

HAROKOPIO UNIVERSITY  

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING

ORFEO ToolBox



“is not a black box”

Mickaël Savinaud
mickael.savinaud@orfeo-toolbox.org

“Copyright (c) 2013 by Mickaël Savinaud, CS-SI.
This work is made available under the terms of the Creative Commons Attribution-ShareAlike 3.0 license”.
<http://creativecommons.org/licenses/by-sa/3.0/>




1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  



OUTLINE

- Background
 - Context
 - History
 - Free and Open Source Solution
- What is OTB ?
- OTB uses cases
- Conclusion

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece




HAROKOPIO UNIVERSITY



OTB BACKGROUND

Once upon a time, at CNES

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece





HAROKOPIO UNIVERSITY

Orfeo ToolBox - Context

➤ **ORFEO: Optical and Radar Federated Earth Observation:**

- **Dual Earth observation satellite system:**
Optic : CNES, France (Pléiades) / **Radar :** ASI, Italy (Cosmo-Skymed)

➤ **ORFEO Accompaniment Program [1]:**


- **Goals :** make easier the *development of new algorithms*, their validation and capitalization, fill the gap between *researchers* and *ORFEO users*.
- **Thematic part :** User's needs (extracted information) / Product definition / Validation.
- **Methodological part :** Coordination of research activities in Image Processing
Solution: A Generic Image Processing Toolbox

➤ **Orfeo ToolBox (OTB) [2]:**



- Designed to prepare, support and promote the use of remote sensing images
- Make the development of new algorithms and their validation easier
- Open source software for image processing labs, users and the industry

www.orfeo-toolbox.org


→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece




HAROKOPIO UNIVERSITY

A bit of History




CENTRE NATIONAL D'ÉTUDES SPATIALES





La force de l'innovation

- 2006 – Everything begins:
 - Started in 2006 by CNES (French Space Agency), funding **several full-time developers (CSSI)**
 - Targeted high resolution images and some applications to other sensors
- 2009 – Monteverdi: the front end of OTB
 - from research to end users use case
 - Provide a capacity building tool
- 2010 – Venµs L2/L3 processing chain:
 - from research to operational use case
- 2011 – Moving towards user friendly applications
 - Offers the OTB power to end-users (non programmers): cli and gui interface
 - Offers the possibility to access at OTB in external software/language: python, QGIS, ...
- 2013 – A new Monteverdi
 - New visualization framework
 - Strong interactions with OTB-applications framework

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece





HAROKOPIO UNIVERSITY

Orfeo ToolBox – A Free and Open Source Software (1/2)

- **Why choose open source?**
 - To encourage end-users (methodological part) and industry (spatial, GIS) to use the available code
 - To capitalize the methodological know how : *Open research/science*
 - To use an incremental approach to benefit from the results of the methodological research.
- **Promotes interoperability and best data support**
 - Standard respects
 - Based on open file formats
- Increase security and reliability: code access, strong community
- Implementation of **popular and strongly used tools**
- **Easy to test and adapt to your needs**
- Reduce development costs by **re-use**

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox – A Free and Open Source Software (2/2)

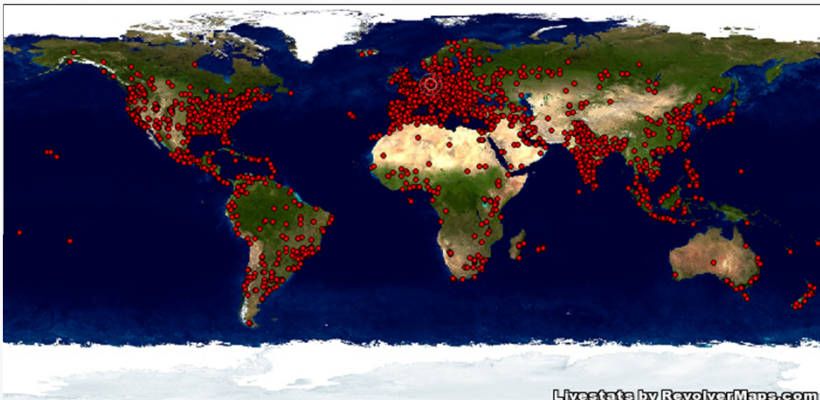
OTB license = CeCILL v3

- License created by CEA, CNES and INRIA, recognized by FSF
- **Similar and compatible with GNU GPL**
 - Software with static or dynamic link to OTB must have a CeCILL license (or GNU GPL)
- No specific duty to the original authors
 - No need to make your sources public if you don't distribute the software publicly
- License related duty applies if the OTB-based application is diffused outside your organization. You have to:
 - Copyright respect : indicate which part is modified, indicate license is CeCILL
 - Keep available the source code for users (who received the piece of software), and only for users
- No “license contamination” of pre-existing software

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox 2013 – An useful open source image processing tool used by large community



Livestats by RevolverMaps.com



→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

OTB WHAT IS IT ?

