

MERGING PHYSICS-BASED AND DATA-DRIVEN MODELS IN BATTERY DEGRADATION STUDIES

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PhD Research Question



How can we blend data science and physics
to better figure out how complex things work?

How can we apply this
to support the energy transition?

This research explores how new advances in **artificial intelligence and data analysis** can be brought together to create **helpful tools for both science and engineering**.

By applying these modern techniques to **energy storage systems** - like the batteries used in electric cars and renewable energy - we aim to **speed up the process of testing new technologies** and make it easier to **monitor these systems in real time**.

Current Work

Methodology: Causal Inference

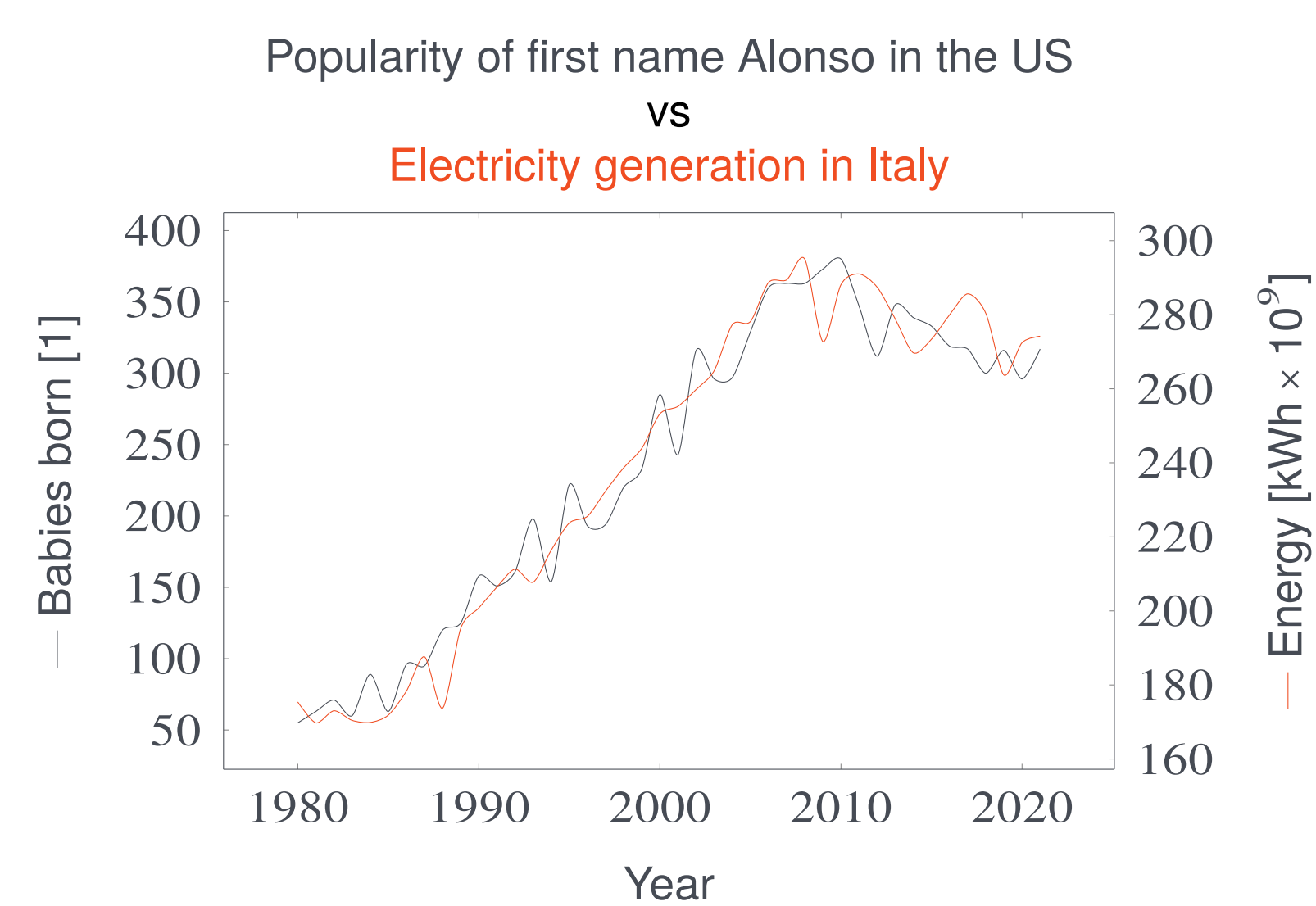


Fig. 1: A spurious correlation is when two things seem to be related to each other, but in reality, they are not. It's like seeing a pattern where none actually exists.

