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OBDP 2021

Applications and Enabling Technologies for On-Board Processing and Information Extraction: Trends and Needs

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- Introduction
- Use cases and applications
- Application tasks
- Information extraction: algorithms & datasets
- Implications for on-board processing system
- Reference architecture for OBDP
- Conclusions

FOPIEA

- “Future On-Board Processing and Information Extraction Algorithms”
- Aims:
  - Analyse if the current state of the art techniques for information extraction for remotely sensed data can be applied in embedded systems
  - Enable news methods in data selection optimisation, mission autonomy and data quality and quantity
- Approaches:
  - Perform a comprehensive survey of all relevant use cases, applications and solutions (hardware, algorithms, datasets)
  - Demonstrate two selected applications using suitable solutions

Application Survey

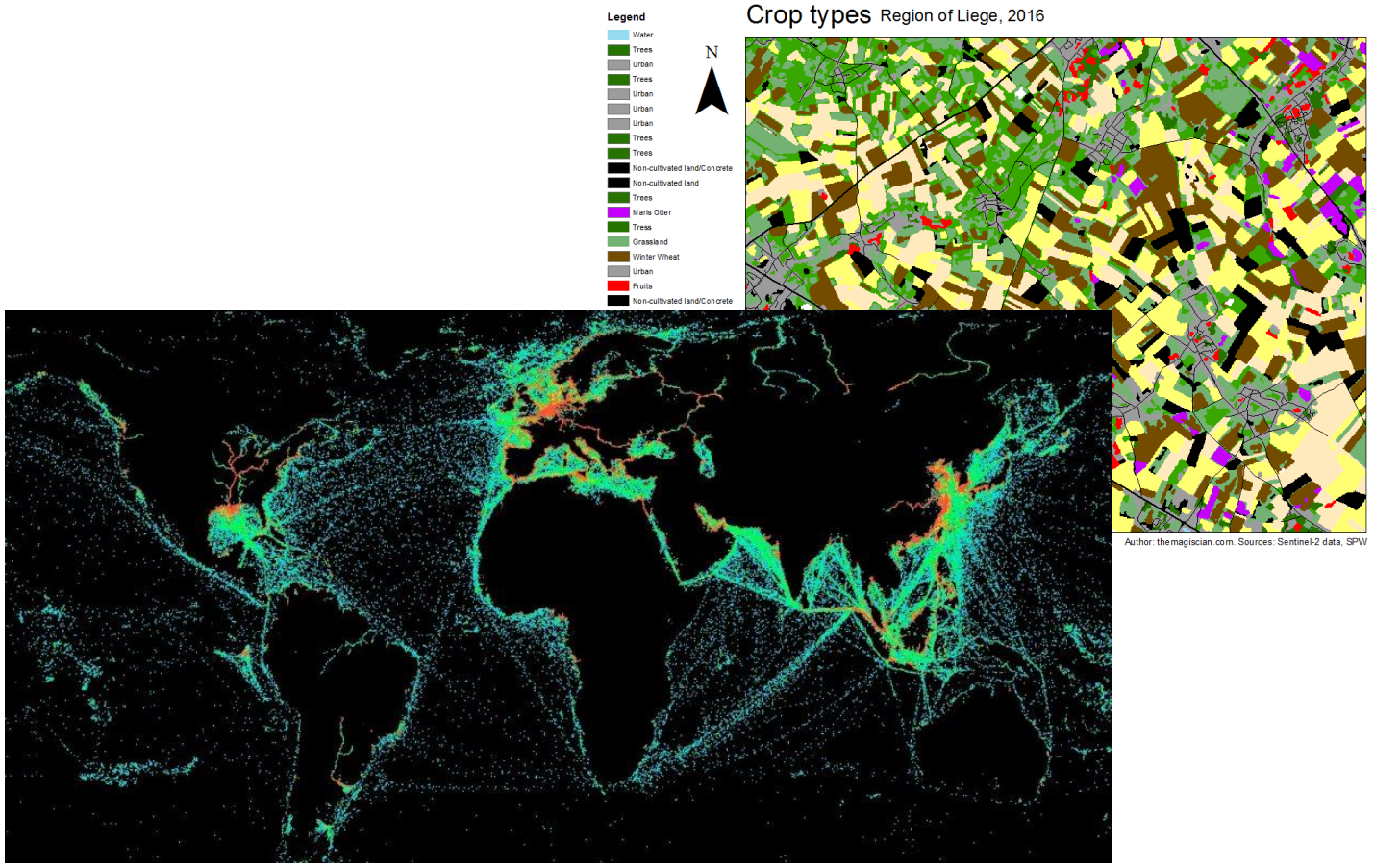
Goal: Analyse all areas where OBDP and information extraction can bring a significant improvement to the end-to-end mission in terms of data management, cost trade-off and scientific return

Approach:

- Web questionnaire, followed by 121 meetings with respondents
- Group ideation workshop
- Broad literature review

Remote Sensing Use Cases

- Agriculture
- Defence
- Disaster response
- Forestry and vegetation
- Hydrology
- Land use and land cover
- Meteorology
- Maritime
- Resource management



Credit: Hawkeye 360

On-Board Applications

Application	Characteristics
Event detection	Instantaneous detection, timely alerts
Event prediction	Data fusion, identification of predicating conditions
Event monitoring	Sustained observation of transient event, change detection
Persistent monitoring	Sustained observation of slowly-changing location / feature, change detection
Damage assessment	Focus on known locations, multiple levels of damage and actionable info
Global mapping	Big data, prioritising changed data and feature abstraction products
Localised mapping	As above, focussed on a smaller region with greater detail
Object detection & tracking	Detection and tracking of mobile objects, autonomous pointing
Scientific measurement	Science applications, high-quality data products

Application Tasks

Information Extraction

Those related to the creation or extraction of information from data

- *Classification*
- *Semantic segmentation*
- *Object detection*
- *Anomaly detection*
- *Change detection*
- *Regression*

Data Autonomy

Those related to making decisions on data form, value and usage

- *Content indexation*
- *Selective compression / reduction*
- *Data fusion*
- *Product creation*

Pre-processing

Information Extraction Algorithms

Traditional Methods

- Feature extraction
  - PCA, ICA, LDA, factor analysis
- Support vector machines
- Random forest
- Naïve Bayes
- K-Nearest Neighbour

Deep Learning Methods

- Convolutional neural nets
  - Classification
  - Semantic segmentation
  - Object detection
- Autoencoders
- Neural regression models

