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Mittag-Leffler stability analysis of multiple equilibrium points in impulsive fractional-order quaternion-valued neural networks

Key words: Mittag-Leffler stability; Fractional-order; Quaternion-valued neural networks; Impulse

Corresponding author: Jin-de CAO
E-mail: jdcao@seu.edu.cn
ORCID: https://orcid.org/0000-0003-3133-7119

Motivation

- The fractional-order derivatives inherently have an excellent memory and hereditary properties in representing the network model. As is well known, there are many advantages to the integer-order NNs and the corresponding fractional-order NNs.
- The main difference is that the fractional-order systems are more accurate than integer-order systems; i.e., there are more degrees of freedom in the fractional-order systems.
- Combining the memory and hereditary properties of fractional-order systems and the impulsive effect, the resulting impulsive fractional-order QVNNs guarantee better outcomes when compared with usual integer-order NNs.

Main idea

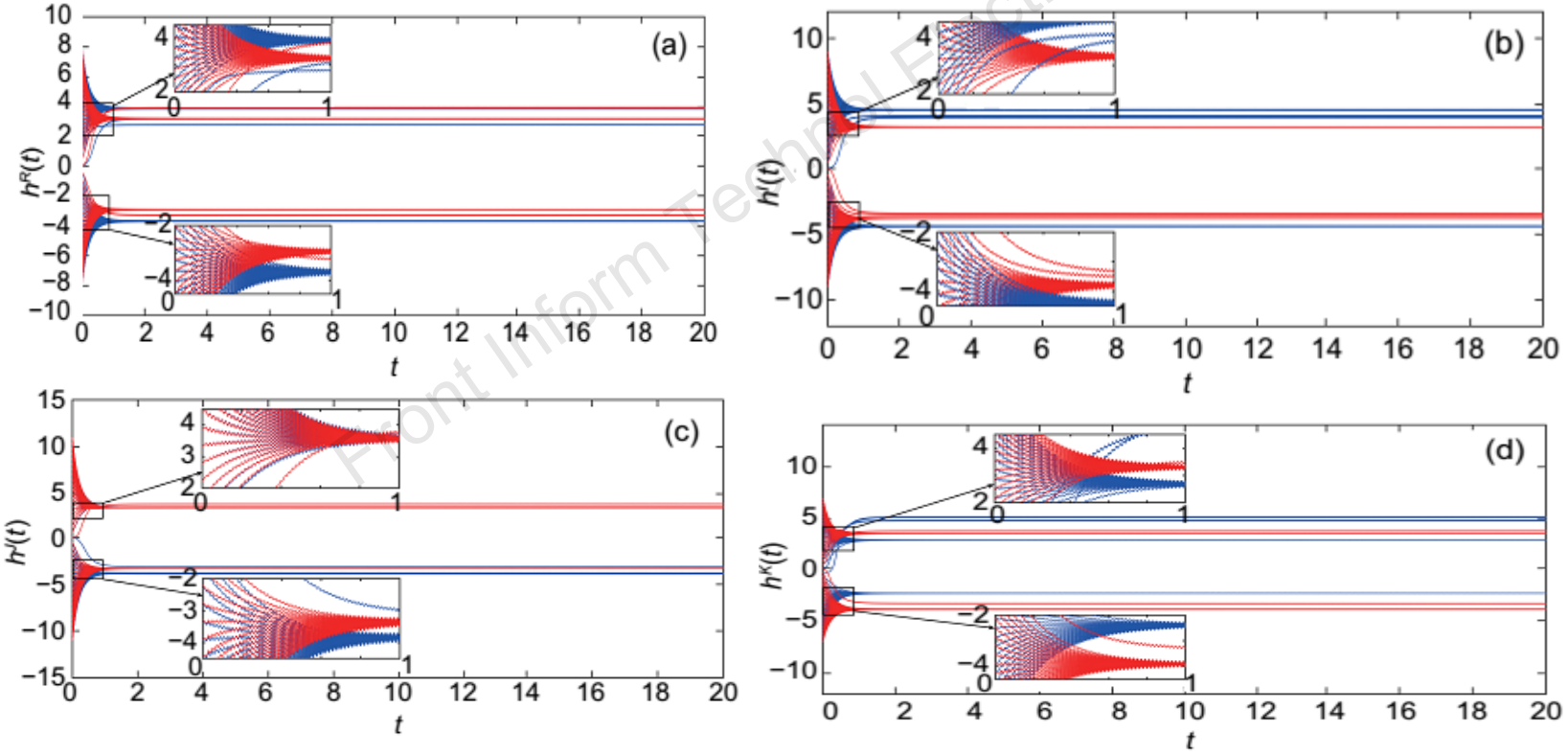
- First, *n*-dimensional QVNNs are converted into a 4*n*-dimensional RVNN system using the decomposition and non-commutative properties of quaternions.
- Then, sufficient conditions for Mittage-Leffler stability are discussed for fractional-order nonlinear systems.