Example source: tylervigen.com/spurious-correlations

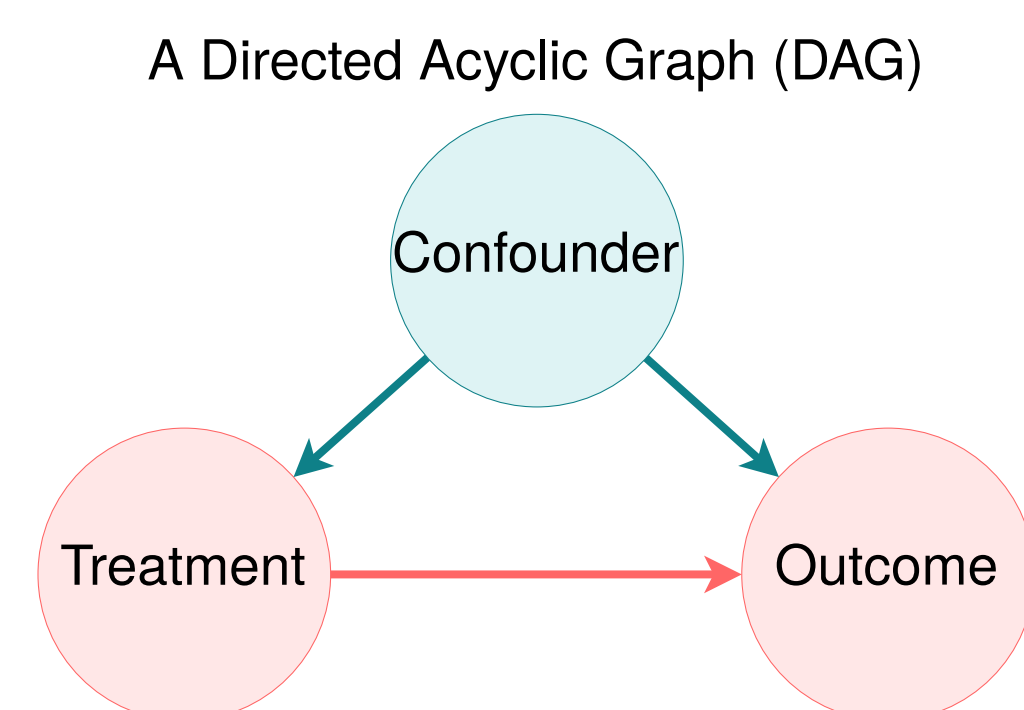


Fig. 2: Is this a coincidence? Two things may just happen at the same time by chance. Something is missing? A third factor may cause both things to happen.