It is not a black box



→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

Orfeo ToolBox – An up to date C++ remote sensing library

- A large set of algorithms:
 - Optical/SAR Filtering, Geometry, Change Detection, OBIA, Classification, Segmentation, Feature extraction, Hyperspectral unmixing, Dimensionality reduction, sensor modeling, Stereorectification
- Handle large data volume processing
- A set of best practices
- A front end application: Monteverdi GUI
- Some thematic chains are available for users in 2 applications framework
 - OTB-Applications: built with the OTB classes to address a thematic problem.
 - OTB Wrappers: share OTB functionalities with external projects.

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox – Address various R&D issues

- Different research works already done with OTB
 - in some labs : CESBIO, ENST Bretagne, DLR, ... (tool for internship and thesis)
 - in some research program (EU-FP7, FR-TOSCA):
 - TOLOMEO [6]:
 - BIOSOS [7]:
- Some R&D studies for ESA and CNES done with OTB
 - Benchmark the impact of pansharpener methods for Pleiades end-users
 - Improve automatic image analysis with exogenous data (risk maps, DEM, OpenStreetMap):
 - How to deal efficiently with large scale segmentation [8]:
 - SAR interferometry (ESA-SOCIS 2011)
- Definition and prototyping of new methods of geometry quality assessment for MTG


ORFEO ToolBox as strong development framework for R&D studies

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

Orfeo ToolBox - Modularity

- **Pipeline:** Automatic input and output management





```

graph LR
  File1[(File)] --> Reader[Reader  
Image]
  Reader --> Filter[Filter  
Image]
  Filter --> Writer[Writer]
  Writer --> File2[(File)]
  
```

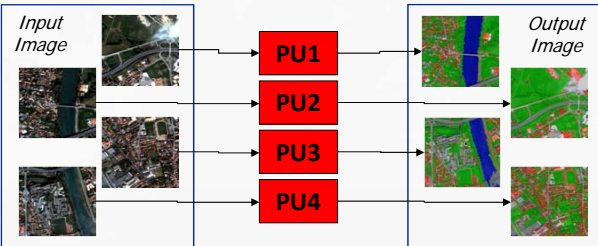
- **Generic programming:** use of templates ⇒ opened and evolutive architecture,
- **Multi platform:** daily tested on multiple configurations,
- **Support of multiple image formats:**
 - classical and remote sensing formats (scalar, complex, mono or multi channels types),
 - GIS database

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  



Orfeo ToolBox – Design to support large files processing

- **Streaming:** Process big images by chunks
 - Control over memory
 - Seamless and Flexible integration for image processing
- **Threading:** process chunks overs available processors
 - It is free: all complexity is hidden
 - Default mode

