SFDS ECAS 2025

"Towards Reliable Machine Learning Transfer & Physics Informed Learning, and Conformal Prediction"

APHP Clinical Research Unit for the University Hospitals Paris West - European Hospital Georges Pompidou
INSERM Clinical Research Centre 1418 – Clinical Epidemiology
INSERM – INRIA – Paris Cité University UMR1346 HeKA

Armelle ARNOUX armelle.arnoux@aphp.fr ; 01 56 09 56 37

- **Biostatistician from an engineering school**

- **PhD in Public Health – Epidemiology**
  - **Antioxydants and pulmonary function**

- **6 years in pharmaceutical and medical devices companies**

- **14 years in public hospitals**

- **Since 2022, joined an academic research team**

- **Accreditation to supervise research (ongoing)**

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My actual positions and interest

- **1st – Clinical research unit European Hospital Georges Pompidou**
  - Assistance Publique-Hôpitaux de Paris: biggest parisian university hospital institution
  - Support the doctors at the hospital to manage their researches
  - Missions
    - Clinical trial design, sample size calculations
    - Protoco, statistical analysis plan
    - Supervision of young statisticians for the whole trial process
      - Funding submission, ethics submission, preparation, statistical analyses, publication

- **2nd – Clinical Investigation Center European Hospital Georges Pompidou**
  - INSERM (national institute for health and medical research)
  - Innovation on designs or tools (randomisation, ML, methodology)
  - Missions
    - Implementation and results on innovative designs and tools for clinical trials for special cases
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- **3rd – Joint Research Unit U1346-HeKA PariSanté Campus**
  - INSERM + Paris Cité University + INRIA (National Institute for Digital Science and Technology)
  - *Digital health research for a learning health system* = develop methods, models, and tools to create, evaluate, and validate learning health systems
  - Missions
    - Implementation and results on tools for large data volume (French health-economics database)
    - New tools based on ML-IA-LLM evaluation
    - Supervision of PhD students and post-doc to get the results

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AP-HP

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What I expect from the training

- **Every day in contact with ML/DL tools either to develop them or to evaluate them for reliability, robustness and reproducibility**

- **New challenges I can see**
  - ➤ Explicability (which features are retained and why)
  - ➤ Generalizability (how to ensure that their conclusion is transposable to other datasets, which raises the issue of quantification and correction of biases in input data among others)
  - ➤ Uncertainty output (how much confidence can we have)

- **Any other challenges for a reliable ML?**
  - ➤ To put the solutions it into practice in the research

- **A view on what is clear through recent results, and which areas still uncertain yet on which it is advisable to remain cautious.**

- **To avoid the traps already known by specialists but the solutions recommended.**

- **Curious about LLM point of view**

- **Note: Coding issues for the training**
  - ➤ I manage the persons responsible for the code.
  - ➤ Although I don't code myself anymore, I can still read more or less the programs.

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Angelo Efoévi Koudou
Maître de conférences, HDR
Université de Lorraine, Institut Elie Cartan de Lorraine
Nancy, France

Flash presentation, ECAS, Fréjus, December 2025

Current research interests

Mathematical statistics: Dependence modelling, studying a new class of copulas, called Lancaster copulas.

Applied statistics:

- ▶ Modeling and simulation of failures in the electrical distribution network of the electricity company of Côte d'Ivoire (collaboration with a university in Côte d'Ivoire)
- ▶ Estimation of the granulometric distribution of submicronic aerosols (inverse problems, collaboration with INRS, Nancy)

Machine learning:

- ▶ Unsupervised latent-event inference via learning on graphs.
- ▶ Ranking of classification algorithms in the presence of noise in the training data.

Previous research:

Probability and mathematical statistics

- ▶ Testing procedures for Generalized Inverse Gaussian models
- ▶ Matsumoto-Yor property : characterization of families of distributions by an independence property
- ▶ Tree networks with random conductivity and the inverse Gaussian distribution
- ▶ Exponential families

