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Fractional-Order 5D Hyperchaotic System: Stability and Modified Projective Synchronization

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Abstract: This paper introduces a novel five-dimensional fractional-order hyperchaotic system derived as a modification of the Lorenz model. The proposed system exhibits richer dynamics than its integer-order counterpart, including multiple coexisting attractors and complex bifurcation structures. The stability conditions of equilibrium points are derived using an extended fractional Routh–Hurwitz criterion, and Lyapunov exponent analysis confirms the existence of hyperchaotic behavior across a broad parameter range. To further explore its practical relevance, a Modified Projective Synchronization (MPS) strategy is applied to both identical and non-identical systems. Numerical simulations validate the theoretical analysis and highlight the potential of the proposed system for secure communication applications.

Keywords: *stability, 5D fractional-order system, Routh–Hurwitz criteria, modified projective synchronization.*

Mathematics Subject Classification (2020): 34A08, 34D06, 37D45, 70K05, 93C41, 93D05.

1 Introduction

Fractional calculus, whose origins go back more than three centuries, has gained much attention in recent studies because it can model complicated physical, chemical, and engineering systems with greater precision [7]. Fractional-order methods differ from conventional integer-order approaches in that they embrace memory and hereditary properties, enabling them to describe real-world phenomena more accurately. There have

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