THE ORFEO TOOLBOX REMOTE SENSING IMAGE PROCESSING SOFTWARE

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ABSTRACT

Orfeo Toolbox, OTB, is a remote sensing image processing library developed by CNES, the French Space Agency. OTB is distributed as Open Source software and is therefore available for any remote sensing scientist or processing chain developer. This paper describes the main features of OTB, how it can be used and the expected evolutions in the coming months.

Index Terms— Orfeo Toolbox, Open Source Software, Remote Sensing

1. INTRODUCTION

Beside the Pleiades (PHR) and Cosmo-Skymed (CSK) systems developments forming ORFEO, the dual and bilateral system (France - Italy) for Earth Observation, the ORFEO Accompaniment Program was set up, to prepare, accompany and promote the use and the exploitation of the images derived from these sensors. The creation of a preparatory program is needed because of the new capabilities and performances of the ORFEO systems for mapping applications (optical and radar high resolution, access capability, data quality, possibility to acquire simultaneously in optical and radar). There is also a need of new methodological developments: new processing methods, or adaptation of existing methods,

One of the main objectives of the program is the definition and the development of tools for the operational exploitation of the future sub-metric optic and radar images (rapid mapping, 3D aspects, change detection, texture analysis, pattern matching, optical and radar complementarity). In this context, CNES decided to develop the *ORFEO Toolbox* (OTB), a set of algorithms encapsulated in a software library. The purpose of the OTB is to capitalize methodological know-how in order to adopt an incremental development approach aiming to efficiently exploit the results obtained in the frame of methodological R&D studies.

Indeed, there is often a gap between published algorithms in conferences or journals and algorithms which are used for real applications. Algorithms presented at conferences may work well on small data sets or with some settings which need

in-depth knowledge of the theory. On the opposite, functional applications need to work on any data set (often huge) without the knowledge of a particular expert. To be able to bridge this gap, implementations of algorithms published in the literature need to be available. These practices play also an important part for the development of reproducible research.

It is also very valuable for researchers and students to have access to a complete implementation of previously published algorithms. For researchers, this enables them to compare their results with these previous algorithms. On the other hand, it saves time for PhD students who often begin by programming again the basic functions.

All the developments included in OTB are based on FLOSS (Free/Libre Open Source Software) or existing CNES developments. OTB is developed in C++ and makes an intensive use of advanced programming techniques.

2. WHAT CAN WE DO WITH OTB?

The goal of OTB is to enable the user to process remote sensing images from different sources (satellite, image provider) with different levels of preprocessing (ortho-rectification, radiometric corrections). OTB proposes the basic functionalities that need to be assembled to meet the needs of a particular user.

About 3000 C++ classes are already available for most of usual operations on remote sensing images:

- image access (optimized read/write access for most of remote sensing raster and vector formats, meta-data access, visualization);

- geometric modeling (sensor models, DEM access, cartographic projections, image registration, disparity map estimation);

- filtering (blurring, denoising, enhancement);

- feature extraction (radiometric indices, textures, interest points, alignments, lines);

- image segmentation (region growing, watershed, level sets) and object oriented analysis;
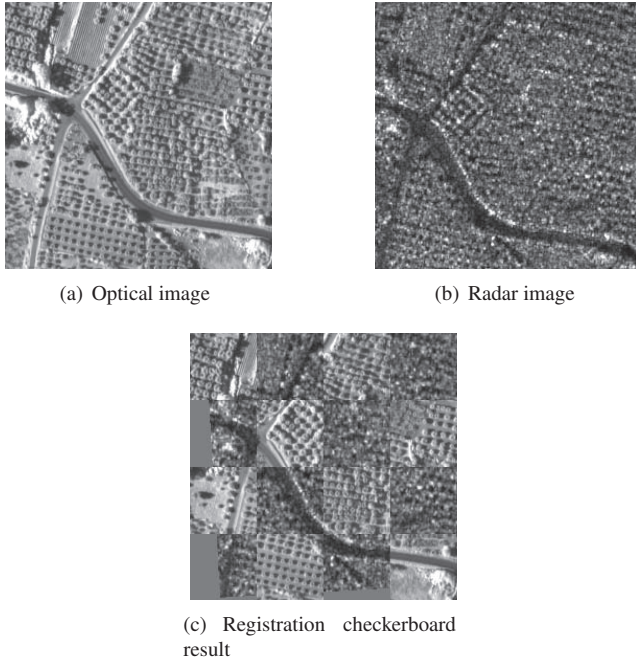
(a) Optical image   (b) Radar image

