Prediction of slump flow of high-performance concrete via parallel hyper-cubic gene-expression programming

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Abstract

Parallel hyper-cubic gene expression programming (GEP) was constructed to estimate the slump flow of high-performance concrete (HPC) by using seven concrete ingredients. HPC is a highly complex material; because modeling its behavior is extremely difficult, robust optimization techniques are required. Because of complications caused by high dimensionality, obtaining globally optimal or nearly optimal solutions to such problems is extremely difficult. GEP is a type of evolutionary algorithm that simultaneously optimizes functions and their associated coefficients and is suitable for automatically discovering relationships between nonlinear systems. However, basic GEP, which generally suffers from premature convergence, is often trapped in local optima. Thus, in this study, various parallel subpopulations were processed to enhance search diversity and avoid local optima during GEP optimization procedures. The hyper-cubic topology rapidly spreads excellent solutions throughout all subpopulations. In addition, a migration mechanism, which exchanges chromosomes among the subpopulations, exchanges information during joint optimization to maintain diversity. In a case study, it was observed that for estimating HPC slump flow, the parallel hyper-cubic GEP is more accurate than the basic GEP and two types of regression model. Although both back-propagation neural networks (BPNN) and the proposed methods performed similarly, the proposed methods were preferable because formulas with measurable parameters were clearly provided.

Keyword: Gene-expression programming, Slump flow, High-performance concrete, Optimization techniques, Nonlinear system, Parallel subpopulations