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Database Self-expansion Based on Artificial Neural Network: An Approach in Aircraft Design

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Abstract

Aircraft design today requires large amount of CFD calculation. For example when Natural Laminar Flow technique is applied to reduce aircraft skin friction drag by extending laminar length over surface, flowfield calculation related with airfoil laminar transition is computationally intense. Situations like this make iterative trial-and-error approach very inefficient. In order to improve this, this paper aims to exploit airfoil database of geometry and aerodynamic performance (from accumulated experiment and CFD calculation results) based on Artificial Neural Network to develop the approach of *database self-expansion.* It can generate airfoils with better aerodynamic performance from original database, so that the new airfoils can be applied to improve local aerodynamic performance of aircraft. The motive of the approach is to utilize the resource of accumulated optimization products in order to aid aircraft design. In this paper, we will discuss its application in laminar length extension over the surface of nacelle and wing. Geometry description in preparation of database establishment, configuration of network training, and workflow will be described in the paper.

Keywords:

Artificial Neural Network; database; airfoil; aircraft design

1. Introduction

The requirement in areas of economy and ecology to produce faster and greener transport aircraft has resulted in dedicated researches to improve aircraft aerodynamic performance [1]. This requires aircraft design to be more accurate in aerodynamics and more economic in computational cost.

Many numerical optimization methods require geometry description and aerodynamic performance of airfoils that constitute aircraft's wing or nacelle, etc. An airfoil not only forms the three-dimensional aircraft geometry, but also determines local aerodynamical performance of an aircraft [2].

Much computational resource will be used in obtaining airfoil aerodynamic performance, if accuracy request is high. For example, Natural Laminar Flow (NLF) technique has been widely used to reduce skin friction drag by extending laminar length over aircraft surface [2][3][4]. NLF applies airfoils with good laminar length performance into construction of aircraft surface. Aerodynamic performance especially laminar-turbulence distribution needs to be calculated in the process. CFD software using RANS model is accurate to obtain laminar-transition-related aerodynamic performance e.g. skin friction coefficient distribution over airfoil surface [5][6]. However it is time-consuming in transonic situation, because transition point of an airfoil is dependent on various upstream instabilities (e.g. receptivity, linear growth, and nonlinear interactions) in high Reynolds and Mach number situation [7][8].

This paper aims to provide a new approach that can provide new airfoils in NLF design from accumulated experiments and CFD calculation results. In the approach, a *database self-expansion* is

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