→ THE ESA EARTH OBSERVATION Φ-WEEK

EO Open Science and FutureEO

12–16 November 2018 | ESA–ESRIN | Frascati (Rome), Italy

AI4EO 5 Challenges

Prof. Mihai Datcu

German Aerospace Center DLR

Data Science

Artificial Intelligence

Information Architecture

Today: Bring INTELLIGENCE to the DATA

Computational Imaging

Computational Sensing

Computational Intelligence

Tomorrow: Bring INTELLIGENCE to the SENSOR

- **Mission Intelligence**
- **Sensor Intelligence**
- **Data Intelligence**
- **Application Intelligence**
- **Business Intelligence**

- **Elaborate an overall EO intelligence for the system of systems:**

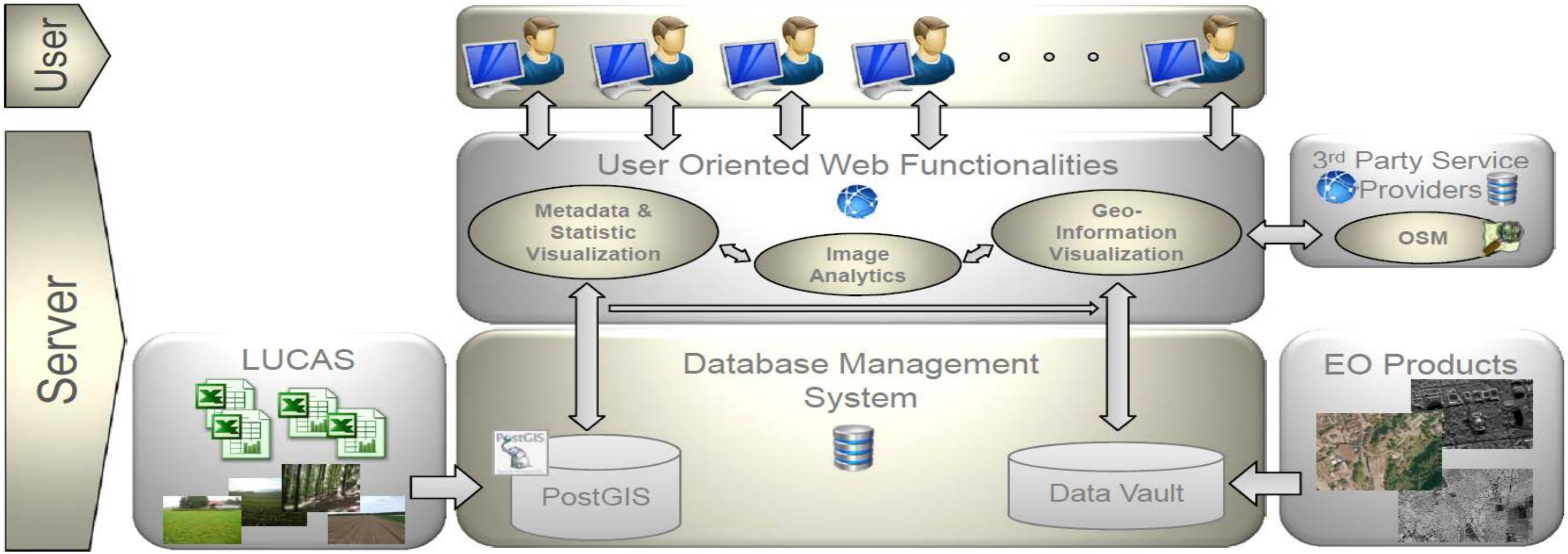
USER - DATA – SENSOR – MISSION – ARCHITCTURE

Ack. ARD/ARTE & Prof. Peter Baumann @ Jacobs University

Challenge 1: Multi-sensors @ multi-modalities

- **Multispectral, SAR, radiometer, altimeters, etc.**
- **EO products & metadata**, location, time of acquisition, instrument parameters, orbit information, product processing level, etc.
- **GIS and maps**, on various thematic, urban, vegetation, topography, etc., in distinct standardization or digital formats, geo-morphological models, models of evolution, textual description, etc.
- **In-situ information & IoT** diversity of sensors in large networks, measuring air or water content, in-situ photography, measurements of physical parameters, etc.
- **Location information**, multimedia location awareness, GPS, tagging, spatial context
- **Internet social networks** or **mobile communication** information, with a fantastic evolution in diversity, and volume, and containing unexpected important information.

EO & LUCAS Visual Browser Architecture



EO & In-Situ Mutisesnor Fusion

Data Set Selection - Vineyard

EO & In-Situ Mutisesnor Fusion

Data Set

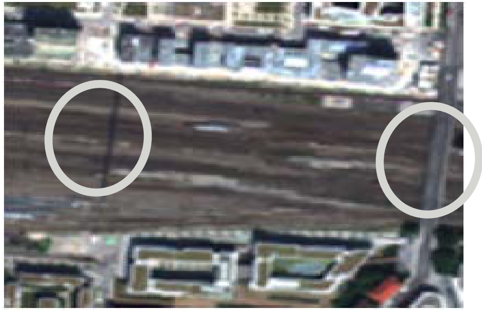
- Mutispectral (WorldView-2), SAR (TerraSARX) both with 1.25 meter resolution.
- OpenStreetMap layer.
- LUCAS survey information from Germany.

