligonithms \bullet \bullet \circ Aligonithms \bullet \bullet \circ Change Registration \circ \circ \circ CorrectionRadiometry \bullet \bullet Aligonithms \bullet \bullet \bullet Anomaly Detectorion \circ \circ \circ Map Projections \bullet \bullet \bullet Aligonithms \bullet \bullet \bullet Aligo			٠	•	
Convolution Filter•••Convert \blacktriangle •••Rasterization••••Rasterization••••Textures••••Alignments••••Interest Points••••Alignments••••Density Features••••Geometric Moments••••Principal Component••••Analysis••••Road Extraction••••Image SegmentationRegion growing•••Image SegmentationK-Means•••ClassificationSVM•••Change Detectors••••Multi-Scale••••Detectors••••MUVI•••••ARVI•••••Orthorectificationmap Projections•••Image FusionFusion Algorithms•••Map Projections••••Multi-Scale••••Detectors••••Map Projections••••Mage FusionFusion Algorithms••			•	A	0
Convert A • A Rasterization •			•	0	0
Rasterization O O Interest Points O O O Alignments O O O O Lines O			•	•	•
Feature ExtractionTextures \bullet \circ Feature ExtractionGeometric Moments \bullet \circ Feature ExtractionGeometric Moments \bullet \circ Feature Extraction \bullet \circ \circ Geometric Moments \bullet \circ \circ Principal Component Analysis \bullet \circ Road Extraction \bullet \circ Cloud Detection \bullet \circ Image SegmentationRegion growing \bullet Region growing \bullet \bullet Level Set \circ \circ ClassificationSVM \circ Simple Detectors \circ \circ Multi-Scale Detectors \circ \circ Multi-Scale Detectors \circ \circ Multi-Scale Detectors \circ \circ Multi-Scale Detectors \circ \circ Orthorectification and Map Projection \bullet \bullet Image Fusion 	-			•	
Interest Points \bullet \bullet Alignments \circ \circ Lines \circ \circ Density Features \circ \circ Density Features \circ \circ Principal Component \bullet \circ Analysis \bullet \circ Road Extraction \bullet \circ Cloud Detection \bullet \circ Urban Area Extract ion \bullet \circ Image SegmentationRegion growing \bullet \bullet Region growing \bullet \bullet \bullet Level Set \circ \circ \bullet ClassificationSVM \circ \bullet Som \circ \circ \bullet Multi-Scale \circ \circ Detectors \bullet \circ Multi-Scale \circ \circ Detectors \bullet \circ Mage Projection A \bullet Image Registration \bullet \bullet CombineMosaic \bullet \bullet Image Registration \bullet \bullet CorrectionRadiometry \bullet \bullet Map Projections \bullet \bullet \bullet Image Registration \bullet \bullet \bullet CorrectionRadiometry \bullet \bullet Image Registration \circ \circ \bullet Image Registration \bullet \bullet \bullet Spectral Processing \circ \circ \bullet Transforms \circ \circ \bullet Solution \bullet \bullet \bullet Statistical Detecton \circ \bullet		Rasterization	•	0	0
Alignments \circ \circ Feature ExtractionDensity Features \circ \circ Geometric Moments \circ \circ \circ Principal Component Analysis \circ \circ Road Extraction \bullet \circ Cloud Detection \bullet \circ Image SegmentationRegion growing \bullet Level Set \bullet \circ Level Set \bullet \circ ClassificationSVM \circ SoM \circ \circ SoM \circ \circ Attistical Detectors \circ Change Detection \bullet Mathier Scale Detectors \circ NDVI \bullet ARVI \circ ARVI \circ OrthorectificationFusion AlgorithmsMap Projection \bullet Image Registration \bullet CorrectionRadiometryAnalysis \bullet Analysis \bullet Analysis \bullet Analysis \bullet Analysis \bullet Analysis \bullet Analysis \bullet Anomaly Detection \circ		Textures	•	0	0
Feature ExtractionLines \circ \circ Feature ExtractionGeometric Moments \circ \circ Analysis \circ \circ Road Extraction \bullet \circ Road Extraction \bullet \circ Image SegmentationRegion growing \blacktriangle Image SegmentationEvel Set \circ ClassificationSVM \bullet ClassificationSVM \circ SoM \circ \circ ClassificationSVM \circ Radiometry \bullet \circ Multi-Scale \circ \circ Detectors \bullet \circ Map Projection \bullet \circ Map Projections \bullet \bullet Image FusionFusion Algorithms \blacktriangle CorrectionRadiometry \bullet Arget Detectors \circ \circ Spectral Processing \circ \circ Target Detection \circ \circ Arget Detection<		Interest Points	•		0
