Abstract

Parameterized analytical models that describe the trimmed in flight behavior of classical aircraft have been studied and are widely accepted by the flight dynamics community. Therefore, the primary role of aircraft parameter estimation is to quantify the parameter values which make up the models and define the physical relationship of the flight vehicle with respect to its surrounding environment. Aerodynamic models play extremely important role during aircraft design cycle and also during aircraft exploitation life for pilot training on modern flight simulators. Aerodynamic model parameters are traditionally defined in experimental tests in wind tunnels and using various computational methods. Identification of aerodynamic model parameters using time processes of motion parameters registered in special flight tests are also now well developed technology. These methods are well documented and widely used meeting needs of aeronautical industry. However new tasks in aeronautics need fast and reliable on-line identification methods for aerodynamic characteristics for example implementation of adaptive automatic control, flight envelope prediction, determination of aerodynamic characteristics for impaired aircraft, etc. Earlier computational intelligence (CI) and machine learning (ML) evaluation methods has been used outside of aeronautical applications have now proved to be potent tools to meet new challenges in aerodynamic model identification. In the present work the identification of aerodynamic models and evaluation of model parameters have been considered on the basis of proposed Adaptive Neuro Fuzzy Inference System (ANFIS) network (Chapter 4) in combination with three different computational optimization intelligent methods, the Particle Swarm Optimization (PSO) method (Chapter 4-ANFIS-PSO), the Genetic Algorithm (GA) method (Chapter 5 - NF-GA), and the Artificial Bee Colony (ABC) method (Chapter-6 - HNFABC). The obtained results for estimated parameter, considering ATTAS, HANSA-3 and HFB-320 aircraft, in all three proposed approaches are compared with results predicted using traditional parameter estimation methods, the Least Squares (LS), the Maximum Likelihood Estimation (MLE) and the Filter Error Method (FEM). Presented comparisons demonstrated the efficacy of the proposed estimation methods based on the artificial intelligence methods and also inherited some of their advantages in case of noisy signals of recorded motion parameters. To validate the methodology, proof of match exercise is carried out and then compared with the predicted and the actual values. The proposed methodology is investigated for parameter estimation of the aerodynamically stable aircraft, the highly maneuvering unstable aircraft. A comprehensive theoretical analysis is carried out to explain the parameter estimation process and nature of the estimates, pertaining to linear and nonlinear unstable aircraft dynamics, using the ANFIS PSO, NFGA , and HNFABC approach. It is shown that the new estimation methods yield results, which closely match with the observed values. Results from classical methods are presented. Equation for the standard deviation is derived and verified through numerical simulation. Moreover, parameter estimates from simulated noisy data for unstable aircraft are also presented to assess and support the theoretical developments presented. It is shown that these methods give comparable results; however, the proposed approaches yield more accurate result in presence of noise. Moreover, the results of the approaches have been compared to the results obtained from the classical methods. The proposed methods approach does not suffer from numerical instability and are robust; those does not rely upon *priori* knowledge, sophistication of mathematical model and choice of initial guess value. These techniques can be extended to the nonlinear aerodynamic regime and to the unstable aircraft parameter estimation.

Keywords: Flight Dynamics, artificial intelligence, ANFIS, Time Domain, Parameter Estimation, System Identification, ABC, PSO, GA.