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Short communication

Implementation of fractional-order electromagnetic potential through a genetic algorithm

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ABSTRACT

Several phenomena present in electrical systems motivated the development of comprehensive models based on the theory of fractional calculus (FC). Bearing these ideas in mind, in this work are applied the FC concepts to define, and to evaluate, the electrical potential of fractional order, based in a genetic algorithm optimization scheme. The feasibility and the convergence of the proposed method are evaluated.

1. Introduction

A closer look upon several phenomena that occur in electrical systems [1] induced a new approach using the tools of fractional calculus (FC). In fact, several researchers [2,3] verified that well-known expressions for the electrical potential are related through integer-order differential relationships and proposed their generalization based on the concept of fractional-order poles. Nevertheless, the mathematical generalization towards FC lacks a comprehensive method for its practical implementation.

This article addresses the synthesis of fractional-order multipoles. In Section 2, we recall the classical expressions for the static electric potential and we analyze them in the perspective of FC. Based on this re-evaluation we develop a GA scheme for implementing fractional-order electrical potential approximations. Finally, in Section 3, we outline the main conclusions.

2. Integer and fractional electrical potential

For homogeneous, linear and isotropic media, the electrical potential φ at a point P produced by several charge configurations, such as, a single charge, a dipole, a quadrupole, an infinite straight filament, two opposite charged filaments,

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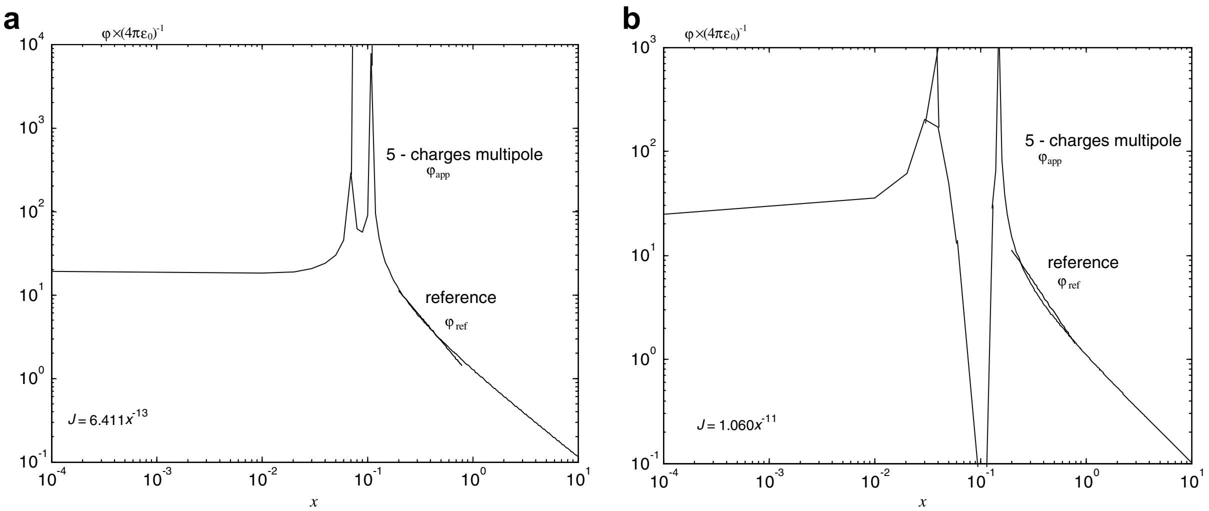

Fig. 1. Comparison of the electric potential φ_{app} and φ_{ref} versus the position x for $\varphi_{ref} = 1.0x^{-1.5}$ (V), $0.2 < x < 0.8$ [m], and a $n = 5$ charge approximation, in both cases.

