Machine Learning for econometrics

Reminders of potential outcomes and Directed Acyclic Graphs

Matthieu Doutreligne

Thanks to Judith Abecassis for the slides on DAGs

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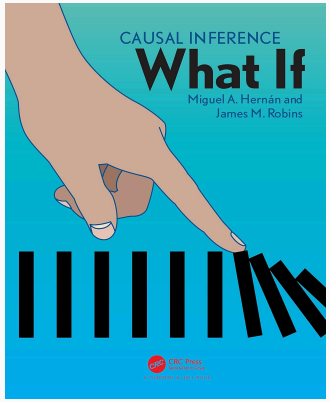
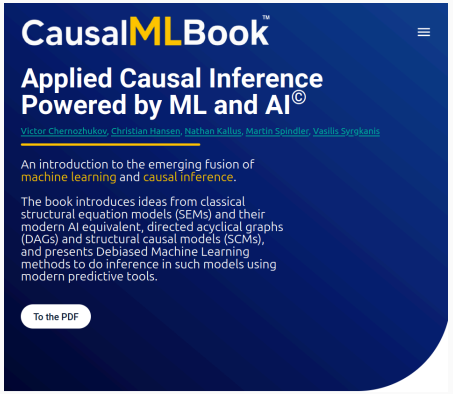
Contents

Causal inference: subfield of statistics dealing with "why questions"





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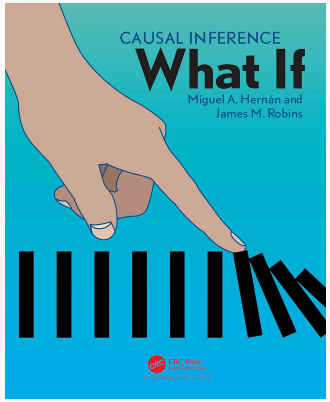

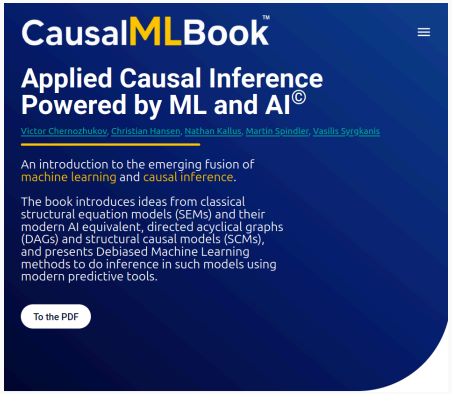

At the center of epidemiology (Hernan & Robins, 2020), econometrics (Chernozhukov et al., 2024), social sciences, machine learning...

Now, bridging with machine learning (Kaddour et al., 2022) : Fairness, reinforcement learning, causal discovery, causal inference for LLM, causal representations...

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This is different from predictive questions

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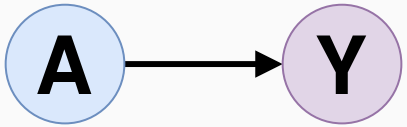

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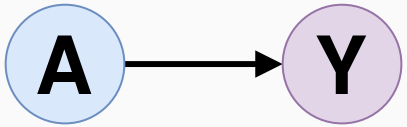

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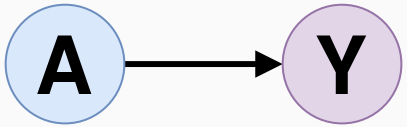

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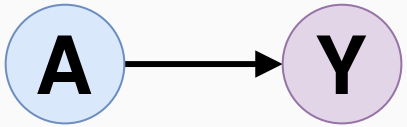

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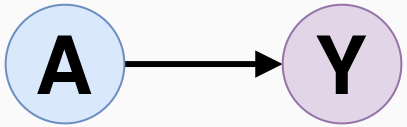

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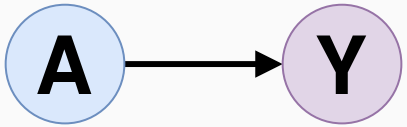