Teaching: Supervised and unsupervised learning for master students; undergraduate mathematics and statistics.
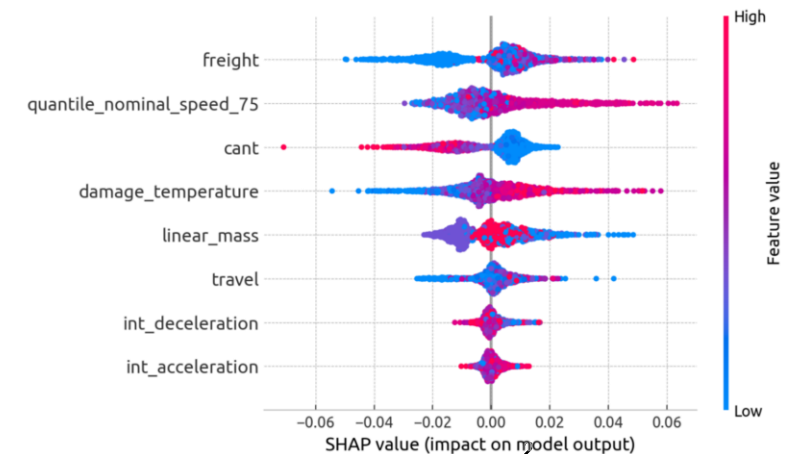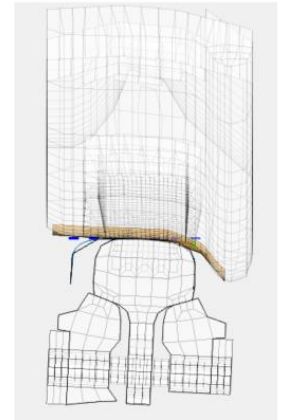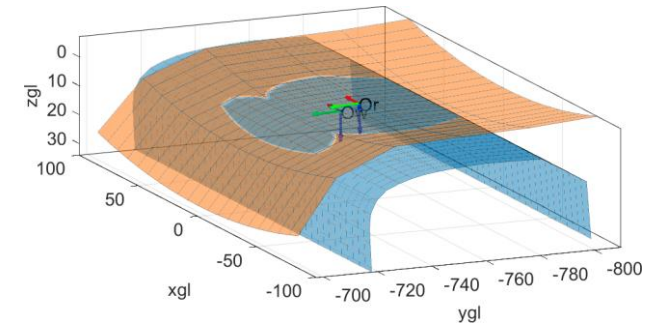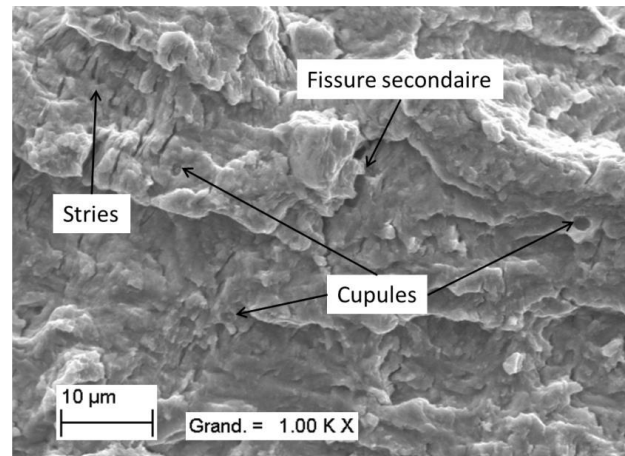
Research activities

Main missions

➢ Focus on Fatigue Crack
➢ Prescriptive and predictive maintenance
➢ Failure analysis
➢ Asset monitoring
➢ Mechanical modeling
➢ Data based modeling
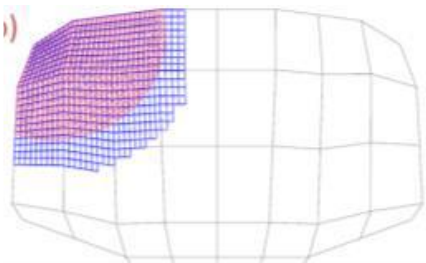
Bayesian Network-Based Method for Accident Scenario Modeling

- **Objective:** Develop a method based on Bayesian Networks to model severe accident scenarios.

- **Key Feature:** Calculates the most probable scenario from observed data.
- **Use Case:**
  - IRSN collected multiple contaminated soil samples after the Fukushima accident.
  - The origin of contamination scenarios was unclear (virtually infinite possibilities).

- **Proposed Solution:**
  - Build a tool that infers the root cause and reconstructs the most probable scenario from observations.
- **Benefits:**
  - Supports decision-making under uncertainty.
  - White-box model
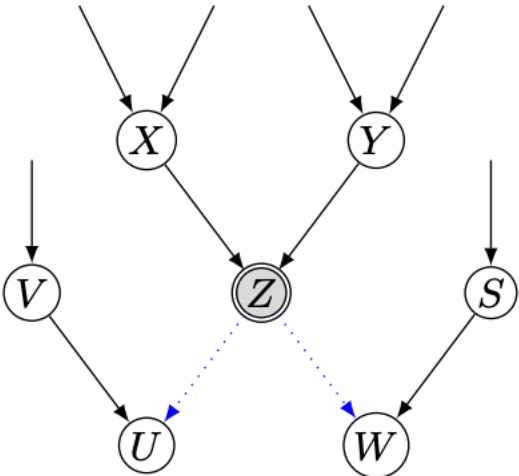 - Provides a structured approach to accident analysis.