WorldView-2

TerraSAR-X

Scene Understanding

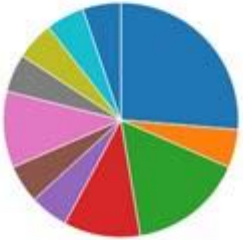
(a) SAR



(b) Multispectral

(c) Map - OpenStreetMap

(d) LUCAS



Common wheat	5	26%
Coniferus woodland	1	5%
Grassland without tree/shrub cover	3	16%
Maize	2	11%
Oats	1	5%
Other fresh vegetables	1	5%
Sugar beet	2	11%
Barley	1	5%
Grassland with sparse tree/shrub cover	1	5%
Pine dominated coniferous woodland	1	5%
Rye	1	5%

Challenge 2: EO Semantic extraction

- **Computer Vision** and **Pattern Recognition**, are needed for new tasks as **detecting, localizing** and recognizing objects
- **Specific EO** task is the **semantic description** of the scenes from sensor data
- Extract **quantitative measures** of the physical meaningful parameters of the scene
- **Registration** of multi-sensor multi-temporal data
- **Fusion of the imaging modes** to provide different types of information about various structures
- Recognition methods to **distinguish huge variability of scene classes** and objects with very good precision

Satellite Image Time Series SITS

Bucharest 1984-2012

112 Landsat images

SITS Evolution Classes and Trends Analytics

Figure 3. Temporal dynamics of the *Morii Lake*

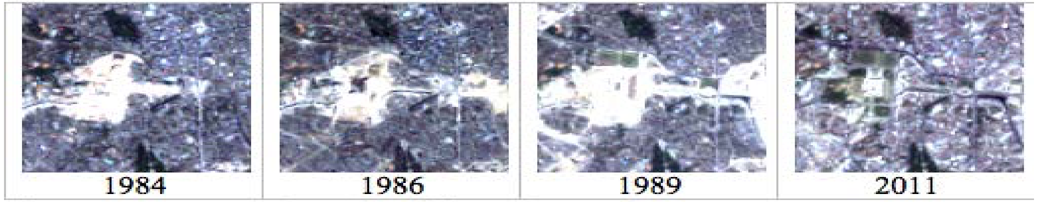


Figure 4. Temporal dynamics of the Bucharest city centre

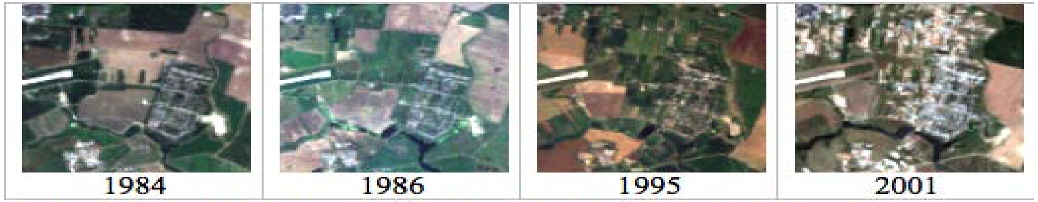


Figure 5. Temporal dynamics of an area situated north of Bucharest

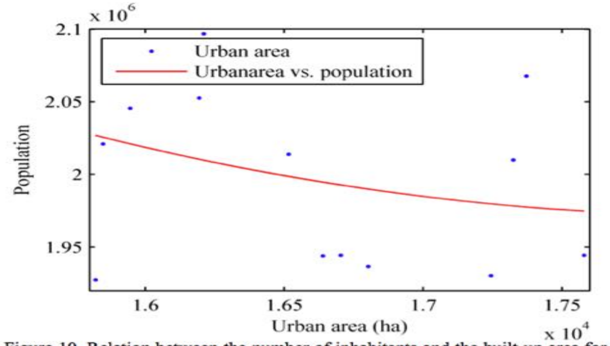


Figure 10. Relation between the number of inhabitants and the built-up area for Bucharest city

