Bio-Inspired Distributed Sensing for Improved Flight Control

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Overview

Motivation: Why Bio-Inspired Distributed Sensing?

Amazing seagull!!!

https://www.youtube.com/watch?v=MZQfxSnOFgA

Motivation: Why Bio-Inspired Distributed Sensing?

- Current UAV autopilot technologies
- Challenges
- Potential use of force and flow information

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- Inertial
- Single point air speed
- GPS
- Vision

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- Intrinsic nonlinear dynamics
- Classic control strategies limitations
- Limitations of inertial controls

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Potential applications

- Availability of aerodynamic variables
  - → Improved flight dynamics model
  - → Stall detection
- Earlier gust detection
  - → Gust rejection/alleviation
- Localised information
  - → Localised control
  - → Load tailoring

Research Problem

Use force and flow sensing to improve performance of UAVs flight control systems.

To achieve this we aim to:

- Develop distributed force and flow a sensing system for a small scale fixed wing UAV
- Integrate force and flow sensing into conventional flight control system architecture
- Measure response of systems to controlled and natural turbulence
- Develop advanced reflexive flight control system

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Previous Research at UoB: Strain sensing

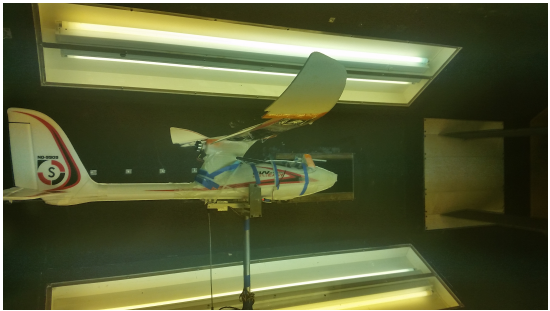

Figure: Strain sensing platform

- 12 full-bridge strain gauges and amplifiers distributed along spar of wing
- Wind tunnel characterisation
- Closed loop free flight
- Outdoor flight testing

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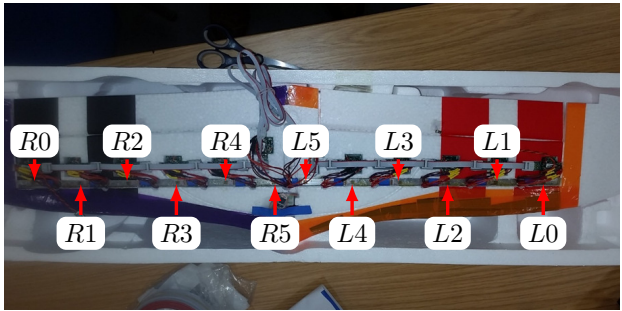

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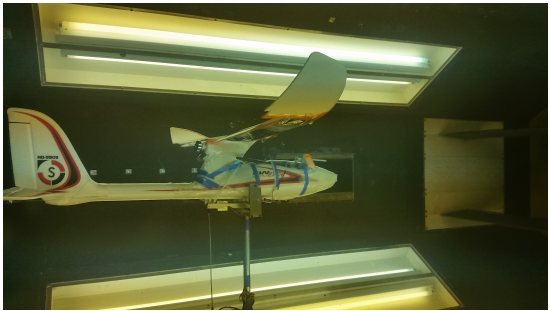

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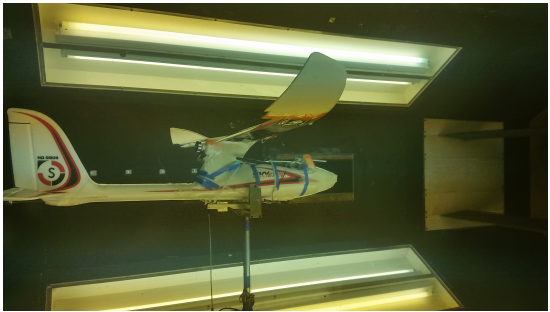

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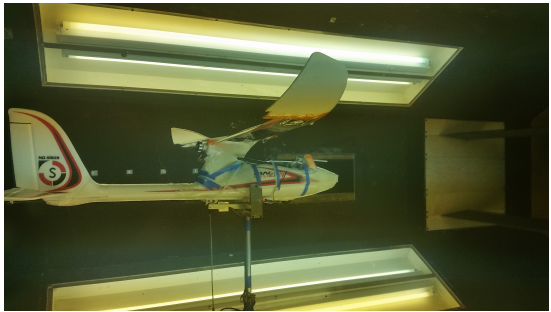

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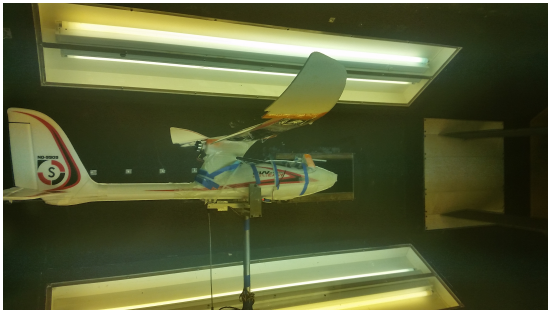

