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RESEARCH ARTICLE

Implementation of Evolutionary Algorithms to Parametric Identification of Gradient Flexible Plate Structure

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ABSTRACT - This paper focused on modelling of a gradient flexible plate system utilizing an evolutionary algorithm, namely particle swarm optimization (PSO) and cuckoo search (CS) algorithm. A square aluminium plate experimental rig with a gradient of 30° and all edges clamped were designed and fabricated to acquire input-output vibration data experimentally. This input-output data was then applied in a system identification method, which used an evolutionary algorithm with a linear autoregressive with exogenous (ARX) model structure to generate a dynamic model of the system. The obtained results were then compared with the conventional method that is recursive least square (RLS). The developed models were evaluated based on the lowest mean square error (MSE), within the 95% confidence level of both auto and cross-correlation tests as well as high stability in the pole-zero diagram. Investigation of results indicates that both evolutionary algorithms provide lower MSE than RLS. It is demonstrated that intelligence algorithms, PSO and CS outperformed the conventional algorithm by 85% and 89%, respectively. However, in terms of the overall assessment, model order 4 by the CS algorithm was selected to be the ideal model in representing the dynamic modelling of the system since it had the lowest MSE value, which fell inside the 95% confidence threshold, indicating unbiasedness and stability.

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1.0 INTRODUCTION

The superiority of flexible plate structures such as lightweight, lower maintenance, lower energy consumption, and faster response intrigues various engineering industries like solar panels, bridge decks, aircraft [1], and ship bodies [2] as well as conveyor systems [3]. Despite the numerous benefits that a flexible structure provides, it is easily affected by vibration due to the presence of disturbance forces. Thus, the unwanted vibration leads to plate structural fatigue and durability problems which affect the plate stability and performance. Subsequently compromising the safety of working environments [4].

Unwanted vibration must be reduced for the plate's performance to be maintained. Therefore, passive vibration control (PVC) has been proposed. PVC primarily involves modifying the dynamic characteristics of the structure by adding an absorber and damper to prevent excessive vibration on the plate. The increase in weight structure, however, limits PVC, as this technology cannot sustain low-frequency vibration on the flexible plate. Therefore, active vibration control (AVC) is consequently introduced. The AVC is a method of suppressing undesired vibration by interfering with the principal disturbance source. To create a successful AVC scheme, the system modeling must be realistic enough to replicate the actual dynamic characteristics of the structure [5].

Dynamic model identification by experimentation is an effective way to obtain dynamic modelling. The characteristics of a complex structure normally identified in the nonlinear system can be included in the dynamic model. Researchers have used the System Identification (SI) method to model systems that approximate physical system behavior under diverse operating situations. Based on the observed input-output data, this method is used to determine the accurate model of a dynamic system [6]. A decent model can be found by employing an appropriate estimation optimization approach. Nowadays, many researchers employ evolutionary algorithms (EA) in their optimization efforts to identify the optimum model because EA has been proven to be effective.

For instance, particle swarm optimization (PSO), which was inspired by the intelligent social behaviour of social organisms such as flocks of birds and schools of fish, has gained researchers' attention in various optimization problem-solving due to its fast convergence as well as fewer parameters that need tuning [7]. For a similar system in research, Khoooshechin et al. investigated the optimal parameters of flexible square cascade multicomponent isotopes. The outcome showed PSO optimization managed to increase the enrichment of each isotope at any concentration [8]. Besides, Negri et al. obtained the natural frequencies and mode shapes by using the simulational model updating method that utilized PSO optimization [9]. In [10], the researchers used an improved PSO algorithm with a two-stage optimization approach to efficiently accelerate particle swarm optimization (EAPSO) for estimating the localization and quantification of the damaged elements in plate structures. Meanwhile, Wang et al. utilized PSO optimization to calculate the optimum

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