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Author(s)	伊藤, 拓也
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# Efficient Program Generation by Genetic Programming

Takuya Ito

School of Information Science,  
Japan Advanced Institute of Science and Technology

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## Abstract

Genetic Programming (GP) can generate computer programs automatically without any explicit knowledge for target programs (solution programs). The solution programs are generated by means of selection and some genetic operators. However, GP has a difficulty, which it often takes too much time to generate solution programs. This may be a critical problem when GP generates large scale programs.

The goal of this work is to generate computer programs efficiently by means of the framework of GP. “Efficient” means to reduce the number of generations which is necessary to generate solution programs. To realize this goal, this work improves a genetic operator of GP. There are three genetic operators for GP, crossover, mutation and reproduction. Among these genetic operators, crossover mainly contributes to searching for solution programs. Therefore, this work improves crossover. The normal crossover selects a crossover point randomly so that it breaks building blocks (i.e., effective small program which contributes to improving fitness performance) due to its blind application. To solve this problem, this work proposes four new crossovers

The first crossover is a “depth-dependent crossover” and the second crossover is a “revised depth-dependent crossover”. “Depth-dependent” means that node selection probability is determined by the depth of the tree structure. On these crossovers, shallower nodes are more often selected, and deeper nodes are selected rarely. The building blocks can be protected by swapping shallower nodes.

The third crossover is a “non-destructive depth-dependent crossover”, which is a combination of the depth-dependent crossover and a “non-destructive crossover”. “Non-destructive” means that offsprings of crossover are kept only if their fitness are better than fitness of their parents. This crossover is proposed to solve the program size problem of the depth-dependent crossover.

The fourth crossover is a “self-tuning depth-dependent crossover”. On this crossover, each individual of the population has a different depth selection probability and depth selection probability of a selected individual is copied to the next generation. This crossover

is proposed to enhance the applicability of the depth-dependent crossover for various GP problems.

This work compares GP performances (i.e., fitness value and the size of generated programs) of the normal crossover with performances of these four crossovers using standard GP problems and an original robot problem. These experimental results clarify that the superiority of the proposed crossovers to the normal crossover.

Furthermore, this work discusses the building block hypothesis, which explains how crossover searches solution programs with a survey of previous works and these experimental results.

**Key Words:** Genetic Programming (GP), the depth-dependent crossover, the non-destructive depth-dependent crossover, the self-tuning depth-dependent crossover, building block, building block hypothesis