Research Objectives

- Develop code for the structural response of a morphing wing
- Have simulation evaluate stress and strain in morphing wing
- Have simulation interface with other aerodynamic simulations
  - Specifically to work with active learning and aerodynamic simulations being developed at A&M
Research Plan

1. Literature search
2. Basic 2D program outputting displacements developed for AERO 306
3. Increase degrees-of-freedom
4. Increase variable inputs
5. Add loading
6. Add drag
7. Validation
8. Verification
Morphing/Perching Background

• Morphing can be found in nature
  – Birds
  – Fish
• Currently we’ve successfully constructed a morphing airfoil

• Perching allows planes to mimic birds in using aerodynamics to brake and land vertically
  - Moving the center of pressure without moving the center of gravity (very much) allows the birds to slow down for landing
• Currently vertical landing only exists using thrust
Background

Micro Air Vehicles:
- (12 inches) small scale
- Slow air speed
- Low weight

Morphing Wings:
- Change in wing shape (allow planes to cruise effectively at multiple speeds)
- One plane instead of many (saves $)
- Change camber, dihedral effect, aspect ratio, leading edge sweep angle
Background

- Cornell
  - Hyper-elliptic cambered span
  - SMA actuators
- NASA Langley
  - ornithopters
- Air force
  - UAV
  - GENMAV
  - University of Florida pocket MAV
- Limited work on morphing micro air vehicles
Sources of Error

• Inputs
  - Modulus of elasticity
  - Moments of inertia
  - Area
• Modeling an airplane wing as a beam
• Formulas for calculating stress and strain
Simulation Tool

• Models morphing as 3D Cantilevered beam
• x, y, and z-axis
• 6 degrees-of-freedom for each node
• Reads point loads (from aerodynamic simulation)
• Calculates
  - K and F matrices
  - Displacements
  - Stress, strain
### Simulation Tool

**Adjustable Input File:**

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**Outputs stress and strain**

**Equations:**

\[
\sigma_{xx} = \frac{P}{A} - \frac{M_y}{I}
\]

\[
M = EI \frac{d^2 y}{dx^2}
\]

\[
\varepsilon = \frac{\sigma}{E}
\]
Conclusions

• Is a good way to evaluate structure response in wings, but not as great for morphing wings

• Simulation relies on moment of inertia and modulus of elasticity inputs in order to calculate stress and strain enabling it to work with any wing setup, but those inputs may be difficult if not impossible to find

• Aerodynamic simulations output must be written into a new input file for structural simulation
Recommendations

If I had it to do over again…

- different language (C++)
- frame rather than beam analysis
Extending the Research

• The simulation needs to be verified (over time)
• A real wing grid needs to be tested on both the aerodynamic and structural simulations
• Faster run time
Lessons Learned

• Research (and graduate studies) requires lots of unstructured time, but allows freedom in where to take the research and how to use it.

• Patience, self motivation

• Plans don’t always work out as planned

• One person cannot eat 3 lbs of steak no matter how tasty it is
References


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