Attractors and Complexity on Pattern Iterations of Flat-Topped Tent Maps

Luís Silva[1,2]

[1] *Center for Research in Mathematics and Applications (CIMA), University of Évora, Portugal*
[2] *Department of Mathematics of ISEL, Lisbon Polytechnic Institute, Portugal*

Corresponding/Presenting author: luis.silva@isel.pt

Talk Abstract

In [1], it was introduced a method of chaos control designated as "control with simple limiters". The general idea of the procedure is to add an external load to the system, which limits the phase space in such a way that the orbits in the forbidden area are eliminated. Since its proposal, control with simple limiters has been widely used in the control of chaos in areas as diverse as cardiac dynamics, [2], telecommunications or electric converters,[8], population dynamics, [4], or market dynamics [3]. In the one-dimensional case, this procedure leads to the introduction of one (or more) flat segment(s) in the one-dimensional map, with the value(s) of the map on the constant thread(s) corresponding to the limiter(s). Very often, we find modeling situations wherein evolutionary equations have to depend explicitly on time, through time-dependent parameters. This is the case, for example, when we want to model populations with time-dependent forcing or to mimic some control or regulation strategies. In this presentation, based in [5], [6] and [7], we will consider the introduction of simple limiters u in the tent map, in the moments where a binary sequence s (the iteration pattern) is 0. We call to these non-autonomous dynamical systems, *pattern iterations of flat-topped tent maps*. We will define local and Milnor attractors in this non-autonomous context and study the dependence of their existence and coexistence on the value of the limiter u and on the pattern s. Using symbolic dynamics, we will be able to characterize the families of pairs (u, s) for which these attractors exist and coexist, as well as fully describe them. We will observe that this non-autonomous context provides a richness of behaviors that are not possible in the autonomous case. Finally we will discuss dynamical complexity in pattern iterations.

Keywords: non-autonomous dynamical systems, interval maps, attractors, symbolic dynamics, bifurcation diagrams.

Acknowledgements

This research was supported by national funds through the Fundação para a Ciência e Tecnologia, FCT, under the project UIDB/04674/2020 (https://doi-.org/10.54499/UIDB/04674/2020), CIMA and ISEL.

References

[1] N.J. Corron, S.D. Pethel, and B.A. Hopper, *Controlling Chaos with Simple Limiters*, Phys. Rev. Lett, **84(17)** (2000), 3835–3838.

[2] L. Glass and W. Zeng, *Bifurcations in flat-topped maps and the control of cardiac chaos*, International Journal of Bifurcation and Chaos, **Vol. 4** (1994), 1061–1067.

[3] X.-Z. He and F. H. Westerhoff, *Commodity markets, price limiters and speculative price dynamics*, J. Econ. Dyn. Control, **29** (2005), 1577–1596.

[4] F. M. Hilker and F. H. Westeroff, *Paradox of simple limiter control*, Phys. Rev. E, **73** (2006), 052901.

[5] L. Silva, *Periodic attractors of non-autonomous flat-topped tent systems*, Discrete and Continuous Dynamical Systems - B, **Vol. 24** (2018), 1867–1874.

[6] L. Silva, *Attractors in pattern iterations of flat top tent maps*, Mathematics 2023, 11(12), 2677.

[7] L. Silva ant T. M. Silva, *Period incrementing on pattern iterations of flat top tent maps*, to appear in Topological Methods in Nonlinear Analysis.

[8] R. Stoop and C. Wagner, *Renormalization Approach to Optimal Limiter Control in 1-D Chaotic Systems*, Journal of Statistical Physics, **Vol. 106** (2002), 97–106.