Look around – Collaborative AI

This program develops AI systems and assistants with advanced capabilities for improved interaction with humans.

Researchers also work on multimodal language as well as mobile robotics with physical interaction capabilities to perform complex tasks in a collaborative manner. They also focus on the development of methods for efficient and scalable anomaly detection and predictive maintenance.

The themes:
- Automated reasoning & decision making
- Data & anomalies
- Language
- Robotic & AI
- Neurosciences & AI
Agenda

Part.1- Brief overview
1. **Anomaly detection** in irregularly sampled and distorted time series for cobot **predictive maintenance** @ Vitesco Technologies
2. Christoffel based **anomaly detection** in data streams @ Carl Berger-Levrault
3. On-board dynamic clustering based **anomaly detection** for radiation hardening of space electronics @ CNES
4. Fault and performance loss **diagnosis** in high power photovoltaïc plants @ FEEDGY
5. **Implicit knowledge extraction** from process flows @ Vitesco Technologies
6. Unboxing using vision-based optimal control for versatile robotics manufacturing @ Continental
7. Dynamograde: artificial intelligence for efficient locomotion
8. Challenge CoHoMa

Part.2- Scheduling @ Airbus => SPEAKER Florent Teichteil

Part.3- Language @ Linagora => SPEAKER Julie Hunter
Part 1: Brief overview
1- Sequence-DTW → segmentation in cycles
2- Soft-DTW → Synthesis of a prototype cycle (soft barycenter)
3- DTW → Outlier detection based on a similarity score between the prototype and monitored cycles

Abnormal cycles

Cifre thesis of Charlotte Lacoquelle
Leveraging the properties of the Christoffel function $\Lambda^\mu_d(x)$

Step 1 detecting outliers candidates vs frontier

Specific level set of $\Lambda^\mu_d(x)^{-1}$
- captures the support of $\mu$
- Anomaly candidates

As $d$ grows, $\Lambda^\mu_d(x)^{-1}$ has:
- POLYNOMIAL growth INSIDE $\Omega$
- EXPONENTIAL growth OUTSIDE $\Omega$
- Anomaly confirmation

Step 2 using growth properties to confirm outliers candidates

Multi-mode system, highly non linear data

Confirmed anomalies

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Cifre thesis of Kevin Ducharlet defended on September 28, 2023

17/11/2023
DyD²

- Anomaly detection on the fly and on-board:
  - Frugal computation to track the data stream
  - Low memory usage
  - Dynamicity to adapt to evolving environments

**Stage 1:**
Detection of signal ruptures

**Stage 2:**
Fast analysis around detected ruptures

**Stage 3:**
Deeper analysis around detected ruptures

**Offline Stage:**
Training normal models

**Update**

**Hierarchical analysis**

- Outer signal features
- Inner signal statistical features

https://github.com/Adrien-Dorise/DyD2_Dynamic_Double_Anomaly_Detection

On-board dynamic clustering based anomaly detection for radiation hardening of space electronics

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CNES/Occitanie Region thesis of Adrien Dorise defended on December 2, 2022
Fault and performance loss diagnosis in high power photovoltaïc plants

Confidential (2nd circle)

Hardware design of an electronic system for on site data acquisition

Feature extraction and selection

Software design of an adaptive diagnosis algorithm

Fault easy to detect with conventional techniques

Fault and performance loss diagnosis in high power photovoltaïc plants

Cifre thesis of Edgar Sepulveda defended on February 16, 2023
(in collaboration with LAAS/ISGE team)
Implicit knowledge extraction from process flows

- Process mining: analysis of process logs to deduce real behavior
- Machine learning & statistics

- Identify product flows / their quality / the time products will spend on the line
- Identify variations based on different attributes (suppliers, team, batch, etc.)
- Identify weak points on the line to trigger maintenance or optimization actions

Design of a product quality index based on conformance checking

Assessment of quality variation over work shifts based on KDE

Prediction of the remaining cycle time based on GNNs

https://github.com/duongtoan261196/RemainingCycleTimePrediction

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Cifre thesis of Le Toan Duong defended on June 26, 2023
• Unboxing: known objects unsorted in a box, to be accurately disposed at the input of the production chain

• Planning: task-and-motion planning (mixed-integer) using HPP
  https://humanoid-path-planner.github.io/hpp-doc/

• Control: model predictive control using full robot model using Crocoddyl
  https://github.com/loco-3d/crocoddyl/

• Vision: model-based object pose (6d) tracking using HappyPose
  https://github.com/agimus-project/happypose
Dynamograde: artificial intelligence for efficient locomotion

Joint laboratory between LAAS-CNRS (Gepetto) and Toward (French office of PAL-Robotics)

• Shared development of locomotion algorithms
• Production of the open-source design Solo
• Exploration of advanced learning-based formulations for robust locomotion
• Technological support for academic projects

https://open-dynamic-robot-initiative.github.io/
https://toward.fr/projets-collaboratifs/dynamograde/
Challenge CoHoMa

Challenge organisé par le Battle Lab Terre (Section Technique de l’Armée de Terre) pour évaluer des solutions technologiques dans le cadre de la collaboration homme-machine.

