Bionic principles applied to MAV design

Introduction

For this class, our team has been tasked to design a MAV (Micro Air Vehicle) following principles from the field of bionics.
It had to be autonomous hand able to perform air-to-water transitions.

Scoping

For the Scoping of the project we referred to the biomimicry modeling wheel (Fig.1). It allowed us to structure our scoping into three distinctive categories:

- Context definition
- Function identification
- Life's principle integration

Context definition

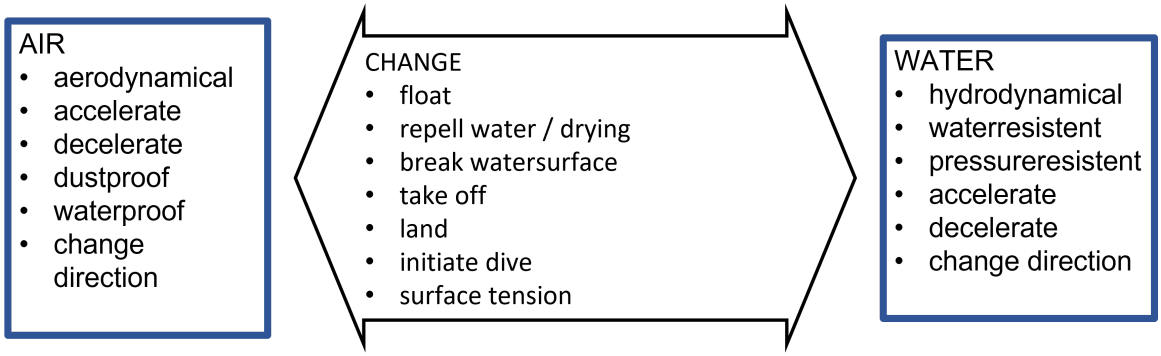
We identified two main contextual areas for our project, and several sub-context, while also considering a transitional context.

The following table summarizes our work in this regard.

AIR	TRANSITION	WATER
WEATHER SUNLIGHT TEMPERATURE HUMIDITY RAIN WIND ICE&SNOW	**DENSITY**	**CONDITIONS** water current waves
HAZARDS animals/insects moving objects abrasives people	**SURFACE TENSION**	**HAZARDS** animals moving objects
TOPOLOGY mountains forests glaciers buildings		**TOPOLOGY** lake/river depth stones/rocks plants

Function's identification

To have a better grasp on what the MAV will have to be able to perform, it's functions had to be placed within their contexts (Fig.2).



Life's principle integration

When looking at how to integrate/use natural engineering solution, we identified the following Life's principle that we wanted to integrate into the project:

1. adapt to changing conditions
2. Change between air and water
3. Temperature change
4. Altitude change
5. be resource efficient
6. Navigation for over and underwater

Discovering

The discovering phase is all about understanding the technical solutions that the natural world has to offer after millions of years of natural evolution.
The objective was to find applicable biological models or answers to the issues and functions that the MAV would have to overcome/perform.

Natural Model discovery

We approached this trough so called "*lenses*", which encapsulate abstract questions into itemizable bits.
so far, we looked through the following lenses:

- **Function Lense**
  How would nature communicate under water / in the air?
  How would nature transition from air to water?
  How would nature navigate under water?
- **Ecological Lens**
  water, air, animals
- **Operating Conditions**
  freezing water, high altitude changes
- **Naturalist Lens**

Abstracted Biological Strategies

Looking for interesting biological solutions to our problems, we identified the following:

- *Water Strides* – Communication by vibration
- *Brown Pelican* – Beak slices into surface at high speed
- *Big Brown Bats* – Navigating via sonar
- *Garden warbler* – Navigation via magnetic fields
- *Spiders* – Flying with silk in negativly charged surface
- *Goldenrod Gall Fly* – Internal antifreeze protein

The following links are relevant:

https://asknature.org/strategy/beak-protects-during-dives/
https://asknature.org/strategy/deep-divers-manage-temperature/
https://asknature.org/strategy/leg-position-initiates-dive/
https://asknature.org/strategy/spinning-makes-safe-dive/
https://asknature.org/strategy/beak-provides-streamlining/
https://asknature.org/strategy/body-protected-from-diving-impact/
https://asknature.org/strategy/legs-reversibly-stick-to-surfaces-underwater/
https://asknature.org/strategy/olfactory-cues-aid-in-prey-detection/
https://asknature.org/strategy/moths-alter-flight-to-deal-with-winds/
https://asknature.org/strategy/sonar-adjusts-to-surroundings/
https://asknature.org/strategy/navigation-underwater/
https://asknature.org/strategy/eyes-see-magnetic-fields/
https://asknature.org/strategy/spiders-surf-on-electric-fields/
https://asknature.org/strategy/how-flies-survive-freezing/
https://asknature.org/strategy/legs-detect-small-vibrations-for-communication/
https://asknature.org/strategy/body-designed-for-fast-efficient-swimming/