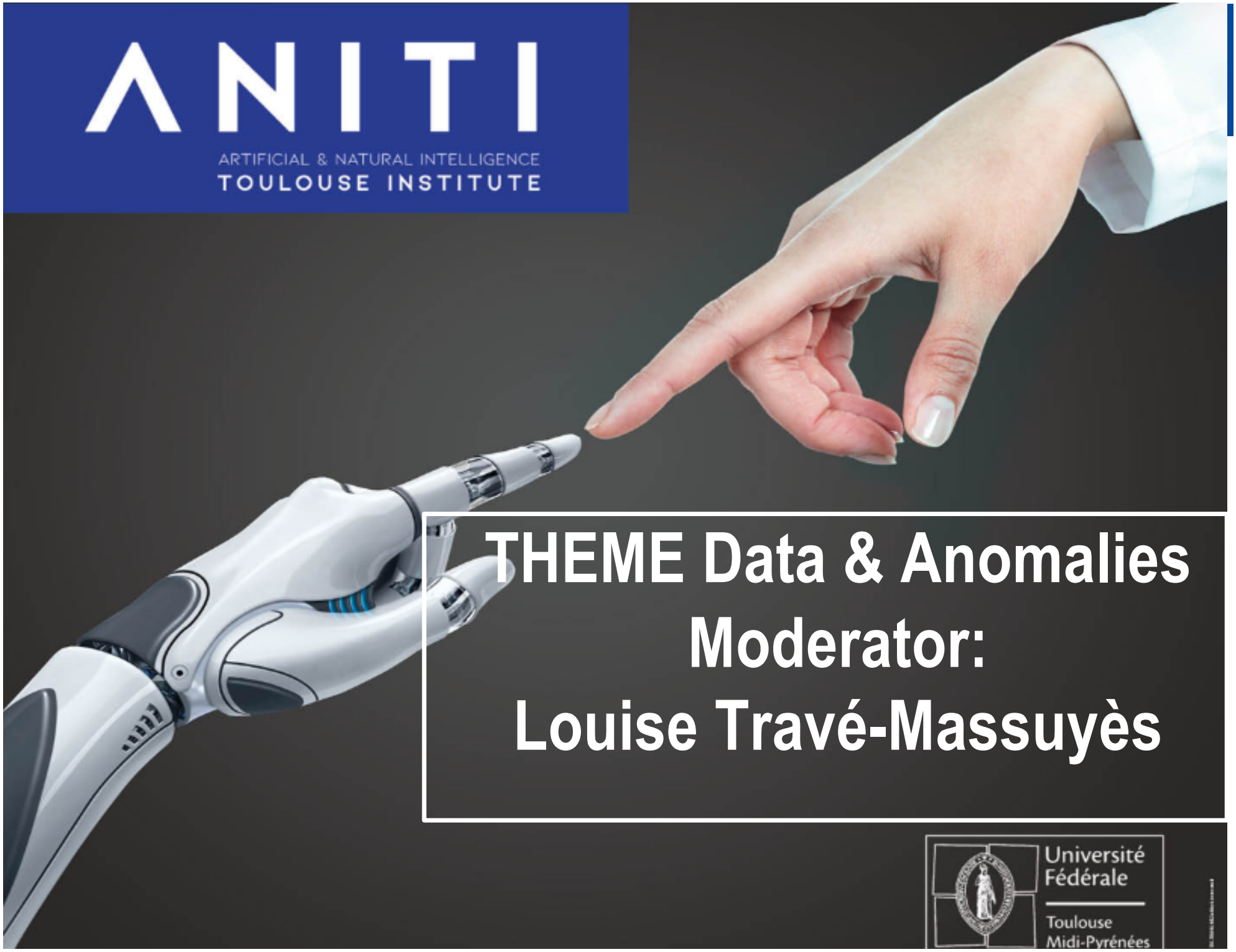
ANITI

ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE



THEME Data & Anomalies
Moderator:
Louise Travé-Massuyès

Université Fédérale
Toulouse Midi-Pyrénées

MEMBERS

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE

Chairs: J.-M Loubes, S. Gratton, J.-B Lasserre, L. Travé **DEEL/OOD: C. Chapdelaine**