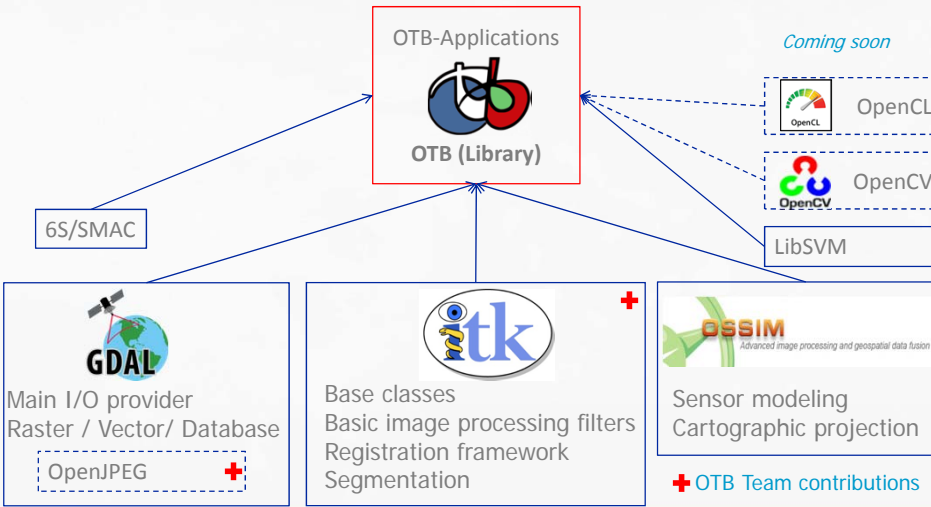


Support of processing on Pleiades/Quickbird/WorldView2 data for example

➤ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  


Orfeo ToolBox – A library based on standard tools




OTB-Applications
OTB (Library)

Coming soon


- OpenCL
- OpenCV
- LibSVM
- 6S/SMAC



GDAL
Main I/O provider
Raster / Vector/ Database
OpenJPEG +

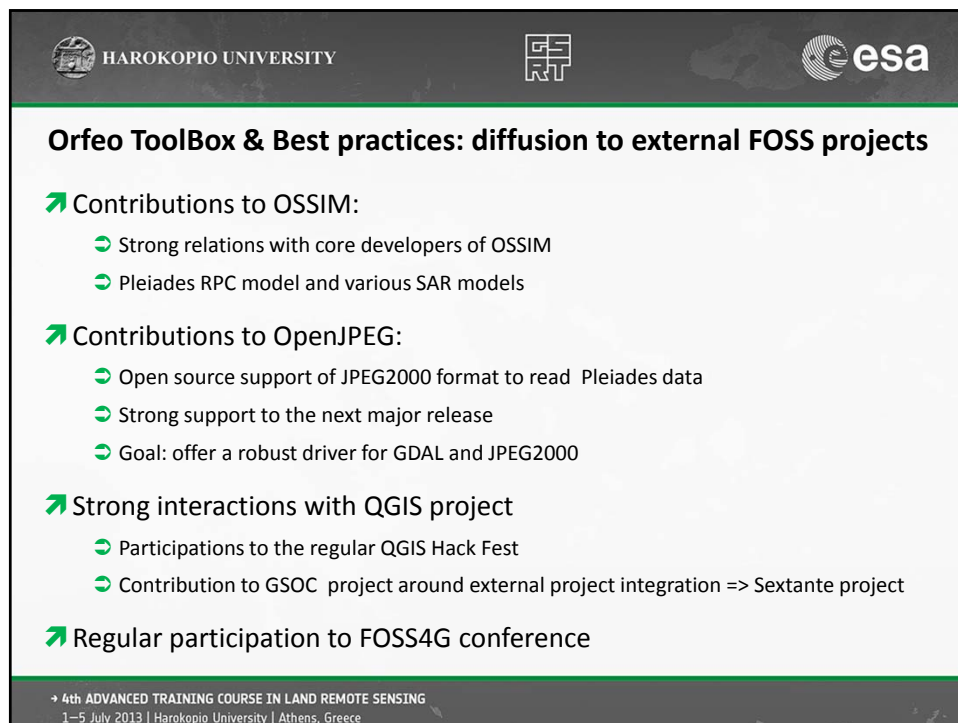
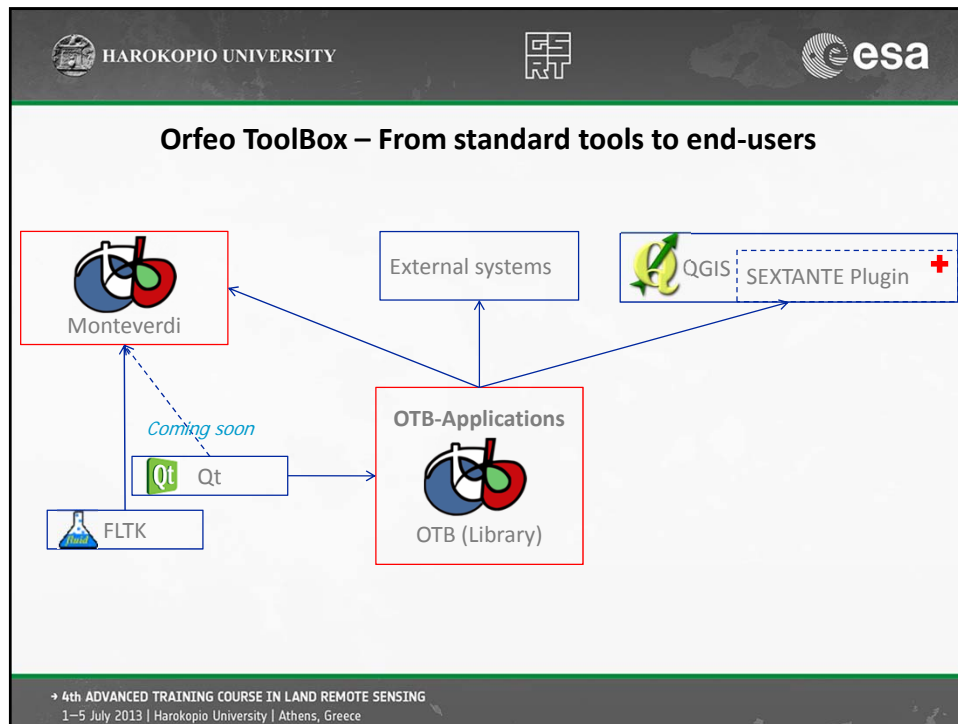





