COMPARISON ANALYSIS OF ESA SOFTWARE PRODUCTS AND THEIR FUNCTIONALITY FOR INTERFEROMETRIC PROCESSING

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Abstract. The main goal of this paper is to present a comparison analysis of the existing ESA Software Products and their functionality for interferometric image processing. In particular the BEST and NEST software are investigated. The emphasize is made on the structure of the Software Products.

Keywords: ESA, InSAR, Interferometrics, SAR.

INTRODUCTION

Interferometric Synthetic Aperture Radar (InSAR) is an exciting and promising technique for the application of remote sensing data which has been substantially advanced in recent years through European Space Agency [1] (ESA) satellites European Remote Sensing [2] (ERS) 1&2 and Envisat [3].

Using the InSAR technique, it is possible to produce directly from Synthetic Aperture Radar (SAR) image data, detailed and accurate three-dimensional height maps of the Earth's surface topography.

These possibilities open up many new potential applications of space-borne SAR data in the areas of cartography, volcanology, geomorphology, ice/glacial motion and land surface classification and motion.

The main goal of the present work is to consider the basic operations in the interferometric signal processing for SAR image extraction of the Earth surface and to perform a comparison analysis [6] of the opportunities and functionalities of the two basic software products BEST [4] (Basic Envisat SAR Toolbox) and NEST [5] (Next ESA SAR Toolbox).

MAIN OPERATIONS IN THE INTERFEROMETRIC PROCESSING

In accordance with the main purpose of this work it is necessary further to investigate the technicalities of the InSAR processing algorithms and to characterize their impact on the practical applications, in particular:

- phase unwrapping, which is a critical step in the production of Digital Elevation Models (DEM),
- optimizing coherence techniques and algorithms with geophysical applications,
- improvement technique of SAR image range resolution (super-resolution) by combining interferometrically several SAR images of the same area.

COMPARISON OF THE SOFTWARE PRODUCTS FUNCTIONALITY

Both BEST and NEST are free of charge Open Source software products and both are multiplatform applications working on Windows, Linux and Solaris operation systems. In the case with NEST it will be available for MAC OS X platform as soon as Apple supports the J2SE.

In order to investigate InSAR processing software instruments provided by ESA with both BEST and NEXT and to accomplish comparison analysis of their functionality it is necessary to underline the base operations that functional toolboxes support: co-registration, phase unwrapping for DEM production, SAR image range resolution improvements and functionality to combining several images that complete interferometric process.

The main qualitative and quantitative indexes to compare the functionality of the software products are: Generalized Information About the Product, Supported Platform, Toolbox Operational Features and Supported Data Product Formats. This information is listed in Table 1 below.

Table 1. Comparison of the Software Products

NEST	BEST
nest next esa sar toolbox	BEST Basic ENVISAT SAR Toolbox
Generalized Information The NEST [5] is used for reading, post-processing, analysing and visualising the large archive of data (from Level 1) from ESA SAR missions including ERS-1 & 2, ENVISAT and in the future Sentinel-1	**Generalized Information** BEST [4] is a collection of executable software tools that has been developed to facilitate the use of ESA SAR data. Toolbox impelements functions to handling of SAR products obtained from the ASAR onboard Envisat and the AMI onboard ERS 1&2.
Supported Platform NEST is programmed in Java and is open	**Supported Platform** The tools are portable on the following

