Introduction

- The development of micro air vehicles (MAVs) is necessary for various military and civil applications, such as indoor reconnaissance and search-and-rescue.
- An insect-inspired MAV can have improved lift production and manoeuvrability by successfully replicating insect wing kinematics.

Biomimetic Design of Flapping Mechanism

- Flying insects augment steady-state “airfoil” lift with a variety of unsteady aerodynamic mechanisms.
- The optimum wing kinematics required to enact these aerodynamic mechanisms are unknown so mimicking values of the main kinematic parameters of suitable insects was used as a design starting point for a flapping mechanism.
- Identifying which kinematic parameters are adjusted for manoeuvres and flight stability is critical to this approach.
- Also, copying insects’ use of elastic storage during wing strokes and resonant wing beat frequency is beneficial to optimising the MAV’s energy efficiency.

Parallel Crank-Rocker (PCR) Mechanism

- In theory linear actuator-driven flapping mechanisms are optimal since they can be under-constrained, highly adjustable and operated at resonance.
- However, limitations in linear actuator performance means the majority of existing flapping mechanisms have been rotary-input with fixed output motion.
- Unlike previous mechanisms, the PCR’s output is partially-constrained, meaning the angle of attack can be adjusted dynamically.
- The PCR mechanism is compact and produces an integrated flapping and pitching output motion.
- PCR is driven through the cranks (labelled as inputs A and B, right), with a phase lag between them to control the angle of attack.

PCR Prototype Development and Testing

- PCR mechanism developed into a non-airborne experimental test-rig.
- Driven by 0.75W DC motor with angle of attack currently manually adjustable.
- Near-MAV scale with 75mm long wings and dimensions of 60 x 25 x 25mm.
- Total mass of 46g (moving parts = 10g).
- Three stages of testing so far:
  1. Wing kinematics verification
  2. Lift force measurement
  3. Wind tunnel flow visualisation

Conclusions and Future Research

- A novel flapping mechanism has been presented that allows control of wing angle of attack, a key kinematic parameter for manoeuvring and flight stability.
- Prototype produced 3.35g of lift in hovering configuration.
- Wing beat frequency lower than expected so optimised elastic storage to be implemented to increase motor speed and hence lift.
- Particle Image Velocimetry to be used to quantify flow fields around wings.
- Large strain Electro-Active Polymer actuators being developed for a highly adjustable, under-constrained flapping mechanism.