(c) Registration checkerboard result

Fig. 1. Registration: the optical and the radar images represent the same area with a deformation. A six parameter transform is used (translation, rotation, scaling) and the metric used is the mutual information.
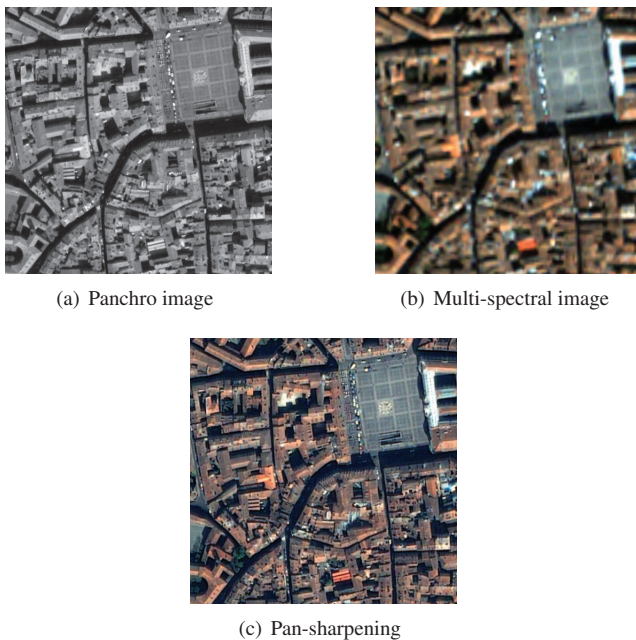

(a) Panchro image   (b) Multi-spectral image

(c) Pan-sharpening

Fig. 2. Pan-sharpening example: high resolution of the panchromatic image is introduced in the multi-spectral image to obtain a multi-spectral high resolution image.

- object extraction (road network extraction, template-based detection);

- classification (K-means, SVM, Markov random fields);

- change detection;

- on-line data access (OpenStreetMaps).

As we can see, the functionalities cover the whole range of image processing, from access to images to applications like change detection. This paper is obviously too short to cover the wide range of available capabilities and the reader is invited to look at the Software Guide [1] and other publications [2].

On figure 1, the registration between an optical and a radar image of the same area is illustrated. A good registration is a compulsory stage before being able to jointly exploit information from both images. The deformation model is implemented here with a centered affine transform which is able to introduce translation, rotation and scaling effects. The similarity metric cannot be a simple correlation due to the completely different acquisition process between the two sensors: mutual information is used instead.

Most current high resolution optical sensors (Spot 1 to 5, Ikonos, Quickbird, the coming Pleiades), have a high resolution panchromatic band and a set of multi-spectral bands with a lower resolution (typically by a factor of four). A pan-sharpening step is necessary to obtain an image with all the spectral bands with the highest resolution. Several pan-sharpening methods are available in OTB. One example is illustrated in figure 2.

Segmentation is a basic task in image processing. Several methods are available (watershed, fast marching, . . .). On figure 3 an example is given for the fast marching algorithm initialized from three different seeds directly on the luminance image.

Fig. 3. Segmentation example: from three different seeds. The fast marching algorithm generates three different areas.
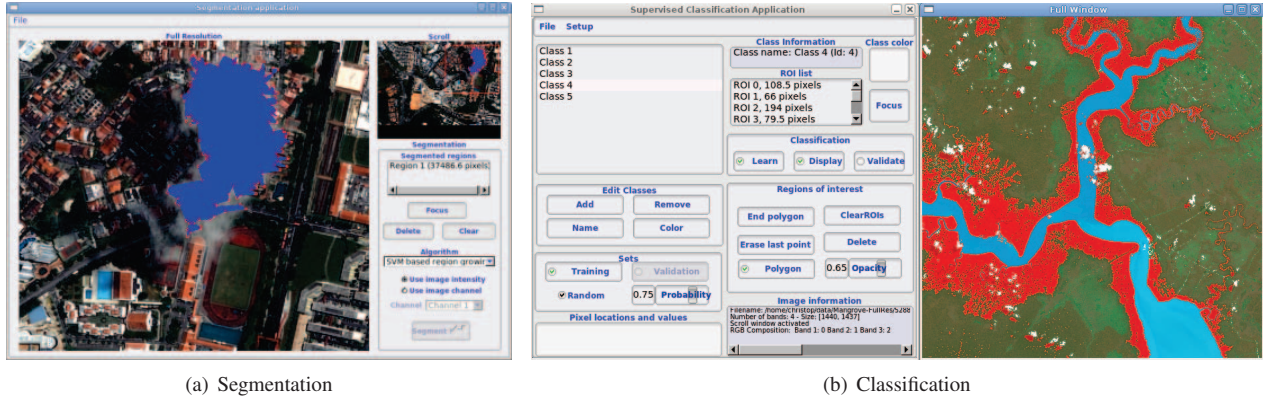
| (a) Segmentation | (b) Classification |

Fig. 4. Some OTB applications: (a) Segmentation application: cloud segmentation on a Quickbird image; (b) Classification application: classification of mangroves on a SPOT 5 image

OTB capabilities have also been assessed in several algorithm competitions such as the IEEE GRS-DFTC Fusion Contest 2008 for hyper-spectral classification or the PRRS 2008 building extraction contest [3]. Each time, OTB has demonstrated a great flexibility and good performances. Participation to these contest also led to the development of improvements to reduce shortcomings of existing methods.

3. USER FRIENDLY APPLICATIONS

OTB is mainly a C++ library, which means that in order to use it, some programming skills are needed. However, most of the potential users of remote sensing imagery are not computer scientists. These end-users are very valuable in terms of feature requests and algorithm validation.