mtk
Base classes
Basic image processing filters
Registration framework
Segmentation



OSSIM
Advanced image processing and geospatial data fusion
Sensor modeling
Cartographic projection
+ OTB Team contributions

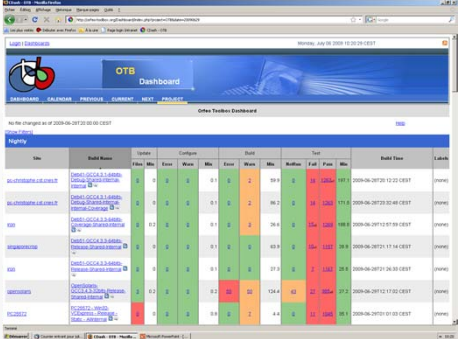
➤ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece










Orfeo ToolBox & Best practices: Maintainability

- Test driven development best practices
 - CMake, CTest, CDash
- Continuous integration – Nightly testing: 2500 tests!!





➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece



Orfeo ToolBox & Best practices: source code and documentation

- Software guide [3]:
 - First steps (Installation, Hello world, etc.),
 - Lots of classes use examples,
 - Examples of image processing chain sorted by thematic,
 - Tutorials.
- Doxygen [4]:
 - List of all OTB and ITK classes ,
 - Each class is described (what, how, which parameters and methods).
- Cookbook [5]:
 - Presentation of OTB Applications
 - A brief tour of Monteverdi
 - Recipes for various remote sensing tasks
 - Applications reference documentation







➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

Orfeo ToolBox & best practices: strong interaction with users

- **Mailing list for OTB users:** otb-users@googlegroups.com
 - Developers and users can ask and answer questions,
 - Read daily by developers, more than a support, it is a place of exchange about your experience using OTB (bugs, evolutions, etc).
- **A blog:** <http://blog.orfeo-toolbox.org/>
- **A wiki:** <http://wiki.orfeo-toolbox.org>,
- **A bug tracker:** <http://bugs.orfeo-toolbox.org>,
- Free training course: OGRS2012, LTC2013, Summer school
- Commercial training course: <http://www.orfeo-toolbox.c-s.fr/>
- Meet the users: SS2 symposium, OGRS, Esa Live Planet conference, IGARSS

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece

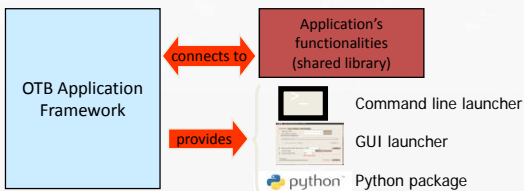
HAROKOPIO UNIVERSITY  

Orfeo ToolBox - OTB Applications framework

- The Orfeo Toolbox (OTB) is a software library
 - First mission: provide building blocks to build applications in remote sensing image analysis
 - User targets: software developers with a good knowledge of C++
- Need for a better accessibility : Using OTB features without a line of code
- ➔ **OTB Applications are a set of user tools for specific image processing tasks**
 - Anyone can use OTB image processing algorithms
 - Less flexibility compared to writing your own program

Technical aspects:



- A program (actually a shared library) providing a simple access to one or several functionalities of the toolbox.
- The same application can be used in several ways



```

graph LR
    OTB[OTB Application Framework] -- connects to --> App[Application's functionalities (shared library)]
    OTB -- provides --> Launcher[Command line launcher]
    OTB -- provides --> GUI[GUI launcher]
    OTB -- provides --> Python[python Python package]
  
