Solving Mixed Integer Non-Linear Programming problem applied to GNSS data

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Nov. 07, 2014

Abstract

The purpose of this paper is to characterize Medium Scale Traveling Ionospheric Disturbances (MSTIDs), by means of Mixed Integer Nonlinear Programming (MINLP). The MINLP techniques are used to for estimating the parameters of the equations that describe the MSTIDs from a set of observations. A new MSTIDs wave detecting method, which we will denote as Ambiguity Resolution in Global Navigational Satellite System (GNSS) Ionospheric Interferometry (ARGII) technique, is designed to model the MSTIDs wave with the data from the wide low-density GNSS receivers network. The ARGII techniques can be set as an special instance of MINLP, because the problem is set as a series of MSTIDs equations including the unknown wave velocity (continuous) and cycle ambiguities (integers). The performance of heuristic and direct search optimization algorithms are evaluated by solving the MINLP problem with techniques bared an different principles, and as benchmark we use the solution obtained by exhaustive

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enumeration of all possible integer solutions. Among the algorithms we have implemented in this work are genetic algorithm, simulated annealing, particle swarm, pattern search and Nelder Mead methods. The GNSS data used to test the these solvers is observed from the wide GNSS network in the north of Poland on the day 353, 2013 whose diameter is more than the half of wavelength and therefore will have phase ambiguities. The evaluating experiments show that the results computed by the simple improved optimization algorithms especially the Nelder Mead have not only high correlations with the reference method (i.e. exhaustive enumeration) but also extremely lower time complexity compared to the benchmark method. Despite unguaranteed global optimal results for the MINLP problems, these methods show the excellent performance in time complexity when computing the velocities of MSTIDs with ARGII techniques from large quantity of the GNSS data.