IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**CFD Study on Hydrodynamics of Fish like Locomotion using Level Set based Immersed Boundary Method**	
Project Number	**IMURA0413**	
Monash Main Supervisor (Name, Email Id, Phone)	Dr. John Sheridan, Professor of Fluid Mechanics John.Sheridan@monash.edu +61 3 9905 4913	*Full name, Email*
Monash Co-supervisor(s) (Name, Email Id, Phone)		
Monash Head of Dept. (Name,Email)	Professor Chris Davies Chris.Davies@monash.edu +61 3 990 54929	*Full name, email*
Monash Department:	Department of Mechanical & Aerospace Engineering	
Monash ADRT (Name,Email)		*Full name, email*
IITB Main Supervisor (Name, Email Id, Phone)	Dr. Atul Sharma, Associate Professor atulsharma@iitb.ac.in, +91 22 2576 7505	*Full name, Email*
IITB Co-supervisor(s) (Name, Email Id, Phone)	Dr. Amit Agrawal, Associate Professor amit.agrawal@iitb.ac.in, +91 22 2576 7515	
IITB Head of Dept (Name, Email, Phone)	Dr. R. P. Vedulla, Professor head.me@iitb.ac.in, +91 22 2576 7500	*Full name, email*
IITB Department:	Department of Mechanical Engineering	

Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?

(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture
2. Infrastructure Engineering
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

Define the problem

We propose to use our in-house 2D code - based on novel level set method based immersed boundary method [1] - for CFD simulation and analysis of fish like locomotion. The 2D simulations are proposed for flow generated by translating (with a velocity u_∞) and undulating fish-like body - modelled as NACA 0012 hydrofoil. The velocity u_∞ and chord length of hydrofoil (NACA0012) C are taken as non-dimensional velocity and length scale, respectively. Shape of hydrofoil needs to be transformed into fish-like body by adding time varying undulations (ΔY) at various X locations from the head of hydrofoil along the axis, given as

$$\Delta Y = A(X)\sin\left\{2\pi\left(\frac{X}{\lambda}-\frac{St\tau}{2A_{\max}}\right)\right\} \quad \text{where } St=\frac{F\,2A_{\max}}{u_\infty}$$

where A_{max} is the maximum amplitude of oscillation at tail, X is distance from the head of hydrofoil along the axis, λ is the wavelength of the wave travelling across hydrofoil, F is the frequency of undulation, τ is the time, St is the Strouhal number. Thus, after giving time varying undulations in vertical direction, the shape of fish-like body is obtained.

Thus, other than the Reynolds number ($Re=\rho\, u\infty C/\mu$), the other governing parameters for a flow generated by a fish-like locomotion are equation of motion for undulation ($A(X)$), wavelength (λ) of the wave traveling across hydrofoil, frequency (F) of undulation and maximum amplitude of oscillation (A_{max}).

Project aims

Define the aims of the project

1. The in-house code will be parallelized for a GPU (graphical processor unit) based parallel processor and a parallel performance study will be done.

2. A detailed parametric investigation - for various flow, geometric as well as locomotion governing flow parameters - will be done for the CFD simulation on hydrodynamics of single fish like locomotion.

3. The 2D simulations will be also be done for various configuration of group of fishes.

4. For single as well as group of fish like locomotion, a detailed CFD analysis will be done for a unified cause-and-effect study.

Expected outcomes

Highlight the expected outcomes of the project

1. Understanding of the role of the various governing parameters in the fish like locomotion - on the mechanism of propulsion and propulsive efficiency - will be one of the major outcome of this study.

2. It will also provide guidelines for efficient operating conditions and design of Autonomous Underwater Vehicles (AUVs).

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

Advanced computational engineering, simulation and manufacture: The present work involves a detailed computational fluid dynamics simulation as well as analysis on hydro-dynamics of fish like locomotion; and will provide guidelines for efficient operating conditions and design of Autonomous Underwater Vehicles (AUVs).

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

QUALIFICATION: The student should have BTech./MTech. in Mechanical/Aerospace/Chemical/Civil Engineering.

CAPABILITIES: Course on advanced fluid dynamics and computational fluid dynamics is desirable. Furthermore, experience in developing or working with in-house computational fluid dynamics code will be helpful.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

We had already interacted with Prof. John Sheridan (Monash University) in this regard and he is interested in this project. Find attached our email interaction in this regard.