```

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

Orfeo ToolBox - OTB Applications framework

- Application « modules » framework
 - Bundle simple or more complex pipelines to access OTB functionalities
 - Integrated documentation
- Reuse in several contexts:
 - Command line


```
02:22:41 jmalik@PC8413: ~/Utils/bin/OTB-gdal-trunk : bin/otbcli1 MultivariateAlterationDetector.sh --in1 ~/home/jmalik/Bureau/ogisdemo/Spot5-Gloucester-before.tif --in2 ~/home/jmalik/Bureau/ogisdemo/Spot5-Gloucester-after.tif --out changes.tif
Writing changes.tif...: 100% [*****] (2 seconds)
02:22:47 jmalik@PC8413: ~/Utils/bin/OTB-gdal-trunk :
```
 - Python/Java




```
from sys import argv
import otbApplication as otb

app = otb.Registry.CreateApplication("Smoothing")

app.SetParameterString("in", argv[1])

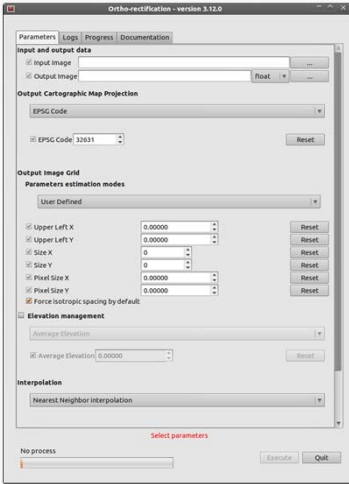
for smooth type in ['mean', 'gaussian', 'anidif']:
    app.SetParameterString("type", smooth type)
    app.SetParameterString("out", argv[2] + smooth_type + ".tif")
    app.ExecuteAndWriteOutput()
```
 - Scheme

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox - OTB Applications framework

- Reuse in several contexts:
 - Automatically generated GUI

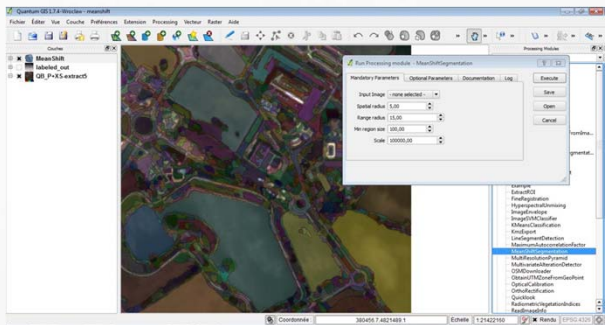


→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox - OTB Applications framework

- QGIS : an open-source GIS which grow
- OTB as plugin in QGIS:
 - based on QGIS plug-in framework and SEXTANTE project

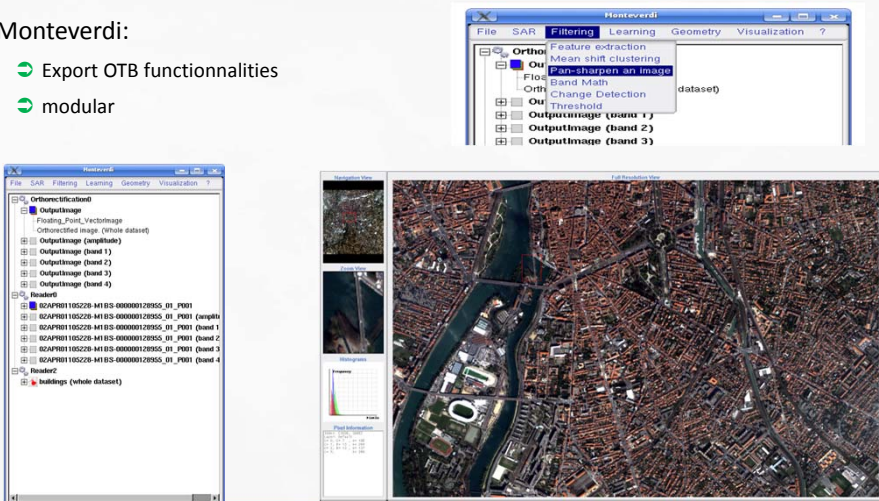


➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox – Monteverdi: bringing OTB power to the end users

- Monteverdi:
 - Export OTB functionalities
 - modular



➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox – Monteverdi: bringing OTB power to the end users

- Geometry
 - Orthorectification,
 - reprojection of ortho-images
 - Superimpose two images
- Filtering
 - Feature Extraction
 - Meanshift clustering
 - Pan-sharpen an image
 - Band math
 - Change detection
 - Threshold
- Miscanlenious:
 - Classification, radiometric corrections, image comparison, ...

