Guide for OTB training courses

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Course

Goal

Give an overview of the ORFEO ToolBox and get familiar with OTB tools (OTB applications and Monteverdi) to exploit and analyze remote sensing image.

Skills acquired at the end of the training

Know how to set up OTB processing and use OTB applications to perform:

- Feature extraction
- Calibration
- Classification
- Segmentation
- Basic SAR processing

Training kit

Data folder

- Data used in all exercises (sub-folder for each exercise)
- Data folder is specified at the beginning of each exercise

Training kit

Documentation folder

Software Guide C++ API (with algorithms definition)

CookBook Guide for non developers (API of applications)

QGIS User Guide QGIS user guide

Guide folder

- Training guide
- Slides
- Installation guide
- Evaluation survey
- Solutions (at the end of the training session)

Dataset

LandSat-8 concatenation of several dates, cloud free (gap-filling) with ground truth (reference data) in ESRI Shapefile format (classification exercise)

Pléiades PHR Bundle PRIMARY Level 1A from the CNES Thematic Commissioning phase over OSR MiPy (Toulouse) acquired in November 2013 (©CNES (2013), distribution Airbus DS/ Spot Image),

Sentinel-1 SLC product (complex) SM (strip Map, 5m ground resolution), polarization (HH and HV) over the South of the Constance lake (Germany).

Data access

LandSat-8 Level 2A (surface reflectance) available on THEIA website (https://www.theia-land.fr/)

Pléiades For French Institute: http://professionnels.ign.fr/images-pleiades

Sentinel-1 Free data available on ESA SciHub (https://scihub.copernicus.eu/) or on the CNES PEPS portal(https://peps.cnes.fr)

Useful information

Meal

Wifi code

Other?

Sommaire

Goals and data

Goals

- Know how to visualize an image and set up rendering in Monteverdi,
- Know how to visualize an images stack in Monteverdi,
- Know how to visualize an image and set up rendering in QGIS,
- Know how to visualize vector data in QGIS,
- Know how to visualize an images stack in QGIS,
- Tips and tricks.

Data

Dataset can be found in the following directories:

- `Data/preprocessing` (Pléiades extract)
- `Data/classification/Extract16bits/` (LandSat8 image series)
- `Data/classification/training/` (vector data ESRI Shapefile)

Program

- Visualize an image in Monteverdi
- Visualize a stack of images in Monteverdi
- Visualize an image in QGIS
- Visualize vector data in QGIS

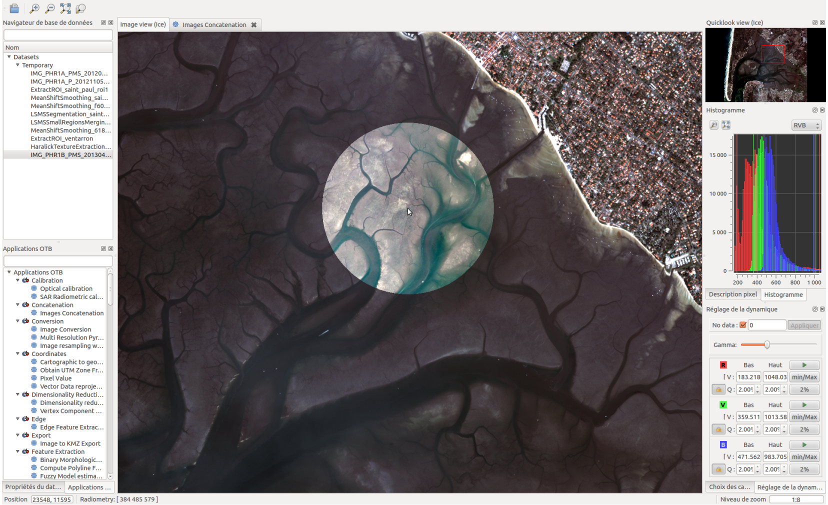
Introduction

- Several software products which share common functions
- But which sometimes differ in term of philosophy (Monteverdi *image oriented*, QGIS *GIS platform*)
- Several ways to do the same operation in these applications

Monteverdi

- At the beginning simple tool to demonstrate OTB library potential
- Move to an integrate application which allow to access to OTB applications
- Graphical User Interface (GUI) based on Qt
- Rendering engine based on Ice (OpenGL+OTB)
- Effects which use Graphic cards capability (shader) to allow to do on the fly rendering (local contrast, transparency, gradient. . .)