Feature ExtractionLines \circ \circ Feature ExtractionGeometric Moments \circ \circ Analysis \circ \circ Road Extraction \bullet \circ Road Extraction \bullet \circ Image SegmentationRegion growing \blacktriangle Image SegmentationEvel Set \circ ClassificationSVM \bullet ClassificationSVM \circ SoM \circ \circ ClassificationSVM \circ Radiometry \bullet \circ Multi-Scale \circ \circ Detectors \bullet \circ Map Projection \bullet \circ Map Projections \bullet \bullet Image FusionFusion Algorithms \blacktriangle CorrectionRadiometry \bullet Arget Detectors \circ \circ Spectral Processing \circ \circ Target Detection \circ \circ Arget Detection<		Alignments	٠	0	0
Feature Extraction Geometric Moments •			•	0	0
Feature Extraction Geometric Moments •		Density Features	•	0	0
Principal Component Analysis \circ \circ Road Extraction \circ \circ Road Extraction \circ \circ Cloud Detection \bullet \circ Urban Area Extract ion \circ \circ Image SegmentationRegion growing \bullet \bullet Region growing \bullet \bullet \bullet Level Set \bullet \circ \circ ClassificationSVM \bullet \circ SOM \bullet \circ \circ Change DetectionSimple Detectors \bullet \circ Multi-Scale Detectors \circ \circ \circ RadiometryARVI \bullet \circ ARVI \bullet \circ \circ Multi-Scale Detectors \circ \circ Orthorectification and Map ProjectionMap Projections \bullet Image FusionFusion Algorithms \blacktriangle \bullet Image RegistrationFusion Algorithms \blacktriangle \bullet CorrectionRadiometry \bullet \bullet Material ID \circ \circ \circ Spectral Processing \circ \circ \circ Target Detection \circ \circ \circ Anomaly Detection \circ \circ \circ SAR ProcessingSpeckle Remove \circ \circ SAR ProcessingSegmentation \circ \circ Compute Intensity \bullet \circ \circ Compute Intensity \bullet \circ \bullet Compute Intensity \bullet \circ \bullet A \bullet \bullet \bullet <t< td=""><td></td><td></td><td>•</td><td>0</td><td>0</td></t<>			•	0	0
Analysis \bullet \circ Road Extraction \circ \circ Cloud Detection \bullet \circ Urban Area Extract ion \bullet \circ Image SegmentationRegion growing \bullet \bullet Region growing \bullet \bullet \bullet Level Set \bullet \circ \bullet ClassificationSVM \bullet \circ SOM \bullet \circ \bullet Change DetectionSimple Detectors \bullet \circ Multi-Scale \bullet \circ \bullet Detectors \bullet \circ \bullet RadiometryARVI \bullet \bullet ARVI \bullet \bullet \bullet OrthorectificationSensor Models \bullet \bullet Image FusionFusion Algorithms \bullet \bullet Image RegistrationMosaic \bullet \bullet CorrectionRadiometry \bullet \bullet Map Projection \circ \circ \bullet Image Registration \bullet \bullet \bullet CorrectionRadiometry \bullet \bullet Spectral Processing \circ \circ \bullet Transforms \circ \circ \bullet SAR ProcessingSegmentation \circ \circ SAR ProcessingSegmentation \circ \circ Compute Intensity \bullet \circ \bullet Compute Intensity \bullet \circ \bullet Ration \circ \circ \bullet CorrectionRadiometry \bullet \bullet CorrectionRadiometry \bullet <td></td> <td></td> <td></td> <td></td> <td></td>					
Road Extraction \circ \circ Cloud Detection \circ \circ Urban Area Extract ion \circ \circ Image SegmentationRegion growing \bullet \bullet Image SegmentationK-Means \circ \circ ClassificationSVM \circ \circ ClassificationSVM \circ \circ Change DetectionSimple Detectors \circ \circ Multi-Scale Detectors \circ \circ \circ RadiometryARVI \circ \circ ARVI \circ \circ \circ Orthorectification and Map ProjectionSensor Models \bullet Image FusionFusion Algorithms Alagorithms \blacktriangle \bullet CombineMosaic \bigstar \bullet Image Registration CorrectionRadiometry \bullet \circ Spectral Processing Anomaly Detection \circ \circ Spectral Processing \circ \circ \circ SAR Processing \circ \circ \circ Compute Intensity \bullet \circ \circ Compu		Analysis	•	0	•