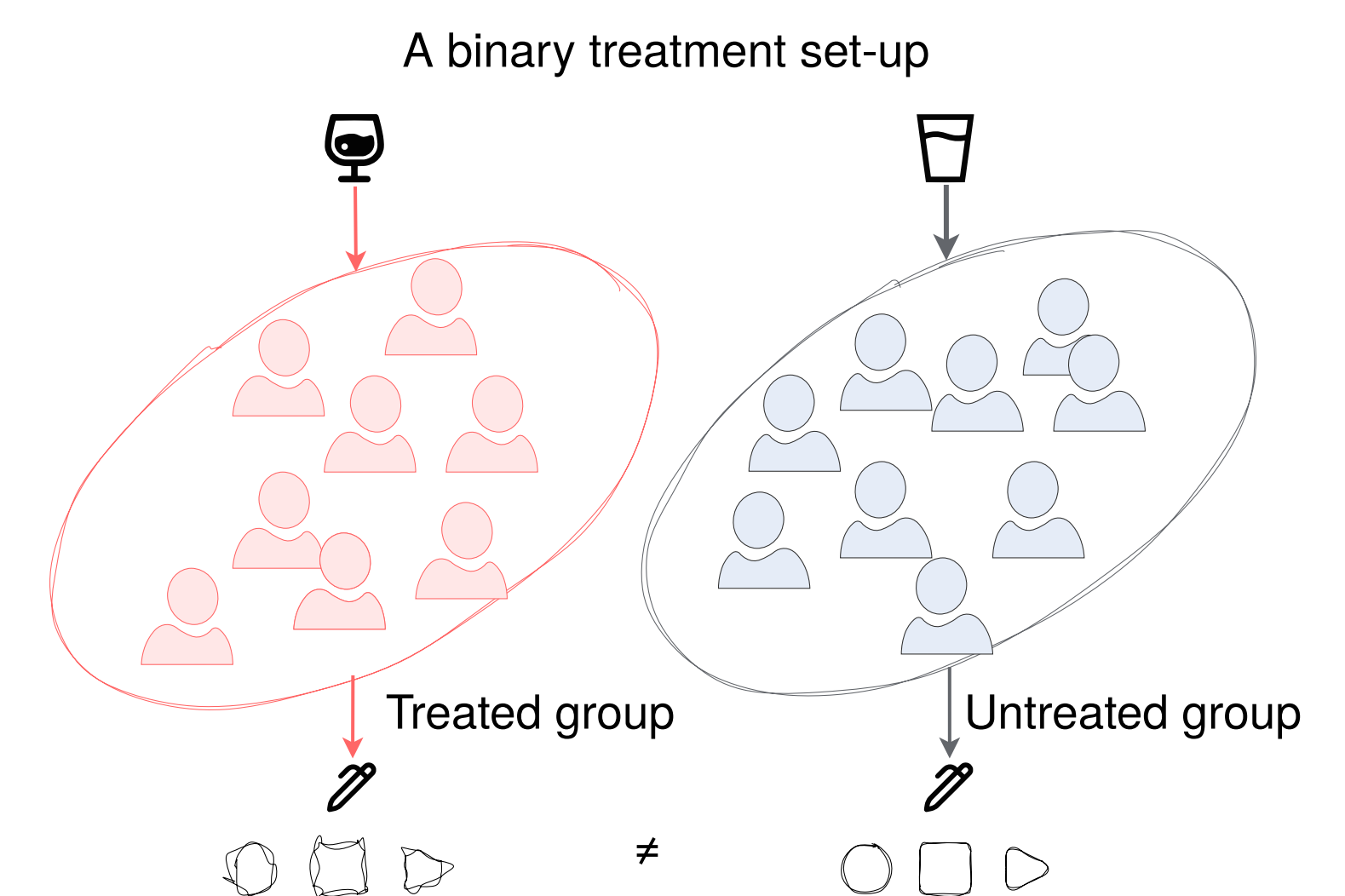


Fig. 3: In binary treatment set-up all factors are kept under control, to isolate the effect of the treatment. So that differences in outcomes between the *treated* and *untreated* groups can be attributed to the treatment itself, helping establish cause-and-effect relationships.

