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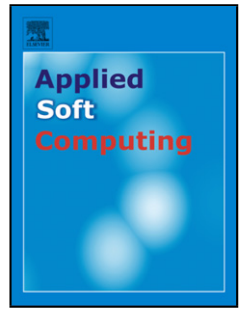

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A Meta Optimisation Analysis of Particle Swarm Optimisation Velocity Update Equations for Watershed Management Learning

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Abstract

Particle Swarm Optimisation (PSO) is a general purpose optimisation algorithm used to address hard optimisation problems. The algorithm operates as a result of a number of particles converging on what is hoped to be the best solution. How the particles move through the problem space is therefore critical to the success of the algorithm. This study utilizes meta optimisation to compare a number of velocity update equations to determine which features of each are of benefit to the algorithm. A number of hybrid velocity update equations are proposed based on other high performing velocity update equations. This research also presents a novel application of PSO to train a neural network function approximator to address the Watershed Management problem. It is found that the standard PSO with a linearly changing inertia, the proposed hybrid Attractive Repulsive PSO with Avoidance of Worst Locations (AR PSOAWL) and Adaptive Velocity PSO (AV PSO) provide the best performance overall. The results presented in this paper also reveal that commonly used PSO parameters do not provide the best performance. Increasing and negative inertia values were found to perform better.

Keywords: Particle Swarm Optimisation, PSO, Velocity Update Equation, Constriction, Inertia, Meta Optimisation, Watershed Management, Function Approximation, Neural Networks, Learning

1. Introduction

Particle Swarm Optimisation (PSO) is an optimisation algorithm that consists of a number of particles exploring a problem space and ultimately converging on a solution [21]. The particles evaluate potential solutions and share information with one another. This information is used to direct their movement so that they move towards the best known solutions. The PSO algorithm has been applied to numerous real world problem domains since its first proposal. These include design, scheduling and routing problems across several disciplines and industries ranging from imaging to energy production [1]. The main advantages of meta heuristic optimisation algorithms such as PSO, Differential Evolution and Scatter Search is their robustness, versatility and applicability to a wide range of problems. Traditional optimisation methods such as gradient decent struggle with certain problems, e.g. problems with noise and problems that are otherwise non differentiable. Such problems do not pose a problem to PSO. Another class of problems that PSO is well suited to are very large problems. Problems that are classified as NP-complete or NP-Hard (non-deterministic polynomial-time). These problems increase in size at an exponential rate as the number of parameters increase and are therefore much too time consuming for deterministic optimisation algorithms to solve. Algorithms such as PSO can provide good approximations to these problems however. The drawback to PSO is that it is heavily reliant on correct parameter selection and cannot guarantee that it will converge on the optimum solution. This research will aim to address the former of these two issues. There are more comprehensive studies that outline in detail the advantages and disadvantages of heuristic optimisation algorithms [46].

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