

Orfeo ToolBox

Open source software for remote sensing image processing

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Introduction

Back in 2006
Key characteristics
Functions and algorithms
What's new in OTB 5.0 ?
Conclusion

Outline

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Back in 2006

Key characteristics

Functions and algorithms

What's new in OTB 5.0 ?

Conclusion

Introduction

Goal of this presentation :

- ▶ Insight of project components
- ▶ Good practises to help starters using the library
- ▶ to go further and advanced use



Orfeo ToolBox is not a black box. . .
Let's start by opening the box !

Things to know about OTB...

The Orfeo ToolBox is :

- ▶ A (The :) **image processing library** dedicated to remote sensing
- ▶ **Free and open source software** under CeCILL-v2 license (equivalent to GPL)
- ▶ **Funded and developed by CNES (French Space Agency)** in the frame of the Orfeo Pléiades program (and beyond)
- ▶ Written in **C++** on top of ITK (medical image processing)
- ▶ Interfaces seamlessly with other IP and RS open-source software, like GDAL, OSSIM, OpenCV...
- ▶ Develop to allow processing of **large data** thanks to parallel and on the flow processing

orfeo-toolbox.org

Outline

Introduction

Back in 2006

Key characteristics

Functions and algorithms

What's new in OTB 5.0 ?

Conclusion

How it starts ?

CNES Orfeo accompaniment program (2006-2014)

- ▶ Pléiades : gap in resolution comparing with SPOT5 which leads to new usages
- ▶ Goals : prepare, accompany and promote the use and the exploitation of the images derived from Pléiades/COSMO-SkyMed satellites
- ▶ Preparatory phase from 2006 to 2012
- ▶ Thematic Commissioning activities from 2012 to 2014

OTB in the Orfeo program

- ▶ Answer to ORFEO user groups needs
- ▶ Capitalize CNES R&D in Information Extraction
- ▶ Deliver generic tools for Pleiades users

Why Open source ?

Showcase

Image processing library dedicated to remote sensing for Pleiades users. Its wide dissemination contributes to the mission promotion.

Quality and efficiency

OTB covers a vast panel of applications and thematic fields. Openness should :

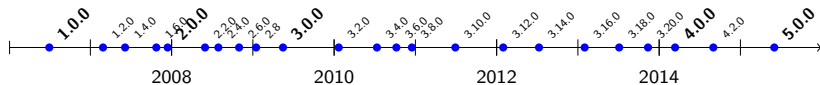
- ▶ Facilitate appropriation and validation for users
- ▶ Encourage contributions and bug reports
- ▶ Available on multiple platforms
- ▶ “The Cathedral & the Bazaar”¹ : the more widely available the source code is for public testing experimentation, the more rapidly all forms of bugs will be discovered

Reproducible research

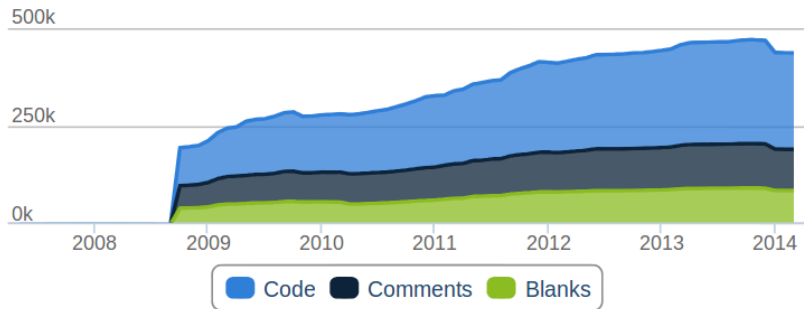
OTB capitalizes a part of the CNES R&D in IP, open source contributes to transparent, **reproducible** and trans-disciplinary **research**.

