Intelligent Strain Sensing on a Smart Composite Wing using Extrinsic Fabry-Perot Interferometric Sensors and Neural Networks.

By

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Overview

• Motivation & Problem Description
• Fiber Optic Sensors
• Experimentation
• Neural Network Implementation
• Results
• Conclusion and Future Work
Motivation and Problem Description

- Aerodynamic parameter prediction
  - Strain: different points on wing
- Varying conditions
  - Angle-of-attack & air speed
- Neural network modeling
- Stall Prediction
Intelligent Sensing System

- Fiber Optic Sensing System:
  - Absolute strain measurement
  - Many advantages
- Neural Networks:
  - Function approximators
  - Intelligent system
Fiber Optic Sensors

Extrinsic Fabry-Perot Interferometric (EFPI) Sensor
Experimentation

Sensor placement

Top View

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Experimentation (Contd.)

- Key Strain points Measured
- Variation in Pressure: 0 to 460 Pa
- Variation in angle-of-attack: $-1.627^0$ to $4.31^0$
Neural Network Modeling

Neural network trained on two types of data
- Max and Min strain
- Average Strain

Typical Strain profile
Training on Max Strain - Results

Simulated Vs Actual Max Strain

Test Samples

Normalized Strain

Simulated
Actual
Training on Min Strain-Results

Simulated Vs Actual Min Strain

Test Samples

Normalized Strain

Simulated
Actual

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Training on Average Strain

Simulated Vs Actual Average Strain

Normalized Strain

Test Samples

Simulated
Actual
Results: Contd.

Average errors in the test set

<table>
<thead>
<tr>
<th>Sensor</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Strain</td>
<td>4.05%</td>
<td>0.71%</td>
<td>2.08%</td>
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<tr>
<td>Min Strain</td>
<td>8.35%</td>
<td>1.92%</td>
<td>0.94%</td>
</tr>
<tr>
<td>Average Strain</td>
<td>3.70%</td>
<td>2.03%</td>
<td>1.05%</td>
</tr>
</tbody>
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Conclusion and Future Work

• Predicted Strain compared with actual strain: tool to predict stall
• Neural network modeling: easy to implement and good accuracy
• Future work:
  ➢ Improve accuracy in measurement techniques
  ➢ Optimal sensor location algorithms
  ➢ Simulation of stall condition

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