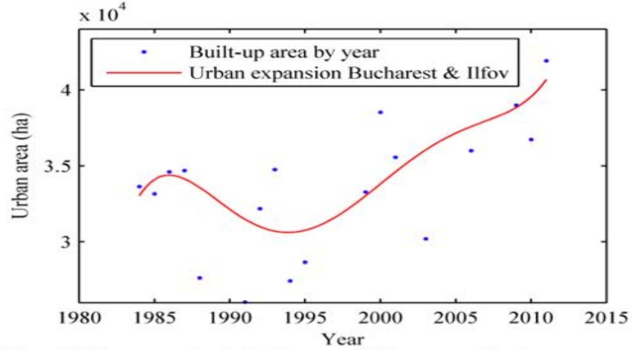
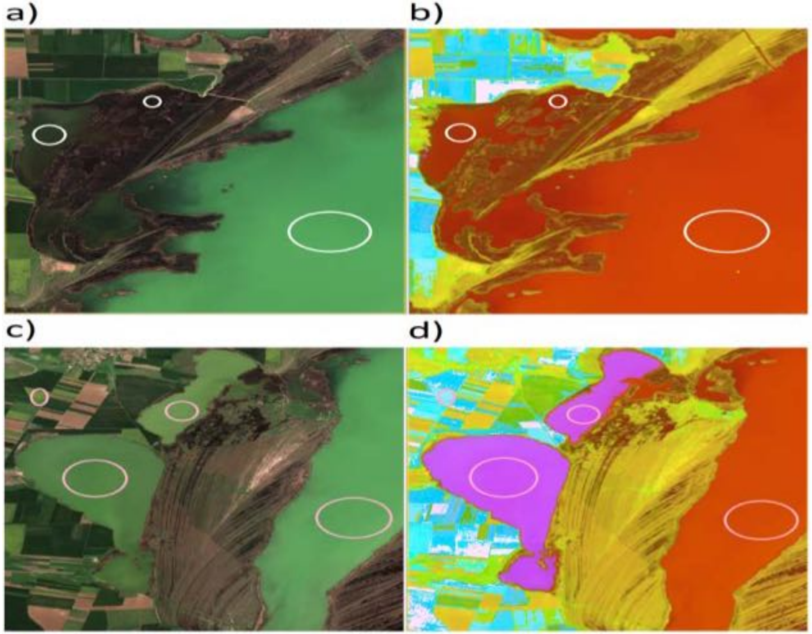


Figure 7. Urban expansion for Bucharest and Ilfov area combined

Vaduva, C.; Costachioiu, T.; Patrascu, C.; Gavat, I.; Lazarescu, V.; Datcu, M., "A Latent Analysis of Earth Surface Dynamic Evolution Using Change Map Time Series," IEEE TGRS, vol.51, no.4,, April 2013

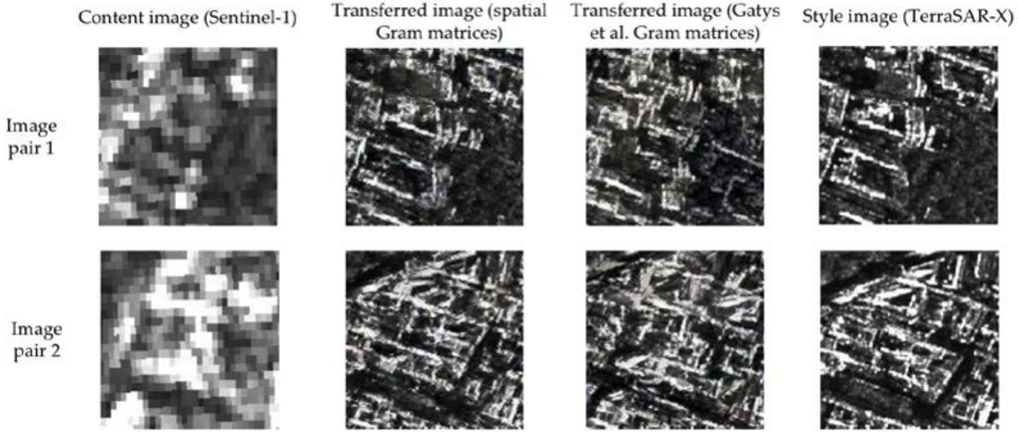
DNN MS true-colour disambiguation



Iulia Neagoe, M. Datcu IGARSS 2018

Dialectical GAN: **Sentinel 1 >> TerraSAR-X**

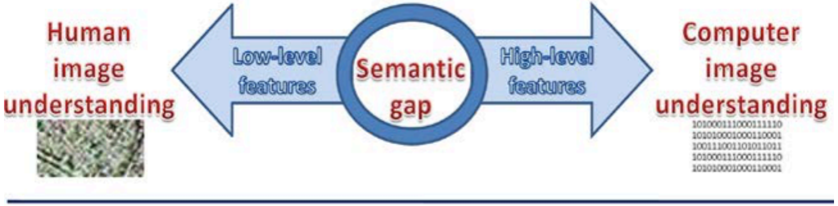
(1) a beginning proposition called a thesis
(2) a negation of that thesis called the antithesis
(3) a synthesis whereby the two conflicting ideas are reconciled to form a new proposition

