AI FOR EO DATA PRODUCTION AND ANALYTICS

RESULTS AND PERSPECTIVES OF CNES' EO DEPARTMENT RESEARCH

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Outline

- Context of EO ground segments
- Presentation of image processing frameworks
- Selection of AI research lead by CNES
    - Analytics on VHR images (Quantcube, Irisa)
    - Scheduling of processing chains (CapGemini)
    - Transfer learning for new EO missions (Thales Alenia Space, Irisa)
    - Detection of clouds using traditional and AI techniques
- Conclusion and future work

Context for ground segment from CNES' perspective

Earth observation is changing

- Increased volume of data and providers
- New actors

Rethinking: data platform and services

- Copernicus and Collaborative GS ➔ http://peps.cnes.fr
- ESA/EU: DIAS, TEP, MEP,
- Market Place business: Initiatives One Atlas and GBDX

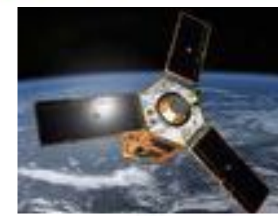
A new business model:

- Users want more reactivity, data lifetime value is shortened
- Open data and open source
- Users want information!

Context for ground segment from CNES' perspective

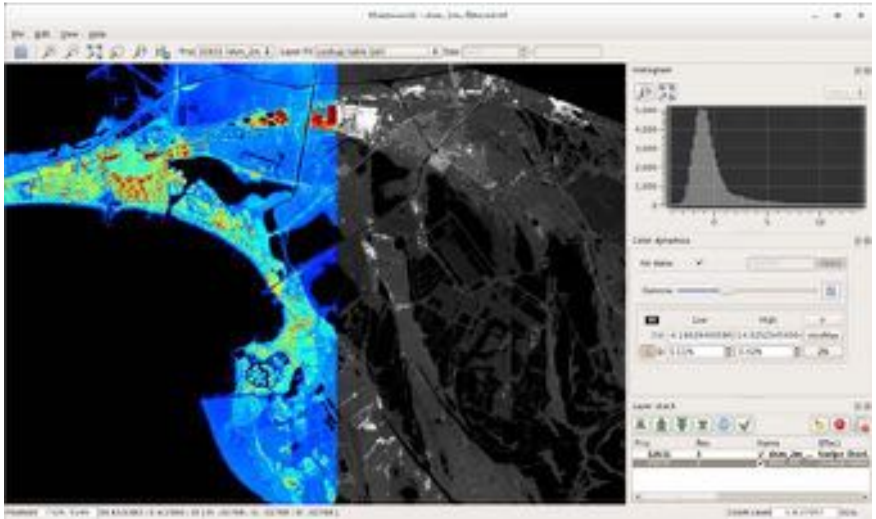
Data is a key element

- ❖ Big amount of EO data available at CNES
  - Sentinel 1,2,3 mirror of ESA
  - Pleiades data (limited to scientific usage)
  - Spot 1-5 archive (30 years)
  - Upcoming missions
- ❖ Current archive not entirely labeled
  - → Permanently growing database



ORFEO ToolBox

https://www.orfeo-toolbox.org/



- **Open-source** remote sensing image processing library
- Large community and easy to contribute: https://www.orfeo-toolbox.org/community/
- Image algorithms written in C++ and wrapped into OTB applications
- Easy to use and to incorporate into Python scripts: in-memory connection of OTB applications: https://www.orfeo-toolbox.org/CookBook/recipes/python.html

Image processing toolboxes

Important set of optimized and generic image processing libraries inherited from legacy missions

- Image resampling, deconvolution, denoising, etc.
- Sensor modeling (camera model)
- Correlation, image matching, image mosaicking, fusion
- Atmospheric corrections (joint algorithm CNES-DLR)
- Segmentation, Classification, 3D
- New: **Tensorflow-module**

Sub-set as open source library available on-line :

https://www.orfeo-toolbox.org/

Machine learning for analytics in VHR images

R&D project in progress

Main goal

- Count the number of vehicles in strategic locations using Deep Learning techniques and databases from various sensors (Pleiades, etc ...)

Challenges

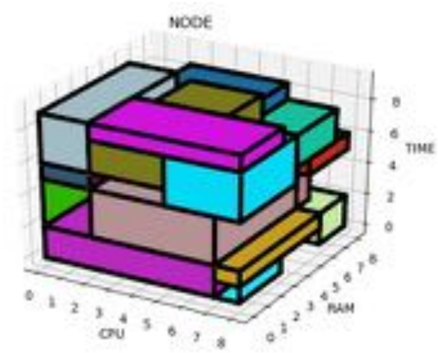
- Definition of strategic points in VHR images
- Constitution of the learning database
- Definition of the neural network architecture
- Generalization of the procedure (detection of planes, boats, etc.)
- Demonstration of maturity for an operational application

Illustration of car detection in parking lots with drones
© University of Vermont Spatial Analysis Laboratory