Introduction
Back in 2006
Key characteristics
Functions and algorithms
What's new in OTB 5.0 ?
Conclusion

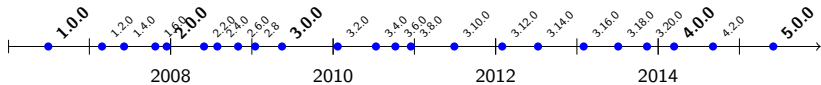
Some numbers



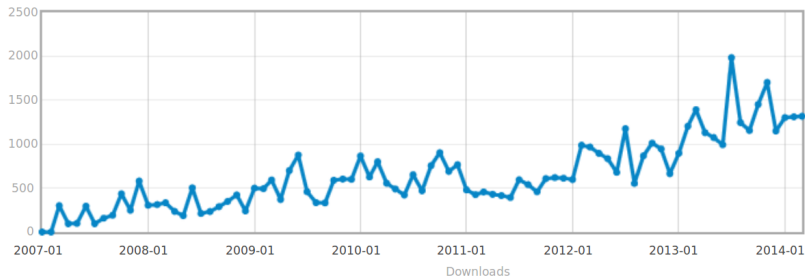
Lines of code



Some numbers



Sourceforge downloads



Outline

Introduction

Back in 2006

Key characteristics

Functions and algorithms

What's new in OTB 5.0 ?

Conclusion

Build on top of other open source IP software

Motivations

- ▶ Interfaces seamlessly with other IP and RS open-source software. . .
- ▶ Reuse is powerful
- ▶ Increase the number of functions
- ▶ Combine tools to create hybrid data pipeline

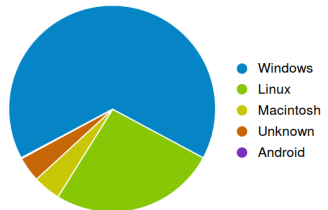
OTB backbone

- ▶ ITK : OTB data processing schema based on ITK *pipeline*
- ▶ GDAL to read/write raster/vector data
- ▶ OSSIM sensor modelling and metadata support
- ▶ OpenCV and LibSVM provide machine learning algorithms
- ▶ MuParser and MuParserX powerful parsing of mathematical expression (band math)

Compatible (and available) on multiple platforms

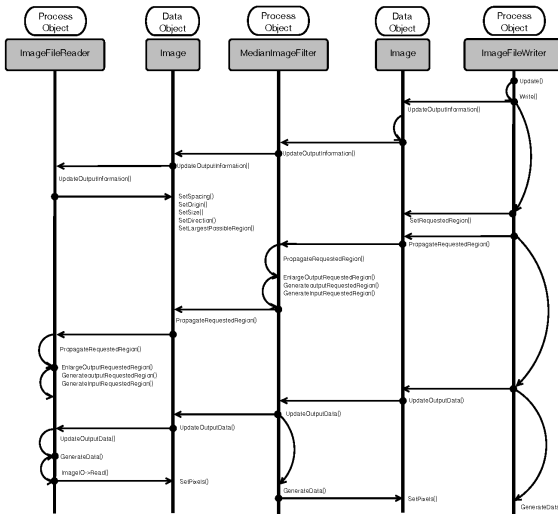
Goal

- ▶ Compile with recent versions of :
 - ▶ GCC
 - ▶ Clang
 - ▶ MinGW
 - ▶ Visual Studio...
- ▶ Binary packages available :
 - ▶ Ubuntu repository (GIS and IP software for Ubuntu)
 - ▶ Experimental Debian packages
 - ▶ Available in OSGeo4W (OSGeo tools on Windows)
 - ▶ Binary installers and Port for Mac OSX...



Number of OTB downloads on Sourceforge per Operating System

Behind the scene



source : <http://www.aosabook.org/en/itk.html>

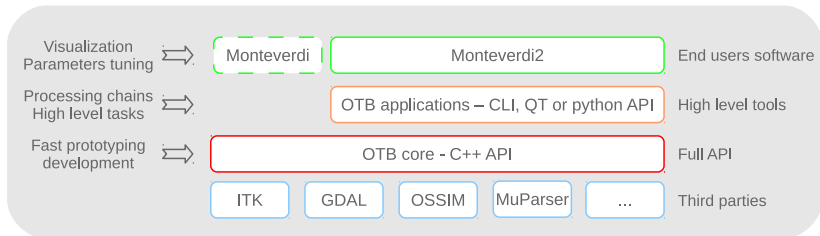
(Near) bleeding-edge techniques

- ▶ Try to keep track of up-to-date information about the latest developments, exchanging ideas, identifying future trends, and making networking
- ▶ Reference implementation of algorithms based on publications
- ▶ e.g. : morphological profil, MeanShift segmentation, Haralick textures, SURF keypoints. . .
- ▶ Reference implementation contributes by authors with their publications. e.g. : Large Scale MeanShift², bayesian fusion³, object detection . . .

