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SIMULTANEOUS COMPUTATION OF MODEL ORDER AND PARAMETER ESTIMATION FOR ARX MODEL BASED ON MULTI-SWARM PARTICLE SWARM OPTIMIZATION

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ABSTRACT

Simultaneous Model Order and Parameter Estimation (SMOPE) is a method of utilizing meta-heuristic algorithm to iteratively determine an optimal model order and parameters simultaneously for an unknown system. SMOPE was originally introduced using Particle Swarm Optimization (PSO). However, the performance was worse than conventional ARX. Hence, the objective of this paper is to introduce a new computational model of the SMOPE which employs multi-swarm strategy in original SMOPE to diversify the search moves of meta-heuristic algorithm when searching for the best mathematical model. Experiments are performed on six system identification problems. The obtained results prove that incorporating the multi-swarm approach is a good idea to improve original SMOPE.

Keywords: particle swarm optimization, multi-swarm, system identification, model order selection and parameter estimation.

INTRODUCTION

System identification is a method employed to obtain a mathematical model of a system by performing analysis on input-output behaviour of the system. Fundamental steps of system identification procedure are generally summarized into four main stages. The primary stage is collection of experimental data. Following that, the model order is selected. The next stage is to approximate the parameters of the model and lastly, the mathematical model is validated.

Auto-Regressive Model with Exogenous Inputs (ARX) is the most basic model in linear black box identification [1]. Conventionally, in addressing the system identification problem of ARX model, the model order selection and parameter estimation are done separately.

There are some techniques reported in literature in solving system identification problems. Hansson *et al.* presented a subspace system identification method based on weighted nuclear norm approximation [2,3]. Moreover, there are some methods proposed to address system identification problem based on meta-heuristic algorithm but it mainly focus on parameter estimation only [4,5].

SMOPE was proposed to address system identification problem efficiently using meta-heuristics algorithms [6]. The technique enabled the computation of model order and parameters values to be done concurrently. This is achievable through the way the problem is encoded in the search agents. Furthermore, SMOPE could also successfully be adapted to fit with other meta-heuristic algorithm like Gravitational Search Algorithm (GSA) [7].

However, SMOPE method unable to offer the best mathematical model and its performance is significantly worse than conventional ARX due to limitation of its computational model. To overcome this defect, inspired by the concept of multi-swarm technique, a new computation model termed as Simultaneous Model Order and Parameter Estimation based on Multi-Swarm approach (SMOPE-MS) is proposed. The strategy is assigning each swarm of meta-heuristic algorithm to each model order of ARX mathematical equation. Outcomes show that the proposed method is valid and can attain better solution quality.

PSO is a bio-inspired optimization algorithm introduced by Kennedy and Eberhart [8]. The search is based on the concept that particles move through the search space from their current positions with velocities dynamically modified depending on their current velocities, best self-experienced position and best global-experienced position with some influence of randomness.

In this paper, the implementation of SMOPE-MS using PSO is studied and compared with original SMOPE as well as Conventional ARX. Six ARX system identification problems are used for verification. The results show that SMOPE-MS is better than original SMOPE and has comparable performance when compared to conventional ARX.

The remainder of this paper is organized as follows: Section 2 briefly reviews the SMOPE technique. Section 3 explains the proposed SMOPE-MS technique. Section 4 provides the experimental settings and discusses the experimental results. Section 5 concludes the paper.

SIMULTANEOUS COMPUTATION OF MODEL ORDER AND PARAMETER ESTIMATION (SMOPE)

Contrary to other system identification techniques, SMOPE obtain the optimal system order and the parameters values simultaneously. The key of SMOPE is the encoding of the search agents. For that reason, by applying same encoding, SMOPE can simply be integrated to other meta-heuristic algorithms. The agent's encoding employed in SMOPE is shown in Table-1. The transfer function of ARX model used in SMOPE is as follow: