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Studies on chaos and hyperchaos in four-dimensional Sprott systems

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Dynamical analysis of chaotic and hyperchaotic attractors have been carried out on generated four-dimensional (4D) Sprott sytems in the present work. J.C. Sprott [1] published a catalogue of nineteen (19) simple three-dimensional (3D) chaotic systems where it was demonstrated that there could be extremely simple three-dimensional chaotic systems compared with the work of Lorenz [2] and Rossler [3] in terms of algebraic representation rather than referring to the physical processes being modeled.
Practically, 4D or higher modes are better models for dynamical systems (dimensions is the number of variables considered in the model) [4]. Rossler [5] proposed the first (4D) hyperchaotic attractor, since then a number of hyperchaotic attractors and techniques for their generation have been reported from a hitherto (3D) chaotic system numerically and experimentally such as the addition of a linear simple-state-feedback controller [6] and in an open-loop manner by sinusoidal parameter perturbations [7, 8]. Generation of hyperchaotic dynamics has relied on mixing bifurcation analysis and computer simulations since there is no unified method for the construction of chaotic and hyperchaotic systems [9].
Lyapunov exponents algorithm was used in the present work to derive 4D algebraically simple chaotic and hyperchaotic Sprott systems from the 3D algebraically simple systems. These set of seventeen (17) (out of the nineteen proposed by Sprott) 4D dissipative systems display simple chaotic and hyperchaotic dynamics with parameter perturbations in the systems. Dynamical analysis was carried out using Lyapunov exponents, bifurcation diagrams, Poincare maps and phase portraits to authenticate the existence of these attractors which have potential applications in secure communications, neural networks, complex biological systems and laser physics.

References

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