Application: Li-ion Battery Status-of-Health Estimation

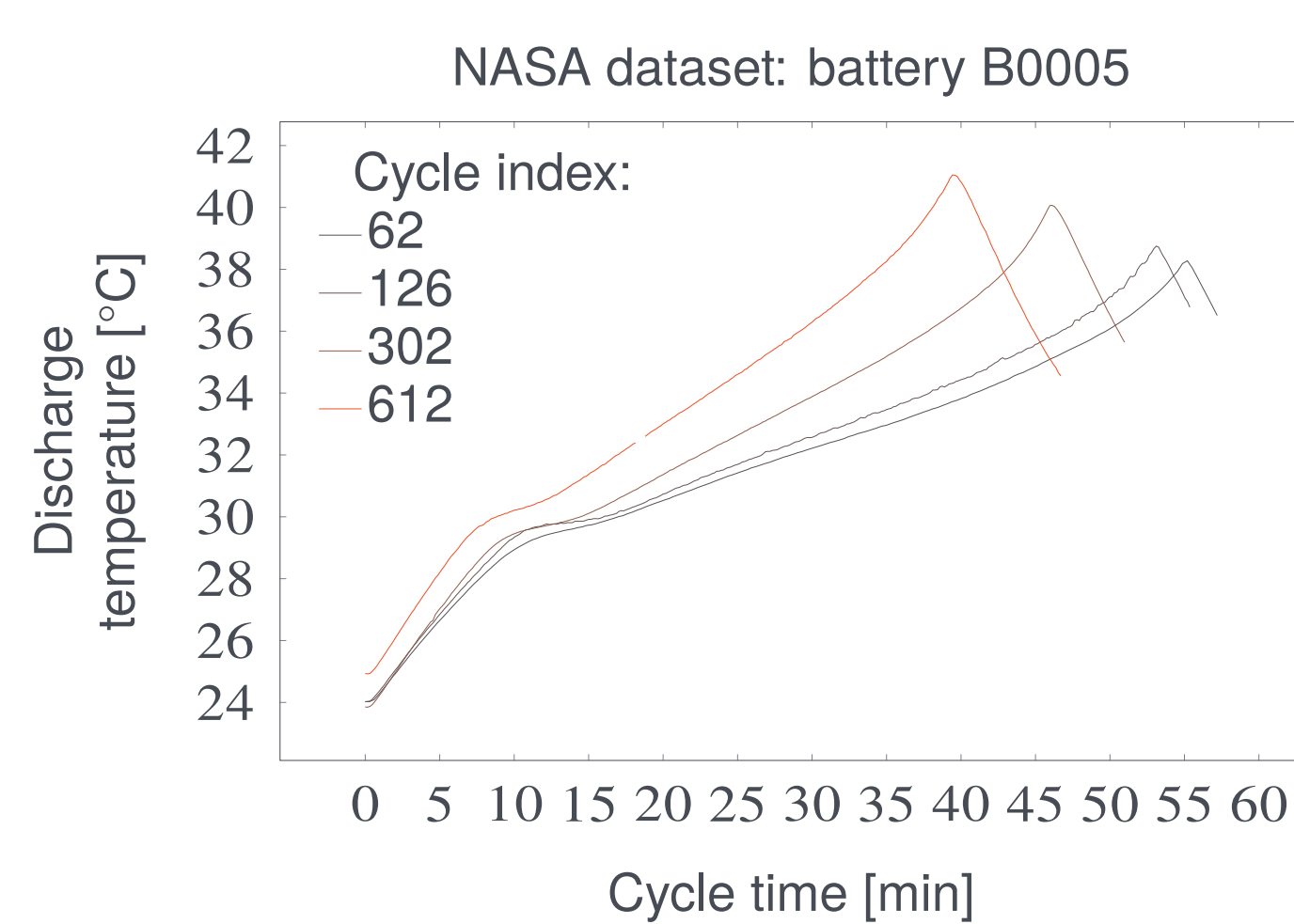


Fig. 4: A salient effect of the process of *ageing in batteries* is an increase in their temperature.

