E201/ME160 UC Berkeley Ocean Engineering Seminar

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Time-spectral finite element methods for CFD

By

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Friday, January 26th, 2024, Room: 3110, Etcheverry Hall
2:30- 4:00 PM

Abstract:

Flow dynamics around a vessel propeller that rotates, the blood flow in the human body caused by the rhythmic beating of the heart, and the reciprocal flapping motion of a fishtail are just a few examples of time-periodic flows. In this talk, I discuss the possibility of simulating these flows in the time-spectral (frequency) domain. I argue that such a shift in formulation can present a significant advantage over conventional methods that are formulated in time. I demonstrate this point through a realistic blood flow modeling problem, where I show the flow is well-approximated using a handful of Fourier modes. That small number, when compared to thousands of time steps required in a conventional computational fluid dynamics (CFD) solver, implies orders of magnitude reduction in the number of computed unknowns. The result is a method that reduces the cost of a typical cardiorespiratory simulation from days to hours. A significant portion of this presentation will be devoted to the finite element method for solving the Navier-Stokes equations in the frequency domain. That includes introducing a method that remains stable in strongly convective flows while maintaining computational efficiency in solving a large coupled system of nonlinear equations.

Speaker Biography:

Dr. Esmaily has been an Assistant Professor in the Department of Mechanical and Aerospace Engineering at Cornell University since 2018. Before joining Cornell, he worked as a Postdoctoral researcher at the Center for Turbulence Research at Stanford University, where he studied particle-laden turbulent flow. In 2014, Dr. Esmaily obtained his Ph.D. from the University of California, San Diego, where he developed computational methods to optimize an operation performed on pediatric patients. His lab's ultimate objective is to build advanced computational methods for modeling cardiovascular flows to facilitate utilization of this technology on a patient-specific basis.

Hosted by: Prof. Reza Alam, (reza.alam@berkeley.edu)