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=MZQfxSn0FgA`

Motivation: Why Bio-Inspired Distributed Sensing?

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

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- Current UAV autopilot technologies
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- Inertial
- Single point air speed
- GPS
- Vision

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Motivation: Why Bio-Inspired Distributed Sensing?

- Current UAV autopilot technologies
- Challenges
  - Intrinsic nonlinear dynamics
  - Classic control strategies limitations
  - Limitations of inertial controls
- Potential use of force and flow information

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- Current UAV autopilot technologies
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- 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

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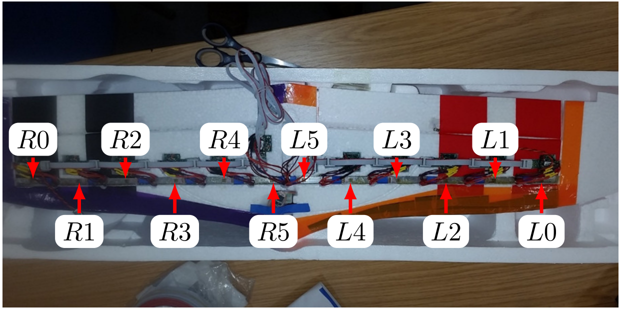

Figure: Strain sensing platform instrumentation

- 12 full-bridge strain gauges and amplifiers distributed along spar of wing
- Wind tunnel characterisation

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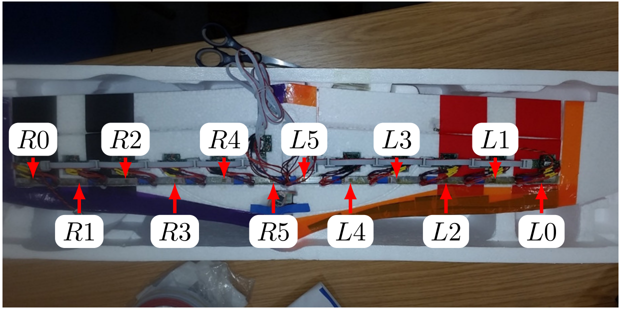

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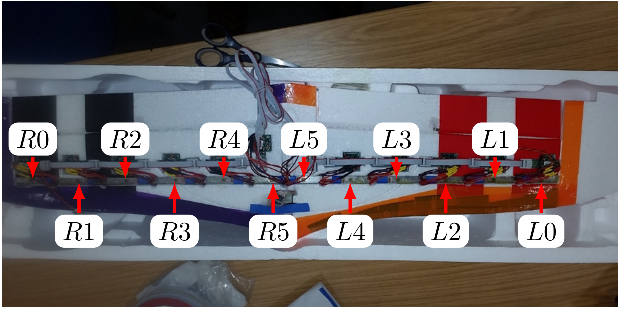

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- Closed loop free flight
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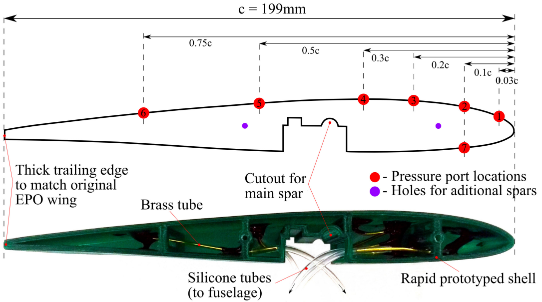

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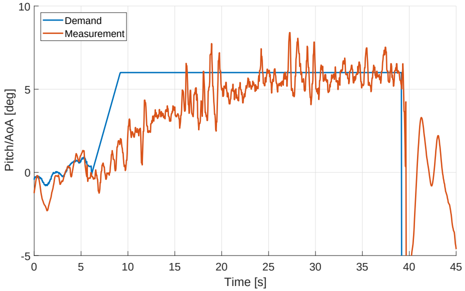