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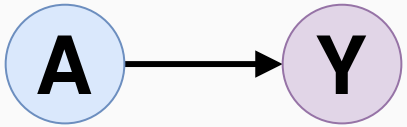

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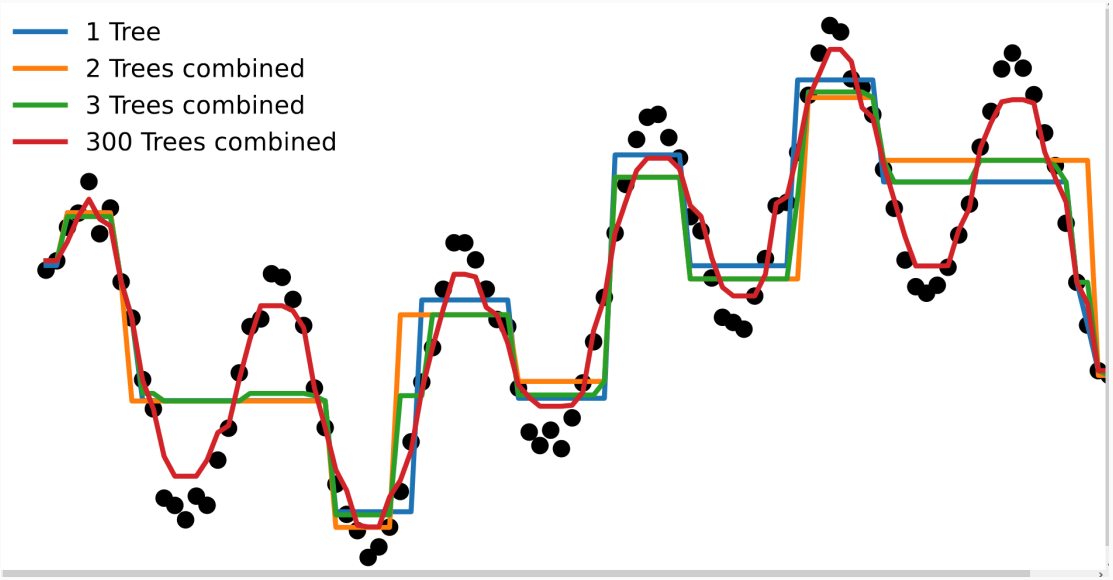
Assumption Train and test data are drawn from the same distribution.

Machine learning is pattern matching

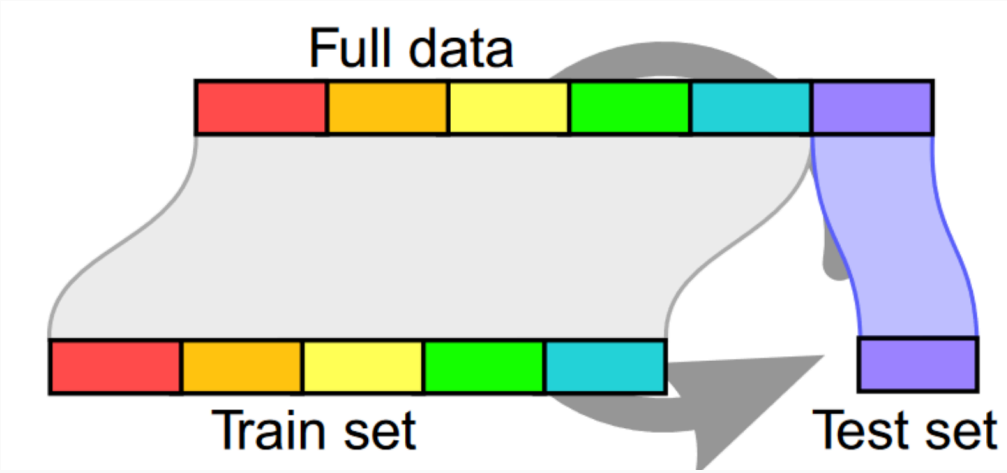
Find an estimator $f : x \rightarrow y$ that approximates the true value of y so that $f(x) \approx y$



Boosted trees : iterative ensemble of decision trees

Machine learning is pattern matching that generalizes to new data

Select models based on their ability to generalize to new data : (train, test) splits and cross validation (Stone, 1974).