2. Michel, J. ; Youssefi, D. ; Grizonnet, M., "Stable Mean-Shift Algorithm and Its Application to the Segmentation of Arbitrarily Large Remote Sensing Images," Geoscience and Remote Sensing, IEEE Transactions on , vol.53, no.2, pp.952-964, Feb. 2015

3. J. R. Dominique Fasbender and P. Bogaert. Bayesian data fusion for adaptable image pan-sharpening. IEEE Transactions on Geoscience and Remote Sensing, 46(6) :1847–1857, 2007. 13.2

How to eat the OTB sandwich ?



Write your own code

Flexible, access to full API, requires C++ knowledge

Use the applications

High level functions (e.g. segmentation), callable from CLI, Qt, Python, can be extended

Use Monteverdi

Visualization, data management, **Access to all applications**

Show me the code !

```
#include "otbImage.h"
#include "otbImageFileReader.h"
#include "otbImageFileWriter.h"
#include "itkCannyEdgeDetectionImageFilter.h"
#include "itkRescaleIntensityImageFilter.h"

int main(int argc, char * argv[])
{
    typedef double PixelType;
    typedef otb::Image<PixelType> ImageType;

    typedef unsigned char OutputPixelType;
    typedef otb::Image<OutputPixelType> OutputImageType;

    typedef otb::ImageFileReader<ImageType> ReaderType;
    ReaderType::Pointer reader = ReaderType::New();

    reader->SetFileName(argv[1]);

    typedef itk::CannyEdgeDetectionImageFilter
    <ImageType, ImageType> FilterType;
    FilterType::Pointer filter = FilterType::New();

    filter->SetInput(reader->GetOutput());

    typedef otb::ImageFileWriter<OutputImageType> WriterType;
    WriterType::Pointer writer = WriterType::New();

    writer->SetFileName(argv[2]);

    writer->SetInput(filter->GetOutput());

    writer->Update();
}
```

The applications : write it once, use everywhere

- ▶ 75 applications are shipped with OTB
- ▶ 1 application = 1 dynamic library (plugin)
- ▶ Applications are auto-descriptive and auto-documented
- ▶ Applications can be extended outside of OTB
- ▶ Several plugins players :
 - ▶ Command-line
 - ▶ Qt auto-generated
 - ▶ Python
- ▶ Applications are meant for integration in external systems

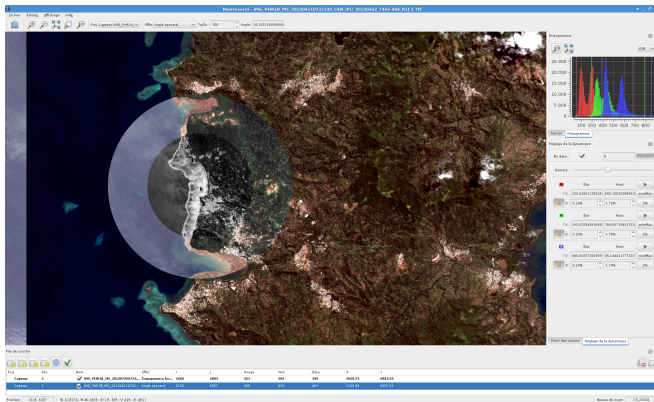


Introduction
Back in 2006
Key characteristics
Functions and algorithms
What's new in OTB 5.0 ?
Conclusion

