Detecting Problematic Vibration on Unmanned Aerial Vehicles via Genetic-Algorithm Methods

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***Abstract*— Unmanned Aerial Vehicles (UAV) problematic vibration detection as a flaw detection and identification (FDI) method has emerged as a feasible tool for assessing a UAV's health and condition. This paper shows the potential of optimization-based UAV problematic vibration detection. A proposed fitness function based on the frequency domain has been detailed. The fitness function with the Genetic Algorithm (GA) optimization method is tested and evaluated based on Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and detection time. 51 sets of data have been collected using software in the loop (SITL) methods and are used to determine the effectiveness of the proposed fitness function and GA. The test results show promising results with obtained mean RMSE = 1407.2303, mean MAPE = 0.7135, and mean detection time = 2.6129s for a data range of between 3955 to 9057.**

Keywords—Problematic Vibration, Genetic Algorithm, Frequency-Domain, Root Mean Square Error, Mean Absolute Percentage Error.

I. INTRODUCTION

UAVs (Unmanned Aerial Vehicles) are becoming increasingly important in a variety of applications, including but not limited to structural health monitoring and fault identification. UAV vibration detection as a means of fault detection and identification (FDI) has emerged as a viable tool for analyzing the health and condition of a UAV.

Previous research has demonstrated the importance of sensor placement and optimization in UAV applications. A study on "Optimisation and control application of sensor placement in aeroservoelastic of UAV" for example, emphasized the incorporation of vibration energy-based observability measurement for sensor location [1]. Furthermore, a study on "A Path Planning Method with Perception Optimization Based on Sky Scanning for UAVs" shows the ability to maximize sensor node lifetime, emphasizing the need for optimization in UAV operations [2].

Furthermore, the employment of optimization approaches for state estimation and problem detection in UAVs has piqued the interest of researchers. For example, a study titled "Optimal control and state estimation for unmanned aerial vehicle under random vibration and uncertainty" highlighted the importance of optimal estimation in inferring information about the UAV state [3]. "Vibration-Based Fault Detection in Drones Using Artificial Intelligence" developed a fault detection method based on multirotor arm vibration, demonstrating the use of a Neural Network in vibration-based fault detection [4].

Furthermore, the integration of computer vision and optimization algorithms for structural vibration assessment utilizing unmanned aerial vehicles (UAVs) has been investigated. A succinct assessment emphasized the advancements and applications of unmanned aerial vehicle-based computer vision in structural dynamics, emphasizing the potential for new measuring methods [5]. A study titled "A Bridge Vibration Measurement Method by UAVs Based on CNNs and Bayesian Optimisation" demonstrated the use of convolutional neural networks and Bayesian optimization for vibration measurement, demonstrating the potential for advanced techniques in UAV-based vibration detection [6].

Other fault diagnostics in UAV are Neural-Network Extended Kalman Filters (NN-EKF) [7], Particle Filter (PF) with k-means cluster, and Multilayer Perceptron (MLP) [8] and EIKF with Bhattacharyya distance [9]. None of the aforementioned articles dealt with optimization-based fault detection and identification.

The suggested method in this work intends to find out the feasibility of using the optimization method as problematic vibration detection for fault detection and identification. This paper will provide the formulated fitness function and the evaluation matrix used to evaluate the formulated fitness function in genetic algorithms (GA) optimization methods.

II. METHODOLOGY

The methodology of this research starts by acquiring data sets for the problematic vibration during flights. As of the date this paper is written, there are no available data sets online. The data sets can be obtained from the author with proper application.

With the data sets acquired, the frequency domain fitness function is established and with the use of Genetic Algorithm (GA), the performance of the fitness function is accessed.

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