"Cross validation" (Varoquaux et al., 2017)

Machine learning is great for prediction on complex data

Images: Image classification with deep convolutional neural networks (Krizhevsky et al., 2012)

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Speech-to-text: Towards end-to-end speech recognition with recurrent neural networks (Graves & Jaitly, 2014)

Text: Attention is all you need (Vaswani, 2017)

ImageNet 1K: 1.5 million images, 1000 classes

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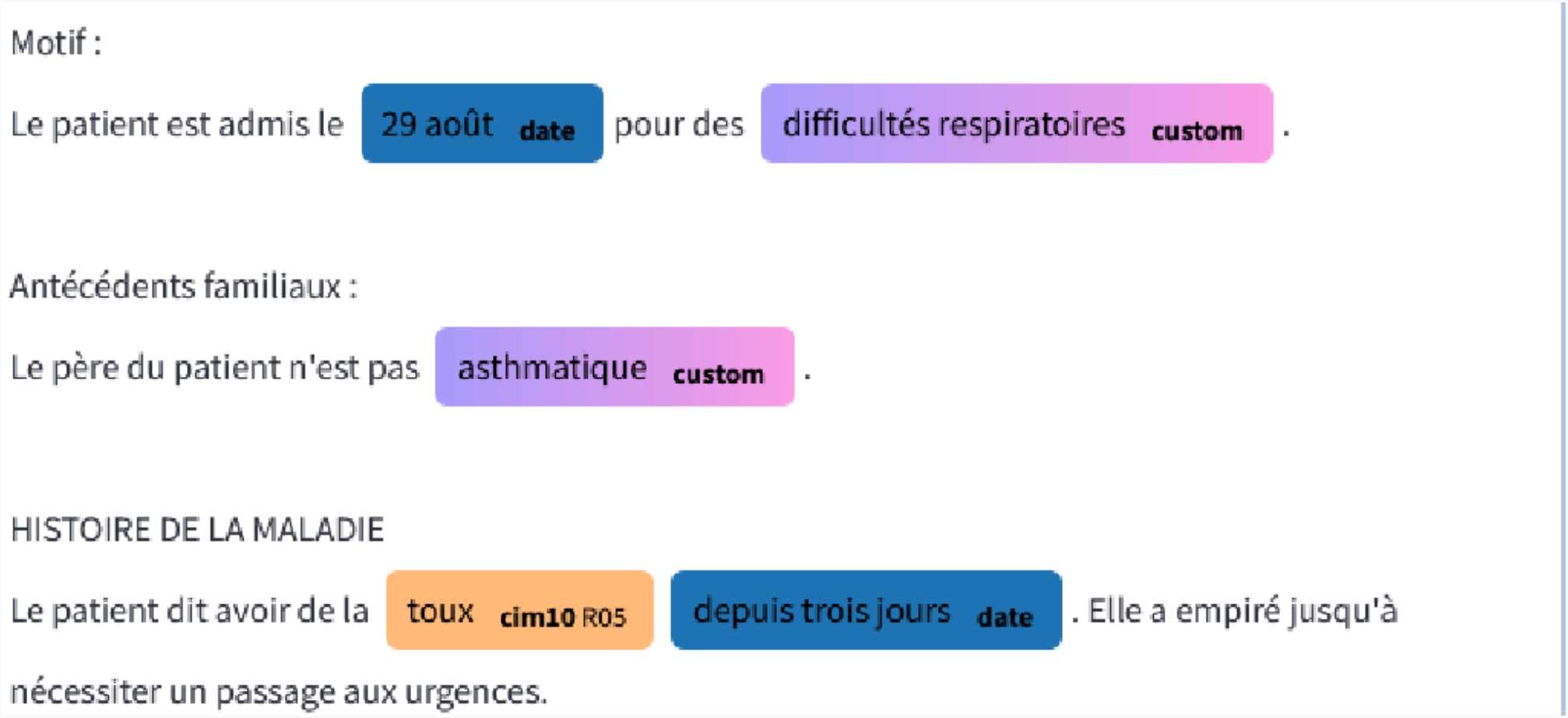