Monteverdi


Navigateur de base de données
Nom
Datasets
Temporary
IMG_PHR1A_PMS_20120...
IMG_PHR1A_P_20121105...
ExtractROI_saint_paul_roi1
MeanShiftSmoothing_sai...
MeanShiftSmoothing_f60...
LSMSSegmentation_saint...
LSMSSmallRegionsMergin...
MeanShiftSmoothing_618...
ExtractROI_ventarron
HaralickTextureExtraction...
IMG_PHR1B_PMS_201304...
Applications OTB
Calibration
Optical calibration
SAR Radiometric cal...
Concatenation
Images Concatenation
Conversion
Image Conversion
Multi Resolution Pyr...
Image resampling w...
Coordinates
Cartographic to geo...
Obtain UTM Zone Fr...
Pixel Value
Vector Data reproje...
Dimensionality Reducti...
Dimensionality redu...
Vertex Component ...
Edge
Edge Feature Extrac...
Export
Image to KMZ Export
Feature Extraction
Binary Morphologic...
Compute Polyline F...
Fuzzy Model estima...
Propriétés du dat...
Applications ...
Image view (Ice)
Images Concatenation
Quicklook view (Ice)
Histogramme
RVB
15 000
10 000
5 000
0
200
400
600
800
1 000
Description pixel
Histogramme
Réglage de la dynamique
No data :
Appliquer
Gamma:
R
Bas
Haut
V :
183.218
1048.03
min/Max
Q :
2%
V
359.511
1013.58
B
471.562
983.705
Choix des ca...
Réglage de la dynam...
Position
23548, 11595
Radiometry: [384 485 579]
Niveau de zoom
1:8

Monteverdi

Main window contains:

- Main menu (open image, close,preferences. . .)
- Top toolbar (shortcut)
- Image displaying (main view)
- Right side dock (color composition, quicklook. . .)
- Stack layer (images stack)

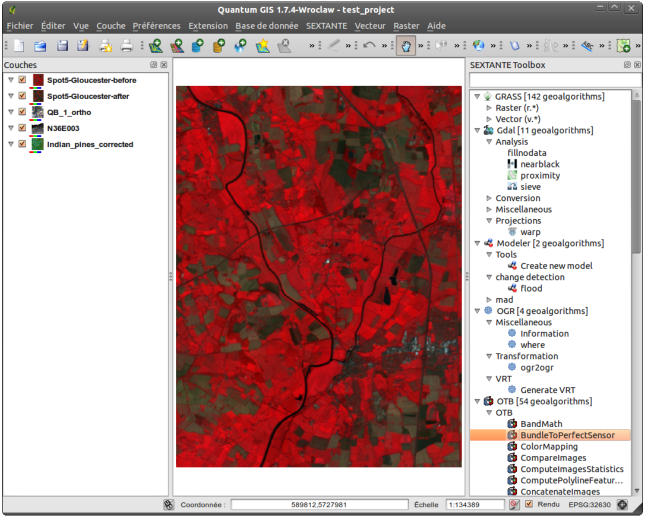
Quantum GIS

- GIS: organize and display spatial data
- Main functions in a GIS :
  - Display and create maps
  - Data acquisition des données
  - Data analysis
  - Data representation
  - Storage
- Lots of tutorials, technical courses available online. . .

Quantum GIS processing (since version 2.0)

- Processing plateform to access to GRASS-GIS,SAGA-GIS, R and OTB!
- Historically based on integrwation of Sextante project in QGIS(Victor Olaya)
- Access to all OTB applications(some of them are customized with a simplified interface)
- Voir QGIS processing documentation

