On-Board Data Processing Workshop
ESA ESTEC
25-27 February, Noordwijk, The Netherlands

DEEP LEARNING FOR ENHANCED ON-BOARD AUTONOMY

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Deep Learning for Enhanced On-Board Autonomy

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spacecraft do not take decisions in real time

hours to days of delays on the ground

downlinked data is not always relevant

data processing is done on the ground, creating bottlenecks

mega-constellations will be difficult to manage

current infrastructure is not ready for these missions
Our technology: MiRAGE library

Telemetry & Payload data + MiRAGE AI Library = Autonomous Operations

www.aikospace.com/#mirage
Software library for autonomous operations
- State of art autonomy: detection, planning, predictive maintenance
- TRL 6

Infused with Artificial Intelligence
- Deep Learning, Knowledge-based Systems
- In-house developed

Compatible with ground and space segments
- Enhances Earth Observation, Telecommunication and Scientific missions
- Automates space missions and supports operators

Funded by H2020 program
Deep Learning for Enhanced On-Board Autonomy

Complete E4 autonomy

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Payload:
- Feature detection
- Segmentation
- Classification

Platform:
- Failure detection
- Anomaly detection
- Behaviour correlation

AI-based

Complete E4 autonomy
Detection

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Reasoning

Goal Generation:
- Relevance of the detected feature
- Characteristics of the event
- System health

Planning

AI-based

Complete E4 autonomy
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**Detection**
- **Payload:**
  - Feature detection
  - Segmentation
  - Classification

- **Platform:**
  - Failure detection
  - Anomaly detection
  - Behaviour correlation

**Reasoning**
- **Goal Generation:**
  - Relevance of the detected feature
  - Characteristics of the event
  - System health

**Planning**
- **Scheduling:**
  - Timing constraints
  - Availability of resources

- Traditional algorithms

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**Complete E4 autonomy**
Benefits enabled

Autonomous
Enabling reaction to events during the missions

Effective
Identifying features, objects and targets in satellite payload data

Mission cost reduction
Operations costs reduction thanks to enhanced autonomy
Is the data being acquired useful for the mission?
- Basic understanding of the data acquired during the mission
- Various types of architectures can be used

Classification is enough to increase autonomy
- Perform data selection / prioritization before downlink
- Trigger enhanced acquisition modes
 ◇ Is the data being acquired useful for the mission?
   - Basic understanding of the data acquired during the mission
   - Various types of architectures can be used

 ◇ Classification is enough to increase autonomy
   - Perform data selection / prioritization before downlink
   - Trigger enhanced acquisition modes
Why is the data useful? What is inside it?

- Deeper understanding of the data acquired
- CNN networks are predominant here

Object Detection enables advanced autonomy features

- Image crop only to relevant portions before downlink
- Tracking of ground features
- Generation of higher-level information
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Segmentation
Can we provide insights on the acquired data?

- Extracting high level information from an image
- Customization of the architecture increases in importance

The satellites provide improved services

- From wake features to speed information
- Estimation of ship speed for security applications
HARDWARE REQUIREMENTS
What is the best architecture?
- Problem-specific
- Platform-specific

What performances requirements?
- State of the art networks that traditionally win image competitions are not compatible with on-board processors
- Mandatory to move towards smaller architectures

Execution times are promising
- < 1s inference time for OD on a ARM9 processor for cloud detection
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Hardware Requirements

Goal: 1 IPS
Hardware Requirements

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Goal: 30+ IPS

Application complexity

FPGAs

TPUs / GPUs

CPUs

Goal: 30+ IPS

FLOPs
Today technology is ready for enhanced autonomy
- COTS processors are already meeting requirements for some Deep Learning algorithms to be run on-board
- Complete E4 autonomy is at reach with COTS CPUs

Evolution of the computing capabilities is required:
- For complex AI applications
- For high FPS

Enhanced autonomy will be a key driver in:
- Reducing operations costs
- Achieving more complex missions
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