Method

1. We investigate the problem of multiple Mittag-Leffler stability analysis for fractional-order quaternion-valued neural networks (QVNNs) with impulses.
2. The *n*-dimensional QVNNs are converted into a 4*n*-dimensional RVNN system using the decomposition and non-commutative properties of quaternions.
3. Using the geometrical properties of activation functions and the Lipschitz condition, the existence of the equilibrium points is analyzed.

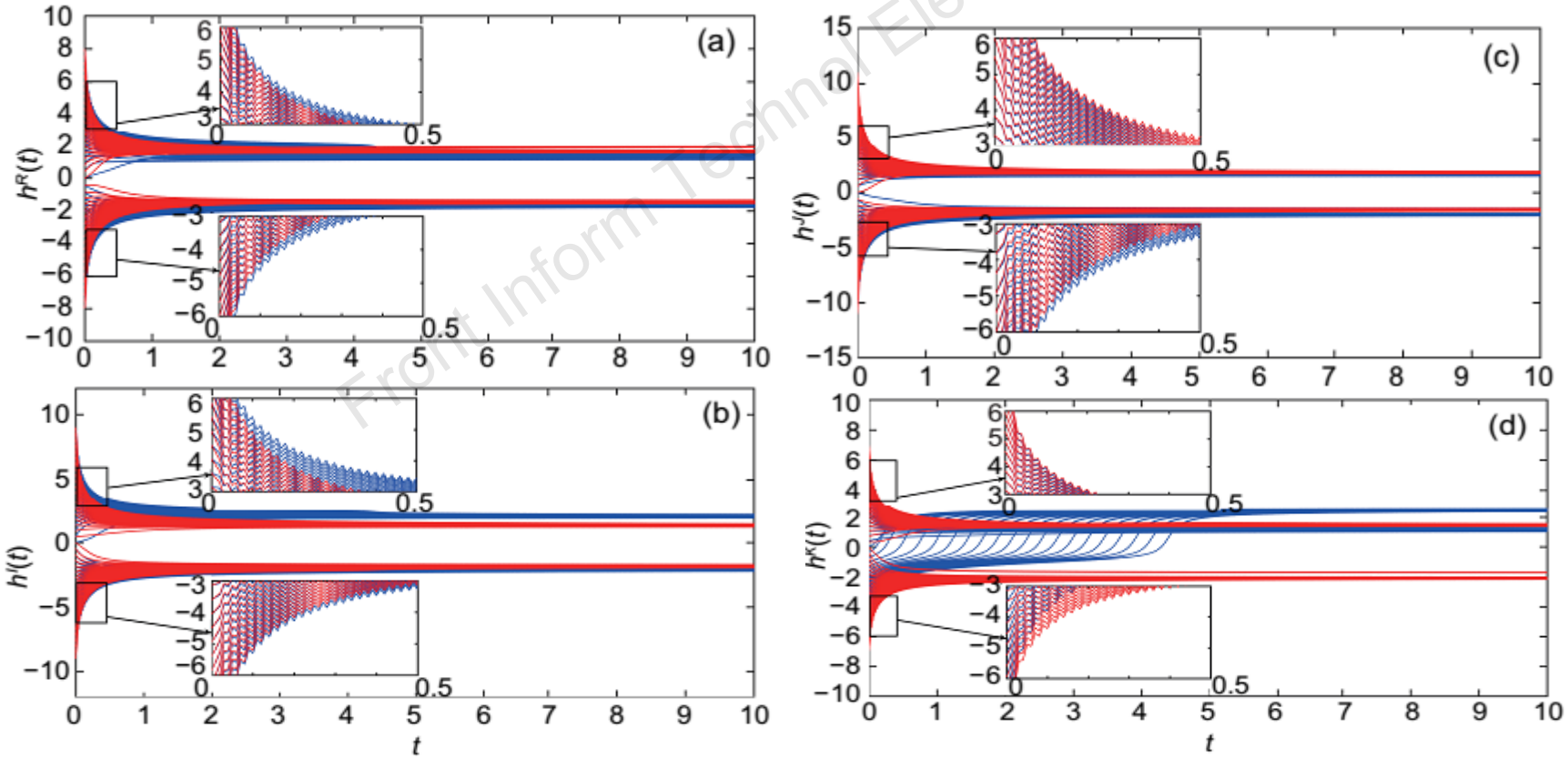
Major results

- The number of equilibrium points of QVNNs is higher than that of CVNNs.



Major results (Cont'd)

- The global Mittag-Leffler stability of multiple equilibrium points for the impulsive fractional-order QVNNs is investigated by employing the Lyapunov direct method.



Conclusions

- The Mittag-Leffler stability analysis of multiple equilibrium points for fractional-order QVNNs with an impulse term was investigated. By employing the non-commutative property of quaternion multiplication, QVNNs were converted into four RVNNs.
- According to the definition of the activation functions, the existence of equilibrium points was analyzed.
- Sufficient conditions were derived to assure the Mittag-Leffler stability of multiple equilibrium points for QVNNs. Numerical simulation results validated our theoretical solutions.