COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

Mohammad Irfan Uddin

for the degree of Doctor of Philosophy (Ph.D.)

"Swimming Control of an Underwater Vessel with Elongated Ribbon Fin Propulsion"

October 13, 2022, 2:00 pm
[Zoom Meeting](#)
Meeting ID: 884 4297 4082
Passcode: CDnZ67

DEPARTMENT:
Ocean and Mechanical Engineering

ADVISOR:
Oscar M. Curet, Ph.D.

PH.D. SUPERVISORY COMMITTEE:
Oscar M. Curet, Ph.D., Chair
Manhar Dhanak, Ph.D.
Edgar An, Ph.D.
Eric Engeberg, Ph.D.
Siddhartha Verma, Ph.D.
Amneet Bhalla, Ph.D.

ABSTRACT OF DISSERTATION
Swimming Control of an Underwater Vessel with Elongated Ribbon Fin Propulsion

Navigation of unmanned underwater vehicles in coastal zones, tight spaces and close to structures such as ports, ship hulls and pipelines remains a difficult challenge. Currently Autonomous Underwater Vehicles (AUVs) use a variety of techniques for motion control, including single thrusters with diving planes or hydrofoils, robotic wrists, or a moving mass. However, these techniques provide limited maneuverability. The objective of this work was to understand the mechanics of elongated fin propulsion for swimming and motion control of underwater vehicles. This bio-inspired propulsion is used by several fishes that swim by undulating a thin and elongated median fin that allow them to perform forward and directional maneuvers. In the first chapter we present the literature review as well as the mathematical formulation using thrust vectoring approach to achieve forward and turning maneuvers. In the second chapter, we used a robotic vessel with elongated fin propulsion to determine the thrust scaling and efficiency. Using precise force and swimming kinematics measurements with the robotic vessel, the thrust generated by the undulating fin was found to scale with the square of the relative velocity between the free streaming flow and the wave speed. In addition, a hydrodynamic efficiency is presented based on propulsive force measurements and a model on the power required to oscillate the fin laterally. The model for propulsive for was compared against experiments. In the third chapter, we experimentally investigated collision avoidance by the bio-inspired robotic vessel. Three different collision avoidance strategy based potential field method were tested with the robotic vessel and the results are presented and compared. It was found that having a circular sensing envelope around the robotic vessel helps to smoothly transition to the target path after avoiding collision with an obstacle. In the fourth chapter, we studied swimming in a perturbed flow where the robotic vessel swims behind a moving circular cylinder that leaves a von Karman vortex street in its wake. Experimental results suggest that robotic vessel with elongated median fin can harness energy from the incoming vortices and requires less energy compared to when it is swimming in calm water. This will encourage new research to utilize the flow interaction between multiple robotic vessels with bio-inspired propulsion moving in close formation. This will help decide the optimal formation for multiple robotic vessels with bio-inspired propulsion unit swimming in close formation.

BIOGRAPHICAL SKETCH
Born in Chittagong, Bangladesh
B.Sc. Engg., Bangladesh University of Engineering and Technology, Dhaka, Bangladesh, 2013

M.S., Norwegian University of Science and Technology, Trondheim, Norway, 2015
Ph.D., Florida Atlantic University, Boca Raton, Florida, 2022

CONCERNING PERIOD OF PREPARATION & QUALIFYING EXAMINATION

Time in Preparation: Fall 2017-Fall 2022

Qualifying Examination Passed: Summer 2018

Published Papers:

M. Uddin, G. Garcia and O. Curet, "Force scaling and efficiency of elongated median fin propulsion," Bioinspiration & Biomimetics, vol. 17, no. 4, p. 046004, 2022.

M. I. Uddin and O. M. Curet, "Modeling and Control of a Bio-Inspired Underwater Vessel with Undulating-Fin Propulsion," in OCEANS 2018 MTS/IEEE, 1-7, Charleston, 2018.

M. Uddin, G. Garcia and O. M. Curet, "Collision avoidance using elongated fin propulsion", submitted to Journal of Ocean Engineering.
M. Uddin, G. Garcia and O. M. Curet, "Swimming performance of elongated undulating fin propulsion in perturbed flow" (in preparation)

G. Garcia, M. Uddin, S. Verma and O. Curet, "Reinforcement Learning for Maneuver Control of a Bio-Inspired Vessel with Undulating Fin Propulsion," in The 32nd International Ocean and Polar Engineering Conference, Shanghai, 2022.

M. Uddin, G. Garcia and O. M. Curet, "Scaling law of ribbon fin propulsion," in Bulletin of the American Physical Society, Chicago, 2020.

M. I. Uddin and O. M. Curet, "Yaw Turning Experiments of a Bio-Inspired Vessel with Undulating Fin Propulsion," in Bulletin of the American Physical Society, Seattle, 2019.

M. I. Uddin and O. M. Curet, "Hydrodynamic and Maneuvering Control of an Underwater Vessel with Undulating-Fin Propulsion," in Bulletin of the American Physical Society 63, Atlanta, 2018.

G. Garcia, M. Uddin and O. Curet, "Cambered Undulating Fin for Heading Control," in APS Division of Fluid Dynamics Meeting Abstracts, 2020.