Efficient Calculation of Compute-Intensive Fitness In Genetic Computations Using A Survival Indicator For Population Members

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Abstract

This paper investigates a novel, robust, easy to implement, method for efficiently calculating population fitness in genetic/ evolutionary computations. The method is useful when evolving solutions to problems which ordinarily require extensive and time consuming fitness calculations for each population member, as is the case in genetic programming. The proposed method employs a scoring function, based upon concepts borrowed from artificial life paradigms, as a heuristic indicator of a population member's future survivability. The scoring function permits a fair comparison of population members of different ages and is used to decide whether a member should remain in, or be removed from, the current population. It permits calculation resources to be concentrated on the older, fitter, members of the surviving population. The method was applied to efficiently calculate fitness in the genetic algorithm solution of a real world queuing simulation problem and in the evolution of a finite state automaton problem (a computer program). A speedup in convergence times was observed for comparable solutions when using the proposed method as opposed to the conventional method.

There are many real world applications which are solved by genetic/evolutionary means which require computationally-intensive fitness calculations for each population member. In general, genetic/evolutionary practitioners are attempting to solve larger and more complex problems which demand more extensive fitness calculations. Efficiency and complexity concerns have led to the use of statistical sampling techniques to approximate the evaluation of fitness for each member of the population.

We propose a novel and robust method for efficient fitness evaluation in genetic/evolutionary computations which employs a scoring function motivated by, and based upon, concepts borrowed from artificial life paradigms. *The scoring function is a straightforward , heuristic indicator of a population member's future survivability.* It is based on a surviving population member's cumulative counts of successes and failures where the counts are updated at each generation. The scoring function allows a fair method of comparing population members of different ages in order to determine which members are more apt to survive and thus should be retained in the population. It allows us to concentrate more calculation resources on the older, fitter members of the population (which are more apt to be closer to a problem solution); thereby introducing efficiency into the overall fitness calculation. This contrasts with the use of just sampling , where the same amount of resources are expended to calculate the fixed fitness of a new member joining the population whether or not that member survives in the population or becomes extinct. The scoring function approach finds the more fit solutions quicker; in effect, we have an "evolutionary" speedup of the convergence time.

We develop a promising, but arbitrary, scoring function which exhibits desirable fairness characteristics. This scoring function is applied to two applications which traditionally require extremely compute-intensive and time consuming population fitness calculations. The first is a real world nonlinear queuing simulation problem where we use a GA to evolve an optimum service distribution for a given empirically derived arrival distribution. The other is the evolution of a simple finite state automaton (fsa) , i.e.,a simple computer program, which is used to identify members of certain classes of bit strings from a large test suite of bit strings. The later application has implications for the efficient calculation of fitness in genetic programming which traditionally requires horrendous calculation resource.

Our intuitive ideas for the efficient calculation of population fitness are borne out by preliminary experimental results. We observed faster convergence times for comparable solutions using the scoring function approach as opposed to the traditional approach, all other parameters being equal.

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Proceedings of the Genetic and Evolutionary Computation Conference

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July 13-17, 1999
Orlando, Florida

Volume 1