Quantum GIS


Quantum GIS 1.7.4-Wroclaw - test_project
Fichier Éditer Vue Couche Préférences Extension Base de donnée SEXTANTE Vecteur Raster Aide
Couches
Spot5-Gloucester-before
Spot5-Gloucester-after
QB_1_ortho
N36E003
Indian_pines_corrected
SEXTANTE Toolbox
GRASS [142 geoalgorithms]
Raster (r.*)
Vector (v.*)
Gdal [11 geoalgorithms]
Analysis
fillnodata
nearblack
proximity
sieve
Conversion
Miscellaneous
Projections
warp
Modeler [2 geoalgorithms]
Tools
Create new model
change detection
flood
mad
OGR [4 geoalgorithms]
Miscellaneous
Information
where
Transformation
ogr2ogr
VRT
Generate VRT
OTB [54 geoalgorithms]
OTB
BandMath
BundleToPerfectSensor
ColorMapping
CompareImages
ComputeImagesStatistics
ComputePolylineFeatur...
ConcatenateImages
Coordonnée : 589812,5727981
Échelle 1:134389
Rendu
EPSG:32630

Principle

- Discover data package and software
- Monteverdi:
  - How to visualize and set up color rendering options
  - Know how to use image stack
  - Explore *Effects* available
- QGIS:
  - How to visualize and set up color rendering options
  - How to visualize vector data
  - Know how to use image stack
- Work in pairs for 15 minutes
- Round table (30 to 45 minutes), every group do a restitution/give a trick/ask a question. . .

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Data and Objectives

Objectives

- Know how to look for an application in the list of available applications
- Know how to set application parameters
- Know where the documentation of an application is
- Know how to use several classical applications.

Data

Data can be found in folder `Data/stegano/`.

Outline

This exercise consists in decoding 6 messages encoded within the images using steganography techniques, using OTB applications.

Quick introduction to OTB applications

- Orfeo TooLBox is a library offering remote sensing features
- Often several features of OTB must be combined within a processing chain
- Need for higher level interfaces (parameters, input and output data, logs ...)
- Each application corresponds to a high level function (segmentation, orthorectification, raster calculator ...)
- And corresponds to a C++ class (*otb::Application*) → library
- Plugin mechanism
- One can develop and distribute his/her own homemade applications

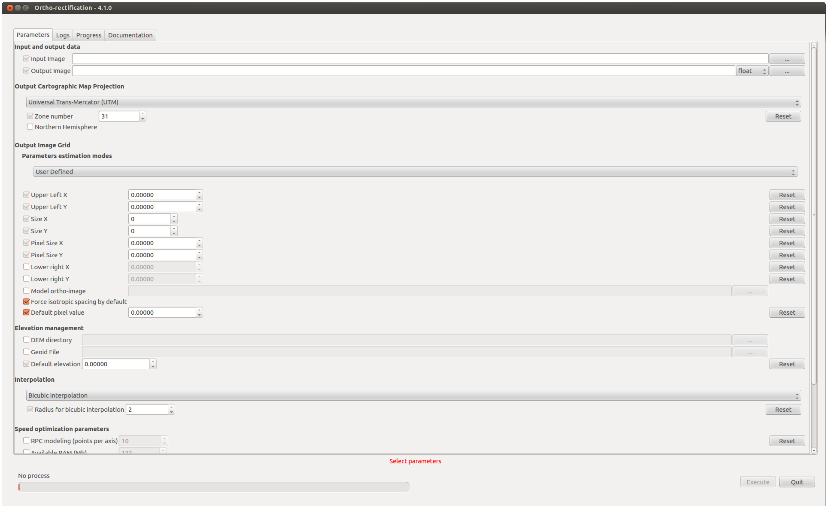
Quick introduction to OTB applications

- Command-line → otbcli_Orthorectification
- With graphical user interface → otbgui_Orthorectification
- Using python:

```
import otbApplication
orth=otb.Registry.CreateApplication("OrthoRectification")
```

- Available from Qgis → *processing* menu
- Available in Monteverdi

GUI


Ortho-rectification - 4.1.0
Parameters
Logs
Progress
Documentation
Input and output data
Input Image
Output Image
float
Output Cartographic Map Projection
Universal Trans-Mercator (UTM)
Zone number
31
Reset
Northern Hemisphere
Output Image Grid
Parameters estimation modes
User Defined
Upper Left X
0.00000
Upper Left Y
0.00000
Size X
0
Size Y
0
Pixel Size X
0.00000
Pixel Size Y
0.00000
Lower right X
0.00000
Lower right Y
0.00000
Model ortho-image
Force isotropic spacing by default
Default pixel value
0.00000
Elevation management
DEM directory
Geoid File
Default elevation
0.00000
Interpolation
Bicubic interpolation
Radius for bicubic interpolation
2
Speed optimization parameters
RPC modeling (points per axis)
10
Select parameters
No process
Execute
Quit

