National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Aerospace

Real-Time Drag Opti-mization Control Framework

Adaptive wing real-time optimization and control solution

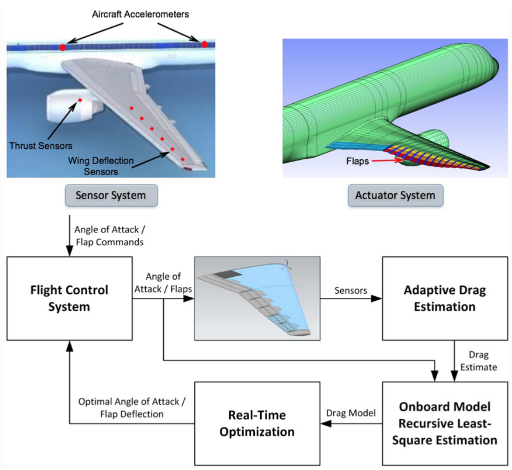
Fuel efficiency is a major aircraft design consideration. Current and future-generation aircraft wing technology is moving toward lightweight, flexible, and high aspect ratio wing design. Wing flexibility can adversely impact aircraft performance, structural integrity, stability, and control. The aerodynamic performance of the aircraft wings can vary greatly over the flight envelope too. Without changing the wing shapes, an increase in drag can incur during cruise, thereby, causing an increase in the fuel consumption, hence fuel cost. NASA Ames has developed a novel technology that is ideally suited for transport aircraft wings ranging from stiff metallic wings to flexible composite wings that are susceptible to aeroelastic deflections during flight. This enabling technology includes a method and process for optimizing drag in real-time using distributed flight control surfaces to change the shape of the wing in-flight, and helps counteract the aeroelastic effects introduced by flexible wings. This improves both aerodynamic performance and fuel efficiency.

BENEFITS

- Works on any aircraft and in any operating conditions
- Iterative approach to find refinement and solution that optimizes drag continuously during flight
- Integrates with existing aircraft flight controls
- Wide variety of applications can be used on passenger aircraft, cargo aircraft, or high performance supersonic jets
- Can be retrofitted to any aircraft with ailerons, flaps, and elevators
- Does not require a specific aircraft math model and, therefore, does not require customization for different aircraft designs
- Ideal for wings susceptible to aeroelastic deflections common in modern aircraft
- Improved performance compared to alternate drag optimization methods and eliminates the need for a table lookup solution
- Economic benefits drag optimization translates to increased fuel efficiency and a reduction in fuel costs for aviation industry
- Environmental benefits increased fuel efficiency translates to reduced carbon emissions from aircrafts

THE TECHNOLOGY

According to the International Air Transport Association statistics, the annual fuel cost for the global airline industry is estimated to be about $140 billion in 2017. Therefore, fuel cost is a major cost driver for the airline industry. Advanced future transport aircraft will likely employ adaptive wing technologies that enable the wings of those aircraft to adaptively reconfigure themselves in optimal shapes for improved aerodynamic efficiency throughout the flight envelope. The need for adaptive wing technologies is driven by the cost of fuel consumption in commercial aviation. NASA Ames has developed a novel way to address aerodynamic inefficiencies experienced during aircraft operation. The real-time drag optimization control method uses an on-board, real-time sensor data gathered from the aircraft conditions and performance during flight (such as engine thrust or wing deflection). The sensor data are inputted into an on-board model estimation and drag optimization system which estimates the aerodynamic model and calculates the optimal settings of the flight control surfaces. As the wings deflect during flight, this technology uses an iterative approach whereby the system continuously updates the optimal solution for the flight control surfaces and iteratively optimizes the wing shape to reduce drag continuously during flight. The new control system for the flight control surfaces can be integrated into an existing flight control system. This new technology can be used on passenger aircraft, cargo aircraft, or high performance supersonic jets to optimize drag, improve aerodynamic efficiency, and increase fuel efficiency during flight. In addition, it does not require a specific aircraft math model which means it does not require customization for different aircraft designs. The system promises both economic and environmental benefits to the aviation industry as less fuel is burned.



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APPLICATIONS

The technology has several potential applications:

- Aeronautics Industry
  - Passenger aircraft, cargo aircraft, or high performance supersonic jets, general aviation aircraft, drones
- Space Launch Vehicles, Space Entry Vehicles
- Automotive industry
  - Cars, trucks, race cars
- Marine industry
  - Ships, submarines

PUBLICATIONS

Patent No: 11,242,134; 9,227,721

Ferrier, Y., Nguyen, N., and Ting, E., Real-Time Adaptive Least-Squares Drag Minimization for Performance Adaptive Aeroelastic Wing, 34th AIAA Applied Aerodynamics Conference, AIAA-2016-3567, June 2016.

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More Information

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