Project CAUSALI-T-AI
CAUSALIty Teams up with Artificial Intelligence

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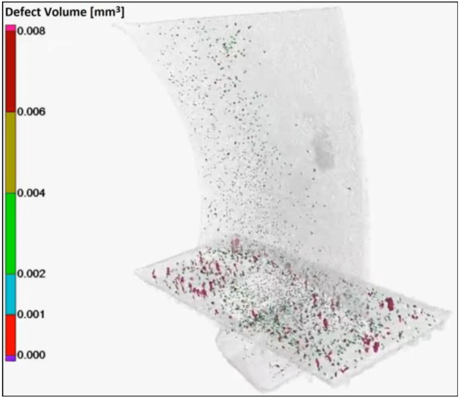
Why causality?

Machine learning systems lack:

- ability to explain what happened



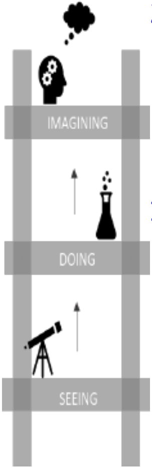
Why causality?

Machine learning systems lack:

- ability to explain what happened
- go beyond correlation relationships

These limitations can be overcome by using causal modeling tools

Causal tools[1]



3. **Counterfactuals** - against existing observations

- invokes counterfactual reasoning
- "What if $\mathcal{X} = x$ **had been** $\mathcal{X} = x'$"
- "Would I had stopped eating chocolate everyday, my cholesterol has improved?"

2. **Interventions** - action-guidance

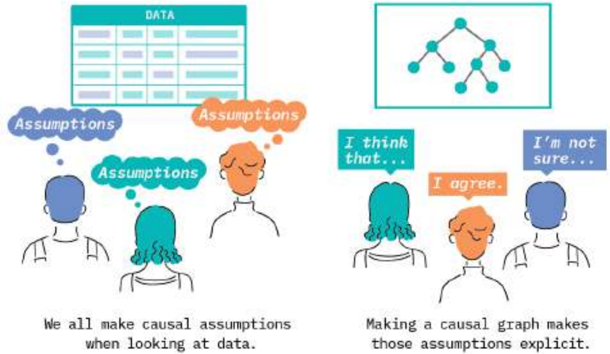
- invokes not only seeing what is but changing what we see
- "What if I **do** $\mathcal{X} = x$?
- "Will exercise lower my cholesterol?"

1. **Observations / associations**

- invokes exclusively statistical relationships
- "What if I **see** $\mathcal{X} = x$"
- "Is symptom X **associated** with disease Y?"

[1]Pearl, J. et al., 2018. The book of why.

Causality: a game changer in explainable AI?



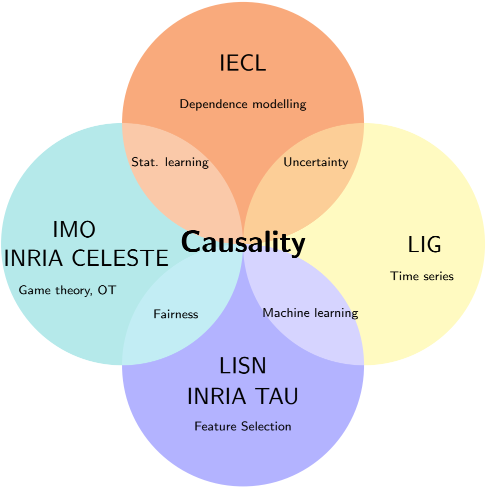
Applications in various domains as economy, environment, material science, biology, medical research..