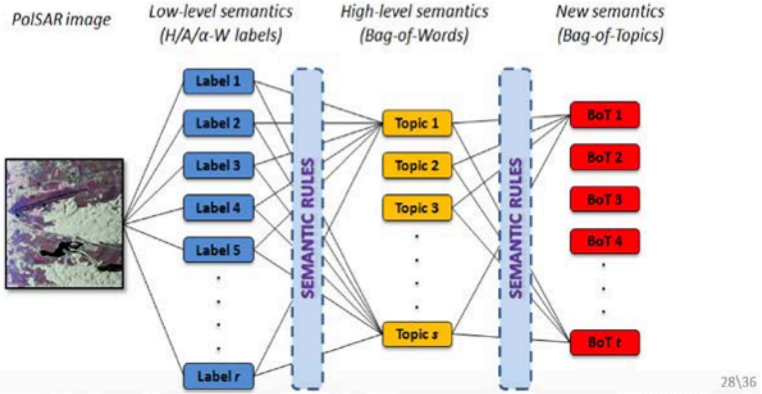


D. Ao, C. Dumitru, G. Schwarz, M. Datcu, Dialectical GAN for SAR Image Translation: From Sentinel-1 to TerraSAR-X, Remote Sensing 10 (10), 2018

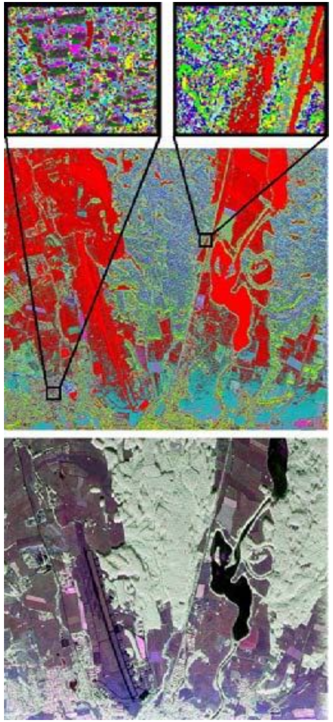
Generative Bayesian Models: Discovery of semantic relationships

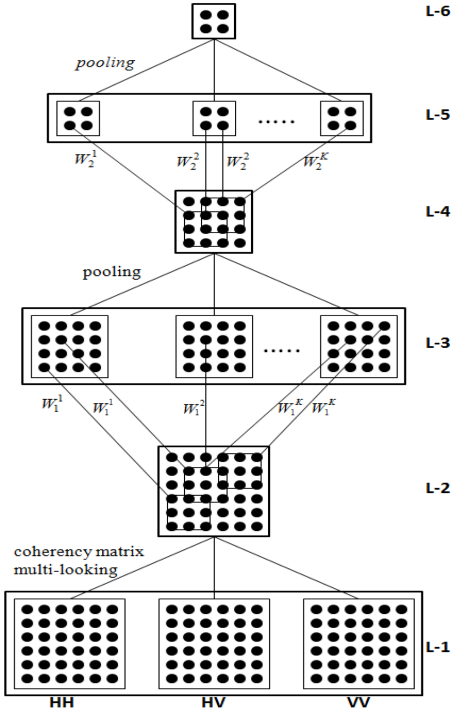
L Band PolSAR Semantics





Convolutional Restricted Boltzmann Machine





CE SpaceTech

R. Tanase, et. al, A Convolutional Deep Belief Network for Polarimetric SAR Data Feature Extraction, IGARSS 16

Challenge 3: Quantum Intelligence

Advanced topics, beyond today techniques and methods:

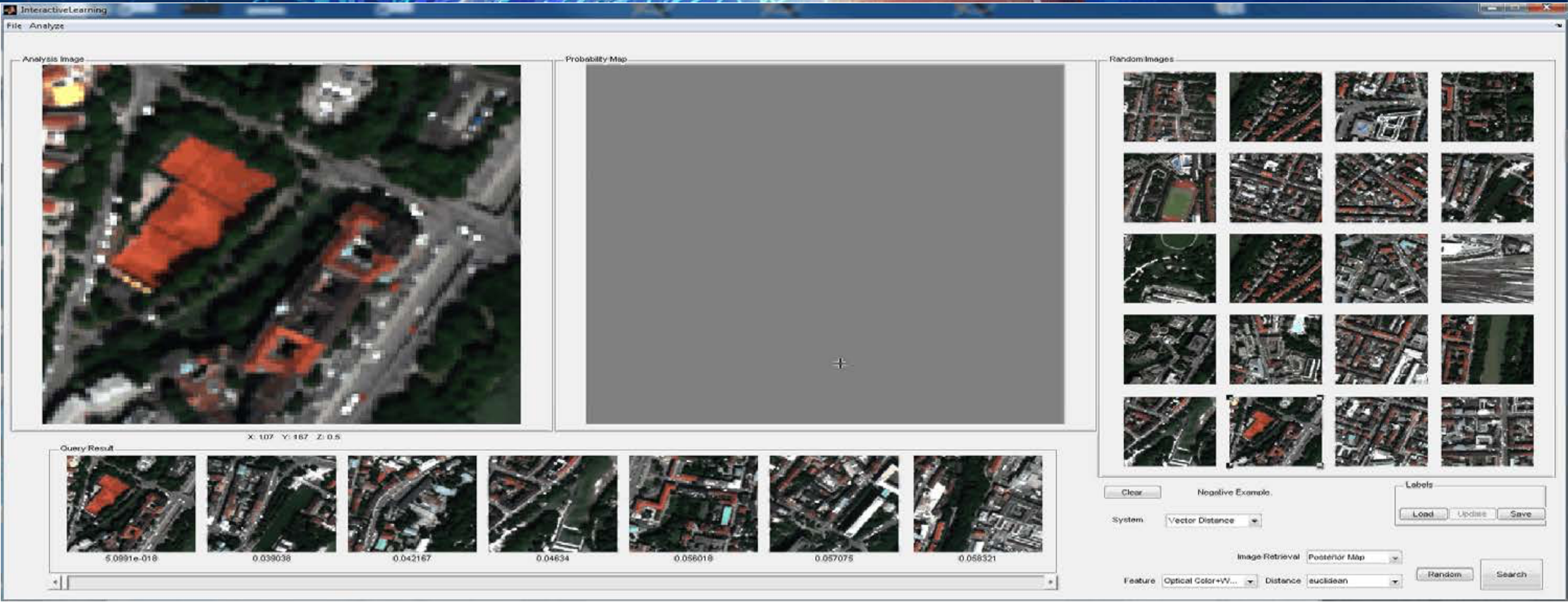
- Computational imaging
- Sensor networks
- Quantum **sensors**

