Fish swimming: hydrodynamics, control and optimization

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Abstract

In this talk, we will address following issues:

Firstly, the hydrodynamics principles of fish swimming, such as the vortex dynamics principles of speed control, direction control and energy-saving of maneuver swimming of fish school will be discussed.

Secondly, we will discuss the technique of flow control with moving wavy wall, and the application of this technique to the fish swimming, in order to completely eliminate vortical wakes of fish swimming.

Thirdly, we will show the result of topology optimization of caudal fin, which is much better than the lunate caudal fin of shark, and discuss the physics behind the optimization process and results.

These results are applicable in the design of bionic fish.

Theory of optimal dynamical systems and applications in fluid mechanics

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Abstract

In the past 25 years, we developed an unique theory of optimal dynamical systems, which includes POD method, and applied the theory in the characteristic analysis of fluid dynamics and the studies of low-dimensional dynamical systems. The theory includes three generations of results, i.e., the optimal dynamical systems with reminder minimization, residual minimization and weighted residual minimization.

The third generation of the theory provides a perfect mathematical framework. The results include the construction of optimal systems of one-dimensional heat transform equation, non-linear Burgers equation and three-dimensional unsteady Navier-Stokes equations, and the helical wave decomposed Navier-Stokes equations, and the analysis of the dynamical properties of the coupled optimal dynamical system of the helical wave decomposed Navier-Stokes equations。

Numerical simulations of moving boundaries problems: Flexible Supersonic Parachute, Space Station Fragment Group Falling Trajectory Prediction and Control, bird flying

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Abstract

This talk report some new progress of applying CFD methods in the studies of complicated moving boundary problems.

First, the free motion of the fluid-structure interactions of Flexible Supersonic Parachute used in the exploration of Mars is studied. Results show that the parachute has very severe breathing effect, and the turbulence and small shock waves in the wake of canopy have important influence to the breathing motion of parachute.

Second, some results of numerical simulations of space station fragment group falling trajectory prediction and rope control are discussed.

Thirdly, we report the progress of numerical simulation of self-propelled bird flying. After 5 years hard working, the numerical simulations of the self-propelled flying of a bird, with the density ratio of bird/air up to 1000, in take-off, cruising and turning are achieved.

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Professor Chuijie WU graduated at Jiangsu University on Jan. 1982, and as a visiting scholar, senior visiting scholar and visiting professor, he worked at Department of Mechanical and Energy Engineering , Cardiff college of Wales University, UK, from 1986 to 1987; University of Tennessee Space Institute, from 1988 to 1989.; Department of Mechanical Engineering, Johns Hopkins University in 2000; Department of Mathematics, Kennesaw State University, USA in 2012.

He was directly promoted from Lecture to Professor on Dec. 1992 at PLA University of Science and Technology. He was Professor of Department of Mechanics, Peking University from 1999 to 2003. He was the one of ten Chair professors at PLA University of Science and Technology from Dec, 2003 to Jan, 2008. As the Founding Dean, he found the School of Aeronautics and Astronautics, Dalian University of Technology on Dec. 2008, and worked till now.

He holds following academic positions:

Executive Member of Council of Chinese Association for Computational Mechanics; Member of International Committee of Asian Computational Fluid Dynamics Conference; Invited Member of Working Party of Computational Mechanics of Chinese Society of Theoretical and Applied Mechanics; Member of Liaison Committee of Southern Computational Mechanics; Member of Consultative Committee of State Key Laboratory of Scientific and Engineering Computing, Chinese Academy of Sciences;

Associate Editor of Advances in Applied Mathematics and Mechanics (AAMM); Associate Editor of Science China-Phys Mech Astron.

Referee of about 20 academic journals, such as Journal of Fluid Mechanics, Journal of Computational Physics etc.
His research fields include:

(1). Aerodynamics, vortex dynamics and flow control

(2). Turbulence and nonlinear dynamics
(3). Computational fluid dynamics

(4). Environment fluid mechanics

Published about 230 papers in above fields.