In order to increase the interaction between end-users and researchers developing processing methods, OTB proposes some small applications. Originally, many of these application where design to illustrate the main capabilities of OTB to several people during several OTB trainings. Afterwards, it has been realized that these application were not only useful as a teaching tool but could also be used in operational environments..

These applications make the use of these new algorithms easier and more user friendly. The feedback from users has been extremely positive. Figures 4(a), 4(b) and 5 show examples of existing applications.

The need for developing new applications easily, has led the OTB development team to build a generic approach. This approach is based in the Model-Controller-View (MVC) approach which separates the processing part (the model) from the user interaction (the view), which both are used by a controller. This approach gives a great flexibility to adapt existing applications.
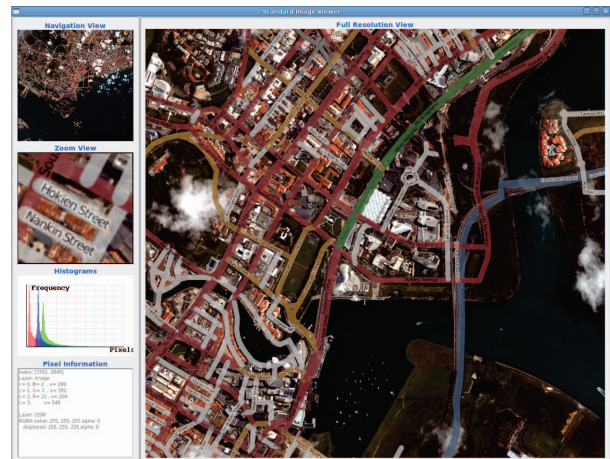

Fig. 5. Contextual information to help the image interpretation.

4. OTB FOR TRAINING

The user-friendly applications presented above can also be used for basic training to get people acquainted with remote sensing images. This is a low-cost way to make users aware of the possibilities of satellite imagery.

Beyond this first kind of training, OTB can be used for advanced remote sensing image processing training. All image processing trainings propose practical courses for image manipulation. OTB offers a very wide range of algorithms which should fulfill the needs of any training. Students can experiment with every step of the information production chain with components which can be glued together easily. Furthermore, since all source code is available, interested students can analyze how things are implemented and even try to modify the algorithms in order to study the impact in terms of quality of the results, computation time, etc.

The OTB Software Guide [1], the 650 page companion

book to OTB, can also be used as reference material. Of course it is freely available on the web, and even the source files can be downloaded and used by instructors to prepare the trainings.

5. WHAT IS COMING NEXT?

The Orfeo Toolbox road-map is quite flexible, influenced by the user requests and of course depends on the contributors, so it is quite hard to predict what will come out in the next few months. But here are some of the directions being explored currently.

5.1. New applications

Two new applications will appear: the tree stand extraction application and the radiometric calibration application (optical and radar). This will be two basic applications and you can expect them to evolve and improve in the following versions.

The land cover application (unsupervised classification), which is based on SVM classification will be improved to make use of the new textures and the radiometric indices introduced in the last version of OTB. A new SVM model will be provided. This should greatly enhance the performances of the application.

The supervised classification application is now pixel based and will be transformed into an object oriented (region based) classification tool. Also, the implementation of active learning features is forecasted.

5.2. Closing the gap with GIS

After the information is extracted, it is usually used in a GIS environment. OTB is now closing the gap with the GIS application. The first step will be the capability to interact with a PostGIS database. This will enable to store the results in a form directly usable by GIS applications. This will also enable the interaction of the strong spatial features of Post-GIS with the image processing algorithms: geospatial analysis will be possible within OTB.

Another way to reinforce interaction between this two domains is the development of OTB plugins for Quantum GIS to make the OTB capabilities available to the GIS user.

Finally, the last part focus on data representation to enable the remote sensing analyst to have a context on the image 5. This will be done by the integration of Mapnik: a mapping library.

5.3. Bindings

OTB is a C++ library, but being able to access the library using other languages is possible. This is done by a process called bindings. Bindings for several languages are in development. Python is mostly working but the documentation is lacking. Most of the work is done for Java, but the bindings are not usable yet.

A cooperation was developed with ITT Visual Solutions to define a method to access OTB through IDL/ENVI. This is working but hard to automate the complete binding generation. A manual is provided for the users who wish to access a specific class of the OTB library.

5.4. GPUs and clusters

OTB has a strong architecture (thanks to ITK), able to take advantage of modern multi-core CPUs. However, the adaptation to GPU or cluster processing is not transparent for the user. Some exploration is going on to provide an architecture to fully use these modern hardware.

6. CONCLUSION

The Orfeo Toolbox provides a strong software architecture and an extensive base of algorithms. Relying extensively on open source libraries has proven to be very powerful, enabling a wide range of well tested capabilities in a short time. Providing access to all these capabilities through a common interface eases the burden on the developer and facilitates the combination of all tasks within the same data pipeline.

OTB is evolving rapidly with a steadily growing user base. Contributions are welcomed!

7. REFERENCES

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