Named entity recognition

Machine learning is not driven by causal mechanisms

- For example people that go to the hospital die more than people who do not[1]:
- Naive data analysis might conclude that hospitals are bad for health.

[1]Example from https://inria.github.io/scikit-learn-mooc/concluding_remarks.html?highlight=causality

Machine learning might be less successful for what if questions

Machine learning is not driven by causal mechanisms

- For example people that go to the hospital die more than people who do not[1]:
- Naive data analysis might conclude that hospitals are bad for health.
- The fallacy is that we are comparing different populations: people who go to the hospital typically have a worse baseline health than people who do not.

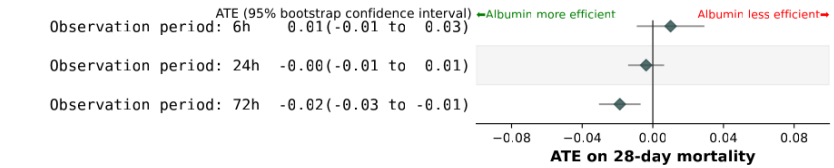
Definition

This is a confounding factor: A variable that influences both the treatment and the outcome.

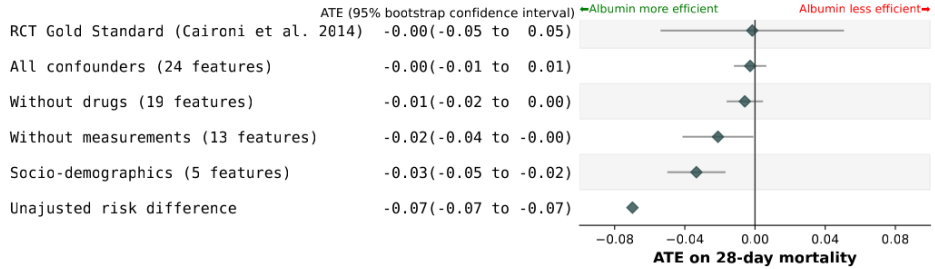
[1] Example from https://inria.github.io/scikit-learn-mooc/concluding_remarks.html?highlight=causality

Full results of the sensitivity analysis

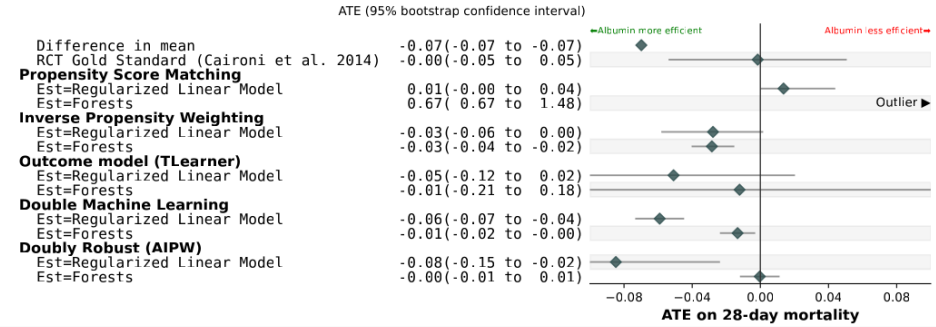
(a) ***Framing – Immortal Time Bias***



(b) ***Identification – confounders choice***



(c) ***Model selection***



Contents

Practical session

To your notebooks! 👩‍💻

- url: https://straymat.github.io/causal-ml-course/practical_sessions.html

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Bibliography

Supplementary material

DAG: Effect modifier

Effect modifier: influences the treatment effect on the outcome.