Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

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Title

Predictions of wing structural responses by physical-based machine learning framework

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Abstract

In order to study the feasibility of machine learning methods in aircraft structural analysis, the paper constructed different neural networks to predict and compare the responses of aircraft wing structures under different loads. First of all, the mean square error of the predictions and the targets were taken as the loss function, with simple structures, such as plates and shells, as the research object, and different capacity of training samples were obtained by the finite element simulation. After training, the neural networks predicted the displacements of the object, and the results were compared with the targets, exploring the relationship between the accuracy and sample size. Then, two physical informed neural networks (PINN), based on the balance equations of the object and the energy equations, were constructed, respectively. The training efficiency and the accuracy of the two PINNS were compared. Finally, based on the results of the researches above, the deflections of the straight wing with two beams under the aerodynamic loads were studied by machine learning method.

The results showed that the size of training sample required increases with the complexity of the problem, and the neural networks get higher accuracy with more trained samples; compared with PINNs based on balance equations, PINNs based on energy equations showed higher accuracy and higher training efficiency in most of the cases. Compared with data-driven neural networks, PINNs do not need to provide a large number of targets as training data. The research shows that the machine learning method is feasible in aerospace engineering application.

References

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