Parameters

- Display help from orthorectification app (good example)
- *parameters groups*
- *mandatory parameters*
- Dynamic parameters dependency
- Default value
- Type of output images (default is float)

Another example: BandMath

- Raster calculator
- Uses the MuParser library
- Input is a list of images (*-il* parameter)
- Mathematical expressions syntax:
  - imXbY:
    - X: index of image in list (from 1 to N)
    - Y: index of image band (from 1 to N)
  - List of available operators
- Examples:
  - *-exp "(im1b4 - im1b1) / (im1b4 - im1b1))"
  - *-exp "acos((123*im1b1+265*im1b2+652*im1b3) / (sqrt(123*123+265*265+652*652) *sqrt(im1b1*im1b1+im1b2*im1b2+im1b3*im1b3)))"
  - *-exp "im1b1>0.5?255:0"*

Useful links

- Introduction to OTB applications
- Application Reference Documentation
- Examples of use
- QGIS processing
- Application help: *otbcli_XXX -help*

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Goals and data

Goals

- Understand OTB's transparent machinery
- Influence the data processing pipeline
- Know where to find important information

Data

The data are in `Data/internals/`.

Outline

The outline for this workshop is as follows:

1. Encoding images
2. geom files
3. Extended filenames
4. Streaming
5. Multi-threading

Encoding images

type	domain	number of bits
uint8	[0,255]	8 bits
int16	[-32 767, +32 767]	16 bits
uint16	[0, 65 535]	16 bits
int32	[-2 147 483 647, +2 147 483 647]	32 bits
uint32	[0, 4 294 967 294]	32 bits
float	[$-3.402823 \times 10^{38,3.402823} \times 10^{38}$]	32 bits
double	[-10^{308}, 10^{308}]	64 bits

geom files

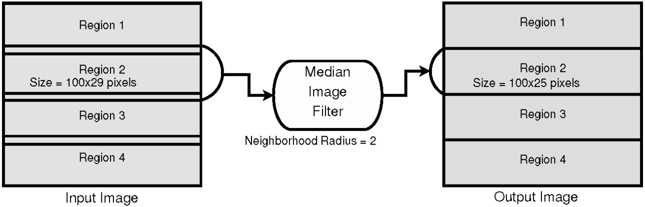
```
[...]
samp_num_coeff_15:  -8.69402623737171e-06
samp_num_coeff_16:  -2.52010136133467e-09
samp_num_coeff_17:  -5.70277370040739e-07
samp_num_coeff_18:  -2.67844954240191e-07
samp_num_coeff_19:  -7.80920276666093e-09
samp_off:  19999
samp_scale:  19999.5
sensor:  PHR 1A
[...]
support_data.image_date:  2012-11-15T11:05:04.4Z
support_data.image_id:  602631101-001
support_data.image_size:  38187 38890
support_data.instrument:  PHR
support_data.instrument_index:  1A
support_data.line_period:  0.0735
[...]
```

Extended filenames

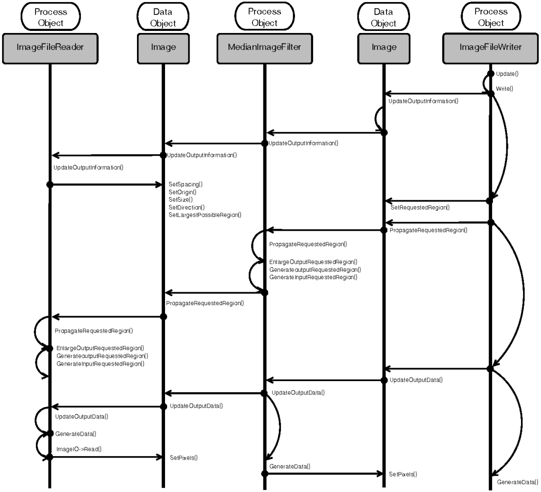
Syntax understood by all OTB code reading or writing images

```
"myImage.tif?&geom=mygeom.geom"
"myImage.tif?&gdal:co:TILED=yes&streaming:type=none"
```

Streaming and multi-threading (1/2)



Streaming and multi-threading (2/2)



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Goals and data

Goals

- Know how to perform optical calibration
- Know how to perform image fusion (pan-sharpening)
- Know how to perform ortho-rectification

Data

Data are available in directory `Data/preprocessing/`. Sub-directories `SRTM` and `Geoid` are also used.