Machine Learning and Analytics **beyond the spatio-temporal physical space**

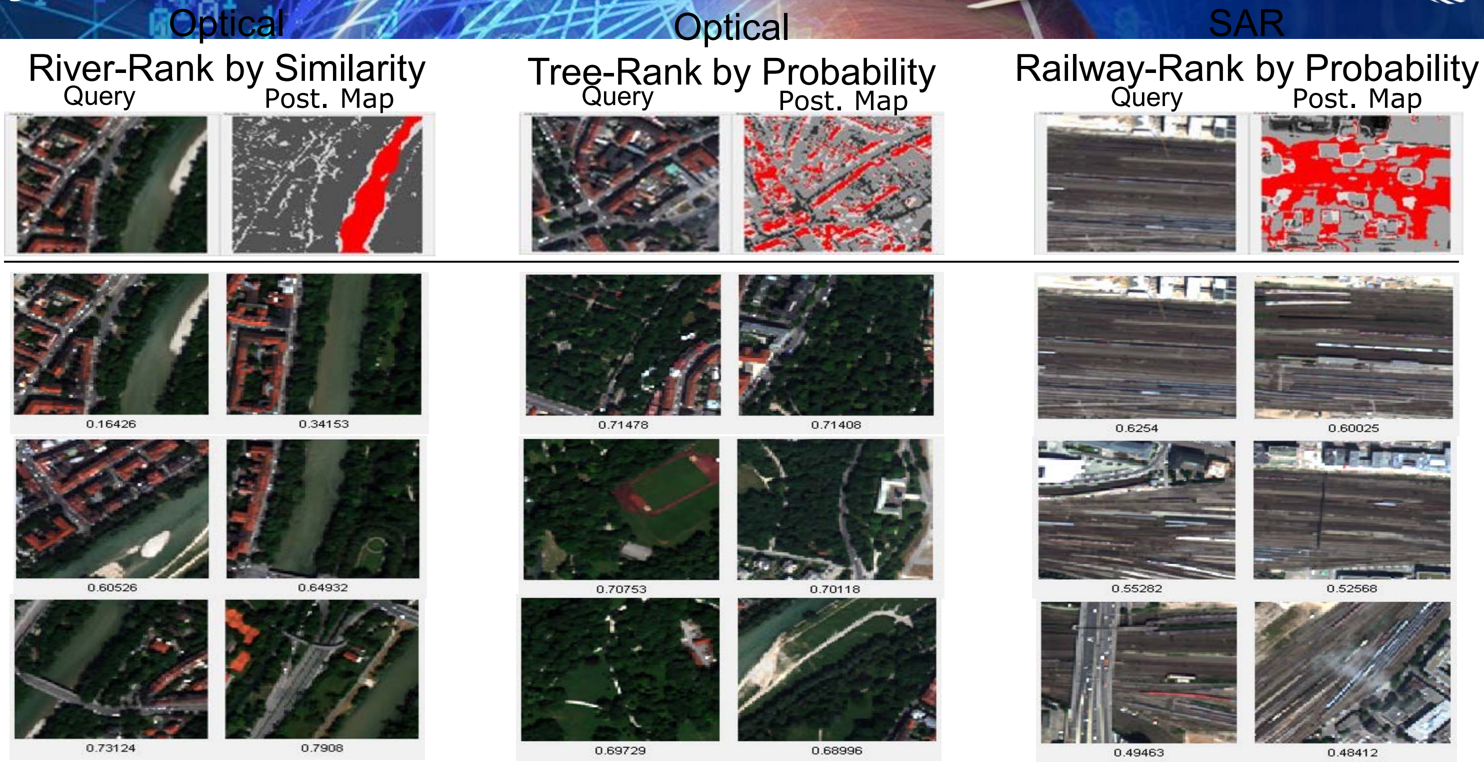
- Quantum **information** theory
- Quantum **signal** processing
- Quantum **machine learning**

