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High Energy Physics Event Selection with Gene Expression Programming

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Evolutionary Algorithms, with Genetic Algorithms (GA) and Genetic Programming (GP) as the most known versions, have a gradually increasing presence in High Energy Physics. They were proven successful in solving problems such as regression, parameter optimisation and event selection. Gene Expression Programming (GEP) is a new evolutionary algorithm that combines the advantages of both GA and GP, while overcoming some of their individual limitations. An analysis of GEP applicability to High Energy Physics event selection will be presented. The description of the technique, the results of its application to specific physics processes and the algorithm performances will be discussed.

Summary

Advanced data analysis algorithms have a gradually increasing presence in High Energy Physics. Neural Networks or Fisher Discriminant techniques are commonly used in many experiments. Other techniques such as Support Vector Machine, Kernel Estimation Technique or Evolutionary Algorithms have also been successfully tested in this field.
Evolutionary Algorithms, inspired by the evolutionary theories from biology, are based on the idea that solutions to a problem can be represented as entities that evolve throughout generations as a consequence of interactions with other candidate solutions, and the application of genetic operators. Genetic Algorithms (GA) and Genetic Programming (GP) are the most known algorithms from this class. Genetic Algorithms were applied mainly to problems such as discrimination and parameter optimisation in both experimental and theoretical particle physics for the last ten years [1]. Genetic Programming was only recently applied to event selection type problems in two particle physics studies [2].
Gene Expression Programming (GEP), invented in 2001 [3], is a new technique of Evolutionary Algorithms for data analysis. GEP uses fixed-length linear character strings to represent solutions of a problem in a form of expression trees of different shapes and sizes, and implements a genetic algorithm to find the best solution. Subsequent studies [4] show that GEP combines the advantages of both GA and GP, while overcoming some of their individual limitations.
A first application of GEP to High Energy Physics data analysis that I recently presented [5] indicates this algorithm as a promising technique.
The present paper will present a detailed analysis of GEP applicability to High Energy Physics event selection. This will include the description of the technique, the results of its application to specific physics processes, the analysis of the algorithm performances and their comparison with performances of the traditional event selection methods. Based on this comparison, advantages and disadvantages of GEP technique for High Energy Physics event selection will be discussed.

`Bibliography`

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