Figure: outdoors angle-of-attack tracking

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- Experimental platform(s) with a distributed array of pressure and strain sensors
- Carry out calibration & characterisation (WT & outdoors)
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Divided into two phases:

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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
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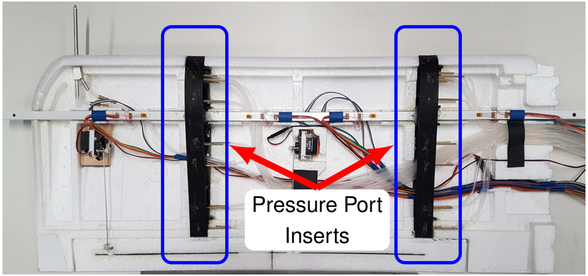

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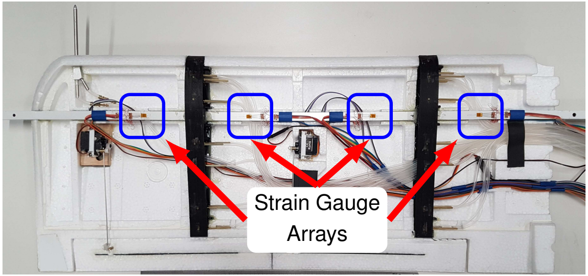

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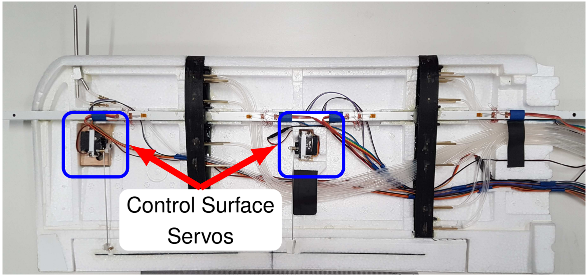

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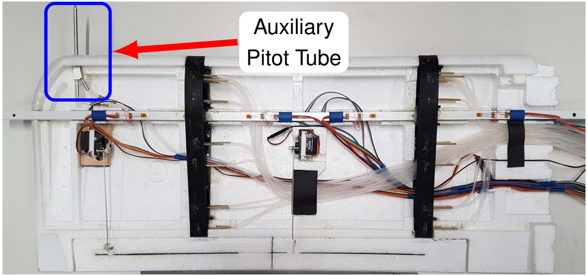

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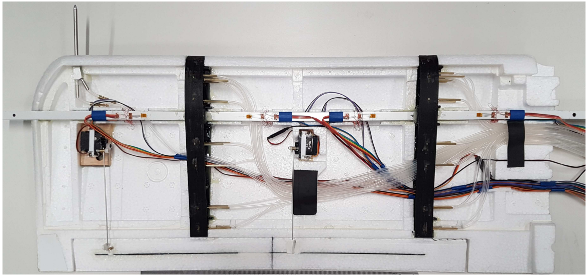

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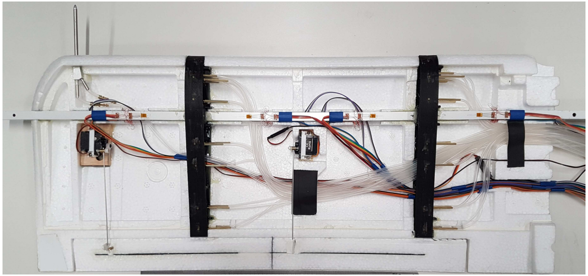