People involved: (co chairs)

Co-chairs (Loubes): Béatrice Laurent, Matthieu Serrurier

Co-chairs (Gratton): P. Bourdier, C. Lapeyre, A. Buttari, S. Gurol

Co-chairs (Lasserre): V. Magron, M. Korba **; Collaborators:** M. Putinar, V. Magron, E. Pauwels, M. Korda

Co-chairs (Travé): E. Chanthery, X. Pucel, N. Barbosa**; Collaborators:** A. Subias, Y. Pencolé, M.-V Le Lann, C. Alonso

Co-workers (Chapdelaine): T. Soumarmon, A. Elfassi, D. Vigouroux

ANITI Resources (post doc, PhD, Mise à Disposition Industrielle, DEEL…)

- 1 CIFRE- William Todo-Loubes not only data driven maintenance – Liebherr
- 1 ANITI- PhD Le Toan Duong-Travé: Knowledge extraction and optimization of electronic board production processes – Aniti/Vitesco
- 1 CIFRE- PhD Kevin Ducharlet-Travé: Anomaly detection and diagnostics of industrial systems represented by digital twins - Berger-Levrault (Carl Software)
- 1 PhD Adrien Dorise-Travé: On-board DIAGnostics for space electronics RADiation hardening (DIAG-RAD) - CNES/Région
- 1 CIFRE Serge Gratton – détection événements extrêmes – BRL
- 1 PhD Louis Béthune – Serrurier (collaboration prevue avec Thalès): Representation learning for few shot learning and anomaly detection : application to spatial data

Expected

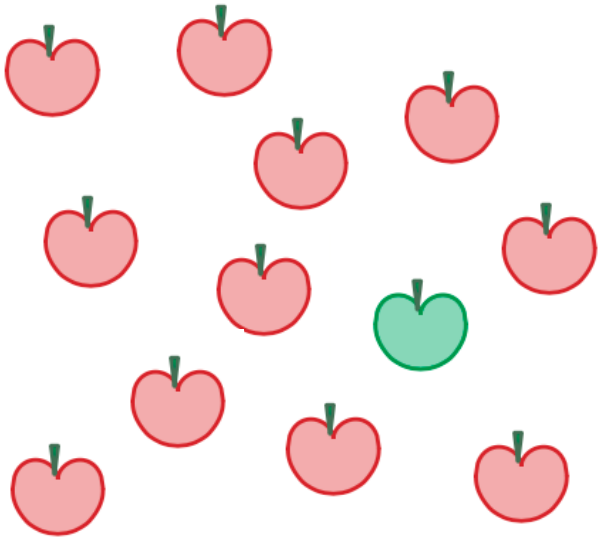
- 1 CIFRE- PhD Kevin Pulido -Travé: Predictive maintenance and diagnosis of cobots – Vitesco
- 1 CIFRE- PhD -Travé: Machine Learning & Business Knowledge for Predictive Diagnosis and Maintenance – ATOS
- 1 post-doc Travé – Nukkai /INRIA/ANITI