Cloud Detection \circ \circ Urban Area Extract ion \circ \circ Image SegmentationRegion growing \bullet \bullet Level Set \circ \circ ClassificationSVM \circ \circ ClassificationSVM \circ \circ Change DetectionSimple Detectors \circ \circ Change DetectionSimple Detectors \circ \circ Multi-Scale Detectors \circ \circ \circ RadiometryARVI \bullet \circ Orthorectification and Map ProjectionSensor Models \bullet \circ Image FusionFusion Algorithms \blacktriangle \checkmark CombineMosaic \blacktriangle \bullet \bullet Image Registration CorrectionRadiometry \bullet \bullet Spectral Processing SAR Processing \circ \circ \circ SAR Processing \circ \circ \circ \circ SAR ProcessingSegmentation Compute Intensity \bullet \circ SAR Processing \circ \circ \circ Segmentation \circ \circ \bullet Solution \circ \circ \circ Solution \circ \circ \circ SupportSegmentation \circ <td< td=""><td></td><td></td><td>•</td><td>0</td><td>0</td></td<>			•	0	0
Urban Area Extract ion \circ Image SegmentationRegion growing \bullet Image SegmentationK-Means \circ ClassificationSVM \circ ClassificationSVM \circ Change DetectoronSimple Detectors \circ Change DetectoronStatistical Detectors \circ Change DetectoronStatistical Detectors \circ RadiometryNDVI \bullet \bullet ARVI \circ \circ Orthorectification and Map ProjectionMoales \bullet Image FusionFusion Algorithms \bullet \bullet CombineMosaic \bullet \bullet Image RegistrationRadiometry \bullet \bullet Spectral Processing \circ \circ \bullet Spectral Processing \circ \circ \bullet SAR Processing \circ \circ \circ <td></td> <td></td> <td>-</td> <td>-</td> <td>0</td>			-	-	0
Image SegmentationRegion growing Level Set \land ClassificationK-Means \circ ClassificationSVM \circ Change DetectoronSimple Detectors \circ Change DetectoronStatistical Detectors \circ Change DetectoronStatistical Detectors \circ RadiometryNDVI \bullet \bullet RadiometryARVI \circ \circ Orthorectification and Map ProjectionFusion Algorithms \bullet Image FusionFusion Algorithms \bullet \bullet CombineMosaic \bullet \bullet Image RegistrationRadiometry \bullet \bullet Spectral Processing \circ \circ \bullet Spectral Processing \circ \circ \bullet Spectral Processing \circ \circ \bullet Speckle Remove \circ \circ \bullet SAR Processing \circ \circ \circ Sagementation \circ \circ \circ SourceSegmentation \circ \circ Source \bullet \circ \circ </td <td></td> <td></td> <td></td> <td>-</td> <td>0</td>				-	0
Image SegmentationLevel Set \bullet \circ \circ ClassificationSVM \bullet \circ \circ ClassificationSVM \bullet \circ \circ Change DetectionSimple Detectors \bullet \circ \circ Change DetectionStatistical Detectors \bullet \circ \circ Change DetectionStatistical Detectors \bullet \circ \circ RadiometryNDVI \bullet \bullet \circ RadiometryARVI \bullet \circ \circ Orthorectification and Map ProjectionSensor Models \bullet \circ Orthorectification and Map ProjectionFusion Algorithms \bullet \bullet Image FusionFusion Algorithms \bullet \bullet \bullet CombineMosaic \bullet \bullet \bullet Image Registration \bullet \bullet \bullet \bullet CorrectionRadiometry \bullet \bullet \bullet Spectral Processing \circ \circ \bullet \bullet Spectral Processing \circ \circ \bullet \bullet SAR Processing \circ \circ \bullet \bullet SAR Processing \circ \circ \bullet \bullet SAR Processing \circ \circ \bullet \bullet Compute Intensity \bullet \circ \bullet \bullet Compute Intensity \bullet \circ \bullet \bullet Compute Intensity \bullet \bullet \bullet \bullet Compute Intensity \bullet \bullet \bullet \bullet Compute Intensity \bullet					
ClassificationK-Means \circ \circ ClassificationSVM \circ \circ SOM \circ \circ Change DetectionSimple Detectors \circ Change DetectionStatistical Detectors \circ Statistical Detectors \circ \circ Multi-Scale \circ \circ Detectors \circ \circ Radiometry \bullet \circ ARVI \bullet \circ Orthorectification and Map ProjectionSensor Models \bullet Orthorectification and Map ProjectionFusion Algorithms \bullet Image FusionFusion Algorithms \bullet \bullet CombineMosaic \bullet \bullet Image Registration \circ \circ CorrectionRadiometry \bullet \bullet Anomaly Detection \circ \circ Material ID \circ \circ Data Merge \circ \circ Tool \circ \circ SAR Processing \circ \circ SAR Processing \circ \circ Compute Intensity \bullet \circ Compute Intensity \bullet \circ Compute Intensity \circ \circ					0
