Traitement de données aéroportées avec MicMac

Satellite image processing

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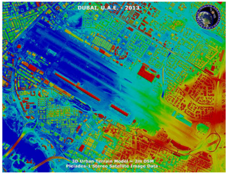
Why images from satellite range

- very high geometric resolution (up to $\approx$ 30cm GSD)
- high temporal resolution
  - revisit times of 1 day throughout the year
  - worldwide coverage
  - long- and short-term change detection in 2D/3D (damage assessment, floods, landslides)
- high radiometric & spectral resolution
  - 8 to 16 bits
  - panchromatic VIS
  - multispectral bands RGB + NIR
  - hyperspectral +10 bands
- four civil satellites (Worldview, GeoEye, Quickbird, Pleiades)
- easily accessible, no acquisition planning necessary

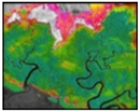
Applications



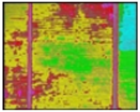
Pleiades-1A (0.5m) Stereo Satellite Imagery

QuickBird (0.6m) Satellite Image

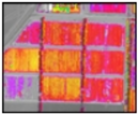
IKONOS (0.8m) Satellite Image



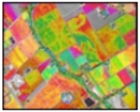
Wetlands Encroachment



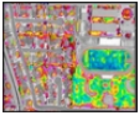
Irrigation Patterns



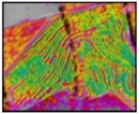
Production Monitoring



Crop Health Variations



Urban Forest and Turf

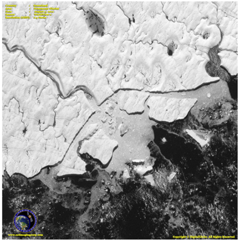


Soils and Fertility Analysis

QuickBird (0.61m) Satellite Images

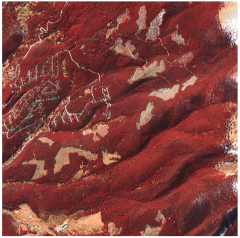
Applications

Ice Calving - Petermann Glacier, Greenland



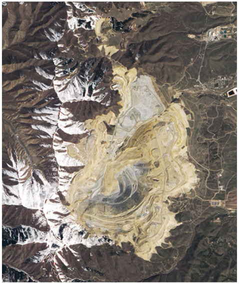
(Image Copyright © DigitalGlobe)

Copper Mountain Ski Resort, Colorado



IKONOS (0.82m) Satellite Image

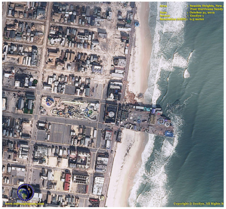
Bingham Canyon Mine Landslide 2013



EO-1 (10m) Satellite Image

(Image Copyright © NASA)

Hurricane Sandy - Seaside Heights, New Jersey



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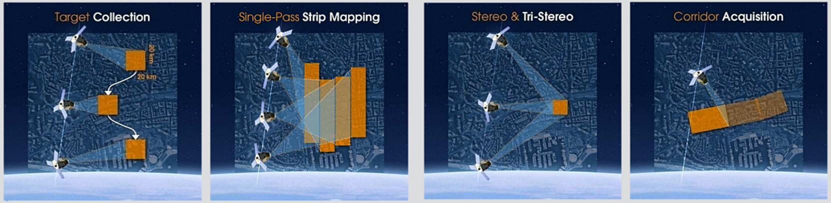
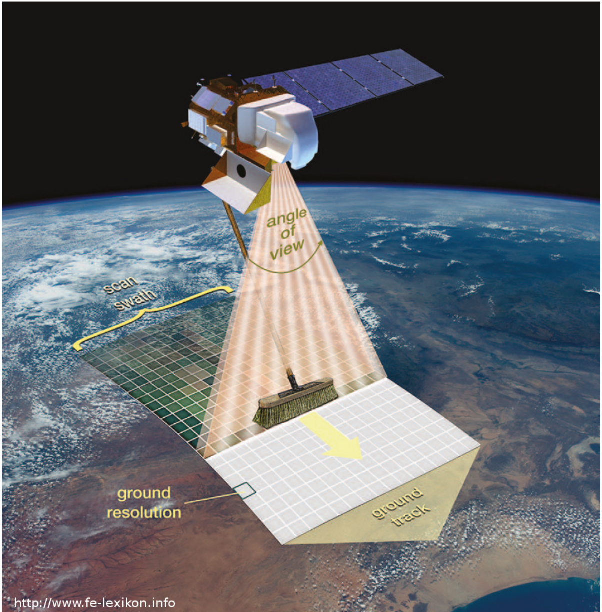
1. Motivation
   - Why?
   - What?
2. Geometry of the sensor
   - Pleiades-HR satellites
   - The mathematical model
3. Processing in MicMac
   - The general pipeline
   - The commands

Pleiades-HR pushbroom satellites

- 2001, established franco-italian cooperation (CNES & ISA)
- 2011/2012, launched Pleiades 1A/1B
- sun-synchronous & near polar orbit,
  180° *phase*, $alt = 694km$, $incl = 98.2^\circ$
  $repeat\_cycle/revisit\_time = 26/1days$
- swath width 20-120km, GSD in PAN 0.7m
- agile acquisition modes



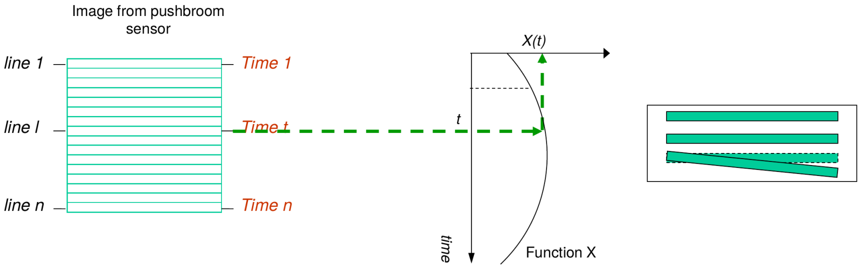
Mathematical model of the pushbroom sensor



Mathematical model of the pushbroom sensor

Physical/rigorous model

- perspective and orthogonal projections
- exterior orientation for each scanline
- collinearity equations must include the time component
- different camera calibration model (wrt frame camera)



Courtesy of Daniela Poli

Mathematical model of the pushbroom sensor

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Problems?