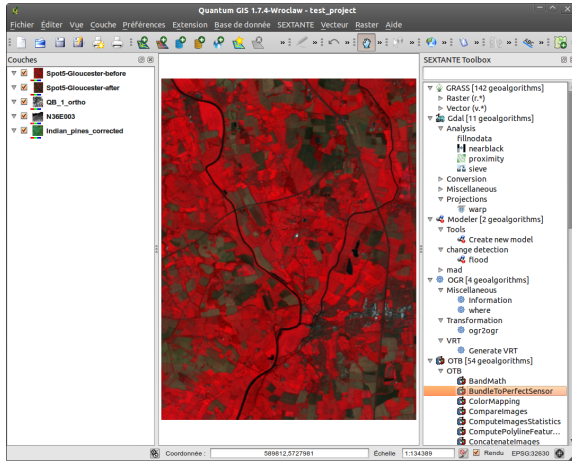
Monteverdi : visualization and processing

Monteverdi 3 Beta available since last week ! Give it a try !

<https://www.orfeo-toolbox.org/packages/>



OTB in Quantum GIS



Outline

Introduction

Back in 2006

Key characteristics

Functions and algorithms

What's new in OTB 5.0 ?

Conclusion

Incomplete list of OTB functions

Pre-processing

- ▶ Radiometric calibration, orthorectification, resampling (raster and vector), pan-sharpening, stereo rectification. . .
- ▶ Sensor supported : Pléiades, SPOT6, SPOT5, Digital Globe satellites
- ▶ Geometric models (thanks to OSSIM), support for DEM (SRTM or GeoTIFF)

Images and vector manipulation

- ▶ Formats supported by GDAL (raster and vector), conversion raster/vector
- ▶ Region of interest extraction, of spectral bands, concatenation or splitting. . .
- ▶ Band math, color mapping, contrast enhancement
- ▶ Linear filtering, Mathematical morphology

(Incomplete) List of OTB functions

Feature extraction

- ▶ Edge detection, scale-invariant feature transform, lines, corners
- ▶ Radiometric indices, textures (Haralick, SFS, PanTex)
- ▶ Local statistics (Flusser moments, Histogram of Oriented Gradient)
- ▶ Keypoints matching (SIFT, SURF...)

Change detection

- ▶ Classic methods with image metrics comparison
- ▶ Multivariate Alteration Detector

Dimensionality reduction, hyperspectral processing

- ▶ PCA, NAPCA, ICA, MAF...
- ▶ Dimension estimation, endmembers extraction, Vertex Component Analysis(VCA)