ClassificationSVM \bullet \circ SOM \bullet \circ \circ Som \bullet \circ Change DetectionStatistical Detectors \bullet \circ Multi-Scale \bullet \circ \circ Detectors \bullet \circ \bullet RadiometryARVI \bullet \bullet ARVI \bullet \circ \bullet Orthorectification and Map ProjectionSensor Models \bullet Orthorectification and Map ProjectionFusion Algorithms \bullet Image FusionFusion Algorithms \bullet \bullet CombineMosaic \bullet \bullet Image Registration \bullet \bullet \bullet CorrectionRadiometry \bullet \bullet Anomaly Detection \circ \circ \bullet Spectral Processing \circ \circ \bullet Transforms \circ \circ \bullet SAR Processing \circ \circ \circ SAR Processing \circ \circ \circ Compute Intensity \bullet \circ \circ Compute Intensity \bullet \circ \bullet Compute Intensity \bullet \bullet \bullet Compute Compute Intensity \bullet \bullet <			-	-	0
SOM • 0 0 Change Detection Simple Detectors • 0 0 Statistical Detectors • 0 0 0 Multi-Scale • 0 0 0 Detectors • 0 0 0 Radiometry ARVI • 0 0 Orthorectification and Map Projection Sensor Models • 0 0 Image Fusion Fusion Algorithms • • 0 0 Image Registration • • • 0 0 Correction Radiometry • • 0 0 Spectral Processing • • • 0 0 0 Spectral Processing • • • • 0 <	-		•	-	0
Simple Detectors \circ Change DetectionStatistical Detectors \circ Multi-Scale Detectors \circ \circ RadiometryNDVI \bullet \bullet RadiometryARVI \circ \circ Orthorectification and Map ProjectionSensor Models \bullet \bullet Image FusionFusion Algorithms \bullet \bullet CombineMosaic \bullet \bullet Image Registration \bullet \bullet \bullet CorrectionRadiometry \bullet \bullet Material ID \circ \circ \bullet Preprocessing \circ \circ \bullet Spectral Processing \circ \circ \bullet SAR ProcessingSpeckle Remove \circ \circ SAR Processing \circ \circ \circ SAR Processing \circ \circ \circ Compute Intensity \bullet \circ \circ Sourcessing \circ \circ \circ Stata Marcessing \circ \circ Sourcessing \circ \circ Substantion <td>_</td> <td></td> <td>•</td> <td>-</td> <td>0</td>	_		•	-	0
Statistical Detectors \circ Multi-Scale Detectors \circ RadiometryNDVI \bullet ARVI \circ ARVI \circ ARVI \bullet Orthorectification and Map ProjectionSensor ModelsOrthorectification and Map Projections \bullet Image FusionFusion Algorithms \bullet CombineMosaic \bullet Image Registration \bullet CorrectionRadiometry \bullet Image Registration \circ CorrectionRadiometry \bullet Preprocessing \circ \circ Image Registration \circ \circ CorrectionRadiometry \bullet Spectral Processing \circ \circ Spectral Processing \circ \circ Speckle Remove \circ \circ SAR Processing \circ \circ SAR Processing \circ \circ Compute Intensity \bullet \circ Segmentation \circ \circ Source Star \circ \circ Star			٠	-	0
Multi-Scale Detectors \circ Multi-Scale Detectors \circ RadiometryNDVI \bullet ARVI \circ ARVI \circ \circ \circ AVI \bullet Orthorectification and Map Projection \bullet Image FusionFusion Algorithms \bullet Image FusionFusion Algorithms \bullet CombineMosaic \bullet Image Registration \bullet \bullet CorrectionRadiometry \bullet Anomaly Detection \circ \bullet Material ID \circ \circ Preprocessing \circ \circ Transforms \circ \circ Data Merge \circ \circ SAR Processing \circ \circ SAR Processing \circ \circ Compute Intensity \bullet \circ Compute Intensity \bullet \circ Compute Intensity \bullet \circ			•		0
Multi-Scale Detectors •			•	0	0
Detectors NDVI • ▲ △ Radiometry ARVI • ○ △ AVI • ○ ○ ○ Orthorectification and Map Projection Sensor Models • ○ ○ Image Fusion Fusion Algorithms ▲ ▲ △ Combine Mosaic ▲ △ △ Image Registration • ▲ △ △ Correction Radiometry • ▲ △ Anomaly Detection ○ ○ △ Spectral Processing ○ ○ △ Transforms ○ ○ ○ Tool ○ ○ ○ ○ SAR Processing Speckle Remove ○ ○ ○ Segmentation ○ ○ ○ ○	-			0	0
RadiometryARVI \bullet \circ AVI \bullet \circ \circ AVI \bullet \circ Orthorectification and Map ProjectionSensor Models \bullet Image FusionFusion Algorithms \blacktriangle \bullet Image FusionFusion Algorithms \blacktriangle \bullet CombineMosaic \blacktriangle \bullet Image Registration \bullet \bullet CorrectionRadiometry \bullet Anomaly Detection \circ \bullet Anomaly Detection \circ \bullet Spectral Processing \circ \circ Preprocessing \circ \circ Speckle Remove \circ \circ SAR Processing \circ \circ SAR Processing \circ \circ Compute Intensity \bullet \circ Compute Intensity \bullet \circ		Detectors	-	-	
AVI \bullet \circ Orthorectification and Map ProjectionSensor Models \bullet \bullet Image Fusion CombineFusion Algorithms \blacktriangle \bullet Image Registration CorrectionMosaic \blacktriangle \bullet CorrectionRadiometry \bullet \bullet Target Detection \circ \bullet \bullet Material ID \circ \circ \bullet Preprocessing \circ \circ \bullet Spectral Processing \circ \circ \bullet SAR ProcessingSpeckle Remove \circ \circ SAR Processing \circ \circ \circ Compute Intensity \bullet \circ \bullet Solution \circ \circ \circ Solution		NDVI	•	A	
Orthorectification and Map Projection Sensor Models Map Projections Map Projections Orthorectification Fusion Algorithms Mosaic Mosaic	diometry	ARVI	•	0	0
Orthorectification and Map Projection Map Projections • • • Image Fusion Fusion Algorithms ▲ • • • Combine Mosaic ▲ • • • • Image Registration • ▲ • • • • • Correction Radiometry • ● • <		AVI	•	0	0
Map Projections • • • Image Fusion Fusion Algorithms ▲ • • Combine Mosaic ▲ • • • Image Registration • ● •<	themestification	Sensor Models	•	•	•
and Map Projection Orthorectification • • • Image Fusion Fusion Algorithms ▲ ▲ • Combine Mosaic ▲ • ▲ Image Registration • ▲ • ▲ Correction Radiometry • • • • Correction Radiometry • • • • Anomaly Detection • • • • • Spectral Processing • • • • • • Transforms • • • • • • • SAR Processing Speckle Remove • • • • • • SAR Processing • • • • • • • • SAR Processing • <td></td> <td>Map Projections</td> <td>٠</td> <td>•</td> <td>٠</td>		Map Projections	٠	•	٠
Combine Mosaic A • A Image Registration • A • A Correction Radiometry • • A Correction Radiometry • • • Target Detection • • • • Anomaly Detection • • • • Spectral Processing • • • • Preprocessing • • • • Data Merge • • • • Tool • • • • SAR Processing Segmentation • • •			٠	•	٠
Combine Mosaic A • A Image Registration • A • A Correction Radiometry • • A Correction Radiometry • • • Target Detection • • • • Anomaly Detection • • • • Spectral Processing • • • • Preprocessing • • • • Data Merge • • • • Tool • • • • SAR Processing Segmentation • • •	age Fusion	Fusion Algorithms			
Correction Radiometry •				•	
Correction Radiometry •	age Registration		•		
Target Detection 0 0 Anomaly Detection 0 0 Material ID 0 0 Preprocessing 0 0 Transforms 0 0 Data Merge 0 0 Tool 0 0 SAR Processing 0 0 Segmentation 0 0		Radiometry	•		0
Anomaly Detection 0 0 Material ID 0 0 Preprocessing 0 0 Transforms 0 0 Data Merge 0 0 Tool 0 0 Speckle Remove 0 0 Edge Detect 0 0 Segmentation 0 0 Compute Intensity 0 0	concetion		-	-	•
Material ID 0 0 0 Spectral Processing 0 0 0 Transforms 0 0 0 Data Merge 0 0 0 Tool 0 0 0 Speckle Remove 0 0 0 Edge Detect 0 0 0 Segmentation 0 0 0 Compute Intensity 0 0 0					•
Spectral Processing 0 0 0 Transforms 0 0 0 Data Merge 0 0 0 Tool 0 0 0 SAR Processing Segmentation 0 0 Compute Intensity 0 0 0					•
Transforms O O Data Merge O O Tool O O Speckle Remove O O Edge Detect O O Segmentation O O Compute Intensity O O					•
Data Merge O O Tool O O Speckle Remove O O Edge Detect O O Segmentation O O Compute Intensity O O	spectral Processing				
Tool O O Speckle Remove • O Edge Detect • O SAR Processing Segmentation O Compute Intensity • O					-
SAR ProcessingSpeckle Remove••••SAR ProcessingSegmentation••••Compute Intensity•••••					•
Edge Detect••SAR ProcessingSegmentation••Compute Intensity•••	CAD Decession				•
SAR ProcessingSegmentationOOCompute Intensity•O					•
Compute Intensity • •					•
			0		
			•	0	
Calibration••Object Based Image Analysis••		Calibration	•	0	•