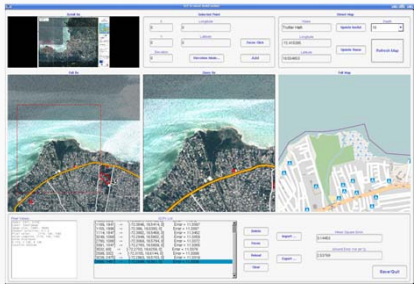
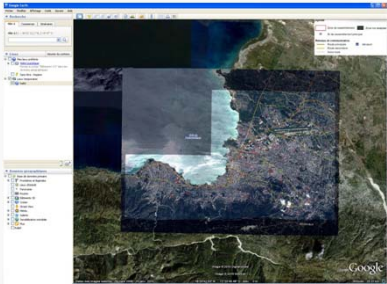
Modular: adding new processing modules or executable is possible

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox – Monteverdi: bringing OTB power to the end users

Export any product or processing result as KMZ for viewing in GoogleEarth
Register GCPs between a scene and Open Street Map data

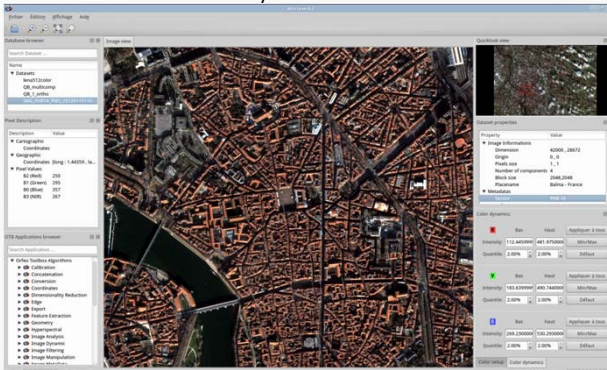
→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

Orfeo ToolBox – Monteverdi 2.0

- Next major version in 2013
 - Based on Qt framework to enhance user experience
 - Interconnect OTB application framework with a user friendly HMI
 - New visualisation tool

- Based on product database
- Native internationalisation



Test it, use it and send us your feedback and your analysis



➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

OTB USE CASES

From research to operational context



➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

HAROKOPIO UNIVERSITY  

Orfeo ToolBox – Venùs L2/L3 processing chain

- Context: Vegetation and Environment monitoring on a New Micro-Satellite
 - Venùs mission: demonstrator for environment monitoring within GMES programme
- Goal: Design and development of L2 and L3 processing chains
 - Aerosol LUT extraction
 - Clouds detection,
 - Atmospheric correction,
 - Shadow detection,
 - Estimation of effect environment
- Use of OTB library to re-use possibility and huge data volume processing
 - OTB filters: statistics, basics filters, resampling, interpolators, reading and writing TIF/JPG/HDF images data and XML data, DTM reading, ...
 - OTB framework: correlation, interpolation, composite filters, IO factories, ...
- Generic implementation of multi spectral camera capability: Formosat, Venùs, Landsat 5/7 (8), Sentinel-2, ...

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox - Sentinel-2 processing

- Multi-mission Atmospheric and Cloud Correction Software (MACCS)
 - Processing multi-temporal and/or multi-spectral images to produce physical measurements
 - Used in the Sentinel 2 ground segment prototype (SL2AP, Simplified Level-2A Processor)
- Sentinel 2 Level-0 and Level-1 Instrument Processing Facility (IPF)
 - Automatic production of large volume of Sentinel-2 L1c products
 - OTB in IDP-SC development: cloud mask computing, resampling, radiometric corrections.
 - Merge OTB best practices and ESA requirements
- Sentinel-2 Mission Performance Assessment (MPA)
 - Analysis module based on ORFEO ToolBox
- Applications demonstrator project: PRO-Fusion (fusion of ProbaV and Sen-2)