Other Resources (other Phd project)…

Anomaly detection

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE

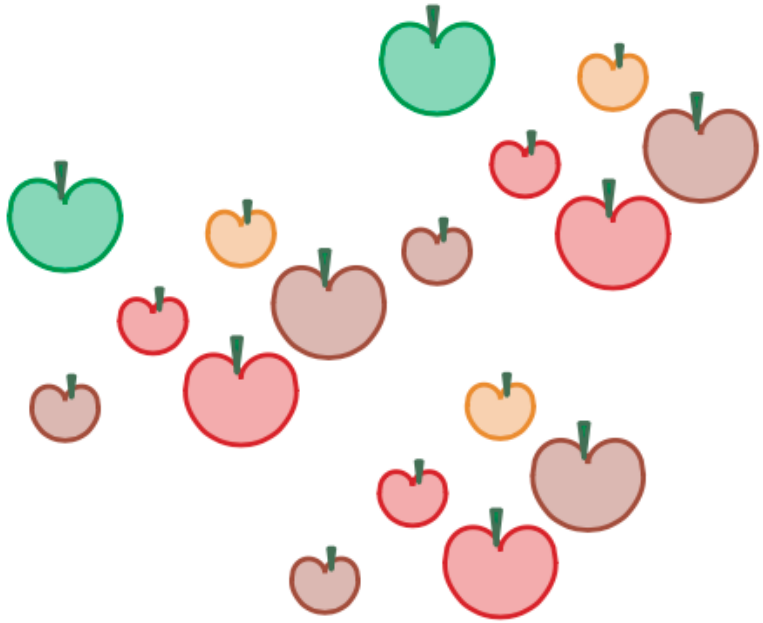
Where is the intruder?



Anomaly detection

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE

Where is the intruder?



Definition/scientific perimeter of the theme

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE

Thread 1:

Anomaly/extreme event detection, diagnosis, prognosis

Thread 2:

Data representation for anomaly detection

Thread 1: Anomaly/extreme event detection, diagnosis, prediction

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE

Define methods based on hybrid AI for detecting and diagnosing anomalies that are generic, explainable, certifiable and adaptive to evolving environment

Objectives:

→ Highlight and understand how model-based and data driven approaches can complement each other

→Abstract data classifiers and map them to symbolic or analytical models suitable for diagnosis reasoning for better explainability and acceptability

Challenges: A general method of detecting anomalies that:

- Is not too dependent on a particular type of data
- takes into account rules from physics or logical constraints
- distinguishes between unbalanced sampling, noise, disturbances, novelty and real anomaly
- adapts to evolving environments and accounts for dynamics,
- enables diagnosis, i.e. identification of root-causes of anomalies)
- is transferable to a twin system with automatic retuning

Tools/Techniques:

- Dynamic clustering, Stream reasoning,
- Temporal pattern mining and process mining,
- Specific types of stochastic graphical models (such as Graphical Event Models) together with relational probabilistic graphical models (eg. using Markov Logic networks).

Application/Use Cases:

- predictive maintenance and diagnosis of production lines, cobots or industrial systems, 3D printers
- detection of floods

Thread 2 : Data representation for anomaly detection

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE

Develop methods to detect current data that are out of the distribution of the training data

Objective :

- Produce a generic framework to detect out-of-distribution (OOD) data
- Find indicators to distinguish in-distribution (ID) and OOD data
- Integrate novelty in a learned model

Challenges :

- Infer support characteristics, based on the knowledge of finitely many moments of the underlying measure
- Produce volume-preserving/measure-preserving models to well-detect OOD data
- Analyze distributions of activations on a learned classification model
- Quantify predictive uncertainty

Tools / Techniques :

- Kernel based methods: Christoffel-Darboux kernels
- Distribution enhancement: Normalizing flows, ordinary differential equations (ODE), extreme value theory (EVT), measure preservation
- Dimensional reduction (NMF, Wavelets, data driven bases)
- Embeddings : manifold embeddings, Variational AutoEncoders (VAEs), Generative Adversarial Networks (GANs)
- Bayesian methods: bayesian neural networks, approximate Bayesian inference

Application / Use cases :

- Anomaly detection in inspection of surfaces
- Anomaly detection in satellite imagery (i.e snow detection)
- Anomaly detection in satellite telemetry
- Detection and adaptation to new satellite signal (i.e new modulation)

On-going work

On-going collaboration between chairs

1 seminar chairs Loubes / Travé + DEEL/OOD

2 meetings chairs Fargier / Travé

Participation to PhD jurys Loubes ←→ Travé

On-going collaboration with ANITI Industrial partners

Liebherr,
Vitesco Technologies
Airbus, Airbus DS
Berger-Levrault, Carl Software
Atos, CEMP
CNES, BRL
DGA
Software Labs Renault
SAFRAN
SCALIAN
SNCF
Thales, Thales Alenia Space
APSYS
Continental