Quantum **computing**

Multisensor search engine



Query Results

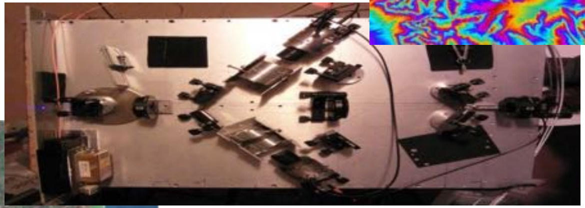


Alonso, K.; Datcu, M., "Accelerated Probabilistic Learning Concept for Mining Heterogeneous Earth Observation Images,", *IEEE JSTARS*, vol.8, no.7, 2015

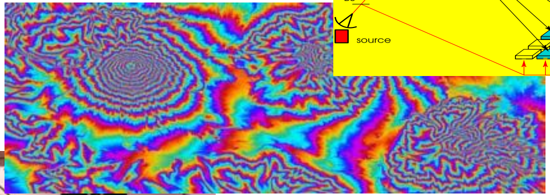
Quantum4EO: a road map

EO problematic

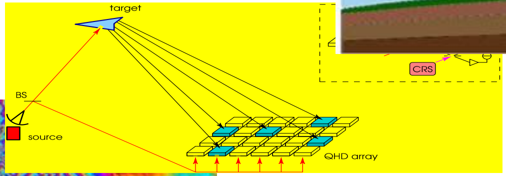
The way to Q



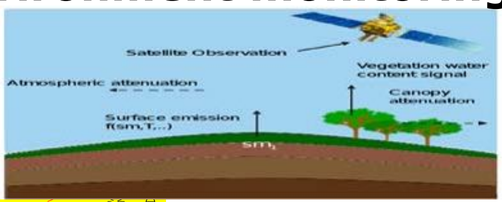
Case study 1: InSAR



Case study 2: Q SAR



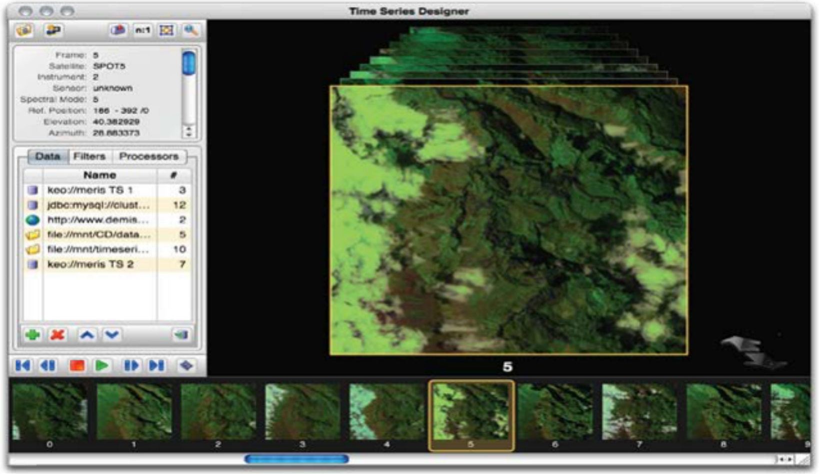
Case study 3: environment monitoring



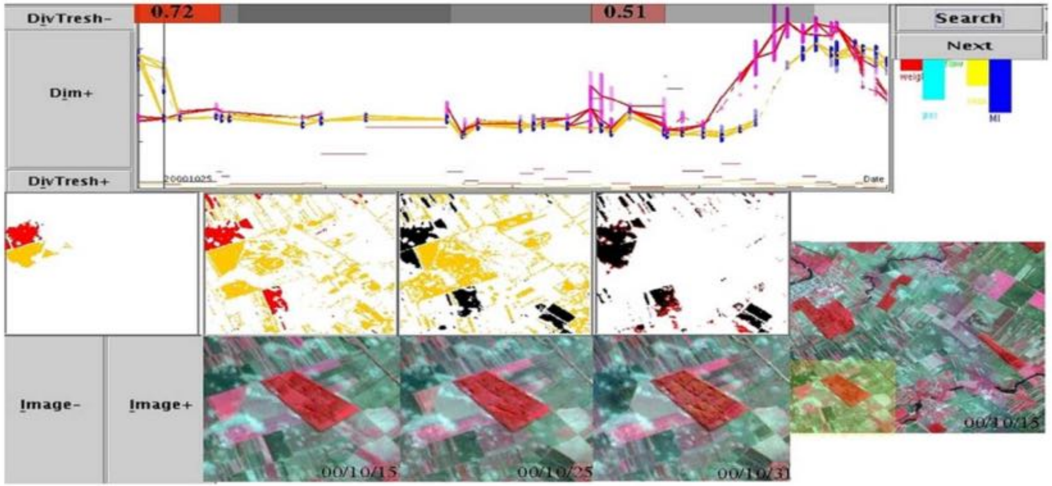
Challenge 4: Human Understandable AI

- Predictive, adaptive **natural User Interfaces**
- Learning and **anticipating the user** behaviour and **collaborate** with the user
- Understand and learn the **user intentions and context**, establish a **dialog**
- Transform **non-visual sensor** data and information in human easy understandable representations.

