UCSD researchers design method of using chaos for communication

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UCSD RESEARCHERS DESIGN METHOD OF USING CHAOS FOR COMMUNICATION

Engineers have long tried to rid their designs of any disorderly or chaotic signals in favor of regular, simple motions on which to build computers and communication systems. This traditional approach may soon be challenged by a newly-discovered capability to communicate using chaotic signals from one laser to another.

Working under a National Science Foundation grant, a team from the University of California, San Diego, the Georgia Institute of Technology and Cornell University has demonstrated that it is possible to use an irregularly pulsing laser the same way you use a radio.

UCSD physicist Henry Abarbanel and post-doctoral researcher Matthew Kennel will publish the design concept, called Stable Nonlinear Transmitter/Receiver. (SANT), in an upcoming issue of Physical Review Letters. The Georgia Tech members of the team, including Rajarshi Roy and Gregory Van Wiggeren, published results of a working demonstration of the SANT concept in the Feb. 20 issue of the journal Science.

Conventional radio modulation schemes include AM, or amplitude modulation, and FM, or frequency modulation, which use amplitude and frequency as "carriers" of information. In the new scheme, a nonlinear chaotic "courier" is the medium of transmission.

Yet despite the difference in transmission mode, the process is the same for the new chaotic concept: a chaotic signal is modulated at the transmitter; the signal is sent down a medium (in this case, off-the-shelf optical fiber); and, at the receiving end, the message is demodulated from the chaotic signal.

"What we've done is learned how to attach a message, it could be one voice, it could be hundreds of people's voices to a carrier that is very irregular," said Abarbanel, director of UCSD's Institute for Nonlinear Science. "The method offers a way to utilize the enormous bandwidth available in optical communication systems."

Using the equations of motion for lasers built from a commercial light amplifier, the UCSD team designed a way to modulate a message, send it through standard fiber optics and demodulate the message at a specially-designed receiver. They found that their method worked even if conditions weren't perfect, such as when the match of the transmitter and receiver was slightly off.

Other researchers have used chaos to mask information in electronic and hybrid optoelectronic systems, but the Georgia Tech team's work reported in Science is the first to use chaos to carry messages in an all-optical system. Their October 1997 demonstration was successfully conducted at 10 million bits of data per second and subsequently has been raised to 150 million bits per second.

Conceptually, the same ideas will be applied during an ambitious UCSD-led project to demonstrate chaos in wireless communications. The group was awarded up to $4.5 million through the Army Research Office and MURI (Multidisciplinary University Research Initiative). Abarbanel will be part of that team.

Using nonlinear signals for communications has become a topic of interest in recent years with earlier demonstrations by a UCSD group that included Nikolai Rulkov and Lev Tsirnring. Abarbanel, Tsimring, Rulkov, Mikhail Rabinovich and A. R. Volkovskii five years ago opened the door to chaos as an information courier by suggesting the concept in a low-frequency electrical context.

The new research also builds on the work of Steven Strogatz, an applied mathematician in Cornell's Department of Theoretical and Applied Mechanics; and Roy, a physics professor at Georgia Tech.

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