source under the GNU GPL. Toolbox is tested under MS Windows™ XP® as well as under Linux and Solaris® operating systems. NEST will be available for Mac OS X as soon as Apple supports the J2SE 6 platform.	platforms: Windows™ 98//NT/XP, Linux, SUN(Sparc) For Windows™ users there is a familiar Visual Basic interface. The HMI for Linux and Solaris2™ users is written in TCL. The TCL/TK software must be installed prior to running BEST on these platforms.
Toolbox Operational Features • Complex Coregistration • New interface for Coregistration • Principle Component Analysis • ALOS PALSAR Calibration • Orbit File Correction - DORIS VOR, POR • HDF 4 & 5 reader, HDF 5 writer • NetCDF reader and writer • Data type conversion • PolsarPro Reader • Undersampling and Oversampling for Envisat and ERS products • Environment for Visualizing Images (ENVI) Reader • A DAT SAR data visualisation, analysis and processing. • A GPT for command line execution of batch processing chains. • A rich collection of readers and writers to allow easy and efficient access to SAR data, abstracted internal representation and output to common formats for compatibility with other software. • Read, display and calibrate ENVISAT ASAR and ERS 1 & 2 • Provide statistics, quick-looks and ingest parts or entire datasets • Convert data to COTS file formats for use with third-party software • Create and process graphs • Tiled image viewing and support for very large datasets	**Toolbox Operational Features** • Data Import and Quick Look: basic tools for extraction of data from standard format ESA SAR products, generation of quick look images, import of TIFF and GeoTIFF files and generic raster data. • Data Export: output of data to selected common formats (TIFF, GEOTIFF, BIL), generation of RGB composites. • Data Conversion: conversion between different image formats, transformation of data by flipping or slant range to ground range re-projection, calculation of sensitivity vectors. ASAR WSS Detection and azimuth mosaicking, Range mosaicking and multilook. • Statistical: calculation of global or local statistical parameters from real image data, computation of the principal components of multiple images. • Resampling: over and under sampling of an image by means of spatial and spectral methods. • Co-registration: automatic co-registration of two or more real or complex images (including ERS/Envisat pairs), evaluation of quality parameters. • Support for Interferometry: computation of orbital baseline from DORIS files, calculation of

• Coregistration of detected products • Slant Range to Ground Range conversion • Time domain mulitlook • Mean, Lee, Frost, Gamma Map Speckle Filtering • ASAR WSS Debursting • Band Arithmetic • Image Filtering • Third-party developers are able to extend software and add new readers, writers and operators.	interferometric coherence, evaluation of altitude of ambiguity. • Speckle Filtering: improvement of the radiometric resolution of a backscatter image. • Image Geo-correction: geocoding process to georeference input ASAR ground range detected product (i.e. ASA_IMP_1, ASA_IMM_1, ASA_WSM_1 etc.) and ERS-PGS (IMP, IMM) data. • Calibration: radiometric correction of Envisat and ERS images including retro-calibration of ASAR products and wide-swath image refinement.
Supported Data Product Formats • ALOS PALSAR • TerraSarX • Radarsat 2 • ENVISAT ASAR, MERIS, AATSR • ERS AMI 1 & 2 (CEOS & Envisat format from PGS and VMP) • JERS SAR • BEAM DIMAP • GeoTIFF • GETASSE30 DEM • ACE DEM	**Supported Data Product Formats** The Toolbox has been designed to handle ESA data products from both the Envisat ASAR instrument and the AMI on ERS 1&2. ASAR data acquired in Image Mode, Wide Swath Mode, Alternating Polarisation Mode or Global Monitoring Mode may be input, along with ERS image data processed both by the VMP processor and by the ERS PGS processor (CEOS and Envisat format). The Toolbox is capable of reading all Level 1b processed data and, in the case of ERS data, products from all 4 ESA Processing and Archiving Facilities plus many "foreign" stations.

NEST software product possesses some advantages in comparison with the BEST software product.

1. The architecture of NEST software toolbox is expanded with: Display and Analysis Tool (DAT) and Graph Processing Tool (GPT).

- DAT provides SAR data visualisation, analysis and processing functionality to the customer.
- GPT is a graphical utility for batch processing chains' execution.

2. NEST provides a rich collection of readers and writers with an abstract internal representation.

3. NEST allows users to develop their own new readers and writers for SAR data processing using Java API.

The NEST data flow and processing that includes: DAT and GPT functionality over the Product Model, Input (Readers) and Output (Writes) formats supported, is represented in Figure 1 [1].

