ABSTRACT

Random Dynamic Neighborhood Structures in Particle Swarm Optimization

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Particle Swarm Optimization (PSO) is a relatively new sub-field in Artificial Intelligence, based on interaction patterns observed in nature. It is a very successful paradigm for solving research and real-world optimization problems.

The pattern of interaction between particles is an important aspect of the system that can determine its performance. This thesis introduces random dynamic neighborhood structures as a method of manipulating interactions. A new method for generating random structures and three new neighborhood operators are presented.

Random dynamic neighborhoods were tested on common research problems and compared to existing PSO configurations. They produced superior results in all but one case and were still not outperformed on that function. To perform optimally, it was necessary to tune the graph's size (n) and uniform out-degree (k), and the dynamism probability of application (p_{dyn}). For a given level of p_{dyn}, there exists a qualitative relationship between n and k that results in optimal performance.

To better understand the relationship between the parameters and the optimization problem, two new classes of functions, called *holes* and *interpolation*, were created that allow for incremental adjustments to function difficulty. One dynamism method, *re-structuring*, performed very well on the holes function and guidelines for choosing n, k and p_{dyn} were established. The interpolation function proved more difficult to optimize, but random dynamic neighborhoods were still the best option.

A mathematical model of a simplified system was developed to find the expected number of iterations that must elapse for a particle to be influenced by its neighborhood best. This led to a qualitative relationship between p_{dyn} and the number of minima in a holes function.

The utility of random dynamic neighborhoods in a real-world scenario was demonstrated by solving an earthquake classification problem. The result was a neural network that can classify at an accuracy level of 96.5%.

Keywords: Arvind Sateesh Mohais; evolutionary algorithms; particle swarm optimization; neighborhood structures; random dynamic neighborhoods, neighborhood re-structuring.