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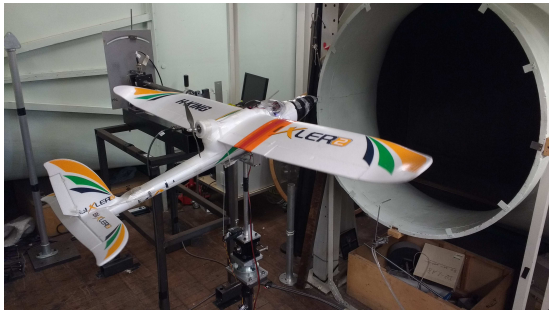

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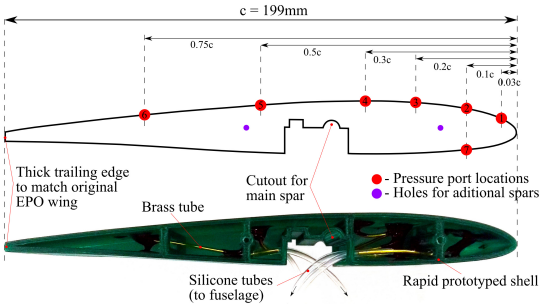

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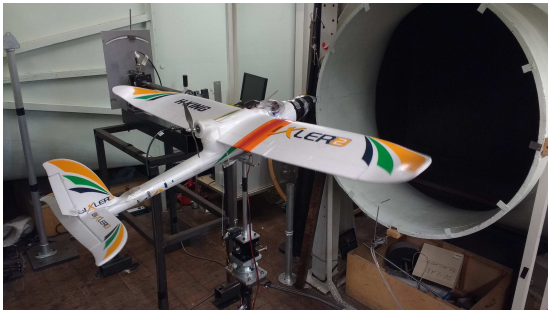

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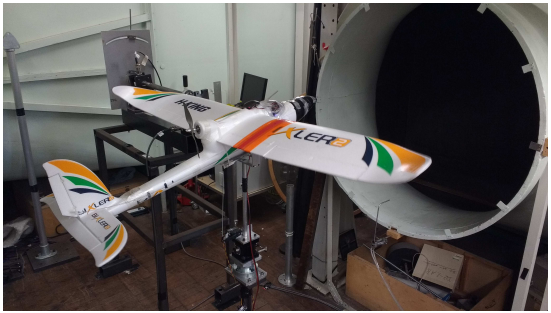

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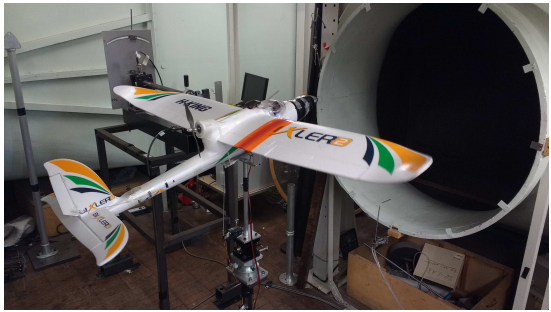

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- Experimental platform(s) with a distributed array of pressure and strain sensors
- Carry out calibration & characterisation (WT & outdoors)
- Design and implement closed loop control algorithms that use information from distributed array

Divided into two phases:

- Phase 1: Wind tunnel experiments using WT model
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Wing model instrumentation:

- Chord-wise array of 30 pressure ports in two sections
- Span-wise array with 16 strain gauges
- Servo actuated control surfaces
- MCU-based data acquisition system using, sampling 100 Hz
- 1-DOF pitch motion servo-driven system for automated motion

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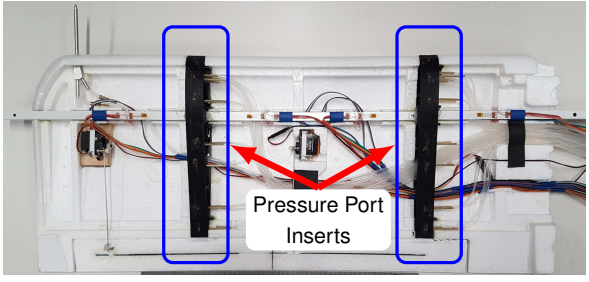

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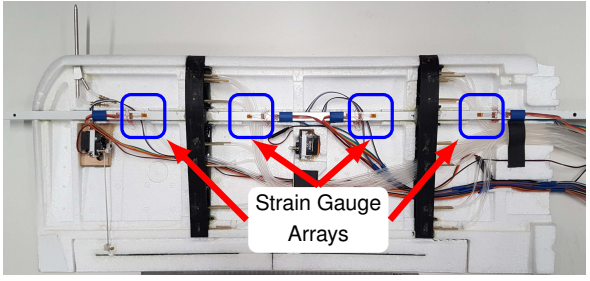