The causal modeling challenges

- Scarcity of available data
  Bottlenecks: acquisition cost huge in practical applications, robustness of causal discovery approaches
- Identifiability of the target model
  Bottlenecks: not reachable in practice, need of a notion of partial identifiability
- Learn interpretable and meaningful representation of complex data well adapted to the causality framework
  Bottlenecks: disentangle the effects of hidden counfounders, robustness of the learned representation
- Handling uncertainties and partial knowledge
  Bottlenecks: quantify and handle uncertainties, including possibly different sources, transportability of causal models

Our consortium

Where statisticians team up with computer scientists



Recent milestones of the consortium

The AISSAI scientific quarter

- Organisation of three international colloquium, two research school, one modelling week and two industrial events from February 2023 to September 2023
- More than 300 participants, coming from US, Canada, Netherlands, UK, Germany, Switzerland...

Two preliminary results

- Identifiability of the total effect in abstract graphs for temporal data (LIG)
- Distributed learning for large-scale causal structure learning (LISN)

Research program and collaborations

WP1: Explore Structural Causal Models as generative models

- Applicable to data augmentation?
- Relax identifiability into stability

Related PhD and postdoctoral projects

- PhD LISN-LIG: propose data augmentation procedure including partial knowledge/invariance of the data structure
- PhD LIG-LISN: relax the identifiability requirement and investigating stability-based training losses

Research program and collaborations

WP2: Causal modeling in structured frameworks

- Learn relevant representation of complex data: temporal data
- Handle counfounders and hidden variables
- Learn surrogate causal models

Related PhD and postdoctoral projects

- PhD IECL-LISN: Mixed causal modelling with time series and point processes
- PhD IECL-LIG: use extension of moments (signature method) to identify hidden counfounders and common causes

Research program and collaborations

WP3: Causal modeling, domain adaptation, optimal transport

- Intervention as domain adaptation
- Counterfactual reasoning via optimal transport
- Use of optimal transport in the perspective of algorithmic recourse

Related PhD and postdoctoral projects

- PhD IECL-IMO: Causal inference and domain adaptation
- Post doc LISN-IMO: Optimal transport and optimal intervention design

Research program and collaborations

WP4: Handling and measuring uncertainty

- in the environment (data/domain)
- in the model

Related PhD and postdoctoral projects

- PhD LIG-IECL: Causal inference in uncertain environments
- Post doc LISN-LIG-IECL: Uncertainty measure of a causal graph

Outcomes : address fundamental questions

What?

- identifiable causal models
- robust wrt large p small n

How?

- change of representation
- transportability (intervention/couterfactual with OT)
- uncertainty quantification

What for?

- data augmentation
- explanation : inspection/verification with human experts
- algorithmic recourse

Scientific outcomes and softwares

Scientific outcomes

- Target venues in top conferences and journals
- 8 PhDs, 6 post-docs

Software and platforms

- Code will be publicly available, which can lead to new application domains.
- Unify and enhance existing platforms as `CAUSEME`[2] to test and benchmark new data and new algorithm in the same spirit

[2] causeme.uv.es

Outcomes : scientific animation

- Take benefit of the dynamic of the AISSAI scientific quarter and organize a community gathering experts in the causality field and practitioners,
- Promote interactions with industrial partners, especially SME and start-ups, develop links within `confiance.ai`
- Disseminate causal approaches among young researchers through research schools and international classes targeting PhD and post doctoral students
- Strengthen the interactions of the CAUSALI-T-AI group with leading international groups (Tübingen, ETH, Columbia..)

Governance

- Steering committee : meeting every quarter to coordinate the effort of each partner
- Potential advisory board : D. Blei (Columbia), E. Duflo (MIT & Collège de France), J. Runge (CIDS, Dresden) , J. Peters (ETH Zürich)

Questions

Questions!

LLM and CAUSALI-T-AI

- Explain the cause of the output of a LLM ?
- Can we find the sources ?
- The textual entailment problem!

Links with other PEPRs

- Within PEPR IA : Foundry, PDE-AI, SHARP
- PEPR NumPex : Need in computing resoources, causal surrogate models
- Applications : PEPR Sous-sol, PEPR FairCarbon

Links with industrial partners

- Big companies : Thales, Renault, SAFT
- SME as AI-vidence, EasyVista...
- Connexion with the SME Datacraft and AMIES to organize industrial events