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Deep Learning to Quantify Chaos in a Dynamical System

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SUMMARY

Lyapunov Exponents are a classical technique used to quantify chaos, and therefore, to study the behaviour of a dynamical system. Standard algorithms only allow to approximate the full Lyapunov Exponents spectrum if all the variables of the system are available (cf. [1]). Recently, it has been shown that Deep Learning techniques perform very well in chaotic analysis (cf. [2]). In this communication, we use Deep Learning to approximate the whole Lyapunov Exponents spectrum from just single-variable time series (cf. [3]). This strategy allows to quantify chaos using partial data from a dynamical system, while speeding up this dynamical analysis respect to standard techniques.

Keywords: dynamical systems, Deep Learning, Lyapunov Exponents

AMS Classification: 37Mxx, 68T07

References

[1] A. Wolf, J. B. Swift, H. L. Swinney and J. A. Vastano. Determining Lyapunov Exponents from a Time Series. *Physica D* **16**(3), 285–317, 1985.

[2] R. Barrio, Á. Lozano, A. Mayora-Cebollero, C. Mayora-Cebollero, A. Miguel, A. Ortega, S. Serrano and R. Vigara. Deep Learning for Chaos Detection. *Chaos* **33**(7), 2023.

[3] C. Mayora-Cebollero, A. Mayora-Cebollero, Á. Lozano and R. Barrio. Full Lyapunov Exponents Spectrum with Deep Learning from Single-Variable Time Series. *Preprint*, 2024.

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