סמינריון

הנך מוזמן/ת להרצאה סמינריונית של הפקולטה להנדסת מכונות, שתתקיים ביום ד' 17.07.2019
(י"ד בתמוז, תשע"ט), בניין דן קאהן, חדר 217, 13:30.

מרצה: אורן ויזל

מנחה: פרופ'/ח יזהר אור

על הנושא:

Optimal control, optimization and asymptotic analysis of simple microswimmer models

The seminar will be given in English

תקציר ההרצאה :

Recent advances in micro- and nano-technologies have accelerated the possibility of creating microscopic swimming devices for medical applications. Such robotic swimmers can be used for targeted drug delivery, tumor detection, assisting sperm motility and more. Importantly, the nature of fluid-swimmer interaction in microscopic scale, where inertial forces are negligible and viscous effect are dominant, calls for methods of propulsion, actuation and control that are drastically different from the conventional ones normally used for the design of large-scale swimming devices. Theoretical analysis of the dynamics and control of microswimmers using simplified mathematical models provides a way of optimizing swimmer's geometries and actuations that lead to more efficient swimming.

Our research begins with studying a simple mathematical model of microswimmer, namely, Purcell's three-link swimmer. First, we employ asymptotic analysis in order to derive approximate expressions for the swimmer's displacement as well as energy expenditure and efficiency. This allows us to obtain optimal stroke amplitudes and optimal designs of the swimmer geometry. Some of the theoretical results have been demonstrated experimentally using a macro-scale robotic prototype of the three-link swimmer in viscous silicone fluid.

Next, we utilized variational methods of optimal control (Pontryagin's maximum principle) in order to find optimal stroke patterns for maximal displacement. We compared numerical methods of optimal control as well as a differential-geometric gait analysis method (in collaboration with a research group from Oregon State University) in order to verify our results. These approaches also help in resolving problematic cases where the variational method fails to find optimal solutions.

Another system with a similar structure is the high Reynolds "perfect fluid" swimmer. This swimmer, governed by inertia and with negligible viscosity, has dynamics with a structure very similar to the low-Re swimmers. We employ the methods of asymptotic analysis and optimal control in order to optimize gaits for this swimmer as well.

Finally, in collaboration with research groups from France and Italy, we investigated energetically optimal gaits in leading order of an N-link microswimmer model. Using a constrained variational formulation, we found that the energy-optimal small-amplitude gaits are ellipses lying in a two-dimensional plane embedded within the N-1 dimensional space of shape variables.

בברכה,

פרופ"מ מתי סאסו
מרכז הסמינרים