A modified DIRECT algorithm for a problem in astrophysics

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Abstract

We present a modification of the DIRECT algorithm, called DIRECT-G, to solve a box-constrained global optimization problem arising in the detection of gravitational waves emitted by coalescing binary systems of compact objects. This is a hard problem since the objective function is highly nonlinear and expensive to evaluate, has a huge number of local extrema and unavailable derivatives. DIRECT performs a sampling of the feasible domain over a set of points that becomes dense in the limit, thus ensuring the everywhere dense convergence; however, it results ineffective on significant instances of the problem under consideration, because it tends to produce a uniform coverage of the feasible domain, by oversampling regions that are far from the optimal solution. DIRECT has been modified by embodying information provided by a suitable discretization of the feasible domain, based on the signal theory, which takes into account the variability of the objective function. Numerical experiments show that DIRECT-G largely outperforms DIRECT and the grid search, the latter being the reference algorithm in the astrophysics community. Furthermore, DIRECT-G is comparable with a genetic algorithm specifically developed for the problem. However, DIRECT-G inherits the convergence properties of DIRECT, whereas the genetic algorithm has no guarantee of convergence.

Keywords: global optimization, DIRECT algorithm, detection of gravitational waves.

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