Workshop on "Resilient and Long-Term Autonomy for Aerial Robotic Systems"

Bioinspired Aerial Robots Session

Introduction

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Bioinspired Aerial Robots

Bio-inspired Flight

- Nature allows us
  - To lose in the mystery surrounding it & its ingenious solutions
  - To design and develop Bio-inspired solutions inspired by birds and dragonflies.
  - To learn in a safe and less intrusive way.
  - Studying flapping flight and developing flapping wing robots
- Currently:
  - Bio-inspired technology is mature, and it is now ready for real world applications
  - Flapping wing drones for non-intrusive and safe drone solutions in shared with humans.
  - The possibilities are infinite

Bioinspired Aerial Robots

Conventional Drone

- Fast spinning
- Propellers need to be protected.
- Interaction is dangerous for humans
- Any impact on the propellers increases the risk of a crash.
- High-pitched buzzing noise typical of drones.

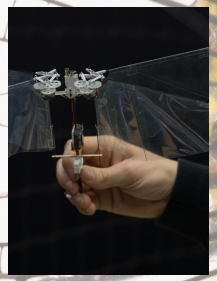
Bio-inspired Flight

- Flying with soft wings in periodical movements.
- Mid-air collision,
  - Wings avoid the damages in the interaction with the environment
  - Avoiding unstable flight crashes.
- The flapping wings also produce a lower-frequency humming sound
- Flapping flight works better at smaller scales
- Are lightweight
- The wing area allows gliding in case of power failure reducing the damages on the crash
- Lower payload











Bioinspired Aerial Robots

Bio-inspired Flight

- Efficiency - flight time - pay load → Open research question
  - Flapping wing designs → still very Young
  - Far from reaching an optimal match between motor, transmission, wing motion and wing shape
- Complex Aerodynamics → Flapping wing aerodynamics are unsteady

  Challenge lies in:

  - Developing an appropriate model that would capture all the phenomena, including
    - Interaction of the aerodynamics &
    - Structural dynamics of the flexible wings.
  - Flapping-flight, inherently complex aerodynamics are actually beneficial -> most prominent flow feature is
    - A leading-edge vortex increasing its lift coefficient.
    - Interaction of the wing with the vortices shed can help recover some of their energy, improving further the overall power efficiency.

These complexities -> rely mostly on experiments and (systematic) trial and error approach

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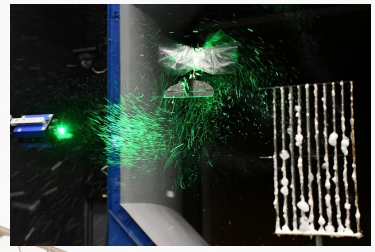
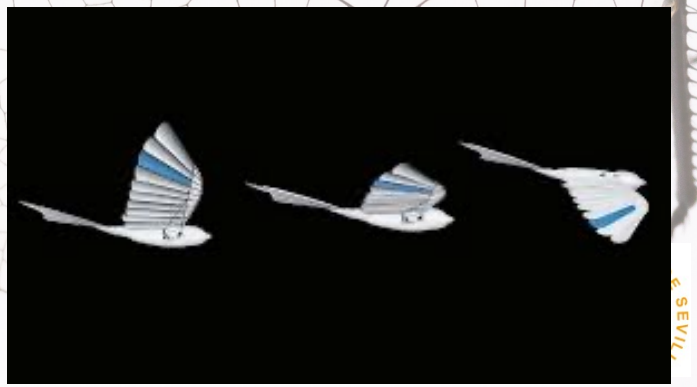
Bio-inspired Flight → Scaling physics

- Looking into nature
  - The smaller & lighter → faster flapping frequency and the easier it is to hover.
  - Large animals → hovering flight is very power-demanding, and sustain it only briefly.
- Currently
  - To go smaller are mostly limited by the available actuator technology,
  - But the physics of flying would be even more favorable.
- For carrying large payloads on long distances
  - Gliding flight → large birds master incredibly well.
  - If hovering flight & agility are important, this gets better at small scales.
    - ➢ carrying additional sensors or vision system for higher autonomy is possible.
- Noise
  - Stopping the wings from flapping and switching to gliding flight is the best option,
  - Learn from nature: night predators such as owls evolved their wings to be virtually silent.





