Chapter 3
Different Approaches in Genetic Programming

ABSTRACT

The GP method explained in previous chapters was about the evolution of computer programs represented by monolithic gene (syntax tree). This is the original and most widespread type of GP that is also referred to as tree-based GP. In recent years, new variants of GP have emerged that follow the basic idea of traditional GP to automatically evolve computer programs, but the programs are evolved/represented in different ways. New variants of GP include but are not limited to stack-based genetic programming, linear genetic programming (LGP), Cartesian genetic programming, grammatical evolution (GE), graph-based GP (GGP), context-free grammar (CFGGP), multigene genetic programming (MGGP), and gene expression programming (GEP). Among these variants, main features, evolution of computer programs, and a brief review of engineering applications of MGGP, GEP, and LGP are introduced in this chapter.

INTRODUCTION

The GP method explained in previous chapters was about the evolution of computer programs usually represented by monolithic tree structure known as genome and genetic operators act on genomes. This is the original and most widespread type of GP. However, there are several different GP approaches and program representations where computer programs are evolved not

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necessarily using tree-shaped genomes. The general motivations behind developing new representations of GP, as is the case in other machine learning methods, are human desire to speed up the execution time and also to obtain more appropriate (optimal) solutions.

From the execution time point of view, linear representation of genomes, as is the case in Linear GP (LGP), Gene Expression Programming (GEP), and Grammatical Evolution, has been suggested and its successful applications have been reported in different problems (e.g., O'Neil & Ryan, 2003; Brameier & Banzhaf 2007; Danandeh Mehr et al., 2013). For example, in LGP, programs are created and manipulated as binary machine code in memory (is explained later in this chapter) and are executed directly without using an interpreter in the course of fitness calculation. This results not only in a significant acceleration of runtime compared to tree-based GP systems (that interpreters or compilers are required to translate genotypes to phenotype as a part of tree-based GP for fitness evaluation) but also in a considerable reduction in memory consumption. Moreover, Brameier and Banzhaf (2007) showed that in linear representation of genetic programs, ineffective codes (introns) can be easily detected and removed whereas it is not the case in tree representation of programs. Furthermore, almost all computer programs are written in linear fashion where the instructions are being normally executed successively (albeit loops, jumps, or conditional functions may change the execution order). Thus, it makes sense to consider linear representation of tree-shaped programs that leads them to rapid analysis.

On the other hand, to obtain optimal solutions, multi-branch evolution of programs such as GEP and Multigene Genetic Programing (MGGP) have been suggested. These are GP variants that emphasize on the combination of low depth GP trees to increase accuracy and decrease complexity of potential solutions. Such methods are more consistent with natural evolution, in which cooperative behavior of programs increase the chance of being more successful. In an analogy with nature, cooperative behavior of predators obviously offers them a much better chance to hunt prey and be survive.

In this chapter, we describe in detail, the fundamental features and evolution of computer programs in MGGP, GEP, and LGP and look at their recent engineering applications as well as their differences with tree-based GP. The type of MGGP, GEP, and LGP systems that are introduce in this chapter was first proposed by Hinchliffe et al. (1996), Ferreira (2001), and Nordin (1994), respectively.

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