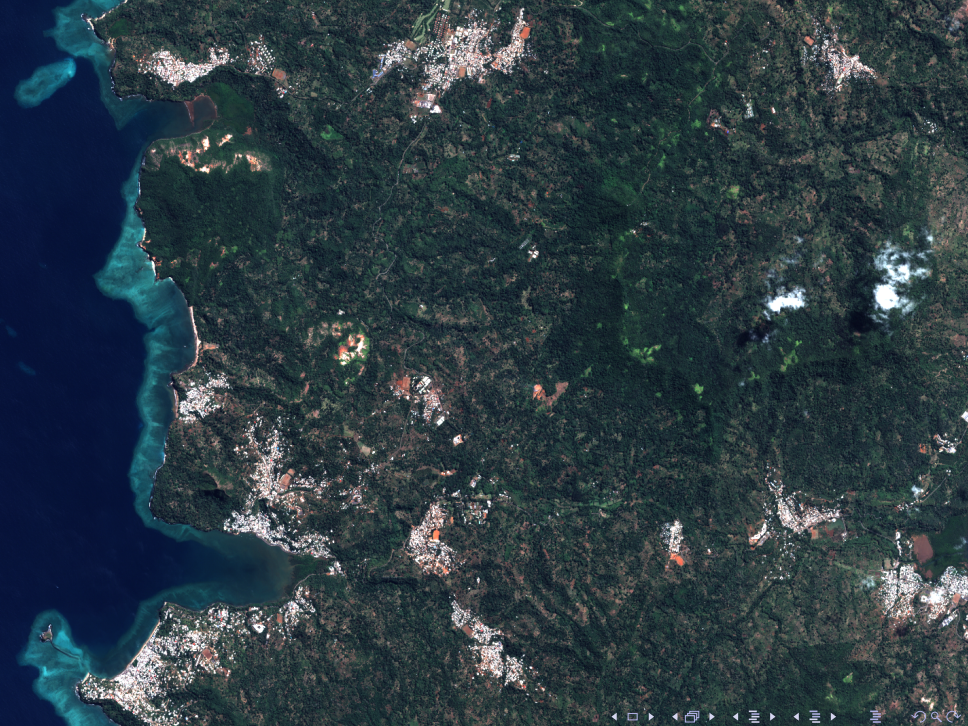
Incomplete list of OTB functions

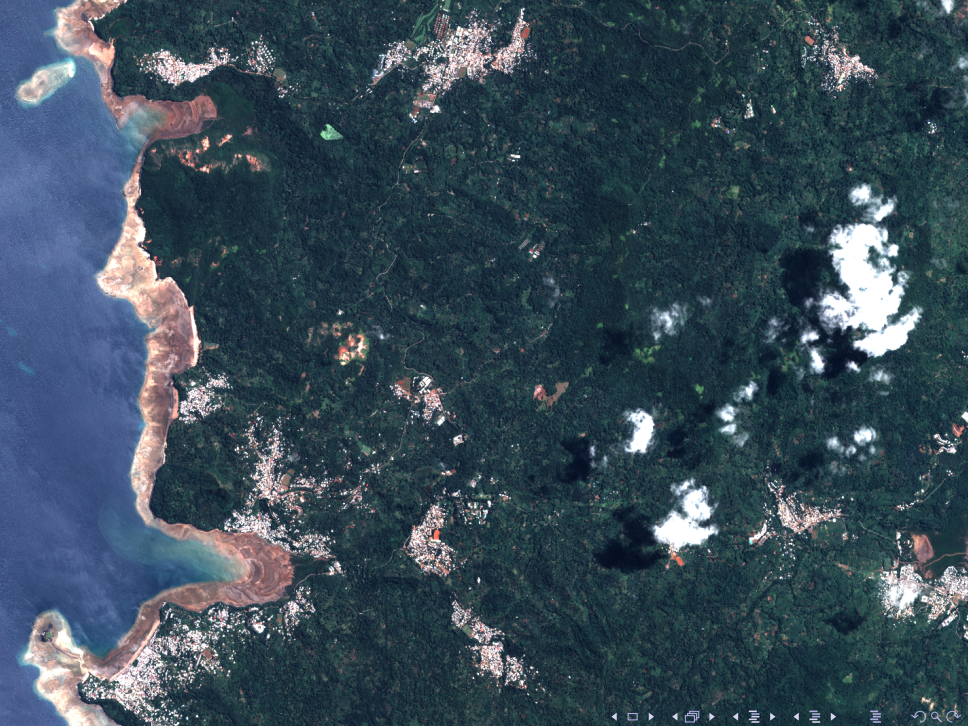
Segmentation

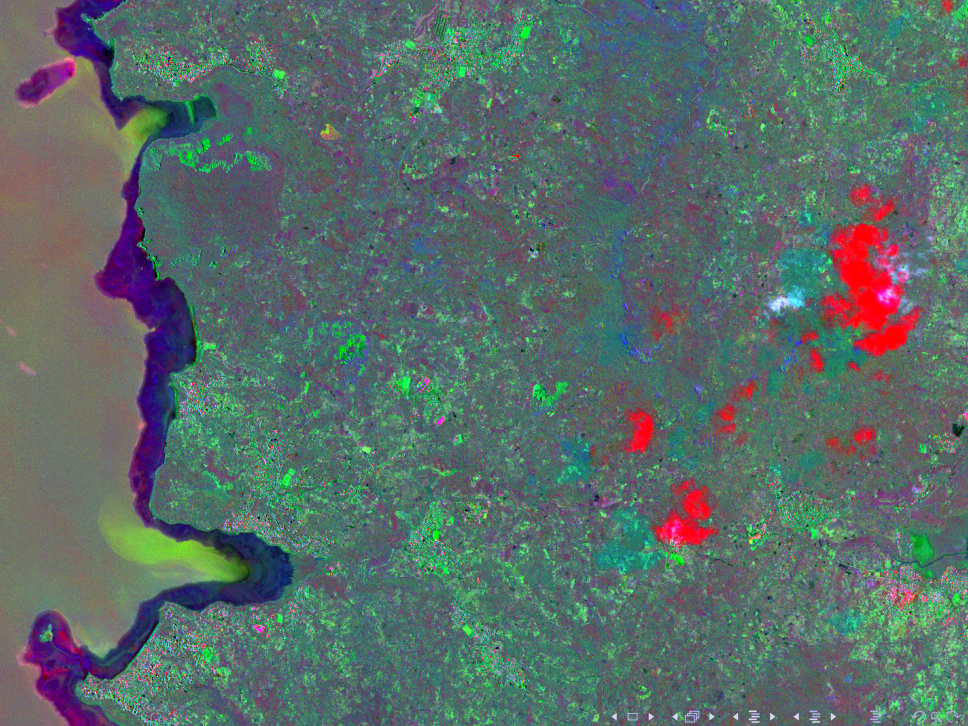
- ▶ Segmentation algorithms : Connected Components, MeanShift, Watershed. . .
- ▶ Methods to apply those algorithms on large dataset
- ▶ Vector or raster representation which allow Object Based Image Analysis

Classification

- ▶ 9 supervised methods available (including SVM and Random Forest)
- ▶ Fusion and regularization of classifications
- ▶ K-Means clustering or Kohonen maps
- ▶ Object classification (from a segmentation)









Outline

Introduction

Back in 2006

Key characteristics

Functions and algorithms

What's new in OTB 5.0 ?

Conclusion

Modular architecture (inspired by ITK 4.x)

What has changed ?

- ▶ Organize the code into conceptual cohesive groups :
 - ▶ OTB 4.4 : 1672 files in 26 directories
 - ▶ OTB 5.0 : 1627 files in 124 **modules** divided in 16 groups
- ▶ Modules contain : tests, source code, applications are grouped
- ▶ Each module can be (de)activate, with automatic dependencies resolutions
- ▶ Good start ! Already 5 remote modules contributed see <https://www.orfeo-toolbox.org/external-projects/>

Advantages ?

- ▶ Third part dependencies are integrated as modules and can be excluded
- ▶ Lots of CMake magic (less code for configuration, better support)
- ▶ Doxygen API documentation follows the new code organization (easier to find class info)