Déploiement de systèmes multi-robots aérien/terrestre pour explorer une zone inconnue et guider un véhicule habité sur le terrain.

Opérateurs dans le véhicule habité n’ont pas de vue sur l’extérieur autre que via les systèmes robotiques.

- Participation équipe ICARE en 2022 et 2023
- ONERA, ISAE-Supaero, ENAC, LAAS-CNRS, Scalian
- Contributions sur :
  - Navigation autonome et analyse de traversabilité
  - Modélisation et conception de comportements autonomes
  - Planification automatique de tâches pour l’opérateur et interaction homme-système
- Vidéo 2022 : https://youtu.be/cUyyPkJkA?si=8zg7_VTQdbdWcoO-
Part 2: Scheduling @Airbus
TUPLES: Trustworthy Planning & Scheduling with Learning and Explanations

- Scale to industry-size problems
- Accurate representation of the world
- Proactively reason about uncertainties
- Adapt to unseen situations and users

- Efficient
- Robust
- Trusted
- Explainable
- Safe

- Explain decisions w.r.t. long-term objectives
- Explain infeasibilities and resolving strategies
- Decisions don't endanger people
- Decisions reach business objectives
Airbus Manufacturing Use Cases @TUPLES

Use Case I
Worker Allocation & Scheduling

**Efficiency**: hybrid scheduling/routing
**Explainability**: multi-objective tradeoffs elicitation, infeasibility recovering, constraint acquisition
**Robustness**: minimise schedule adaptations on disruptions

Use Case II
Beluga Logistics Planning

**Efficiency**: scale to large realistic problems
**Explainability**: multi-objective tradeoffs elicitation, infeasibility recovering
**Robustness**: handle uncertain Beluga arrivals and factory demands
Beluga Logistics Planning: an MDP problem

#states = \( O(2^{\#jigs} \times \#trailers \times (2 \times \#racks + \#hangars) \times \#trailers \times !^{\#jigs}^{\#racks}) \)

#actions = \( O(\#jigs \times \#racks \times \#trailers) \)

Pull-back jig1 from rack1 using trailer2
Beluga Logistics: exploit domain knowledge
Hybrid model-based / data-driven decisions

Use Case I
Worker Allocation & Scheduling

• Active Learning of Constraints
  
  ![Active Learning Diagram](image)

• Learn to Schedule
  
  ![Learn to Schedule Diagram](image)

See talk of the knowledge compilation chair on scheduling with GNNs

Use Case II
Beluga Logistics Planning

• Learn To Plan with ASNets
  
  ![Learn To Plan Diagram](image)

• Hybrid Planning / Reinforcement Learning
  
  ![Hybrid Planning Diagram](image)
Explainable infeasible schedule relaxations

• Exploring *Minimum Unsatisfiable Sets, Minimal Correction Subsets*
• Interactive constraints relaxation
And much more...

- Explaining tradeoffs between conflicting objectives
- Checking deep learning scheduling policy performance
- User study experiments and acceptability properties elicitation

Towards ANITI-2 HEROIC - *Hybridizing lEarning, seaRch and combinatorial Optimization for Industrial deCision-making*

- Industrial chair
- 6 academic labs + 4 industrial use cases in the initial proposal; we're happy to welcome more!
Part 3:
Language @Linagora
Programming through conversation

Industrial moonshot:

Get tools for my next task & inspect wings
Interdisciplinary, hybrid approach

- Camera vision & other sensors
- Natural Language for instructions/goals/knowledge
- Multimodal grounding

PERCEIVE

Hybrid AI to keep compositionality from language symbols/structure to actions

ACT

Actions

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Building a playground

- Virtual factory-like environment
- Scripts for randomization & language generation

Experimenting learning algorithms

- Visual-based RL (inspired by DrQ v2, Dreamer v3...)
- Augmented with language modality (e.g. with pretrained LLM encoders)

Early results:
- Go to the hammer located on blue table
- Drive to the wrench on top of the red table
**RL as alternative to MPC for quadruped locomotion**

**Manipulated data:**
- sensor data + heightmap
- point cloud for reconstruction of heightmap (real robot)

**Methodology:**
- RL with PPO + teacher-student
- curriculum (terrain diff)
- Simulated sensor noise, domain randomization
Multimodal systems

A bright red diamond, pointing to the bottom right
A green triangle at the top, towards left
An egg-shaped oval, dark-blue, pointing up, on the bottom-left of the image

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sim2real (with LAAS)

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LLMs and semantic faithfulness:

- remove or shift predicate argument structure on which Q&As depend. LLMs even GPT DaVinci 002 003 don’t do very well.
- Limits for learning for LLMs. Logical and precise concepts

Conversation to build cooperatively

The Minecraft Dialogue Corpus

- represent semantic relations between utterances
- discourse parser for automatically building discourse structure
- integration with builder
Thank you for your attention!