Table 1.	Comparative	list for	function	types of	OTB,
	OSSIM and O	pticks, a	s of the ha	lf of 2011.	

OTD OCCIM Out day

[Note] •: Supported feature, \blacktriangle : Partly supported feature, \circ : Weakly supported feature.

		ROI_PAC 3.0.1	DORIS 4.04	GMTSAR GMT 4.5.5
Command	Line	•	•	•
GUI		×	×	×
InSAR		•	٠	•
DInSAR		•	•	•
Geocoding		•	٠	•
Supported Operating System		Linux/ Unix	Linux/ MacOSX/ Unix	MacOSX, Linux
	ERS-1&2	•	•	•
	ENVISAT	•	•	•
Supported SAR Data	RADARSAT	•	٠	0
	JERS-1	•	٠	0
	ALOS PALSAR	•	٠	•
	TERRASAR-X	•	٠	•
	COSMO-SkyMed	•	•	0

Table 2. Comparative list for function types of DORIS,ROI_PAC and GMTSAR, as of June, 2011.

which is open source software for InSAR processing having command line interface.

Furthermore, new modules for database and metadata are added. Consequently, we can search and display the results of InSAR processing in mobile app in Kang and Lee [3]. Kang and Lee's study [2] started to improve the existing programs for remote sensing. As mentioned in the second section, most of open source software doesn't provide user friendly interface and it causes the limits of public user access. DORIS is good to deal with InSAR process but inconvenient because users should manually correct files using edit programs and execute them using command. Even if software offers many functions, users won't choose the software if it were not intuitive and convenient. However, users can improve open source software through customizing as open source code is publicly available. Kang and Lee [2] integrated various open source applications to offer the functions in DORIS using GUI. DORIS was used as core program to handle InSAR process and FLTK for developing GUI, OTB to display SAR images, PostgreSQL and Post GIS for database are used. Android 2.2, which is open operating system, is used for mobile app. For browsing app, gvSIG was used. Fig. 1 shows the process to modify files and to execute program in Linux terminal. In Fig. 2, the GUI of software developed by Kang and Lee is presented.