Active Learning for SITS Analytics



Time Series Indexing and Visualization



Spatio-temporal patterns learning and Visualization

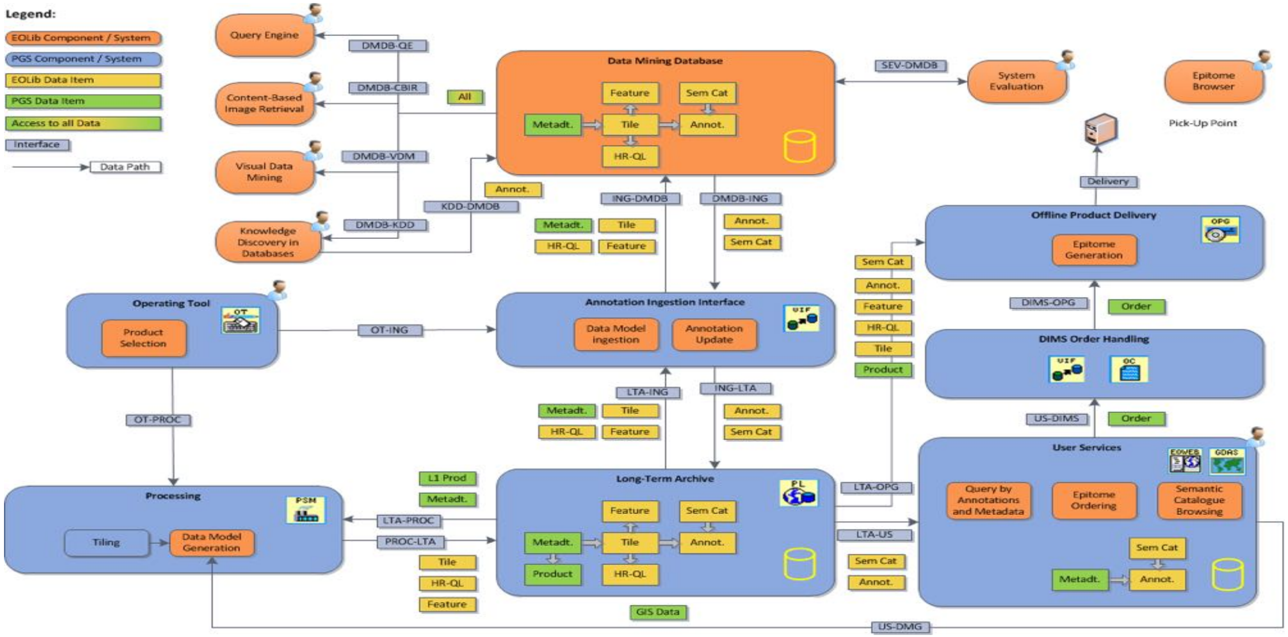
Heas, P.; Datcu, M., "Modeling trajectory of dynamic clusters in image time-series for spatio-temporal reasoning," IEEE TGRS , vol.43, no.7, 2005

IMMERSIVE VISUAL DATA MINIG
SEMANTIC DISCOVERY

Challenge 5: Information platform

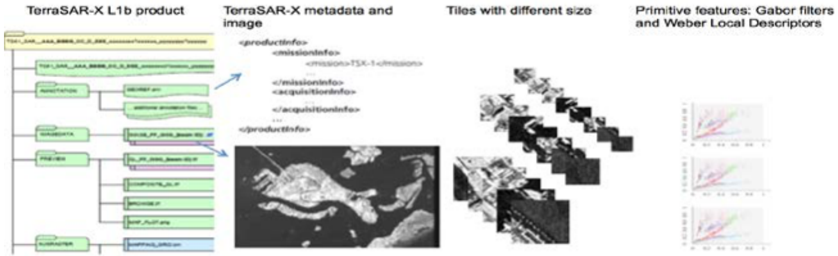
- **Web based** interactive technologies and tools
- **Distributed** architecture systems
- Adaptations to specific applications, and **real-time for interactive operation**
- **Cloud computing** should enable tasks not achievable with actual resources
- **Federated** systems
- **Block chain**

EOLIB – Earth Observation Image Librarian



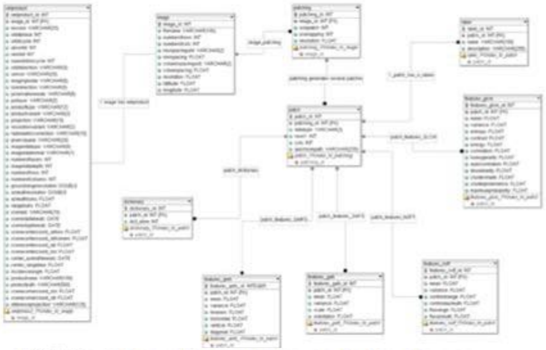
D. Espinoza-Molina and M. Datcu, *"Earth-Observation Image Retrieval Based on Content, Semantics, and Metadata,"* IEEE TGRS, vol. 51, no. 11, 2013.

Data Model Generation



Metadata Extraction → Image Tiling → Quick – looks generation → Primitive Feature extraction → Create the product model

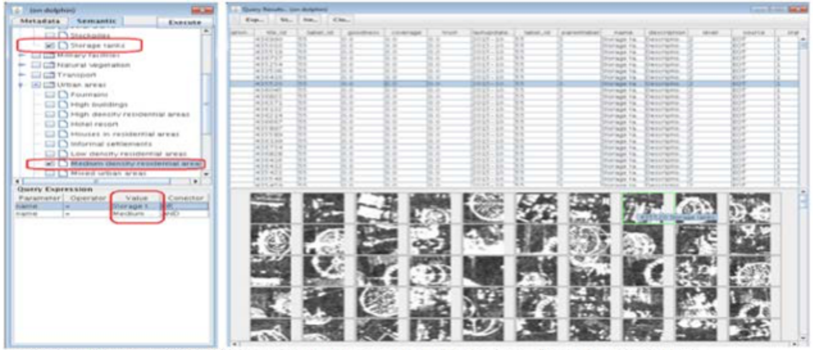
Data Mining Data Base



DMDB is a relational database
Main tables are:
- Metadata
- Image
- Tiles
- Features
- Labels

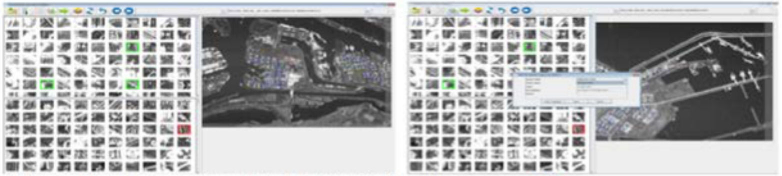
DMDB comprises about
- 8 millions of tiles
- 20 thousand metadata entries.
- 106 semantic labels

Query Engine

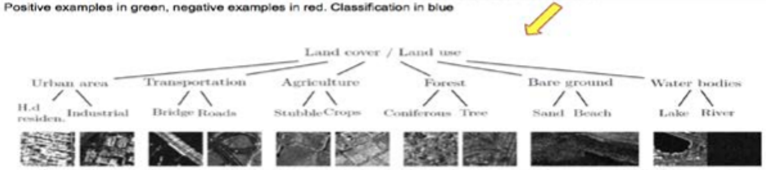


Example of query: Storage tanks and Medium density urban area are the query parameters

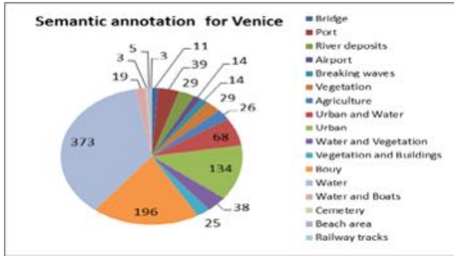
KDD: Graphical User Interface

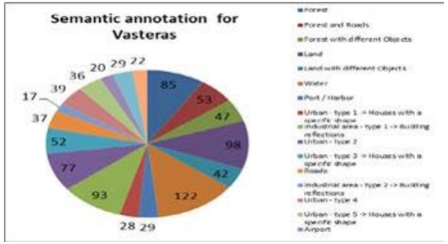


Positive examples in green, negative examples in red. Classification in blue

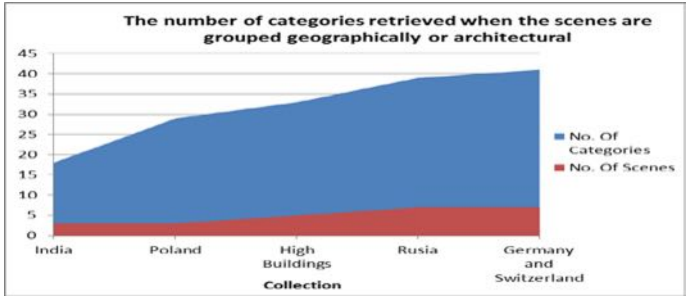


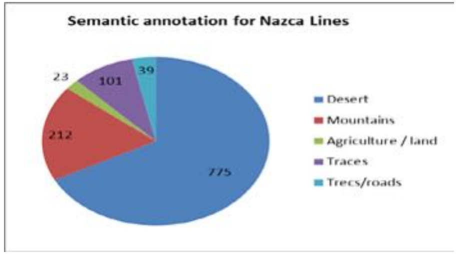
EOlib archive semantic catalogue





- 300 Cities
- 1300 Semantic Labels





AI4EO

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