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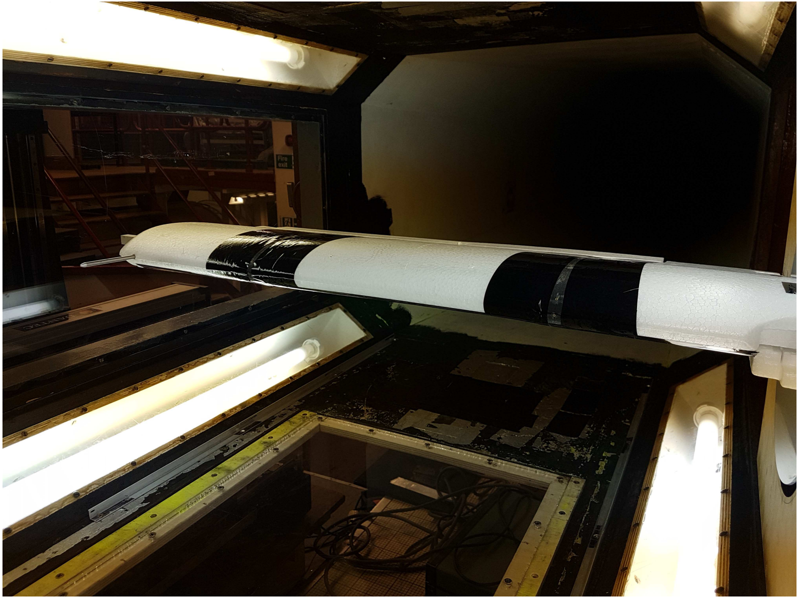
Fire exit

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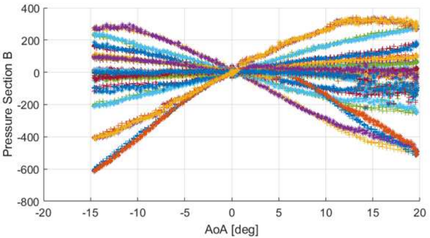
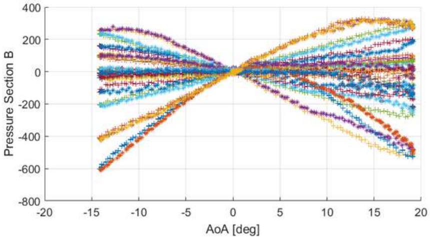


Figure: Pressure response for $q = \pm 20^\circ \mathrm{s}^{-1}$



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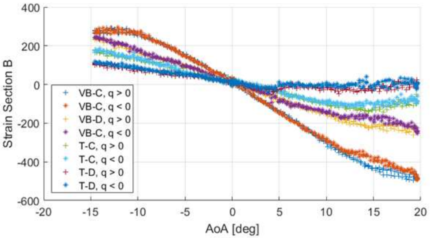
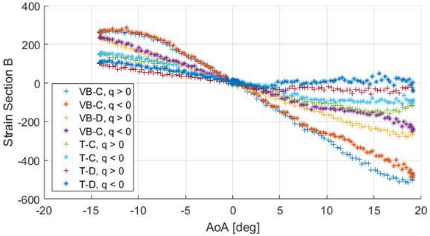


Figure: Strain response for $q = \pm 20^\circ\,\mathrm{s}^{-1}$



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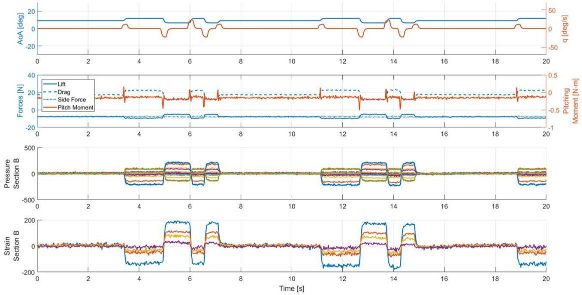

Figure: Pressure & strain response to dynamic input

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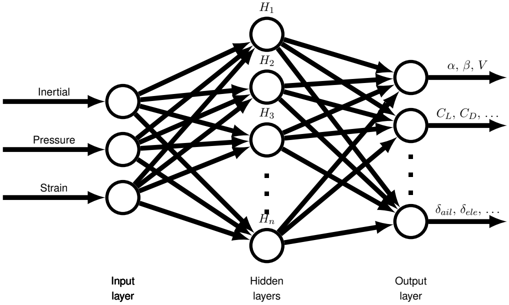