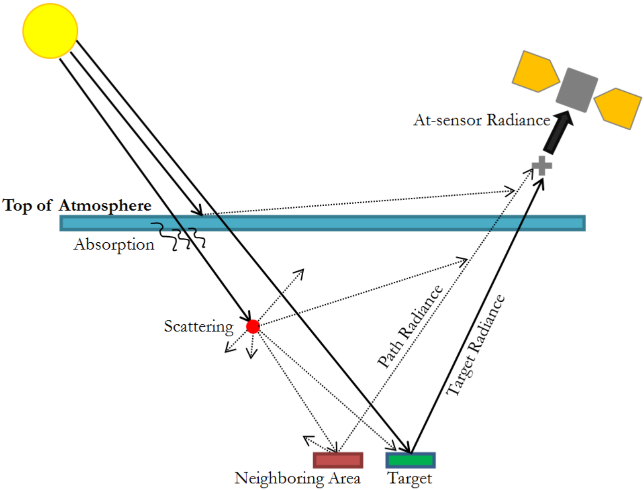
Outline

The outline for this workshop is as follows:

1. Atmospheric corrections
2. Fusion P+XS
3. Ortho-rectification

Optical calibration

Atmospheric correction



Schematic of atmospheric attenuation of the electromagnetic energy while going from sun to target and then to the sensor

Fusion (pan-sharpening)

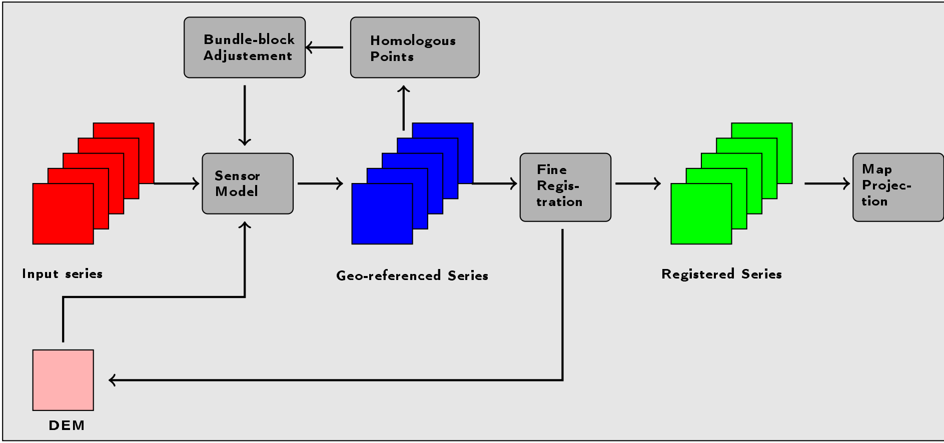
What is pan-sharpening ?

- Most VHR sensors acquired 2 images separately:
  - The multi-spectral bands cover a narrow range with less spatial resolution (than PAN)
  - The panchromatic band with a larger spectral range and a greater spatial resolution (4x greater generally)
- Pansharpening = process of merging high-resolution panchromatic and lower resolution multispectral imagery to create a single high-resolution color image

PXS in a nutshell

1. Fine superposition of Pan and XS bands
2. Fusion algorithm

Orthorectification



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Goals and data

Goals

- Know steps to perform image segmentation with OTB
- Know how to optimize segmentation parameters
- Export segmentation results to a GIS

Data

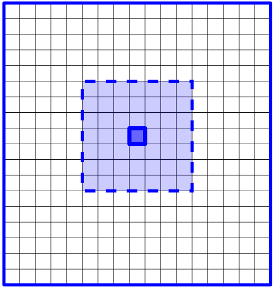
Dataset for this exercise can be found in folder: `Data/segmentation`.

