New framework embraces uncertainty to make sense of history

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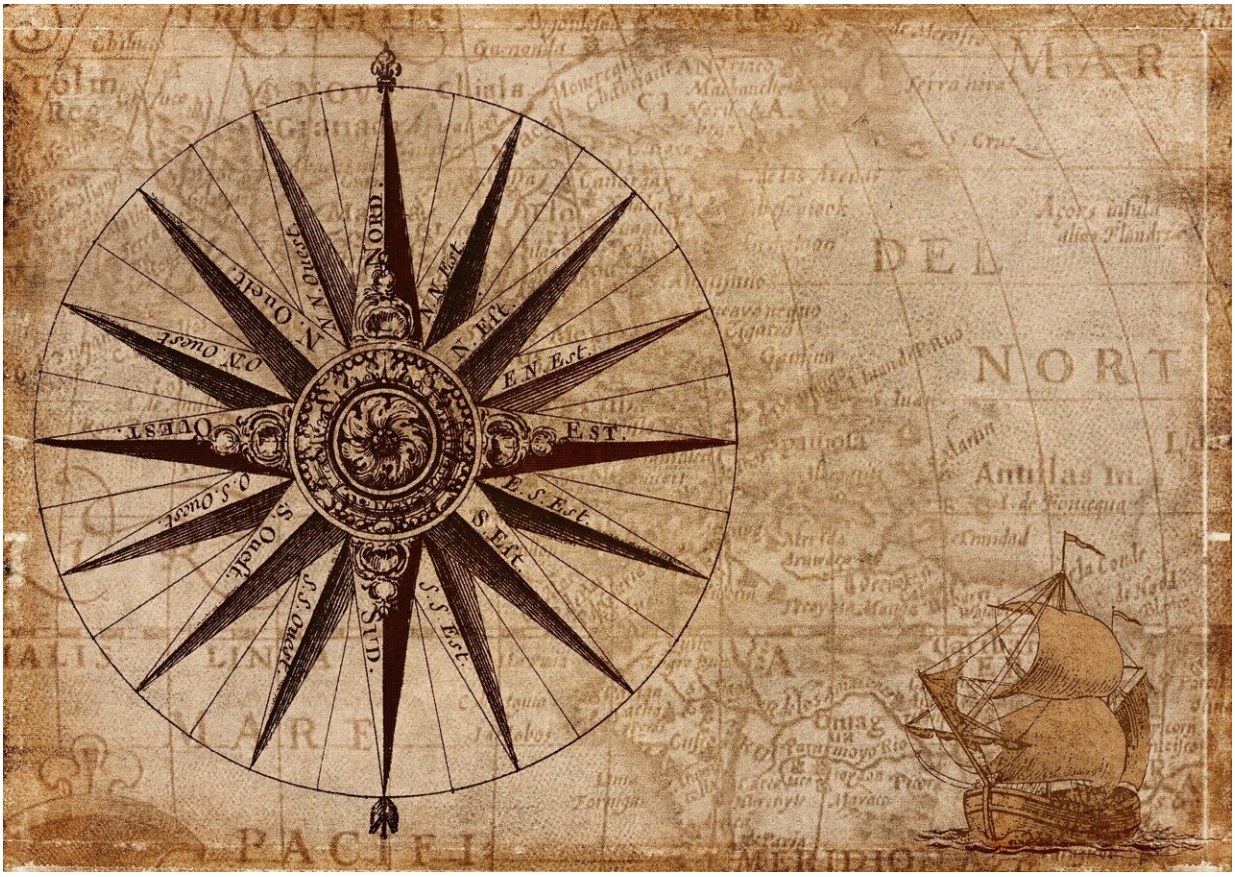

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There are many things we don't know about how history unfolds. The process might be impersonal, even inevitable, as some social scientists

have suggested; human societies might be doomed to decline. Or, individual actions and environmental conditions might influence our communities' trajectories. Social scientists have struggled to find a consensus on such fundamental issues.

A new framework by SFI faculty and others suggests a way to unify these perspectives. In a new paper in the *Journal of Computer Applications in Archaeology*, multidisciplinary researchers describe how using stochastic processes to analyze historical datasets could reveal surprising patterns that have gone unnoticed in previous models.

A stochastic model, which incorporates uncertainty and randomness, would treat historical shifts not as deterministic but instead as probabilistic. Stochastic models have previously been used to study systems in a range of fields, from biology to physics to information theory, but have remained under-explored in the study of history and archaeology.

Taking this approach to studying historical data doesn't only potentially unite previous ideas; it may also yield new ideas about how historical systems change over time. "Adopting a stochastic process also forces us to be precise and explicit in our thinking about the dynamics underlying any particular historical data set," says physicist and SFI Professor David Wolpert, senior author on the study.

Stochastic processes let the data speak for itself and can remove potential interpretive biases, says SFI External Professor and co-author Stefani Crabtree (Utah State University), who in her work uses diverse methodologies to model systems in social sciences and ecology.

Where previous approaches begin with a preconceived idea and then find data to support it, a stochastic framework instead can "allow the data itself to identify how human social groups evolve, possibly possible

unanticipated revelations," she says. "It could lead to the detection of sometimes surprising patterns that would be missed in more traditional analyses."

The diverse forces that shape the evolution of history are complex, notes biologist and SFI External Professor Manfred Laubichler (Arizona State University), another co-author on the paper. Laubichler's work focuses on evolution in its many guises, from genes to knowledge systems. Instead of treating historical evolution as a deterministic process, he says the new framework allows for probabilities of different events to evolve.

Using randomness, the new approach suggests a structured way to identify the causes of historical shifts. Those might be individuals in society who take dramatic actions that change the course of history, or they might be natural forces external to society, like volcanoes or climate change, that nonetheless are critical forcing factors. The proposed model also provides a new way to compare cases from different points in history.

The researchers say their framework could be used to find patterns in archaeological data. (Or, in cases where data is missing from the historical record, it might be used in tandem with machine learning systems.) It might also help elucidate drivers of the Great Acceleration—the exponential growth, ongoing since the beginning of the 1950s, in many areas of earth and social systems. It could help differentiate random occurrences from truly transformative events, says Wolpert.

He notes that the new framework isn't an end-all solution; rather, by grounding investigations of social dynamics in stochastic models, the researchers hope to unearth new, data-driven tools for finding patterns in historical records.

"Not only does this perspective allow us to unify the analyses of computational history," Wolpert says, "it also allows us to align how we investigate human history with how it is done in the other historical sciences."

More information: David H. Wolpert et al, The Past as a Stochastic Process, *Journal of Computer Applications in Archaeology* (2024). DOI: 10.5334/jcaa.113

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