Dataset Selection

Popular Use Cases

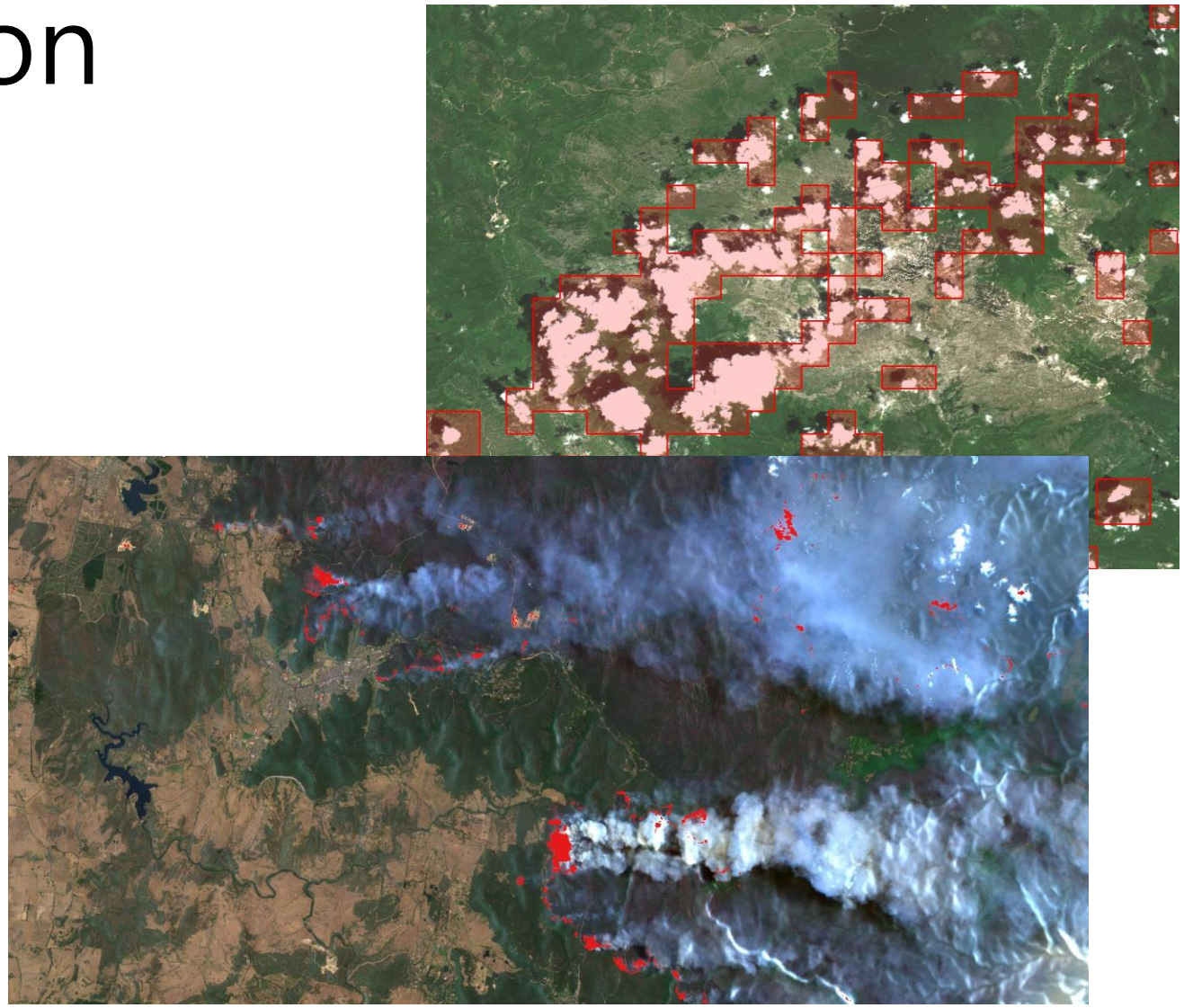
- Land cover and land use
- Cloud detection and masking
- Ship tracking
- Disaster monitoring
  - Active fires
  - Oil spills

Popular Sources

- Sentinel-1 SAR
- Sentinel-2 MSI
- Landsat 8
- Planet
- Worldview
- Google Earth Engine
- UAVs

Dataset Selection

- Size and diversity
- Application
- Label format
- Ground truth
- Licence
- **Instrument source**
- **Processing level**

