Professional SAR Data Processing

SAR Tutorial at EUSAR 2012 in Nürnberg (Germany)
Dr. Thomas Bahr

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Agenda

SAR Exploitation in an operational environment

09:00 Professional SAR Data Processing
   Thomas Bahr, EXELIS Visual Information Solutions, D

11:00 Operational Monitoring and SAR Applications with TerraSAR-X
   Oliver Lang, Astrium GEO-Information Services, D

14:00 Rapid Mapping and operational monitoring exploiting the capabilities of the COSMO Skymed Constellation
   Robert Siegmund, GAF, D

16:00 Forest Mapping using SAR
   Alberto Meroni, EXELIS Visual Information Solutions, I

17:00 Discussion / End of Tutorial
Exelis Visual Information Solutions

Our Mission:
Empowering people to easily extract useful information from complex data in the pursuit of discovery.

Our Company:
Exelis Visual Information Solutions creates software technologies to help professionals access, analyze and share data and imagery.

Combined with a host of support services, we offer the most complete data visualization, image processing and image delivery solutions available today for desktop and enterprise environments.

Our Products & Services

ENVI
The Complete Image Processing Platform

ENVI is the premier application for extracting geospatial information from remotely-sensed imagery.

SARscape
The Solution for SAR Data Processing

SARscape is the world leading application for processing SAR data with the help of advanced algorithms.

E3De
LiDAR Visualization & Feature Extraction

E3De addresses user needs across industries to quickly and accurately get 3-D products from LiDAR data.

IDL
The Data Analysis & Visualization Environment

IDL is a programming environment used for data analysis, visualization and cross-platform application development.

Consulting & Training
Custom software development, system integration, project management, training, and technical support.
SAR Data Processing

Supported Spaceborne SAR Sensors

- COSMO-SkyMed -5/6/7/8: 2014 - X-band <1 - 100 m
- SAOCOM -1/2: 2013/2014 - L-Band 10 - 100 m
- ALOS-2: 2013 - L-Band 1 - 10 m
- SENTINEL-1 A&B: 2012/2013 - C-band 5 - 25 m
- RISAT-1: 2012 - C-band 2 - 50 m
- PAZ: 2012 - X-band 1 / 3 / 16 m
- Tandem-X: 2010 - X-band 1 / 3 / 16 m
- SAR-Lupe 1-5: 2006 - 2008 - X-band 0.5 / 1 m
- COSMO-SkyMed -1/2/3/4: 2007 - 2010 - X-band <1 - 100 m
- RADARSAT-2: 2007 - C-band 1 - 100 m
- TerraSAR-X-1: 2007 - X-band 1 / 3 / 16 m
- ALOS PALSAR: 2005 († 2011) - L-band 7 - 100 m
- ENVISAT-ASAR: 2002 († 2012) - C-band 15 - 1000 m
- RADARSAT-1: 1995 - C-band 8 - 100 m
- ERS-2 SAR: 1995 († 2011) - C-band 25 - 1000 m
- JERS-1 SAR: 1992 († 1998) - L-band 18 m
- ERS-1 SAR: 1991 († 2000) - C-band 25 - 1000 m
Supported Airborne SAR Sensors

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Band</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>OrbiSAR-1</td>
<td>X/P-band</td>
<td>3.3 m</td>
</tr>
<tr>
<td>TELAER</td>
<td>X-band</td>
<td></td>
</tr>
<tr>
<td>E-SAR</td>
<td>X/C/L/P-band</td>
<td>0.25 / 0.3 / 0.4 / 0.5 m</td>
</tr>
<tr>
<td>RAMSES</td>
<td>Ku/Ka/X/C/S/L/P-band</td>
<td>0.9 m (X-band)</td>
</tr>
</tbody>
</table>

SARscape Modules

SARscape Basic Module

- Includes processing functionality for generating airborne and spaceborne SAR products, based on intensity & coherence.
- The following processing capabilities are supported:
  - Multilooking
  - Coregistration
  - Despeckling
  - Geocoding and Radiometric Calibration
  - Mosaicking
  - Feature Extraction
  - Segmentation
  - Classification

© DLR

© COSMO SkyMed 1 & 2 StripMap data, ASI
SARscape Modules

SARscape Basic Module
> This module is complemented by:
  > Focusing Module
    Provides Single Look Complex (SLC) products starting from the following raw data:
    ERS-1/2 SAR, JERS-1 SAR, ENVISAT ASAR, and ALOS PALSAR-1 data.
  > Gamma & Gaussian Filter Module
    Includes SAR-specific filters and algorithms based on Gamma/Gaussian-distributed scene models.
    For SLC data, polarimetric SAR data, Single channel & multi-channel detected data.

King Fahd International Airport, Dammam, Saudi Arabia
COSMO SkyMed Spotlight, “SLC Gaussian DE MAP” filtered
© Cosmo SkyMed data, ASI - eGEOUS

SARscape Interferometry Module
> Enables the generation of DEMs (InSAR technique) and surface deformation maps (DInSAR technique).
> InSAR generates accurate (up to a vertical resolution of few meters) and detailed surface and terrain height products.
> DInSAR can detect centimeter-scale displacements over time spans of days to years.
> Applications:
  > Geophysical monitoring of natural hazards like earthquakes, volcanoes, and landslides.
  > Structural engineering, particularly for the monitoring of subsidence and structural stability.
  > ...

