QUB - Mechanical and Aerospace Engineering PhD Project 2019-2020

Title: High Fidelity Computational Tools for Swimming Hydrodynamics

Project description:

Swimming and flying are ubiquitous in nature. The ability of an object or a body to propel itself forward by adjusting its kinematics seems to be a glaring impossibility at first. Nature however provides us with a *medium* that responds to changes of the body, and these changes are then reflected back on the body itself. For flying, this *medium* is air and for swimming, it can be water or any other liquid (biological flows to be specific). Swimming as applied to competitive sports is thrilling, and for the fluid dynamicist it is a conglomeration of highly non-linear phenomena, ranging from wave breaking, bubble entrapment to beautiful vortical structures.

Computational tools to understand this flow physics or hydrodynamics is gaining maturity with the advent of industry standard open source fluid dynamics codes such an OpenFOAM. However, for swimming specific applications, there still exists large opportunities for specific development. For example, the tumble turn of a swimmer or the transition to break-out involve large body deformation which calls for the usage of immersed boundary methods (IBM). Moreover, immersed boundary methods require a good Cartesian grid near the body to capture the actual geometry of body that is being modelled. Overset grid based methods can be used in this case where there are several overlapping grids, with the finest possible grid in the vicinity of the body. This project will leverage on a very primitive, existing *in-house* immersed boundary overset grid solver based on OpenFOAM, to be used for complicated swimming like applications. Detailed modifications to the code including verification and validation will be conducted.

Physical aspects that can be studied(but not limited to) are as follows:

1. Optimal body postures during the dive entry to the break-out phase.
2. Hand and head positions during the swimming phase.
3. Optimal time for the turn.

Numerical aspects(Not limited to the following):

1. Effect of turbulence modelling for practical predictions purposes.
2. Multiphase flow (effect of waves, water depth etc.)
3. Meshing strategies (Overset, immersed boundary).

Further collaboration with UK Sport is anticipated based on the development of this project. Computational tools developed for this framework can also be used for biological, offshore and marine applications.

Aims and Objectives:

The aim of this project is to develop a fast and accurate way of predicting swimming performance based on computational fluid dynamics (CFD) tools. Specifically, the objectives are as follows:

1. Establish a semi-automated computational framework for assessing swimming performance.
2. Fine-tune the computational framework to meet the verification and validation criteria.
3. Understand the physics – What is actually happening for different kinematical situations?
4. Propose improved methodologies to improve performance (in terms of drag or any other parameter that is relevant to the motion).

Key skills required for the post:

1. Basic fluid dynamics theory
2. Basic computational fluid dynamics – knowledge of commercial and open-source software
3. Knowledge of programming (C/C++/MATLAB) (C++ Considered an advantage)
4. Good written communication skills.

Key transferable skills that will be developed during the PhD:

1. Advanced knowledge in applied CFD
2. Ability to work in groups
3. Problem solving ability
4. Management of the assigned projects in a timely manner.

Lead supervisor:	Dr. Dominic D. J. Chandar
Other supervisor(s):	Dr Marco Geron
Guaranteed stipend:	£15,009
Conditional top-up available:	

PhD students in the School have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.