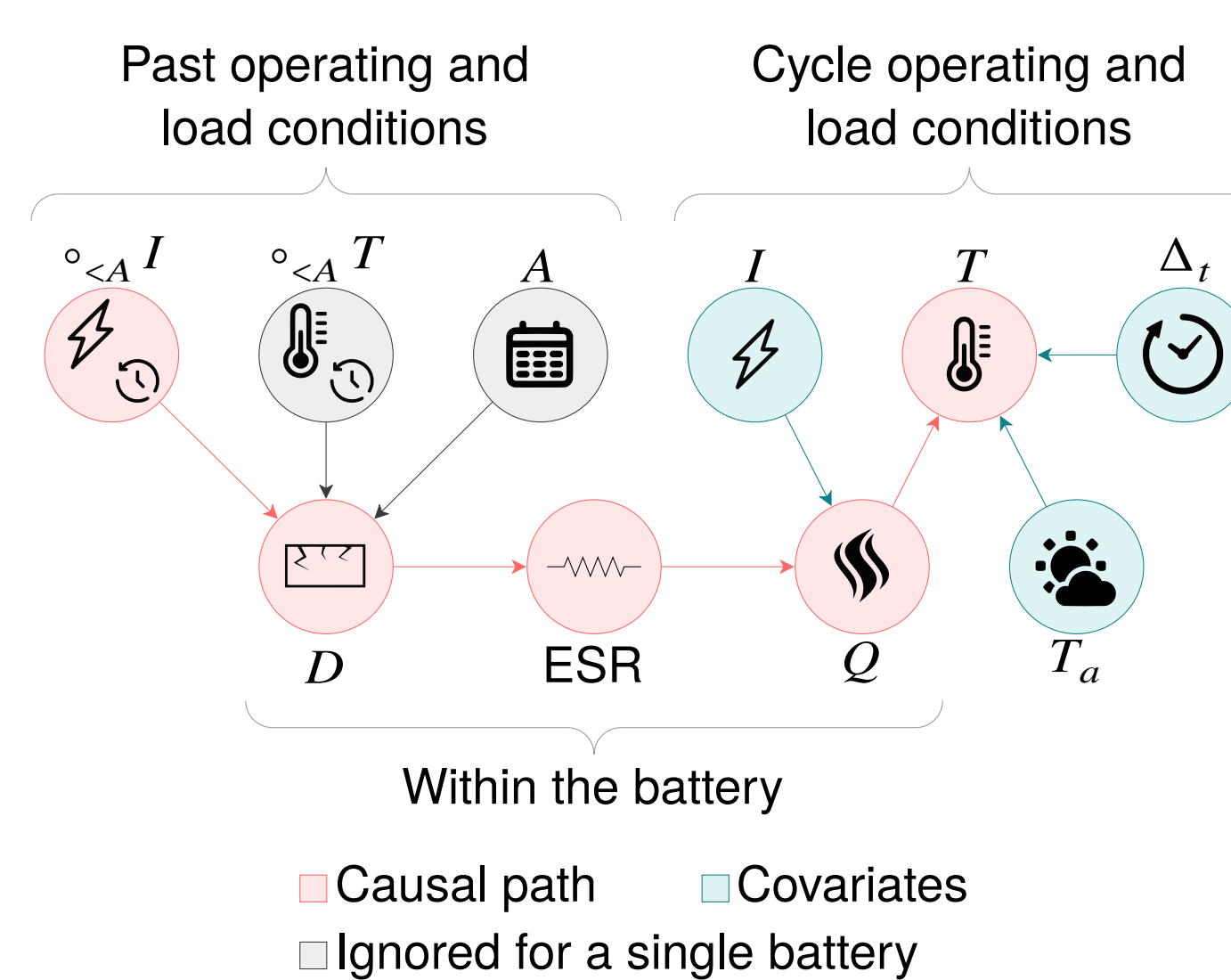


Fig. 5: A Directed Acyclic Graph (DAG) helps to reason about and visually represent the causal relationship between variables.

