

ICRAMCS 2026

THE EIGHTH EDITION OF THE INTERNATIONAL CONFERENCE ON
RESEARCH IN APPLIED MATHEMATICS AND COMPUTER SCIENCE

April 23-24-25, 2026 | Marrakech, Morocco



Controllability Criteria for Delayed Fractional Systems via Mittag–Leffler Functions

Communication Info

Authors:

Youssef AFDIFID¹
Ali EL MFADEL¹
M'hamed ELOMARI¹

¹ Laboratory of Applied
Mathematics and Scientific
Computing, Sultan Moulay
Slimane University, Beni
Mellal, Morocco

Keywords:

- (1) Controllability;
- (2) Nonlinear fractional systems;
- (3) φ -Mittag–Leffler functions.
- (4) Delayed fractional Gramian matrix;
- (5) Schauder's fixed point theorem;

Abstract

The controllability of nonlinear fractional control systems with state delays is investigated via the Caputo fractional derivative with respect to a strictly increasing function φ . This generalized operator, introduced in [1] and developed in [2], allows the modeling of memory-dependent dynamics on non-uniform time scales. Using the analytical properties of the associated φ -Mittag–Leffler functions and their delayed forms, whose stability has been studied in [3], an integral representation of mild solutions is established.

The linear delayed system is characterized through a delayed fractional controllability Gramian in the φ -Caputo framework, extending classical delay results [4] to the fractional setting. Sufficient conditions for the controllability of the nonlinear system are then derived via Schauder's fixed point theorem, following approaches used for nonlinear fractional delay systems [5]. Numerical examples illustrate the applicability of the results.

© ICRAMCS 2026 Proceedings ISSN: 2605-7700

References

- [1] R. Almeida, *A Caputo fractional derivative of a function with respect to another function*, Communications in Nonlinear Science and Numerical Simulation, 44 (2017), 460–481.
- [2] J. Vanterler da C. Sousa, E. Capelas de Oliveira, *On the φ -Caputo Fractional Derivative and Applications to Memory-Dependent Delay Systems*, Chaos, Solitons & Fractals, 135 (2020), 109780.
- [3] M. Li, J. Wang, *Exploring delayed Mittag–Leffler type matrix functions to study finite-time stability of fractional delay differential equations*, Applied Mathematics and Computation, 324 (2018), 254–265.
- [4] J. P. Dauer, *Controllability of Nonlinear Systems with Time Delay*, Journal of Mathematical Analysis and Applications, 56 (1976), 597–614.
- [5] M. Nawaz, W. Jiang, J. Sheng, *The controllability of nonlinear fractional differential system with pure delay*, Advances in Difference Equations, 2020:183 (2020).