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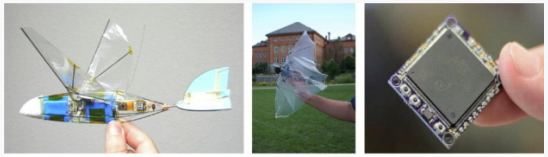
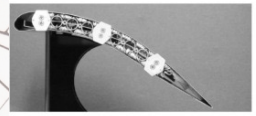
Bio-inspired Flight → New materials & production techniques



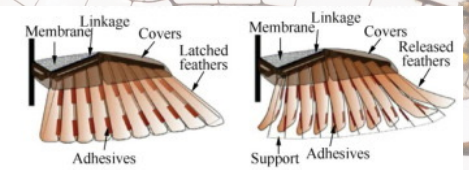
(a) Microbat [7] (b) Bat Bot (B2) [41] (c) B2's MCB [42]

- Technological advances made in the past 20 years, driven by mobile technology
  - Lightweight materials such as carbon fiber composites and apply techniques such as 3D printing
  - High-energy-density batteries
  - Powerful yet lightweight and energy efficient micro-computers and sensors
  - Miniature and lightweight sensors
  - Soft materials
  - Bio-inspired Soft Aerial Robots using adaptive Morphology for High-Performance Flight

(a) MFC actuation device [72]

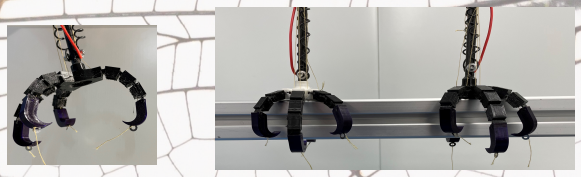


(b) SMA actuated cellular vertebral structure [75]



(a) In latched state (b) In unlatched state

- Despite the recent developments in drones-> Lighter and more powerful DC motors
  - Their power efficiency drops at small scales making the achievable flight times short and many times impractical.



Bioinspired Aerial Robots

Bio-inspired Flight → Target markets

- ***Moving towards a roboticized society and drones become part of our environments.***
- ***Bio-inspiration, introduce a new class of flying robots, just like natural fliers.***
  - ***Drones do not need to be scary and annoying.***

Flapping-wing robots will become a new class of drones

Indoor applications

- It is needed a safe and un-intrusive robot that can
  - Fly near people
  - That is resilient to minor collisions.
- Stock monitoring in warehouses,
- In greenhouses to monitor plants-> even pollinate
- Applications like a personal flying guide in a museum or a store.

Outdoor applications

- Co-working with operators for inspection and maintenance
- Guide a person.
- Health control and monitoring.

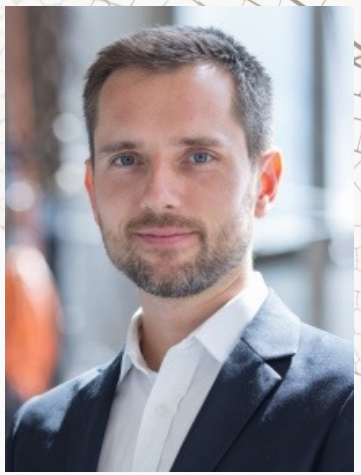
Bioinspired Aerial Robots

Speakers

Prof. Gupta Satyandra

University of Southern California

Prof. Mirko Kovac



Imperial College London

Prof. Aníbal Ollero

Universidad de Sevilla

Panel Discussion

- Enrico Ajanic (EPFL)
- Speakers and attendants

Thank you for your attention

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