The second case is approach for GEOBIA with database (Lee and Kang [5]). This is different from other software for OBIA based on file system because it used database, open source software and library. This pilot program was implemented to deal with GIS data and remotely sensed images simultaneously integrating various open source applications. FLTK is supporting GUI part. PostgreSQL and PostGIS

[moto@aaa Inputfiles]\$ ls input.coregistration input.filter_unwrap inp	ut.m_initial input.products
(b)	Open
# READFILES (master)	
· · · · · · · · · · · · · · · · · · ·	
C M_IN_METHOD JERS C M_IN_METHOD RSAT	// uses ERS ceos reader // uses RSAT ceos reader
MIN_METHOD ATLANTIS	<pre>// uses RSAT ceos reader // uses ALOS ceos reader</pre>
<pre>#_IN_MEINOD ALOS # select following 5 for ERS ceos reader</pre>	
1_IN_METHOD ERS	// default
1_IN_VOL /CDROM/SCENE1/VDF_DAT.001	<pre>// slc volume file // slc lenderfile</pre>
vol /coron/scenel/vor_onl.001 4_IN_LEA /coron/scenel/vor_onl.001 4_IN_DAT /coron/scenel/vor_onl.001 IN_DAT /coron/scenel/vor_onl.001 IN_NULL dummy	// slc data file
1_IN_NULL dummy	11
, #or select following 2 for ERS	
M_IN_METHOD ERS_N1	// ERS1/2 in Envisat format
M_IN_DAT SAR_IMS_1PXDLR19951008_144123	_00000017G150_00096_22128_3605
, #or select following 2 for ENVISAT	
M_IN_METHOD ASAR	// ENVISAT
M IN DAT ASA IMS 1PXPDE19911013 214038	00000015X000 00000 04784 0002
(c)	
[moto@aaa Inputfiles]\$ [moto@aaa Inputfiles]\$ doris ./input.m_initial	Execute
INFO : @(#)Doris InSAR software, \$Revision:	
INFO : @(#)Doris insak software, skevision: INFO : input file: "./input.m initial"	TIOTIT \$, \$MULHOI: IDDELIL \$
INFO : Current time: Sun Nov 13 17:18:29 20	11
INFO : SCREEN: verboseness:	INFO
INFO : BEEP: beeping enabled at lev	el: WARNING
INFO : PREVIEW: ON: generation of SUNr	aster files enabled.
INFO : ORB INTERP: polynomial fit for inte	rpolation

Fig. 1. (a) The part of DORIS execution file, (b) Some of contents of input.m_initial file and (c) the example of input.m_initial execution.

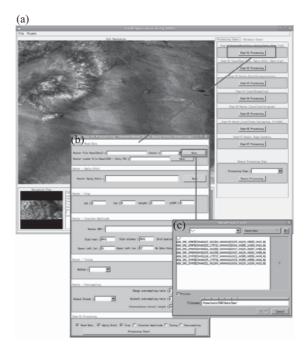


Fig. 2. (a) The main frame of software for InSAR processing based on DORIS, (b) The window for master imaging and (c) the dialogue to open SAR image.

which are open source DBMS are used to save shapefiles and results of the software. The program is developed through combining various open sources for different functions. Although an open source has been developed and used for one or

[[]Note] •: Supported feature, \circ : Weakly supported feature, \times : Not supported feature.

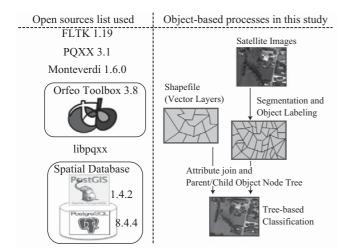


Fig. 3. Work flow for object-based processing and open sources used in this study. More detailed description in [5].

multi-purpose, advantages might be highlighted through combining various open sources. Currently, most of open sources software for remote sensing consist of several open sources and this type will be maintained and used more frequently. The basic ideas about GEOBIA and the list of used open sources which are suggested by Lee and Kang [5] is shown in Fig. 3.

Fig. 4 shows the display windows of the implemented software.