Machine Learning for performance optimization of processing chains

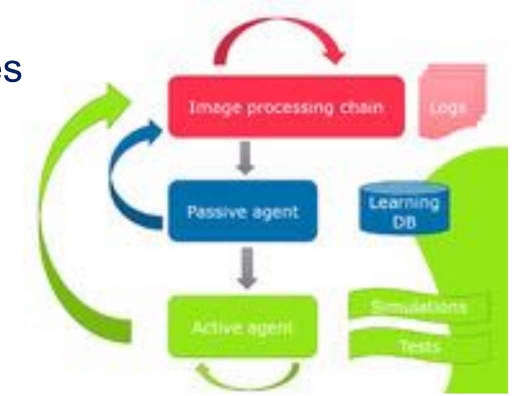
Completed R&D activity

Capgemini



Main goal

- State-of-the-art of Machine Learning techniques for scheduling optimization with Reinforcement Learning
- Identification of available status (CPU, RAM, IO) and possible action (parameters)
- **AI** development to optimize orchestration and reduce production times
- Simulation strategies to explore optimal orchestrations



Results

- Successful implementation of genetic learning and reinforcement learning
- Compromise between generalization and learning time

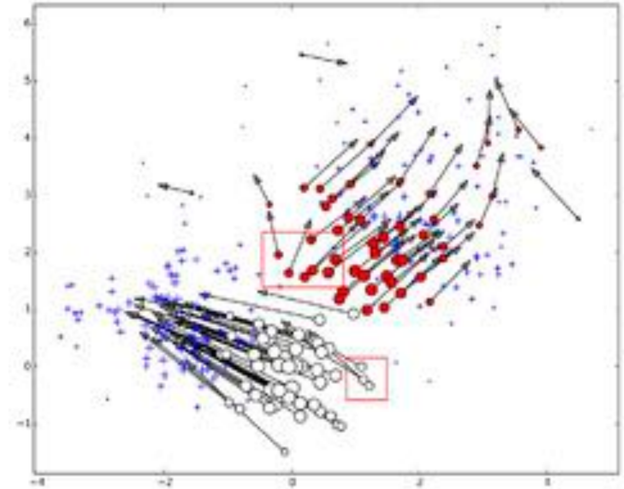
Transfer learning

PhD work in progress (2018-2021)

Main goal

- ❖ Quantification of Deep Learning pros/cons vs. traditional methods
- ❖ Transfer learning to other sensors in order to obtain a fast and usable result at a lower cost

  → production of enriched data from the beginning of a new earth observation mission



Nicolas Courty © Irisa

Challenges

- ❖ Adapt Deep Learning models from one sensor to another (adaptation layers) and answer the question: How to transfer knowledge between different feature spaces?
- ❖ Improve the efficiency of current processing chains through the combined use of Deep Learning and traditional methods

Machine learning for cloud detection and transfer learning

Ongoing internal project

- Development of a new Deep Learning processing chain for cloud/snow/shadow detection in Sentinel-2 images
- Comparison with the output masks of MAJA

Illustration of cloud detection with MAJA on S2 images
© Cesbio

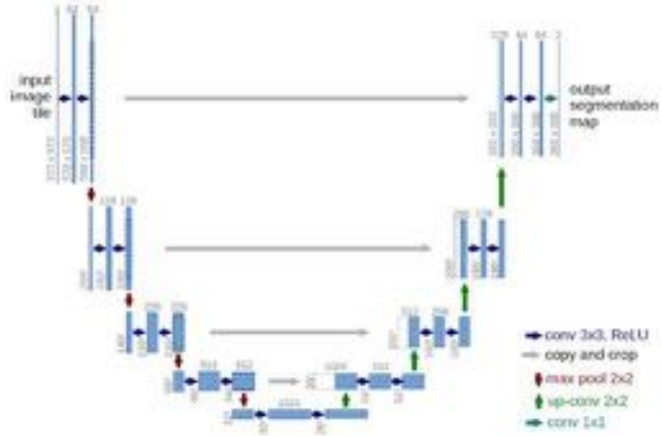
Cloud detection in detail

❖ Training, Validation and Comparison: MAJA’s Level-2 cloud masks, coming from THEIA:

❖ Resampling of images to same resolution as MAJA (240m/120m) → Equal conditions

→ Total of 1000 Level-2 and Level-1 Sentinel-2 products available **daily**

Cloud detection in detail:



Unet illustration_© Uni Freiburg

Creating an adaptable model

Different configurations for the output classes:

