Suppression of Aeroelastic Instabilities in High Ratio Wing Structures Using Principal Component Analysis

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The aeronautical industry struggles to find a balance between making aircraft efficient and durable simultaneously, high-ratio wings are able to provide efficiency at the loss of structural integrity. Aircraft wings are vulnerable to fatigue at high speeds and turbulent conditions, these conditions lead to limit cycle oscillations and wing flutter putting stress on the structure of wing and decreasing aircraft efficiency. I designed a wing structure in conjunction with a machine learning algorithm that is optimized to predict turbulent conditions based off weather radar data from the cockpit and modify surface controls on the aircraft to proactively handle unfavorable regions of air. I simulated each wing in real-world scenarios and collected data on: dynamic pressure, turbulence intensity and length, sheer stress, and velocity for all three axes. By preventing aircraft from entering limit cycle oscillations or conditions where the wing starts to flex, it protects the structural integrity of the wing and improves aircraft performance. To simulate all flow tests, I used SolidWorks and SolidWorks Flow Simulation 2016. I 3D-Printed a wing, and created a functioning wing using a series of servo motors, altimeter/barometric/temperature sensor, and 9-axis gyroscope/magnetosphere/accelerometer sensor, and an Arduino board. The results showed that the time taken to overcome a limit cycle oscillation in the control group wing was 539 iterations compared to 166 iterations for the experimental machine learning wing. The data suggests the experimental wing and machine learning algorithm would prove effective in reducing the stress on wing structures and increase aircraft performance and efficiency.

Awards Won:

First Award of $5,000