IV. CONCLUDING REMARKS

In this study, we described fundamentals of open source for remote sensing and compared functions in more detail than previous studies. We believe that outcomes of this study will be of help to select adequate open source software and to replace commercial software with open source software. Meanwhile, developers can refer to this study in order to save time for developing programs, to secure the reliability and to add or modify functions. Moreover, two cases of open source software for remote sensing were implemented. The implemented open source applications have many advantages compared with existing applications. They provide user friendly interface so users who don't know programming languages can access these applications easily. GIS and RS data which should be processed separately can be handled and displayed simultaneously in a single application. Moreover, functions for searching from database and visualization in mobile devises are implemented.

Consequently, the quality of open source software is as good as commercial software, but actual applications of open source software are relatively few due to some problems. However application areas have been expanded, and functions and reliability have been improved due to strengths of open source applications. Therefore open source will be more important and more useful. We expect that open sources in

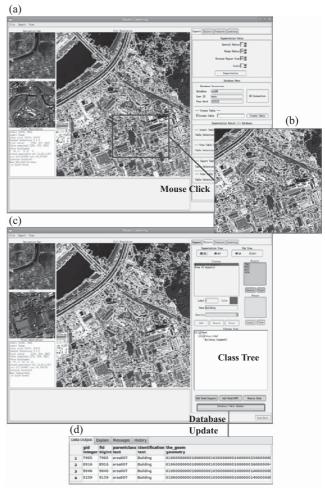


Fig. 4. The execution display of GEOBIA software: (a) Display window for the result of satellite image segmentation, (b) Display window for clicked image, and (c) Overlay polygon shape and segmentation/the sub-window for class tree and (d) Result of updated database.

remote sensing field will be widely used through this study to introspect and prospect open sources using actual applications. Also, this research will be a good guide for users and developers of OSRS. Concerning the further work, these implementations are now prototype versions, so that more strategic consideration and practical modification are necessary. As well, open source application will be tested in a target purpose dealing with multiple formats or types in remote sensing area, not limited to generic or general uses.

ACKNOWLEDGMENTS

This research was financially supported by Hansung University.

APPENDIX

The URL list of open sources cited or used in this study.

- OTB: http://www.orfeo-toolbox.org/otb/
- OSSIM:
- http://www.ossim.org/OSSIM/OSSIM_Home.html • Opticks:
 - http://opticks.org/confluence/display/opticks/Welcome+To +Opticks
- PostGIS: http://postgis.refractions.net/
- PostgreSQL: http://www.postgresql.org/
- ROI_PAC: http://pages.uoregon.edu/das/WikiRoiPac/doku.php
- DORIS: http://doris.tudelft.nl/
- GMTSAR: http://topex.ucsd.edu/gmtsar/

REFERENCES

1. Christophe, E., Inglada, J., and Giros, A., "Orfeo toolbox: A complete solution for mapping from high resolution satellite images," *The International Archives of the Photogrammetry, Remote Sensing and Spatial In-*

formation Sciences, Vol. XXXVII, Part B4 (2008).

- Kang, S. and Lee, K., "Design and prototype implementation of smartphone application for InSAR information service," *Korean Journal of Remote Sensing*, Vol. 27, No. 5, pp. 555-563 (2011).
- 3. Kang, S. and Lee, K., "Mobile application of open source remote sensing using DORIS and OTB as application server," *2011 Proceedings of Asian Conference on Remote Sensing*, Taiwan, Taipei (2011).
- Lee, K. and Kang, S., "Open source remote sensing of ORFEO Toolbox and its connection to database of PostGIS with NIX File importing," *Korean Journal of Remote Sensing*, Vol. 26, No. 3, pp. 361-371 (2010).
- Lee, K. and Kang, S., "Applicability of geo-spatial processing open sources to Geographic Object-based Image Analysis (GEOBIA)," *Korean Journal of Remote Sensing*, Vol. 27, No. 3, pp. 379-388 (2011).
- Simonetto, E. and Follin, J.-M., "An overview on interferometric SAR Software and a comparison between DORIS and SARScape package," Presentation material in International Opensource Geospatial Research Symposium, France, Nantes (2009).
- Steiniger, S. and Hay, G. J., "Free and open source geographic information tools for landscape ecology," *Ecological Informatics*, Vol. 4, No. 4, pp. 183-195 (2009).