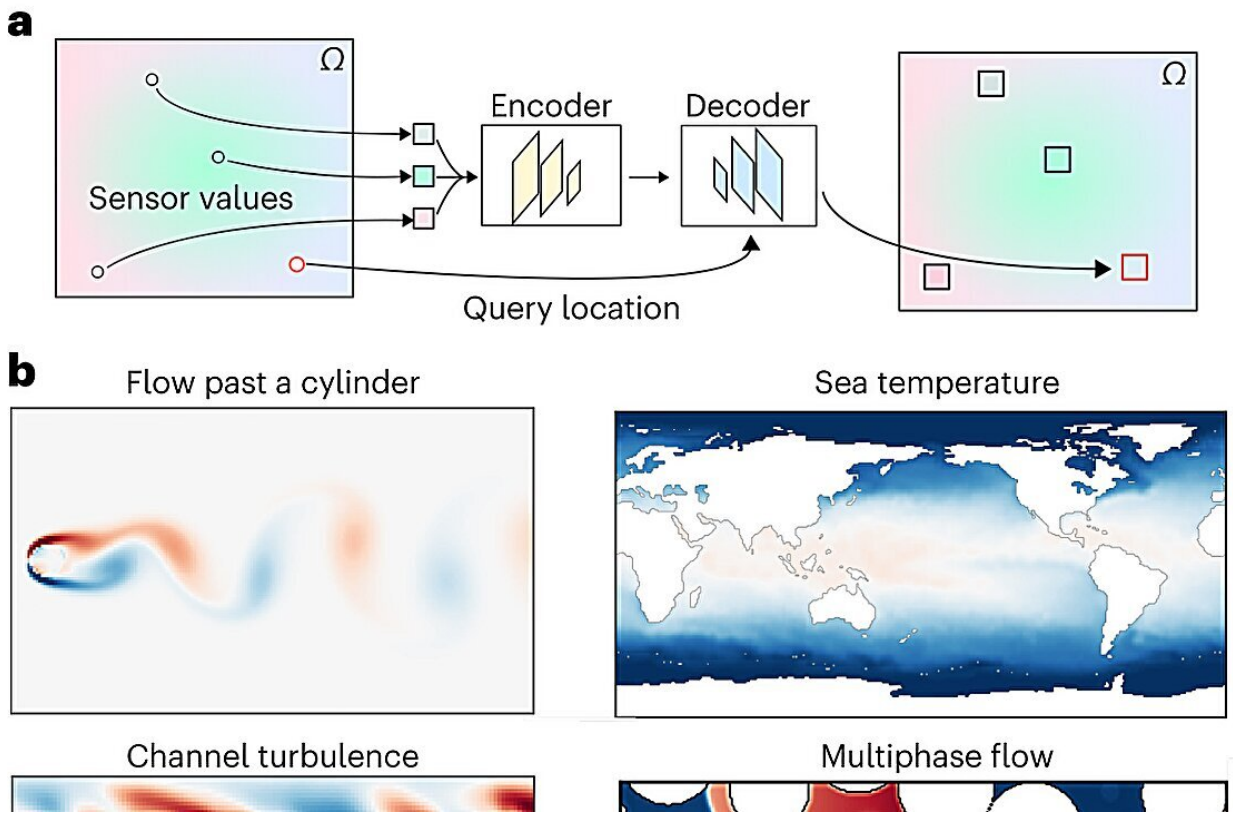
Novel approach using natural-language models opens AI applications for edge computing

November 13 2023



Overview of sparse reconstruction using the Senseiver model. a, The workflow of the Senseiver innovations for the sparse-sensing problem. We use sensor values and precise query locations that are sparse in the field domain and allow greater computational efficiency. The sensor values are processed by an encoder, and the resulting latent representation is passed along with the query information to a decoder, which estimates the field at a new location. In this example, the

output is decoded into a structured grid. b, Overview of applications in this work. Credit: *Nature Machine Intelligence* (2023). DOI: 10.1038/s42256-023-00746-x

An innovative approach to artificial intelligence (AI) enables reconstructing a broad field of data, such as overall ocean temperature, from a small number of field-deployable sensors using low-powered "edge" computing, with broad applications across industry, science and medicine.

"We developed a neural network that allows us to represent a large system in a very compact way," said Javier Santos, a Los Alamos National Laboratory researcher who applies computational science to geophysical problems.

"That compactness means it requires fewer computing resources compared to state-of-the-art convolutional neural network architectures, making it well-suited to field deployment on drones, sensor arrays and other edge-computing applications that put computation closer to its end use."

Novel AI approach boosts computing efficiency

Santos is first author of a paper published by a team of Los Alamos researchers in *Nature Machine Intelligence* on the novel AI technique, which they dubbed Senseiver. The work, which builds on an AI model called Perceiver IO developed by Google, applies the techniques of natural-language models such as ChatGPT to the problem of reconstructing information about a broad area—such as the ocean—from relatively few measurements.

The team realized the model would have broad application because of its

efficiency. "Using fewer parameters and less memory requires fewer central processing unit cycles on the computer, so it runs faster on smaller computers," said Dan O'Malley, a co-author of the paper and Los Alamos researcher who applies machine learning to geoscience problems.

In a first in the published literature, Santos and his Los Alamos colleagues validated the model by demonstrating its effectiveness on real-world sets of sparse data—meaning information taken from sensors that cover only a tiny portion of the field of interest—and on complex three-dimensional-fluids datasets.

In a demonstration of the real-world utility of the Senseiver, the team applied the model to a National Oceanic and Atmospheric Administration sea-surface-temperature dataset. The model was able to integrate a multitude of measurements taken over decades from satellites and sensors on ships. From these sparse point measurements, the model forecast temperatures across the entire body of the ocean, which provides information useful to global climate models.

Bringing AI to drones and sensor networks

The Senseiver is well-suited to a variety of projects and research areas of interest to Los Alamos.

"Los Alamos has a wide range of remote sensing capabilities, but it's not easy to use AI because models are too big and don't fit on devices in the field, which leads us to edge computing," said Hari Viswanathan, Los Alamos Laboratory Fellow, environmental scientist and co-author of the paper about the Senseiver. "Our work brings the benefits of AI to drones, networks of field-based sensors and other applications currently beyond the reach of cutting-edge AI technology."

The AI model will be particularly useful in the Lab's work identifying and characterizing orphaned wells. The Lab leads the Consortium Advancing Technology for Assessment of Lost Oil & Gas Wells (CATALOG), a federal program tasked with locating and characterizing undocumented orphaned wells and measuring their methane emissions. Viswanathan is the lead scientist of CATALOG.

The approach offers improved capabilities for large, practical applications such as self-driving cars, remote modeling of assets in oil and gas, medical monitoring of patients, cloud gaming, content delivery and contaminant tracing.

More information: Javier E. Santos et al, Development of the Senseiver for efficient field reconstruction from sparse observations, *Nature Machine Intelligence* (2023). DOI: 10.1038/s42256-023-00746-x

Provided by Los Alamos National Laboratory

Citation: Novel approach using natural-language models opens AI applications for edge computing (2023, November 13) retrieved 12 May 2024 from https://techxplore.com/news/2023-11-approach-natural-language-ai-applications-edge.html

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