Figure: Possible UAV control strategies

Currently working on:

- Use strain and pressure signals to estimated
  - AoA, airspeed
  - Aerodynamic loads
- Design and implement closed loop control:
  - Classic control architecture (SISO)
  - Algorithm using information from distributed array (e.g. MISO, MIMO)

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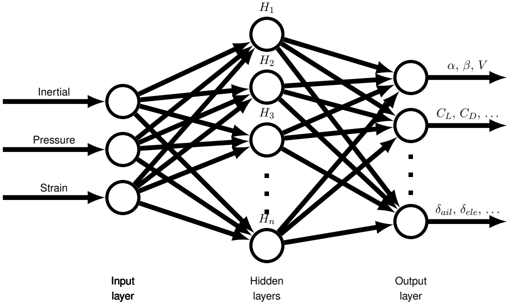

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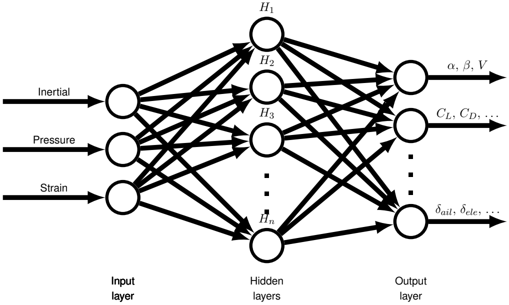

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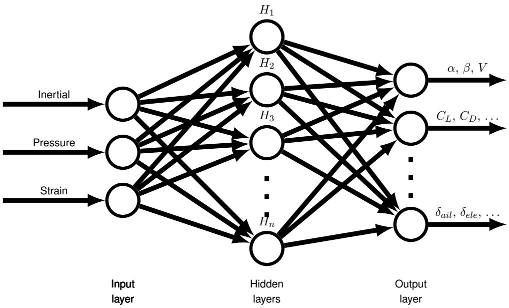

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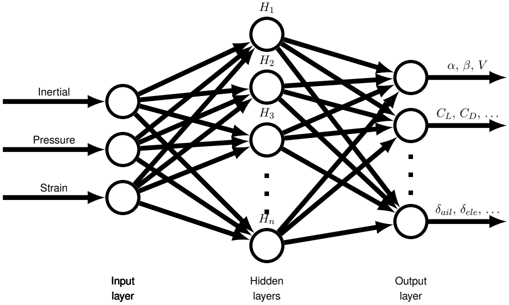

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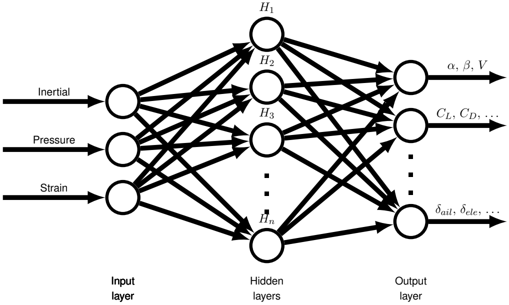

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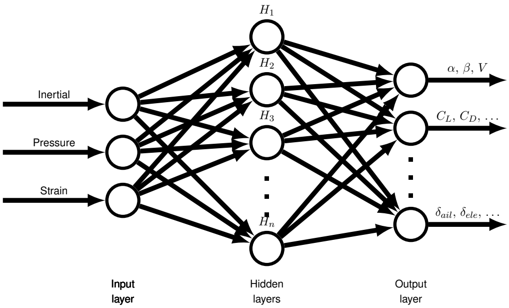

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  - Design and implement closed loop control algorithms
  - Carry out closed loop wind tunnel experiments
- Phase 2: Flying platform
  - Build and instrument flying platform
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Further Work

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  - Design and implement closed loop control algorithms
  - Carry out closed loop wind tunnel experiments
- Phase 2: Flying platform
  - Build and instrument flying platform
  - Wind tunnel experiments
  - Outdoors flight tests

Thank you