Differential interferogram, Bam, Iran. © ENVISAT ASAR data, ESA
DEM based on TerraSAR-X StripMap, Bolivia. © TerraSAR-X data, Infoterra
SARscape Modules

**SARscape Interferometry Module**

- This module is complemented by:
  - **ScanSAR Interferometry Module**
    - Offers the capabilities to process InSAR and DInSAR data over large areas (400 km by 400 km).
    - Allows to generate Digital Elevation Models, Coherence and Land Displacement maps based on ENVISAT ASAR Wide Swath.
  - **SAR Polarimetry / Polarimetric Interferometry Module**
    - Supports the processing of polarimetric and polarimetric interferometric SAR data.

Detection of different land cover types by Entropy-Alpha-Anisotropy, Munich, Germany.
© ALOS PALSAR data, JAXA

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**Interferometric Stacking Module:**

**Persistent Scatterers (PS) & Small Baseline Subset (SBAS)**

- Integrates point-based (PS) and area-based (SBAS) techniques for the processing of interferometric stacks.
- This combined approach allows analyzing deformation phenomena affecting both extended area and local structures.
- Related to natural (volcanic or seismic activity, landslides, salt domes, etc.) or man-made features (building failures, mining, etc.)

Average displacement rate [mm/year] between 2003 and 2010 after exploiting 31 Envisat ASAR acquisitions...
SARscape Modules

Interferometric Stacking Module:
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SARscape Batch System

> All interactive steps can be stored within a batch procedure and then modified using a simple interface:
Core Capabilities

- Simple to use – interactive or in batch mode.
- End-to-end processing chain.
- Operational processing.
- Standard open formats used for all generated products.
- Support of Windows and Linux operating systems.
- Algorithms continuously improved through:
  - Internal developments,
  - ESA-financed and other research projects,
  - Collaborations with many universities and expert groups.
- Integration with the powerful image processing environment ENVI, allowing users to exploit a wide base of tools together with the specific capabilities of SARscape.
- Technical support through developer team of SARscape.
Core Capabilities

- Cross-mode
  - Processing optimised for all different cases
- Spotlight
  - TerraSAR-X, COSMO-Skymed, SAR-Lupe
  - Height dependent coregistration
  - Proper handling of azimuth-varying Doppler spectrum
- ScanSAR Interferometry
  - ENVISAT ASAR WS
  - Proper handling of azimuth-varying Doppler spectrum
- Airborne SAR
  - Proper handling of motion compensated data
  - Height dependent coregistration
  - Proper handling of azimuth-varying Doppler spectrum

The Power to Extend SARscape

- A simple IDL object accesses to all the SARscape’s functionalities:
  
  oSB = OBJ_NEW(‘SARscapeBatch’)

- Can be used within your IDL code!
IDL - SARscape API

; Scope: Multilooking, Filtering, and Geocoding of a CSK-SLC product
;
; PRO SARscape_Batch_Example,DataIn,DataOut
;
; Multilooking
oSB = OBJ_NEW('sarscapebatch',module='BASEMULTILOOKING')
oSB->SetParam, 'input_file_list', DataIn
oSB->SetParam, 'output_file_list', 'C:\Temp\PowerImage'
OK  = oSB->Execute()
IF ~OK THEN RETURN
;
; Coregistration

; Filtering

; GeoCoding
ok = oSB->setUpModule(module='BASICGEOCODING')
oSB->SetParam, 'input_file_list', MyDataFilter
oSB->SetParam, 'output_file_list', DataOut
oSB->SetParam, 'ocs_state', 'UTM-GLOBAL'
oSB->SetParam, 'ocs_zone', 33
OK = oSB->Execute()

Print,' End of the process '  
END

SARscape: Cooperation with ENVI

; Scope: Multilooking, Filtering, Geocoding, and Segmentation of a CSK-SLC product
;
; PRO ENVI_SARscape_Batch_Example,DataIn,DataOut

ENVI,restore_base_save_files
ENVI, batch_init
;
; Multilooking
oSB = OBJ_NEW('sarscapebatch', module='BASEMULTILOOKING')
;
ok = oSB->Execute()  
;
; Coregistration

; Filtering
;
; GeoCoding
ok = oSB->SetUpModule(module='BASICGEOCODING')

ok = oSB->Execute()  
;
ENVI_OPEN_DATA_FILE, MyDataGeo , R_FID=CSKFid
ENVI_FILE_QUERY, CSKFid, POS=pos, DIMS=dims
ENVI DOIT, 'envi_segment_doit', FID=CSKFid, POS=pos, DIMS=dims, MIN_POPULATION=100, CLASS_PTR=class_ptr, /ALL_NEIGHBORS, OUT_NAME=DataOut
ENVI BATCH_EXIT
Print,' End of the process '  
END
SARscape: Integration with ArcGIS®

> Delivers powerful functionality to GIS users, such as:
  > Coherent Change Detection
  > DEM Generation
  > Displacement map generation
> Users can now run scientifically-proven SARscape capabilities from within the familiar ArcGIS Toolbox.
> Upon installation of SARscape, powerful SAR processing tools will appear in ArcGIS.
> Create custom SARscape Tools.

SARscape: Integration with ArcGIS®

> Customize the SARscape Toolbox to create and add your own image processing tools.
> Add tools to an ArcGIS model to take advantage of full geospatial analysis capabilities.
Summary

> The SARscape® platform provides a suite of
> operational modules
> enabling users to exploit all the technologies today available
for information generation from SAR data.
> The modular set of functions is
> integrated in the ENVI/ArcGIS environments,
> supports all the data and acquisition modes available from
the today existing spaceborne and airborne SAR sensors.
> The key subject of the forthcoming releases will be
> data fusion (SAR-SAR, SAR-Optical),
> generation of DEMs from SAR stereo data.
> Customized solutions are provided on request.

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