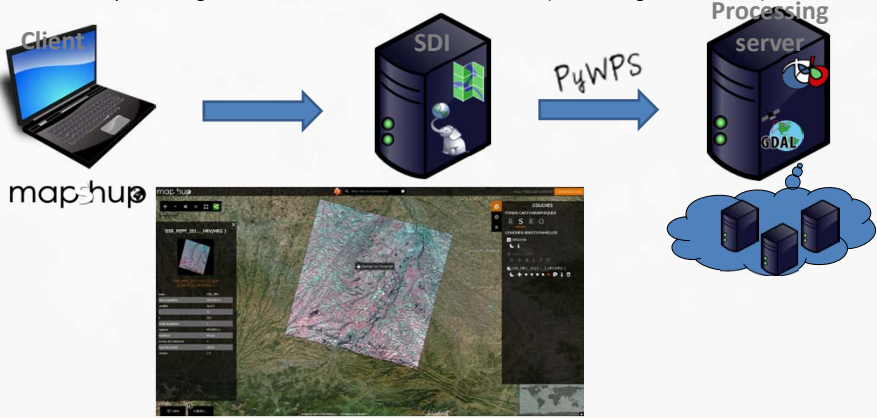
OTB already participate to the Sentinel-2 adventure

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece



HAROKOPIO UNIVERSITY  

Orfeo ToolBox - Plateforme Aval Pleiades: OTB and Web Services

- Use OTB to extract information from Pleiades product used by ORFEO community
 - Generate data for product database (ingestion, radiometric calibration, ...)
 - Online processing based on WPS and OTB functionalities (stereo, segmentation, ...).



→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece




HAROKOPIO UNIVERSITY  

Orfeo ToolBox – Into various projects

ESA-KEO: integrate OTB into a modular/scalable Component-based Processing Environment	CNES-Kalideos: land-cover processing based on OTB
CNES-PEPS: online processing based on OTB for French administration	SATERRE: online processing based on OTB for agriculture management
OTB and Education: learn remote sensing at school (Qgis Plugin and simple IHM)	PTSC/GEOSUD: French initiative to organize skills around EO processing
SYRHIUS: continental water quality management with EO data and OTB	TPZ-EARTHLAB: regional initiative to offer remote sensing service to end-users
2 external front-end applications Gnorasis and Mustic software	ESA-TIGER: Forest monitoring based on EO data
UNESCO World Heritage site monitoring[9]	IRD-FOTO_METRICS: estimation of forest biomass based on textural analysis with OTB
MAISEO: include OTB processing chain to monitor agricultural practices	

More and more uses cases

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece








CONCLUSION

- OTB has strong assets to be used as a development framework for image processing of big data volumes
 - Flexible: open source, bindings (java, python)...
 - Completeness: many algorithms available
 - Performance
 - Maintainability: documentation, strong development rules, ...
- OTB a robust development framework and
 - Compatible with several contexts and use-cases
- OTB-Monteverdi a modular visualization and execution tool
 - Bring to end-users the best of the library and the possibility to visualize EO products
 - Merge thematic issues and image processing solutions
 - Offer a tool to simplify the prototype validation
 - Share state of art of image processing solution in an open-source tool

Address more and more issues to enhance OTB ecosystem

➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece

Bibliography

[1] TINEL, C., FONTANNAZ, D., DE BOISSEZON, H., GRIZONNET, M., AND MICHEL, J. The orfeo accompaniment program and orfeo toolbox; IGARSS 2012

[2] INGLADA, J., AND CHRISTOPHE, E. The orfeo toolbox remote sensing image processing software; IGARSS 2009.

[3] Software guide: <http://www.orfeo-toolbox.org/SoftwareGuide>

[4] Doxygen: <http://www.orfeo-toolbox.org/doxygen/classes.html>

[5] Cookbook: <http://www.orfeo-toolbox.org/CookBook>

[6] TOLOMEO: <http://tolomeofp7.unipv.it/>

[7] BIOSOS: http://www.wageningenur.nl/en/Expertise-Services/Research-Institutes/alterra/Projects/BIO_SOS.htm

[8] OTB team, Open tools and methods for large scale segmentation of Very High Resolution satellite images, OGRS 2012

[9] http://www.congrexprojects.com/docs/12c04_doc/4-sentinel2_symposium_radoux.pdf?sfvrsn=2

➔ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1-5 July 2013 | Harokopio University | Athens, Greece