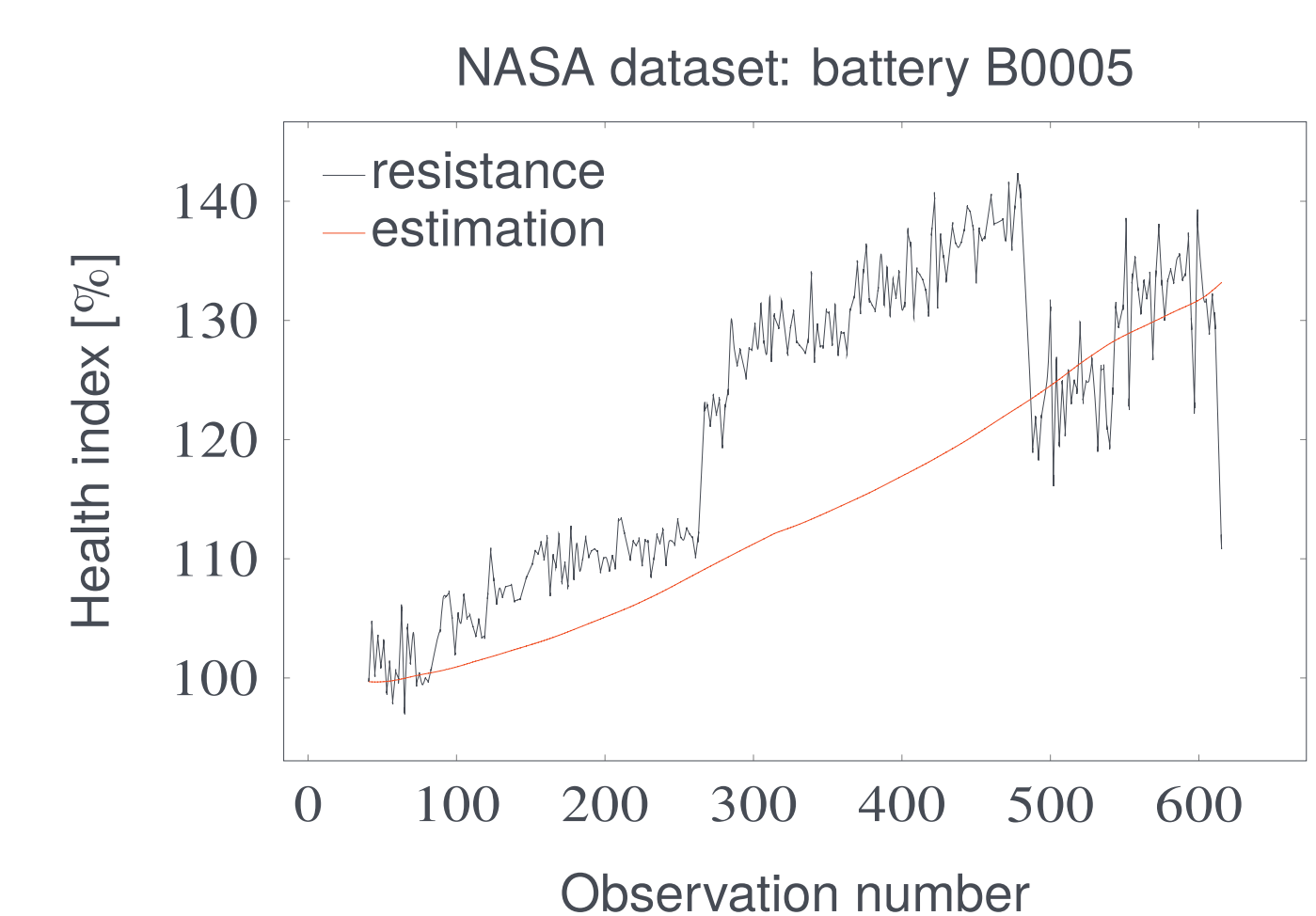


Fig. 6: Temperature variation are linked, through average currents, to the equivalent series resistance, whose variations are identified over time.

What's next

Methodology: Scientific Machine Learning and Continual Learning

Deploy ML only for those aspects of a dynamical systems that are unknown or too complex to be explicitly modelled. *Deterioration is regarded as a state of the system*, and neural networks are employed to model the cause of its variations.

Application: Status-of-Health Prognostics and Embedded Real-Time

The method is implemented to address *critical embedded applications* that operate under resource constraints. It is essential to balance the need for high performance with effective capabilities and efficiency requirements.

Opportunities for Collaborations

My method, your application I have tools to analyze data; you bring the real-world questions.

Your method, my application You have great ideas? I have data to test them.

My research, your resources I have the expertise, but need access to computing power or labs to move forward.

Connect



PhD
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