On-going collaboration with external projects (national, EU, industry…)

Cocotier (DGAC) – Avocettes (CORAC)

PhD E. Sepulveda (Cifre Quantom) – PhD A. Gaffet (Cifre Vitesco)

On-going ANITI Phd & Post doc

6 PhDs: 3 Cifre PhD, 1 ANITI PhD (to be transformed into Cifre), 1 PhD CNES/Région, 1 PhD

Highlight & main results

Selected Publications

C. Barreyre, B. Laurent, J-M. Loubes, L. Boussouf and B. Cabon, "Multiple Testing for Outlier Detection in Space Telemetries," in *IEEE Transactions on Big Data*, vol. 6, no. 3, pp. 443-451, 1 Sept. 2020, doi: 10.1109/TBDATA.2019.2954831.

C Barreyre, L Boussouf, B Cabon, B Laurent, JM Loubes. "Statistical methods for outlier detection in space telemetries » in Space Operations: Inspiring Humankind's Future, 513-547, 2020.

Barbosa Roa, N. B., Travé-Massuyès, L., & Grisales-Palacio, V. H. (2019). DyClee: Dynamic clustering for tracking evolving environments. Pattern Recognition, 94, 162-186.

Ducharlet, K., Travé-Massuyès, L., Le Lann, M. V., & Miloudi, Y. (2020, September). A Multi-phase Iterative Approach for Anomaly Detection and Its Agnostic Evaluation. In International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems (pp. 505-517). Springer, Cham.

J.B. Lasserre, E. Pauwels. The empirical Christoffel function with applications in data analysis, Adv. Comp. Math. 45, pp. 1439—1468, 2019

E. Pauwels, M. Putinar, J.B. Lasserre. Data analysis from empirical moments and the Christoffel function. Found. Comput. Math., 2020

Le Toan Duong, Louise Travé-Massuyès, Audine Subias, Nathalie Barbosa Roa, Assessing product quality from the production process health status, 31th International Workshop on Principles of Diagnosis (DX-20), Universe, 26-28 Sept. 2020.

L. Travé-Massuyès. Contributions of diagnosis reasoning to the general demand for AI in the industry, 32nd International Conference on Industrial, Engineering & Other Applications of Applied Intelligent Systems (IEA/AIE 2019), Graz, Autria, July 9-11, 2019 (Invited Talk).

Scientific event organization (conference, workshop, GDR) & participation

Participation, reviewing, invited talks: ECAI 2020, IJCAI 2020, DX 2020 and DX 2019 Workshops, IEA-AIE 2019 and 2020

Editorial boards: AIJ Associate Editor

Submissions to ANR, EU… related projects

ANR Proposal MODERNIST: Monitoring et prOnostic DE stRuctures aéroNautiques compoSiTes (not accepted)

EU COST Action on Stream Reasoning to be submitted this fall.

Scientific animation of the theme

ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE

Description of the theme agenda

(Bi ?)monthly workshops following the roadmap

Emerging collaboration between chairs & industrial partner

→ *Umbalanced data :* Themes « Learning with little or complex data » & « Data, Bias and Fairness » (supervised vision of anomalies)

→ *Diagnosis/Prognosis:* « Explainability » & « Automated reasoning and Desision »

Theme roadmap

Year 2:

- ✦ Mapmaking of types of anomalies and classes of anomaly detection problems
- ✦ Creation of a library of exemplifying industrial data sets

Academic / Industrial interactions

Year 3:

- ✦ Map anomaly detection methods to classes of problems
- ✦ Create gitlab
- ✦ Test on industrial data sets in the library