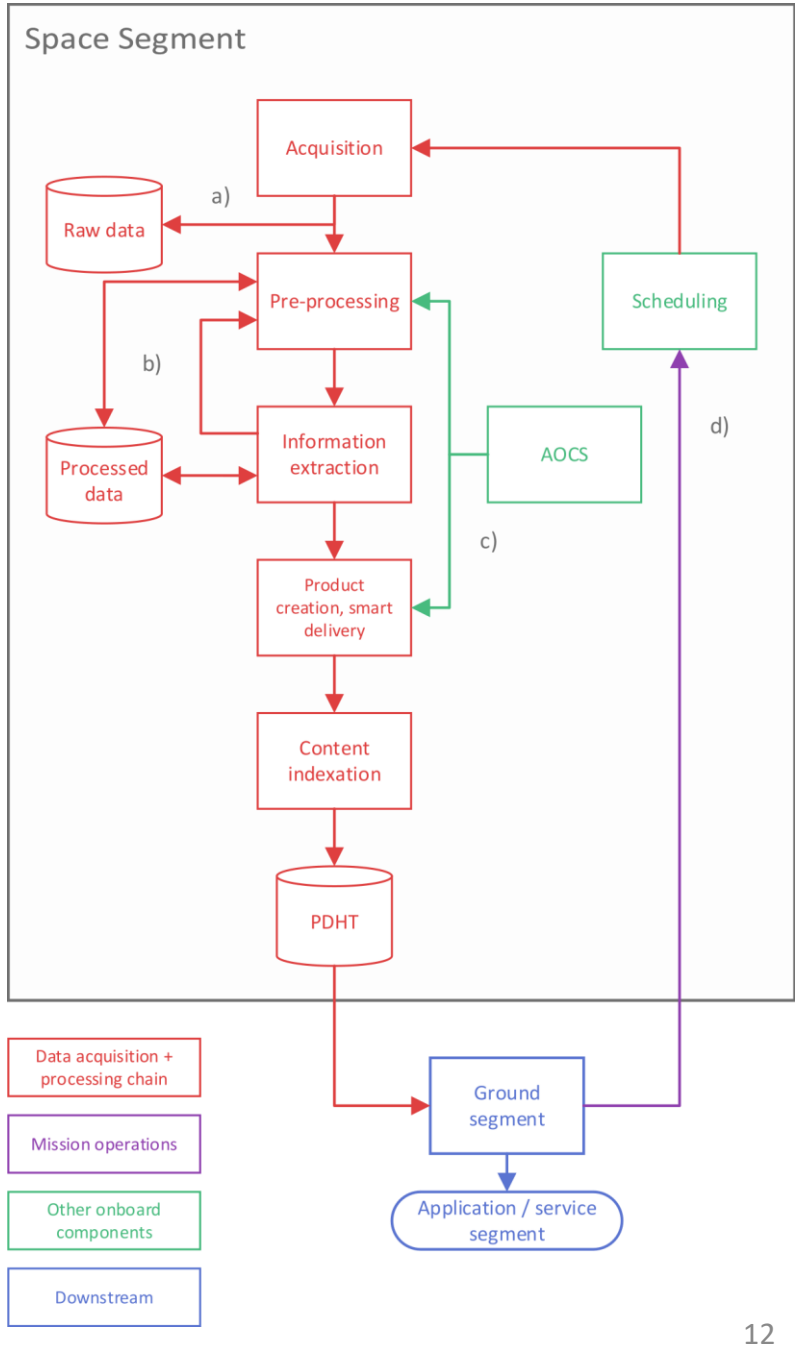


Implications of Adoption

- Interfaces – what external data and auxiliary components does the application need?
- Timing – when is processing performed? Immediately after acquisition, after a filtering stage or purely offline?
- Reconfigurability – ML models must be updated during commissioning and beyond
- Fault tolerance – how does algorithm selection impact availability of HW and SW error checking solutions
- Criticality – data processing tasks could be mission critical

Reference Processing Architecture

- Reference architecture targeting all generic applications
- Focussed on non-mission critical operations
- Early data storage for redundancy
- Feedback loops for real-time and offline processing and multi-stage processing
- Separation of stages aids unit testing and assurance



Conclusions

- On-board data processing and information extraction has many challenges
  - How to conceptualise and re-use processing tasks?
  - Algorithm selection and device/toolchain support
  - Dataset selection and assurance
  - Impact on on-board system – criticality, assurance, integration with other subsystems
- An algorithm doesn't exist in isolation
  - How does it affect data management, processing and delivery?
  - When is feature detection accurate or precise enough? – very application dependent

To the Future

- New use cases, applications and algorithms are appearing all the time
- New mission concepts can be enabled by and created to support onboard EO applications
  - Autonomous ADCS and instrument scheduling
  - Autonomous comms and pass management
  - Payload performance tasks
  - Tip and cue and fleet management
- Do you have use cases and applications to fit into a larger operational concept?
  - Please get in touch!

Thanks for listening

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Notes

- Cloud detection as an “app” doesn’t exist in isolation
  - What need is it addressing?
  - How does this affect the context of what it delivers?