



Introduction

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One contribution of 14 to a Theme Issue
Fractional calculus and its applications.

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Fractional calculus and its applications

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Fractional calculus was formulated in 1695, shortly after the development of classical calculus. The earliest systematic studies were attributed to Liouville, Riemann, Leibniz, etc. [1, 2]. For a long time, fractional calculus has been regarded as a pure mathematical realm without real applications. But, in recent decades, such a state of affairs has been changed. It has been found that fractional calculus can be useful and even powerful, and an outline of the simple history about fractional calculus, especially with applications, can be found in Machado *et al.* [3].

Now, *fractional calculus and its applications* is undergoing rapid developments with more and more convincing applications in the real world [4, 5]. This Theme Issue, including one review article and 12 research papers, can be regarded as a continuation of our first special issue of *European Physical Journal Special Topics* in 2011 [4], and our second special issue of *International Journal of Bifurcation and Chaos* in 2012 [5]. These selected papers were mostly reported in *The Fifth Symposium on Fractional Derivatives and Their Applications (FDTA'11)* that was held in Washington DC, USA in 2011.

The first paper presents an overview of chaos synchronization of coupled fractional differential systems. A list of coupling schemes are presented, including one-way coupling, Pecora–Carroll coupling, active–passive decomposition coupling, bidirectional coupling and other unidirectional coupling configurations. Meanwhile, several extended concepts of synchronizations are introduced, namely projective synchronization, hybrid projective synchronization, function projective synchronization, generalized synchronization and generalized projective synchronization. Corresponding to different

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