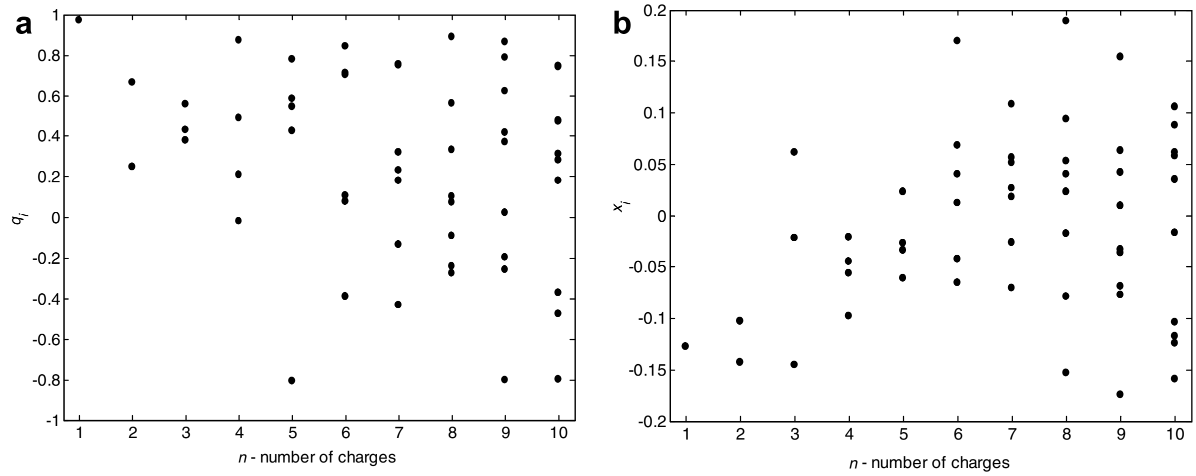

Fig. 2. Values of (a) charges q_i and the (b) corresponding positions x_i versus n, for a distribution of charges with $n = \{1, \ldots, 10\}$, $\varphi_{ref} = 1.0x^{-1.5}$ [V], $0.2 < x < 0.8$ [m], for the best case of $N_{GA} = 10$ executions.

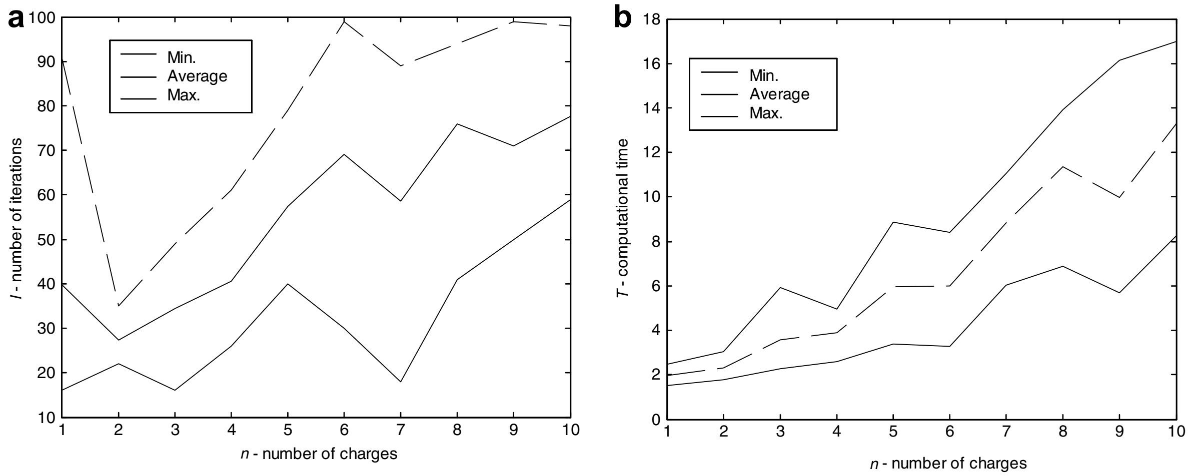

Fig. 3. Performance of the GA scheme versus the number charges $n = \{1, \ldots, 10\}$ for $\varphi_{ref} = 1.0x^{-1.5}$ [V], $0.2 < x < 0.8$ [m], (a) number of required iterations I, (b) computational time T, for $N_{GA} = 10$ executions.