Mathematical model of the pushbroom sensor

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↓

Problems?

- rigorous model not always disclosed by the space agencies
- no standard set of physical parameters
- no standard nomenclature
- difficult to maintain in a software tool

Mathematical model of the pushbroom sensor

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↓

Solution → use an empirical model

- replace the collinearity equations with an empirical function
- rational polynomial functions (RPC) are the most common replacement model
- they are delivered with all modern HR satellites

Mathematical model of the pushbroom sensor

Empirical model is just an approximation!!!

- it is derived from the physical model
- it is accurate up to the accuracies of the on-board direct georeferencing
- as such it is not apt for accurate mapping
- refinement of the provided RPC parameters is a must

→ compensate for the inaccuracies by modelling them with **a 2D polynomial function**

→ estimate the function's parameters in **a bundle adjustment routine** (`Campari`)

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The general pipeline

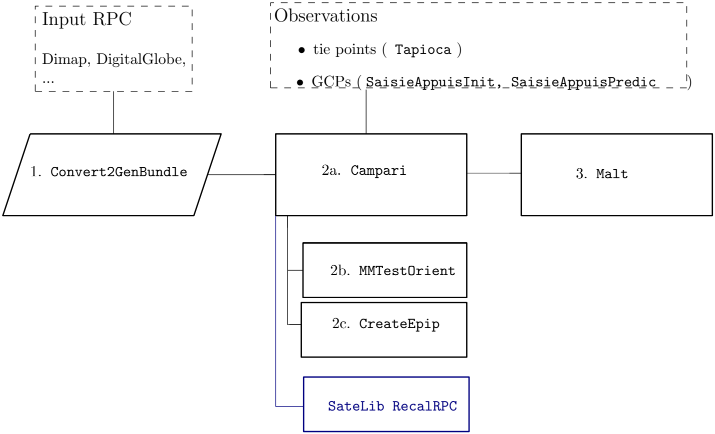

Figure : Satellite images processing workflow for DSM generation. The MMTestOrient is a supplementary operation aiming at evaluating the goodness of the orientation parameters. The CreateEpip is obligatory only in case the user wants to perform dense matching in this geometry. SateLib RecalRPC recalculates the original RPCs to include the adjusted corrections.

The commands : the dataset

- download a sample dataset from
  http://www.geo-airbusds.com/en/23-sample-imagery
- the folder structure & image display

```
cd /home/prof/Documents/XXXXYYYY
ll
mm3d Vino IMG_PHR1A_P_201202250025329_SEN_PRG_FC_5110-001
```

- the RPC file (coefficients and validity zone)
- histogram stretch in Vino
  → right-click
  → select `Histo ..`
  → draw a rectangle and finalize with Shift+left-click
- crop in Vino
  → use `Z1 HCur` i.e. zoom 1, current histogram

The commands

- ~~extract tie points~~ (already precomputed!)

  `mm3d Tapioca All ".*.tif" 20000`

- display the tie points
  (NB=binary, NT=txt formats)

  ```
  mm3d SEL ./
  IMG_PHR1A_P_201202250025329_SEN_PRG_FC_5110-001_R1C1.tif
  IMG_PHR1A_P_201202250025599_SEN_PRG_FC_5108-001_R1C1.tif
  KH=NB
  ```

  → the images appear superposed (`i1 & 2`)
  → right-click and switch to single images (e.g. `i1`)
  → scroll-click to activate the display

The commands

- indicate the coordinate system for the processing [1]

```
<TypeCoord>eTC_Proj4</TypeCoord>
<AuxStr>+proj=utm +zone=55 +south +ellps=WGS84
+datum=WGS84 +units=m +no_defs</AuxStr>
```

→ all dimensions must have the same unit
→ the Z-axis must be approx tangent to the Earth patch visible in the images

- convert the input data to MicMac format

```
mm3d Convert2GenBundle
IMG_PHR1A_P_201202250025329_SEN_PRG_FC_5110-001_R1C1.tif
RPC_PHR1A_P_201202250025329_SEN_PRG_FC_5110-001.XML
RPC-d0 ChSys=WGS84toUTM.xml Degre=0
```

[1] http://spatialreference.org/

The commands

- refine the RPC-based orientations

  `mm3d Campari ".*.tif" RPC-d0 RPC-affine`

  → possible GCP
  → display deformations `mm3d SateLib SATD2D Ori-RPC-affine/GB-Orienttion..xml`

- create masks to constrain matching to a region

  `mm3d SaisieMasq IMG_PHR1A_P_201202250025329_SEN_PRG_FC_5110-001_R1C1.tif`

  → mask for each image

The commands

- calculate DSM with the new orientation

```
mm3d Malt UrbanMNE ".*R1C1.tif" Ori-RPC-affine
ZMoy=0 ZInc=500 MasqIm=Masq ZoomF=4 EZA=true
```

→ specify image pattern to exclude the masks
→ `ZMoy`, `ZInc` are mean terrain height and incertitude
→ default `SzW=1` correlation window will be used
→ `ZoomF` final zoom (to speed-up the computation)
→ `EZA=1` final DSM will contain absolute Z-values