Batoid Dynamics

Bioinspired Structures | Undulatory Propulsion

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INTRODUCTION

Figure 1. DARPA Manta Ray UAV

- Novel designs for underwater vehicles encourage the investigation of new propulsion systems. Batoids are fast, maneuverable, and highly efficient.
- The hydrodynamic merits are better established (Fish, 2016), but the structural dynamics have yet to be thoroughly investigated.

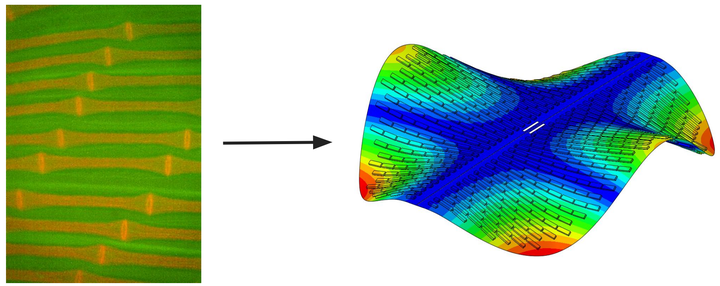

Figure 2. Left: Fluorescence image of a section of skate fin skeleton. Right: Modeshape of a batoid inspired structure

- Conventional undulatory propulsion designs require complex actuation and control.
- Our previous work demonstrates that batoid inspired structural characteristics undulate with simple excitation.
- We propose that Batoids exploit shape and structure induce, facilitate, and control undulatory motion.
- We intend to investigate this across the vast morphological and functional diversity (Martinez, 2016) of Batoids.

METHODS

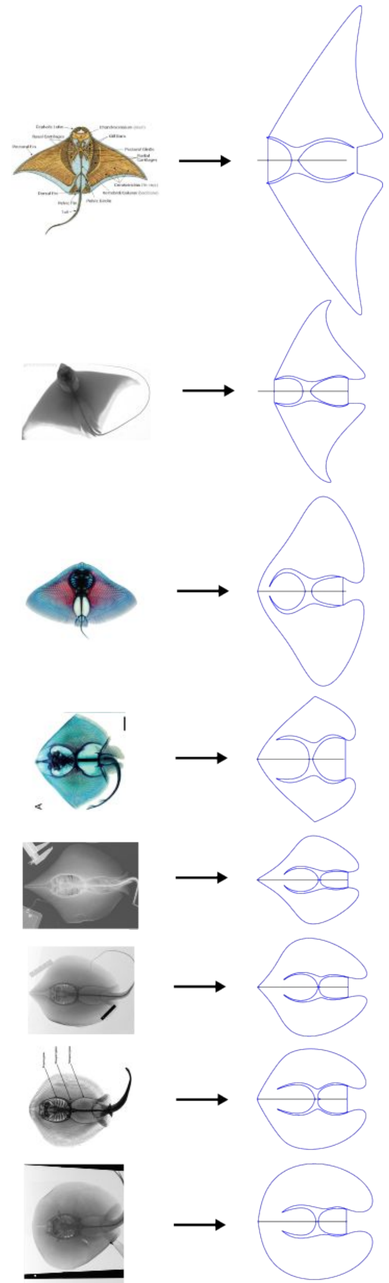

Figure 3. From Top to Bottom: *Mobula birostris, Aetomylaeus nichofii, Gymnura crebipunctata, Raja clavata, Dasyatis acutirostra, Himantura imbricata, Urobatis maculatus, Potamotrygon iwamae* (Image sources in Acknowledgements)

- A simplified approach to characterize the fundamental dynamics of different species of batoids:
- We use Bezier functions to model the curvatures of the pectoral fin, and extended pectoral girdle.
- Laser cut flat plates can be stacked to create simple bi-stiffness structures for dynamic analysis.

DISCUSSION

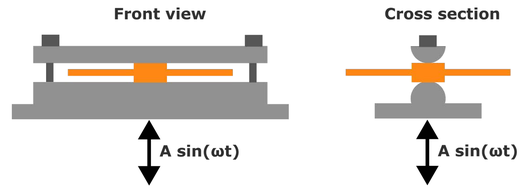

Figure 4. Flat plate model modal test rig

- Using optical dynamic techniques we can characterize the modes and modeshapes of various morphologies.
- This will inform our future work exploring and designing more complex undulatory structures:

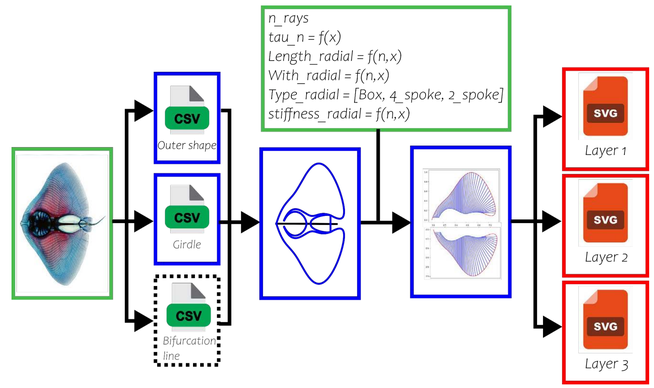

Figure 5. Workflow for designing batiod inspired structures with control over fin ray arrangement and radial stiffness matrix

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