Journal of Advanced Research in Applied Mechanics 118, Issue 1 (2024) 167-182

SEMARAK ILMU
PUBLISHING
202103268166(003316878-P)

Journal of Advanced Research in
Applied Mechanics

Journal homepage:
https://semarakilmu.com.my/journals/index.php/appl_mech/index
ISSN: 2289-7895

Mayfly Algorithm for Modelling a Horizontal Flexible Plate Structure

Aida Nur Syafiqah Shaari[1], Muhamad Sukri Hadi[1], Annisa Jamali[2,*], Intan Zaurah Mat Darus[3]

[1] School of Mechanical Engineering, College of Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia
[2] Faculty of Engineering, Universiti Malaysia Sarawak,94300, Kota Samarahan, Sarawak, Malaysia
[3] School of Mechanical Engineering, Universiti Teknologi Malaysia, 81310, Skudai, Johor, Malaysia

ARTICLE INFO

Article history:
Received 29 February 2024
Received in revised form 26 April 2024
Accepted 10 May 2024
Available online 30 May 2024

ABSTRACT

Flexible plates are widely used in engineering and the industry, primarily due to the lightweight nature compared to rigid counterparts. These structures offer benefits such as cost savings, lower energy consumptions and improved operational safety. However, a notable drawback is that flexible structures are vulnerable to unwanted vibrations, which can cause structural damages. Hence, the development of specialized models are essential to effectively addressing this challenge. Researchers have devised various approaches to suppress unwanted vibrations, with contemporary studies often employing system identification techniques utilizing swarm intelligence algorithms to construct dynamic models of flexible structures. Therefore, this research employs the potent mayfly algorithm (MA), known for its effectiveness in optimization tasks. The developed models using MA were then compared with traditional approach known as recursive least square (RLS) through a comparative analysis. The outcome reveals that RLS exhibited the lowest mean square error (MSE) at 3.7392×10^{-6}, while MA had an MSE of 5.5185×10^{-6}. Yet, MA adeptly depicted the characteristics of the system, outperforming the RLS in these validation by indicating a 95% confidence level in the correlation test and exhibiting robust stability in the pole-zero diagram. Consequently, MA serves as a fitting algorithm to accurately depict the real behaviour of the flexible plate structure.

Keywords:
Modelling; Mayfly algorithm; optimization; flexible structure; swarm intelligence algorithm

1. Introduction

In this modern technological era, the extensive utilization of flexible plate structures are evident across various engineering and industrial sectors including, aerospace, construction, maritime and energy [1-4]. These structures are favored for their exceptional structural and material properties. Notably, flexible structures are renowned for being lightweight, dependable, efficient, and capable of facilitating swift operations compared to rigid counterparts. Moreover, flexible structures come in diverse shapes and sizes. Presently, these structures play a pivotal role in manufacturing industries, offering advantages such as reduced labor requirements, cost-effectiveness, enhanced speed, ease of operation, and a decrease in workplace accidents [5]. However, despite their numerous merits,

* *Corresponding author.*
E-mail address: jannisa@unimas.my

https://doi.org/10.37934/aram.118.1.167182

flexible structures do have limitations, primarily related to their susceptibility to both internal and external disturbances, resulting in unwanted vibrations. This study aims to revolutionize the modelling of horizontal flexible plate (HFP) structures by introducing an intelligent approach, namely, the Mayfly Algorithm.

Unwanted or excessive vibrations pose a range of problems, such as machinery damage, diminished capability, bending, fatigue, and reduced overall performance. Hence, it is crucial to address and minimize these undesirable vibrations in flexible structures to maintain their optimal functionality. Therefore, to achieve this, the development of suitable models and effective control methods are essential, ensuring that flexible structures continue to play a significant role in various industries. Several approaches have been suggested by prior researchers and academic experts to address the concerns of undesired vibrations experienced by flexible plate structures [6]. Traditionally, passive vibration control (PVC) techniques have been employed to dampen excessive vibrations exerted towards such structures. Passive control can be applied in the form of mechanical solutions, such as incorporating vibration dampers or dynamic vibration absorbers into the system. However, passive control mechanisms are effective primarily in high-frequency range systems and tend to be less efficient in low-frequency ranges [7].

Furthermore, in engineering applications, greater emphasis is placed on utilizing lightweight systems. The inclusion of dampeners could lead to an increase in overall system weight, making it impractical. More recently, active vibration control (AVC) techniques have gained attention as a promising approach to reduce and manage vibrations, given their higher efficiency and reliability [8-9]. Hence, to address the limitations of passive vibration control (PVC) techniques, this research introduces an active vibration control (AVC) approach. However, before an effective controller can be developed for vibration suppression in a flexible plate system, it is crucial to create an accurate model of the structure. System identification (SI) techniques have emerged as the preferred method to determine the most suitable model structure.

SI involves constructing a mathematical model of the dynamic system based on collected vibration data [10]. The parameter estimation to construct mathematical model can be acquired from traditional and optimization approaches. Nonetheless, in situations where obtaining a model structure using traditional techniques proves challenging, intelligent methods become a desirable option [11-13]. Various forms of artificial intelligence, including glowworm swarm optimization (GSO), neural network systems, and mayfly algorithm (MA), have proven effective in parameter identification [8]. MA algorithm has been extensively studied for optimization and system identification across diverse applications, included but not confined to the automotive industry, engineering, function optimization, and task scheduling [14-16].

Mayflies belong to the Ephemeroptera order and are fragile insects renowned for their brief existence [17]. There are more than 3100 identified species of mayflies globally, and they spend nearly a year in anticipation of their brief emergence, with most having a lifespan of just one day. Their primary focus is on reproduction, often neglecting the need for food. Male mayflies form swarms for mating, which can vary in size from a few individuals to hundreds. These swarms form at an altitude of 1 to 4 meters above the ground and last for approximately 1.5 to 2 hours in the early morning. During this time, male mayflies engage in a distinctive up-and-down nuptial dance. After the dance, the males approach the females within the swarms, and the pairs descend into vegetation to mate before flying away separately.

This idea has been transformed into an optimization technique known as the MA. The algorithm is constructed by integrating elements from firefly algorithm (FA), particle swarm optimization (PSO) and genetic algorithms (GA) [18-20]. By incorporating the strengths of each of these approaches, the MA algorithm was devised. In this algorithm, it is assumed that every candidate is an adult ready for