THE ESA EARTH OBSERVATION Φ-WEEK

EO Open Science and FutureEO
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AI4EO 5 Challenges

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Today: Bring INTELLIGENCE to the DATA

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 – ARCHITECTURE**
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

User

Server

User Oriented Web Functionalities

Metadata & Statistic Visualization

Geo-Information Visualization

Image Analytics

3rd Party Service Providers

OSM

LUCAS

Database Management System

PostGIS

Data Vault

EO Products

www.DLR.de  •  Chart 6

> IGARSS

Kevin Alonso, Daniela Espinoza Molina & Mihai Datcu > July 2015
Selection of optimal datasets and ground truth information for change detection on EO image time series.

Query changes for specific changes on user defined regions.

LUCAS survey information from Germany.

Data Set Selection - Vineyard
Data Set

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

(a) SAR

(b) Multispectral

(c) Map - OpenStreetMap

(d) LUCAS

- Common wheat: 5% (26%)
- Coniferous 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%)

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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.
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

Deep sensing

DNN MS true-colour disambiguation

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

Iulia Neagoe, M. Datcu IGARSS 2018

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

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
Quantum4EO: a road map

Case study 1: InSAR
Case study 2: Q SAR
Case study 3: environment monitoring

The way to Q

EO problematic

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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

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**
Data Model Generation

- TerraSAR-X L1b product
- TerraSAR-X metadata and image
- Tiles with different size
- Primitive features: Gabor filters and Weber Local Descriptors

Metadata Extraction → Image Tiling → Quick - locks generation → Primitive Feature extraction → Create the product model

Data Mining Data Base

DMOB is a relational database
Main tables are:
- Metadata
- Image
- Tiles
- Features
- Labels
DMOB comprises about:
- 8 millions of files
- 20 thousand metadata entries.
- 105 semantic labels

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
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