- ▶ Facilitate external contributions with powerful mechanisms call **remote module**

Superbuild : installing OTB has never been so easy

Before in OTB 4.4

- ▶ Some of the OTB third part dependencies could be build internally
- ▶ External source code was integrated in OTB source tree (not a good idea)

In OTB 5.0, on Superbuild !

- ▶ No more third party library sources integrated in OTB
- ▶ External project called **superbuild** which allows to download/configure/build/install OTB and all dependencies in one pass !
- ▶ Allow to build OTB on an (almost) empty platform (CMake, gcc, zlib, curl), and everything is automatic. . .
- ▶ There is also an *offline* mode which does not require Internet

Project Steering Committee : OTB governance structure

- ▶ Open governance
- ▶ High level guidance and coordination for the ORFEO ToolBox
- ▶ Animation of OTB community, communication, orientation of the project
- ▶ Everyone can participate
- ▶ All members have equal standing and voice in the PSC (1 member = 1 vote)
- ▶ Proposals are written up and submitted on the otb-developers mailing list for discussion and voting (public)
- ▶ Status and decision process are completely public⁴
- ▶ Start in practice in September 2015 (IRC meeting, public decision making procedure⁵)

Outline

Introduction

Back in 2006

Key characteristics

Functions and algorithms

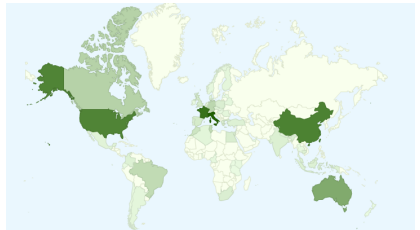
What's new in OTB 5.0 ?