Planning

Planning of the practical work:

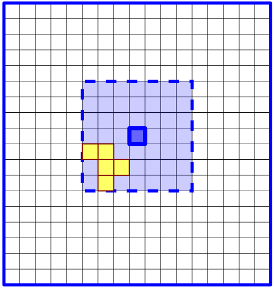
1. Image smoothing with the MeanShift algorithm
2. Segmentation
3. Handle small regions
4. Vectorization
5. Filter segments in QGIS

MeanShift algorithm (1/4)



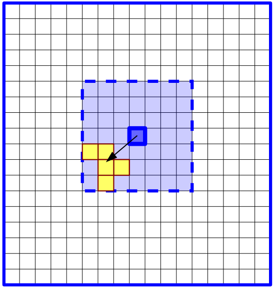
Search in pixel neighborhood *nearby* spectrally

MeanShift algorithm (2/4)



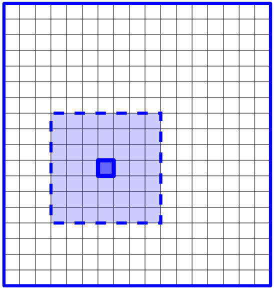
Spatial and spectral mean for pixels in the given window

MeanShift algorithm (3/4)



Move pixel to the barycentre and set value with spectral mean

MeanShift algorithm (4/4)



Go back to step 1 (iterative process). Stop after convergence

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Goals and data

Goals

- Understand the applications needed for the supervised classification procedure
- Use the different learning algorithms
- Measure the quality of classification results
- Know the available post processing steps

Data

The data are available in the `Data/classification` directory, with the following sub directories:

- `Extract16bits`: the Landsat 8 time series
- `training`: the training data in the *shp* format
- `testing` the testing data in the *shp* format

Planning

Planning for this workshop:

1. Introduction to the Landsat 8 data set
2. Single date classification
3. Multi date classification
4. Classification with a NDVI profile
5. Classification post processing

Introduction to the Landsat 8 data set

Spatial resolution: 30 meters

Dates

2014-03-09
2014-04-01
2014-04-17
2014-05-28
2014-06-20
2014-07-31
2014-09-01
2014-10-03
2014-10-26

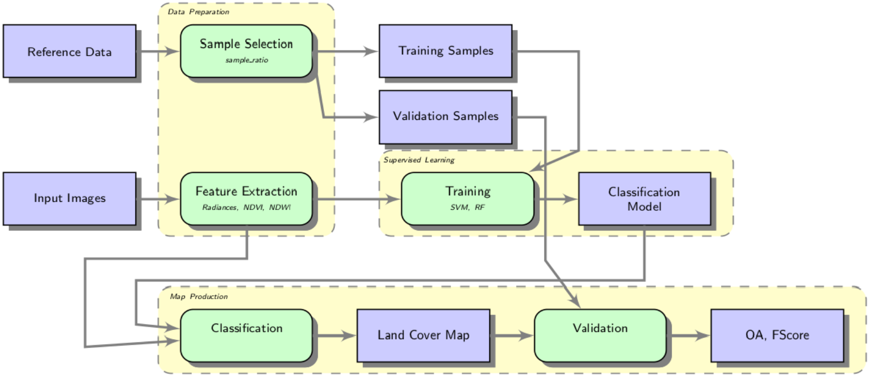
Bands

0	Coastal aerosol
1	Blue
2	Green
3	Red
4	Near Infrared (NIR)
5	SWIR 1
6	SWIR 2

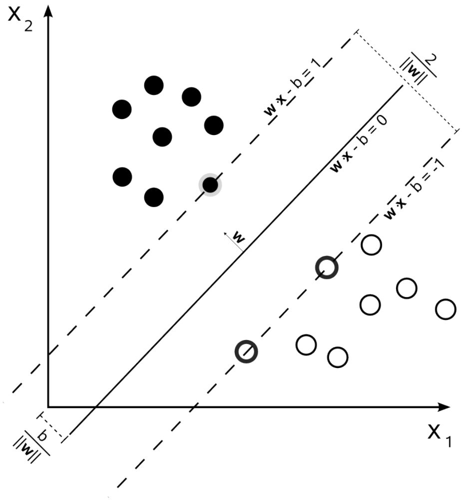
Introduction to the training and testing data

Code	Name	#polygons
11	Summer	7898
12	Winter	8171
31	Mixed forest	867
32	Evergreen forest	125
34	Grass	45
36	Woody plant	386
41	Building	4719
51	Water	1280
211	Grasslands	5647
221	Orchard	204
222	Vine	559

Supervised classification



SVM algorithm



RF algorithm

A set of random decision trees.