A	p(A)
a	0.70
$\bar{a}$	0.30

A	N	p(N|A)
a	n	0.20
a	$\bar{n}$	0.80
$\bar{a}$	n	0.05
$\bar{a}$	$\bar{n}$	0.95

A	S	p(S|A)
a	s	0.15
a	$\bar{s}$	0.85
$\bar{a}$	s	0.01
$\bar{a}$	$\bar{s}$	0.99

N	S	D	p(D|N,S)
n	s	d	0.95
n	s	$\bar{d}$	0.05
n	$\bar{s}$	d	0.40
$\bar{n}$	s	d	0.60
n	$\bar{s}$	$\bar{d}$	0.45
$\bar{n}$	s	$\bar{d}$	0.55
$\bar{n}$	$\bar{s}$	d	0.15
$\bar{n}$	$\bar{s}$	$\bar{d}$	0.85

S	W	p(W|S)
s	w	0.70
s	$\bar{w}$	0.30
$\bar{s}$	w	0.10
$\bar{s}$	$\bar{w}$	0.90

Age A → Neuronal Atrophy N, Stroke S → Dementia D, Wheelchair W
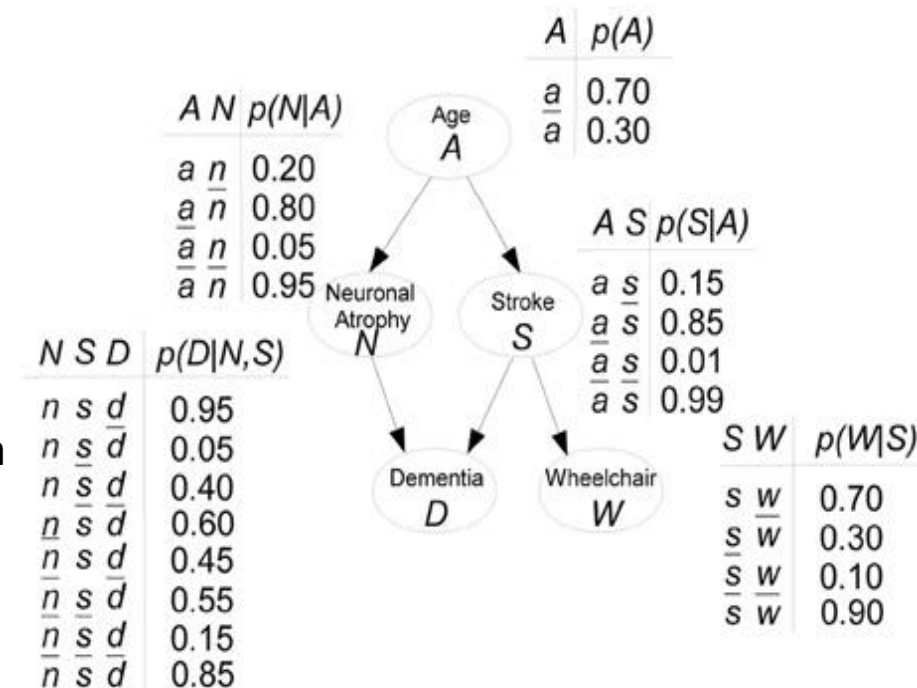
Main Research

1. **Learning Bayesian Network Structures from Nuclear Data**

- Adapt state-of-the-art algorithms to constraints in nuclear data
- Address challenges of incomplete or noisy datasets
- Enhance reliability for nuclear safety and risk assessment

2. **Developing a Multivariate Discretization Algorithm**

- Preserve essential properties of nuclear data
- Minimize information loss during discretization
- Enable accurate probabilistic modeling and inference

Multivariate discretization

Bayesian network structure learning

My current position: research engineer at ENGIE

Applying AI Techniques to Renewable Energy Domain

Predictive Maintenance of Wind Turbines
- Detect anomalies and prevent failures
- Optimize maintenance schedules
- Reduce downtime and operational costs

Text Classification
- Sentiment Analysis of Customer Feedback
- Categorize documents and messages automatically
- Automate reporting and summarization

R&D activities
- PhD Supervision in collaboration with Aix-Marseille University
- Research Project on Distributed Energy Resources (DER) with Stanford University
- Mentoring of an Apprentice and a Master's Student (M2)

Anomaly detection on wind turbine (Gearbox component)