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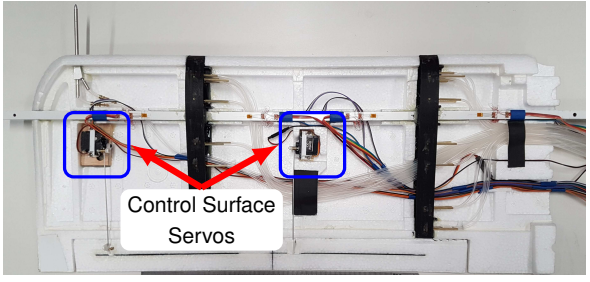

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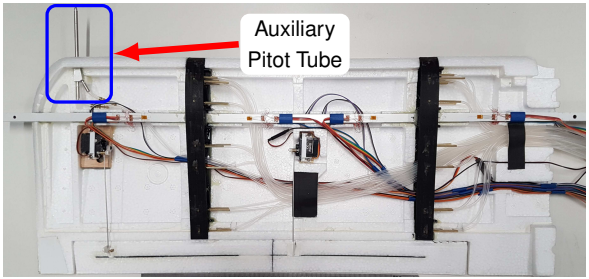

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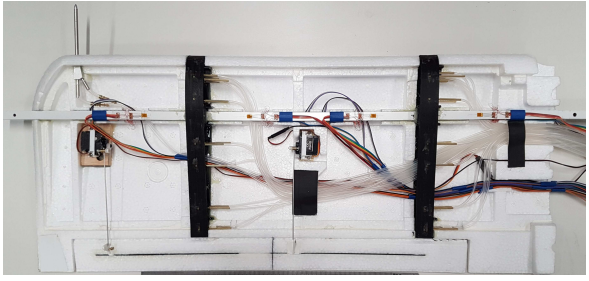

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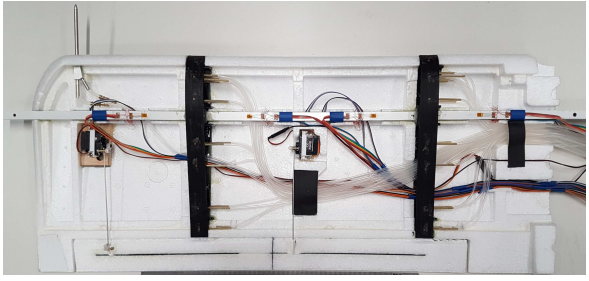

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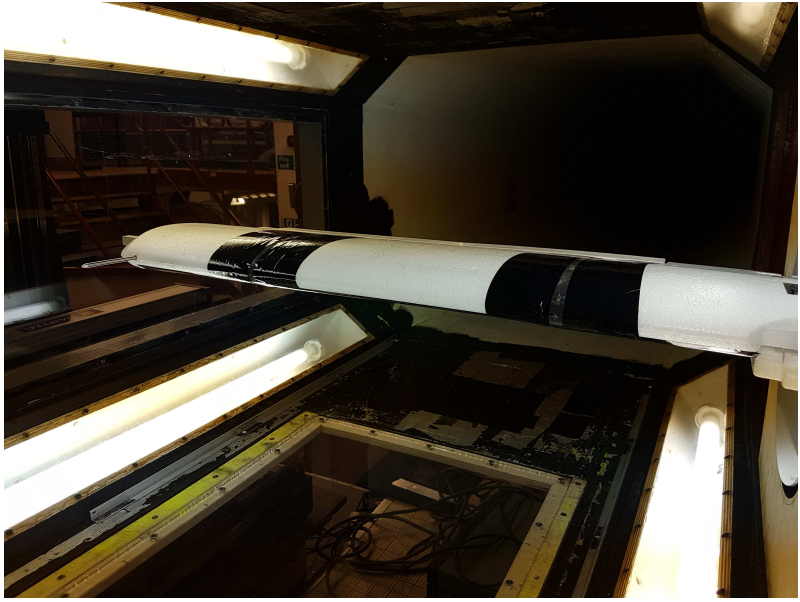

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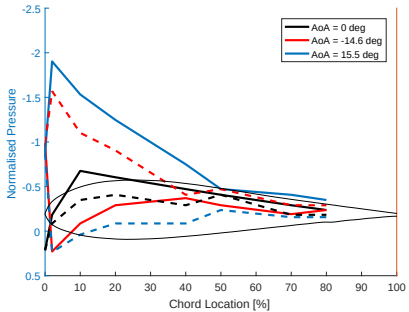

Figure: Chord-wise Normalised Pressure

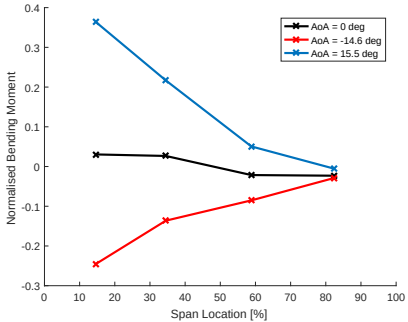

Figure: Span-wise Normalised Bending Moment

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  - Pressure and strain signal show linear response with A_{WT}
  - Shift detection potential
- Strain-based roll control similar performance to IMU based control
- Pitch pressure-based control weaker to IMU based control
  - Information not available using $\Delta\omega$, A_{WT}, shift, non-linearity

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- Phase 2: Flying platform
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