Learning

1. Separate the learning set in k random sets S_k
2. For each S_k, choose randomly F_k primitives
3. Recursivly build a decision tree, for each node:
    1. Choose $f \in F_k$ and the threshold t_k to separate the remaining set in two subsets:
    2. Stop when the remaining set is too small

Decision

Majority voting between all random trees

Confusion matrix

	Pred. 1	Pred. 2	Pred. 3
Ref. 1	True pos. 1		
Ref. 2		True pos. 2	
Ref. 3			True pos. 3

- $precision = \frac{VPi}{\sum pred.i}$
- $recall = \frac{VPi}{T \sum ref.i}$
- $accuracy = \frac{\sum VPi}{Total}$
- $Kappa = \frac{Accuracy - chance}{1 - chance}$

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Goals and data

Goals

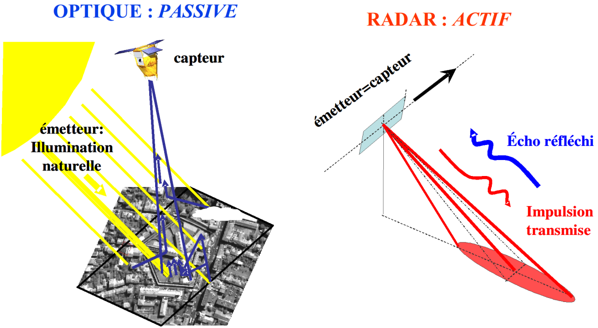
- Know how to manipulate SAR images
- Know how to perform SAR calibration
- Know how to perform SAR orthorectification
- Know methods to reduce speckle noise in images
- Know more about features extraction in SAR images

Data

Data are located in the `Data/sar` folder.

Outline

Optic vs Radar



(source CNES: Book "IMAGERIE SPATIALE Des principes d'acquisition au traitement des images optiques pour l'observation de la Terre")

Introduction SAR

- Radar: measuring objects properties from distance with dedicated instruments
- SAR: Synthetic Aperture Radar
- Active sensor
- Day and Night imaging capability
- Atmosphere mainly transparent to SAR
- Complementary information to optical systems

Principles

- Use the flight path of the platform to simulate an extremely large antenna or aperture electronically
- Properties from distance
- Repeat echoes in the second dimension (azimuth)
- Complex signal (amplitude and phase)

Radiometric calibration

- Radar reflectivity (backscattered signal) of targets as a function of their position
- backscattered coefficient can be a positive number if there is a focusing of backscattered energy towards the radar
- backscattered coefficient can be a negative number if there is a focusing of backscattered energy way from the radar
- Rugosity, humidity...
- Calibration -> DN to backscattering coefficient
- Examples:
  - Very high backscatter (above -5 dB) -> man made surfaces
  - High backscatter (-10 dB to 0 dB) -> rough surface, dense vegetation
  - Moderate backscatter (-20 to -10 dB) -> medium level vegetation, crops
  - Low backscatter (below -20 dB) -> smooth surface (water)

Geometric corrections

- Spatialize images
- Range (depend on the PRF) and Azimuth Resolutions (depends on the size of the antenna for a Radar System
- Resolutions
  - $azimuthResolution = \frac{H * \lambda}{L * \cos(\theta)}$
  - $rangeResolution = \frac{c * prf}{2 * \sin(\theta)}$
- geometrical distortions (foreshortening and layover)

Speckle

- Granular 'noise' that inherently exists in and degrades the image quality
- Strong!
- Speckle noise in SAR is a multiplicative noise, i.e. it is in direct proportion to the local grey level in any area
- Several methods to try to reduce this noise
- Try to reduce speckle effects without loosing to much details
- Speckle filtering allows to improve image quality and facilitate interpretations

To go further

- S1 ToolBox (SNAP)
- Polarimetry: ESA PolSARPro
- Lot of useful resources related to SAR on the Internet (ENSG moodle, ESA training, PolSARPro tutorials, SAREDU DLR online courses. . .)