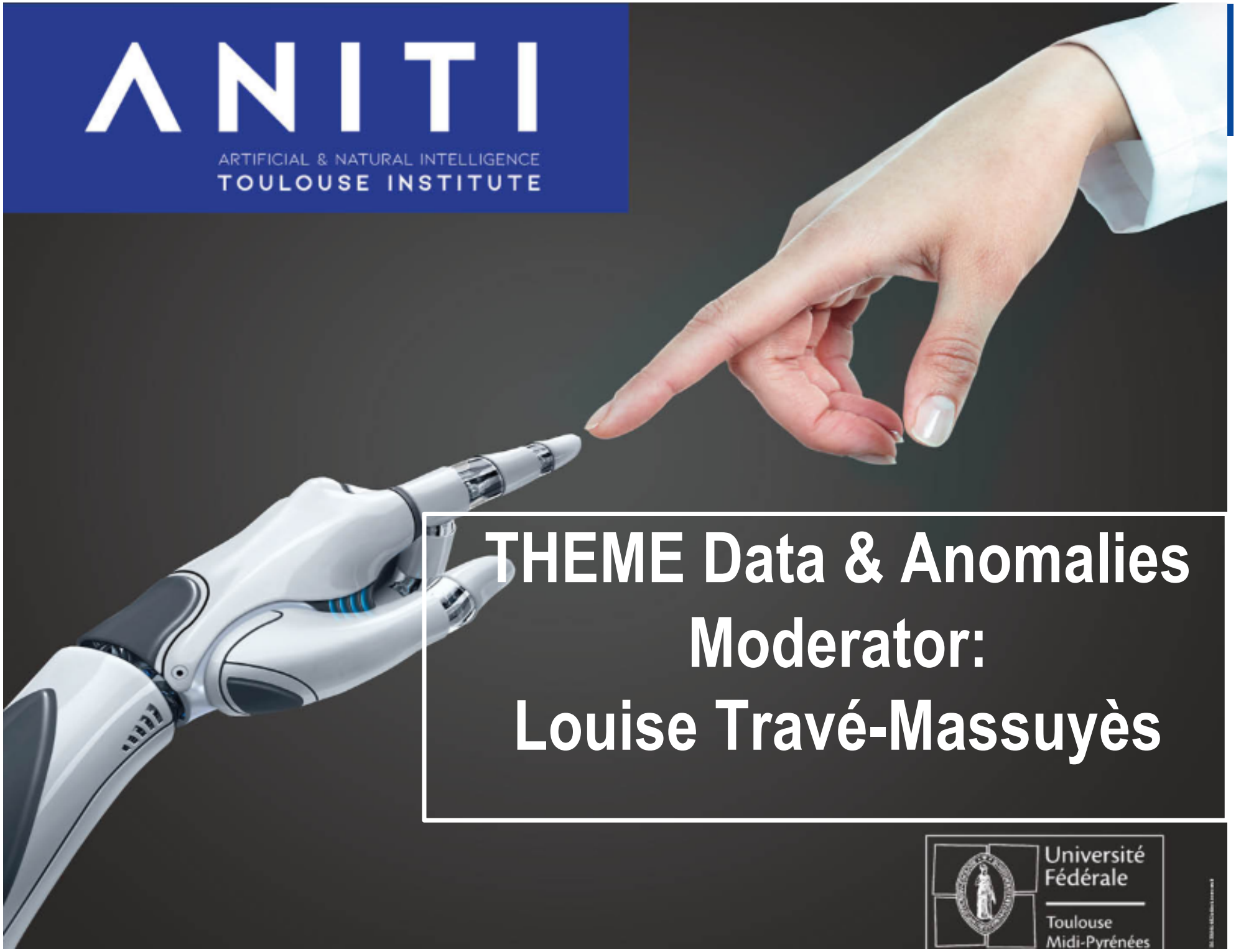
Inter-themes interactions

Year 4:

- ✦ Handing off to Industrial partners for further development

ANITI

ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE



THEME Data & Anomalies
Moderator:
Louise Travé-Massuyès

Université Fédérale
Toulouse Midi-Pyrénées