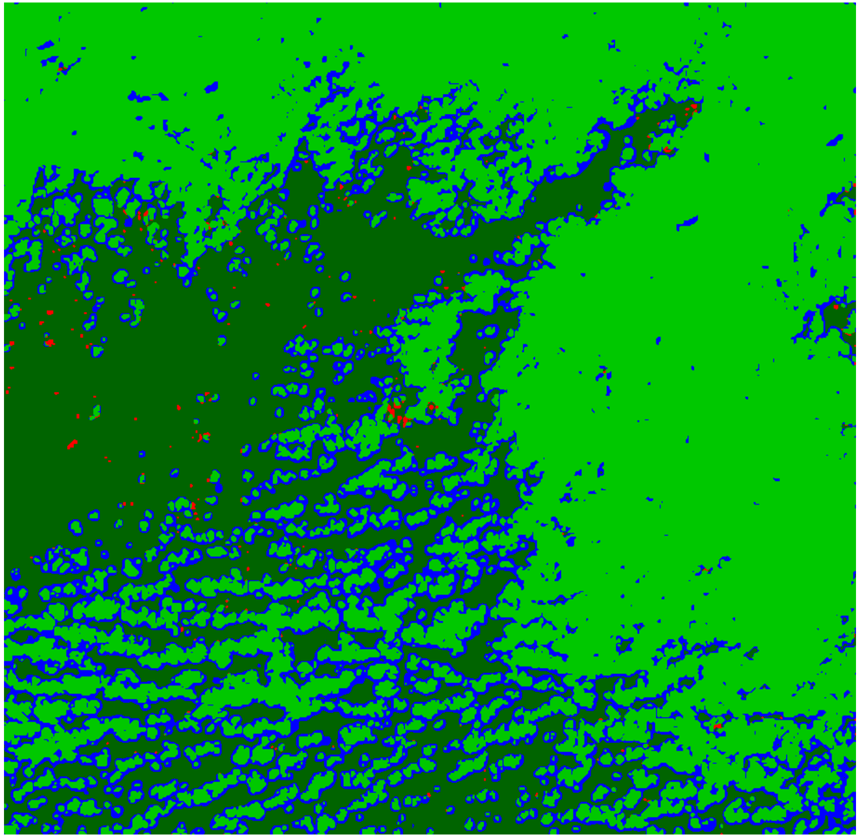
- ❖ Clouds (different types)
- ❖ Shadows (with and without)

Transfer learning approach

- ❖ Using existing models: Unet, VGG etc. → Variation with regularization techniques
- → Current best F2-Score for single class (clouds): **91% (Unet)**
- → **Usage of active learning for the future**

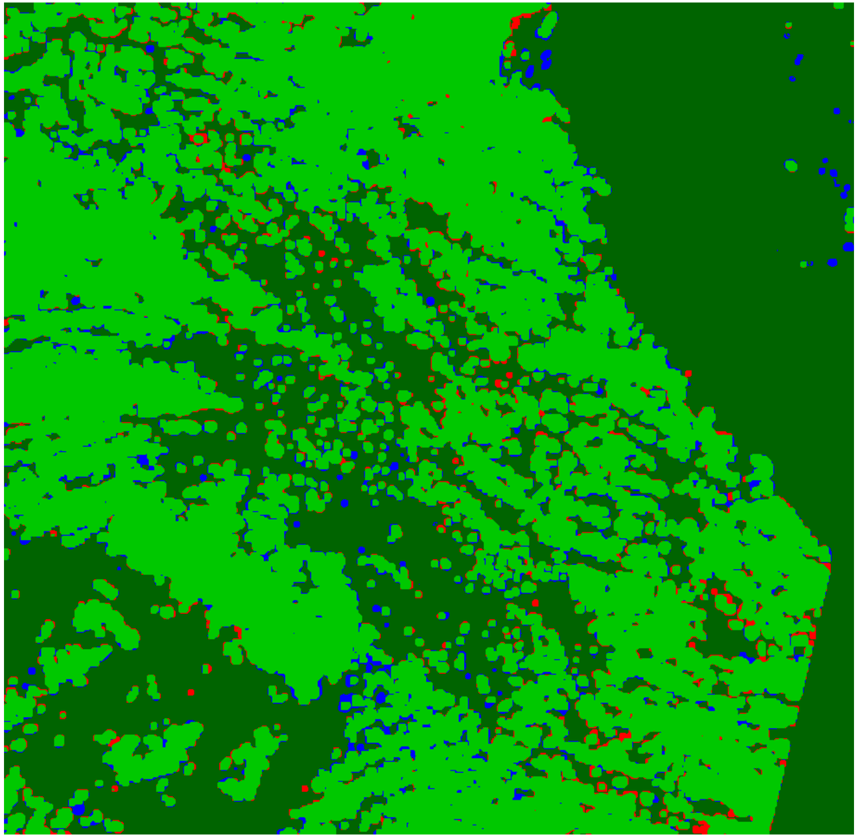
Cloud detection in detail

Cloud Clear Omission Overdetection



Cloud detection in detail

Cloud Clear Omission Overdetection



Conclusions and future work

Continuous researches together with industry, startups and academics

- Preparation of future EO missions and applications with innovative technologies
  - Deep Learning for analytics
  - Artificial intelligence combined with traditional approaches

Perspectives

- Validation of AI implementations for operational services
- Deployment on existing platforms (HPC, DIAS)

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