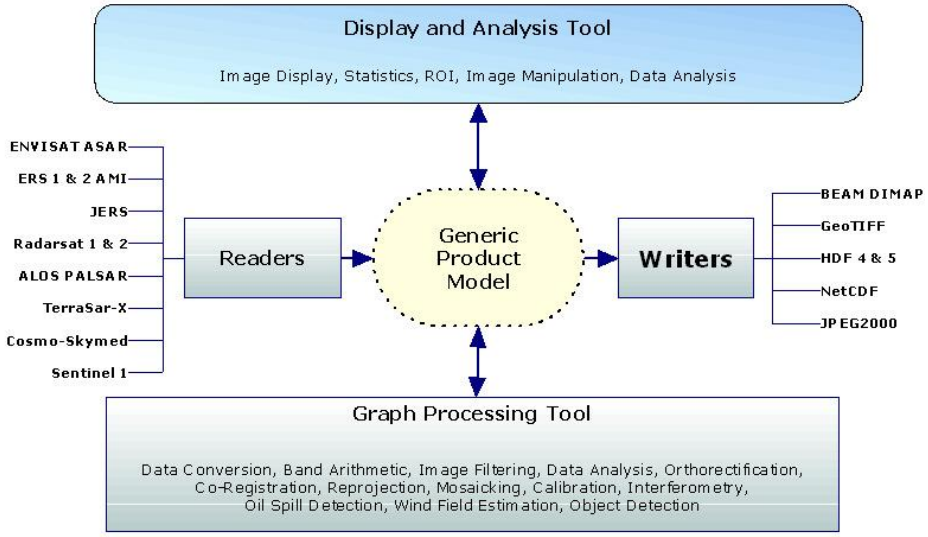

Figure 1. NEST data flow and processing.

CONCLUSIONS

NEST has been built using the Basic ERS & Envisat ATSR and BEAM Toolbox. NEST covers the functionality of the BEST. The new major functionalities of NEST in comparison with BEST are: integrated viewer, orthorectification and mosaicking of SAR images. Plus NEST allows users to easily develop new readers, writers and post-processors for SAR data by means of a Java API. Also NEST includes a DAT - SAR data visualisation, analysis and processing, a GPT for command line

execution of batch processing chains and a rich collection of readers and writers with an abstract internal representation to allow easy and efficient access to SAR data.

ACRONYMS AND ABBREVIATIONS

AATSR = Advanced Along-Track Scanning Radiometer

ALOS = Advanced Land Observing Satellite

AMI = Active Microwave Insrtument

API = Application Programming Interface

ASAR = Advanced SAR

BEAM = Basic ENVISAT Toolbox for (A)ATSR and MERIS

BEST = Basic Envisat SAR Toolbox

CEOS = Committee on Earth Observation Satellites

DAT = Display and Analysis Tool

DEM = Digital Elevation Models

DORIS = Doppler Orbit determination and Radiopositioning Integrated on Satellite

ENVI = Environment for Visualizing Images

ERS = European Remote Sensing

ESA = European Space Agency

GeoTIFF = Geostationary Earth Orbit Tagged Image File Format

GPL = General Public Licence

GTP = Graph Processing Tool

IM = Image Mode

IMS = Image Mode Single Look Complex

InSAR = Interferometric SAR

J2SE = Java 2 Platform, Standard Edition

JERS = Japanese Earth Resources Satellite

MERIS = The Medium Resolution Imaging Spectrometer

NEST = Next ESA SAR Toolbox

RGB = Red, Green, Blue

SAR = Synthetic Aperture Radar

TCL = Tool Command Language

TIFF = Tagged Image File Format

VMP = Verification Mode Processor

WSS = Wide Swath Single Look Complex

REFERENCES

[1] ESA website - http://www.esa.int

[2] ERS ESA satellite website - http://ers.esa.int/

[3] Envisat ESA satellite website - http://envisat.esa.int/

[4] BEST - http://earth.esa.int/best/

[5] NEST - http://www.array.ca/nest/

[6] Comparattve Analysis - http://www.fas.harvard.edu/~wricntr/documents/CompAnalysis.html