SISSA
Scuola Internazionale Superiore di Studi Avanzati

PRESS RELEASE

Navigating the grey area of causality

A new statistical analysis method developed at SISSA allows detecting cause-and-effect relationships in ambiguous situations.

Trieste, May 18, 2024

Detecting cause-and-effect relationships is a crucial problem for all sciences; however, especially when dealing with complex systems that cannot be directly manipulated, such as climate, finance, or social sciences, it is very challenging to distinguish between the absence of causality and very weak effects. Correlation is not causation: the fact that two quantities vary similarly in time does not necessarily mean that a causal relationship between them exists.

A new study from SISSA, resulting from a collaboration between physicists Vittorio del Tatto and Alessandro Laio and neuroscientists Gianfranco Fortunato and Domenica Bueti, published in the prestigious journal PNAS, has developed a new statistical analysis method to distinguish the absence of cause from causes that generate very small effects.

The new statistical measure, called "Informational Imbalance," drastically reduces the number of false positives, namely causal relationships between variables that actually do not exist.

SISSA

Scuola Internazionale Superiore di Studi Avanzati

The method was tested on data obtained through electroencephalography (EEG), a technique that measures the electrical activity of different brain areas. The EEG was recorded while a group of healthy volunteers was asked to judge the duration of visual stimuli. This test showed that the *informational imbalance,* by avoiding false positives, can correctly identify when and in which direction the information flow about the duration of the stimuli travels from the occipital/visual part of the brain to more frontal areas where the duration information can be used for decision making. "The same method, applied in ad-hoc experiments, could be used in neuroscience to improve our understanding of the flow of information between different brain regions," explains Domenica Bueti,professor of Cognitive Neuroscience at SISSA.

"Many methods for finding cause-and-effect relationships require making assumptions about the equations that describe the system," explains Alessandro Laio, professor of Statistical and Biological Physics at SISSA and co-author of the article. "These assumptions may be unjustified. Our method, however, does not require such assumptions: it does not assume any specific form of system evolution over time but distinguishes only between correlations and cause."

The approach can be applied to all complex systems with variables that evolve over time. "We are already trying to use this method to study causality in gene expression networks in cells and in meteorological and climatic data. The potential fields of application are vast," concludes Laio.

Useful links
Paper:
PNAS

Photo credits:
mindandi via freepik

SISSA
Scuola Internazionale
Superiore di Studi Avanzati
Via Bonomea 265, Trieste
W www.sissa.it

Facebook, Twitter, Instagram
@SISSAschool

CONTATTI
Alessandro Tavecchio
M atavecch@sissa.it
T +39 040 3787513

Francesca de Ruvo
M fderuvo@sissa.it
T +39 040 3787231