Conclusion

How many users ?

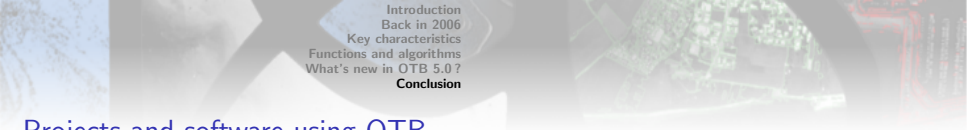
Hard to tell...

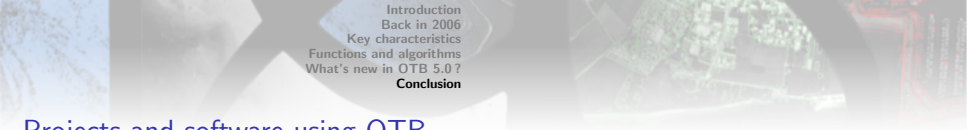
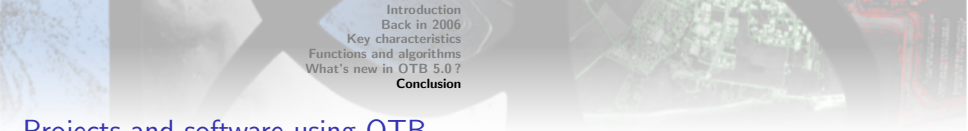
- ▶ $\approx$ 600 members on the otb-users list
- ▶ Between 100 and 150 mails by months
- ▶ $\approx$ 100 members on the developers list
- ▶ $\approx$ 118 user accounts on the bug tracker
- ▶ $\approx$ 50 contributors in the documentation
- ▶ $\approx$ 3400 downloads for OTB 5.0 on SourceForge(released June 1, 2015).



Introduction
 Back in 2006
 Key characteristics
 Functions and algorithms
 What's new in OTB 5.0 ?
Conclusion

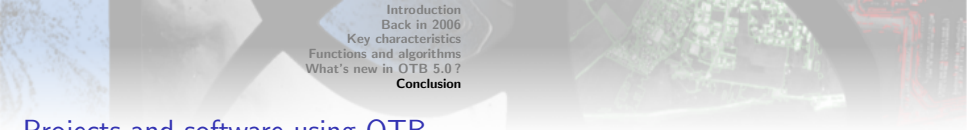
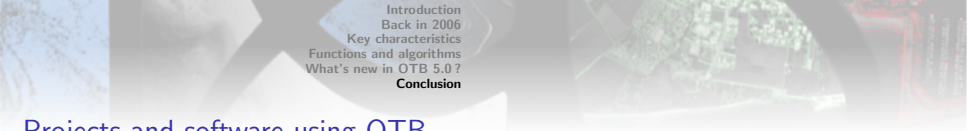
Projects and software using OTB

- 
- Introduction
 Back in 2006
 Key characteristics
 Functions and algorithms
 What's new in OTB 5.0 ?
Conclusion
- Projects and software using OTB



Introduction
 Back in 2006
 Key characteristics
 Functions and algorithms
 What's new in OTB 5.0 ?
Conclusion

Projects and software using OTB



Introduction
 Back in 2006
 Key characteristics
 Functions and algorithms
 What's new in OTB 5.0 ?
Conclusion

Projects and software using OTB

Support/Help/Contribute

General resources

Site web orfeo-toolbox.org

Wiki wiki.orfeo-toolbox.org

Blog blog.orfeo-toolbox.org

Documentation and help

Doxygen doxygen

Guides Software Guide and CookBook (remote sensing recipes)

Users mailing list otb-users@googlegroups.com

Developers mailing list otb-developers@googlegroups.com

Follow-up

Look at the code? git.orfeo-toolbox.org

Find a bug? bugs.orfeo-toolbox.org

Agile? scrum.orfeo-toolbox.org

Weather? dash.orfeo-toolbox.org

Thank you ! Any questions ?

