Chemical Genetic Programming – Coevolution Between Genotypic Strings and Phenotypic Trees

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Abstract. Chemical Genetic Programming (CGP) is a new method of genetic programming that introduced collision-based biochemical processes and realized dynamic mapping from genotypic strings to phenotypic trees.

Chemical Genetic Programming (CGP) [1,2] proposes a new method of genetic programming that enables evolutionary optimization of the mapping from genotypic strings to phenotypic trees. The phenotypic tree of an individual is created by rewriting an initial expression using a series of grammatical rewriting rules. The information stored on DNA serves two purposes. First, it determines which rewriting rules to apply in building an individual's phenotypic tree. Secondly, the DNA is used to create this set of rewriting rules. CGP uses a collision-based method for translating DNA into the set of rewriting rules. Fig. 1 shows the structure of a cell in CGP.

An initial set of rewriting rules is supplied that provides the system with the syntactical structure within which all programs must be generated. These rules allow only executable programs to be generated, but do not place any artificial limitations on the complexity or structure of these programs. Individuals are initially randomly generated, then evolved to form the population of successive generations. The fitness value of an individual is calculated using a correlation function that compares the target function with the individual's generated function. Based on their fitness values, cells, including both the DNA and the rewriting rules, are selected and then evolved. Evolution consists of mutation of DNA units, single point DNA crossover and molecular exchange between two cells, and selection of cells. Evolution adaptively changes not only the DNA information, but also the rewriting rules in cells. This enables the evolutionary optimization of the genotype (DNA) to phenotype (tree) mapping, by which we expect CGP to find the best translation grammar for creating a solution from the one-dimensional genotypic information.

To examine the effectiveness of CGP, it was applied to a selected symbolic regression problem, and the results were compared against those of Grammatical Evolution (GE) [3], which uses static translation from genotype to phenotype.

K. Deb et al. (Eds.): GECCO 2004, LNCS 3103, pp. 715–716, 2004.

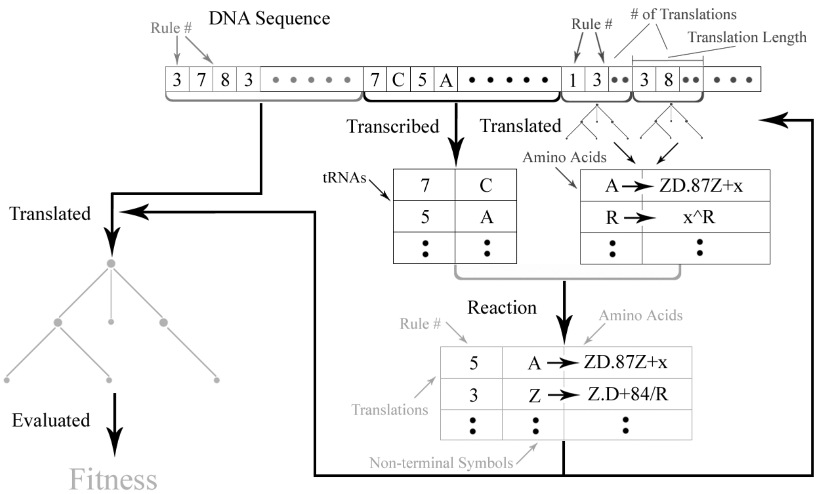

Fig. 1. A cell's architecture in chemical genetic programming. The DNA sequence is translated into amino acids, and transcribed into tRNAs. Amino acids and tRNAs react together using a collision-based method to form an individual's rewriting rules. This revised grammar set is used for translation of the DNA to form the final evaluation tree.

The same problem with a similar parameter set was solved by both GP methods. The results obtained to date have shown CGP to be effective in this problem domain, as 8 of 10 trials were able to find a good solution while only 2 of 10 GE trials were able to find a good solution.

This research was supported by the Telecommunications Advancement Organization of Japan. The second author's work was also partly supported by Doshisha University's Research Promotion Funds.

References

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