Mehdi Jabbarzadeh

Curriculum Vitae

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EDUCATION

University of Utah — May 2018
Ph.D., Mechanical Engineering, awarded May 2018
Advisor: Prof. Henry Fu
Research focus: Experimental and computational fluid dynamics with application to biomechanics, biophysics, and microrobots.

Sharif University of Technology (SUT) — January 2009
Master of Science (M.Sc.), Mechanical Engineering
Advisor: Prof. Mohammad Durali
Research focus: Underwater acoustics, noise sources, and wave propagation

Amirkabir University of Technology (AUT) — September 2005
Bachelor of Science (B.Sc.), Naval Architecture and Marine Engineering
Advisor: Prof. Firoz Bakhtiari-Nejad
Research focus: Design and control of an Ambulance Boat Stretcher for high-speed crafts

EXPERIENCES

Postdoctoral Research Associate
Department of Mechanical Engineering, University of Utah — 2018 – present

Computational methods/algorithms for fluid-flexible body interactions, inspired by biology: Developing algorithms for parallelizing Accelerated Stokesian Dynamics to simulate large-scale complex biological fluids for near- and far-field hydrodynamic interactions on highly parallelized computers using MPI, OpenMP and GPUs.

Project Team Leader, Photoelastic spheres for experimental investigation of locomotion in granular media: Leading a team of students in the fabrication and calibration of highly sensitive photoelastic gelatin spheres to measure micron-order forces exerted as organisms burrow through granular media. Superviseingtwo Ph.D. students as well as multiple M.S. and B.S. students in this project and teaching them numerical simulations and mathematical modeling.

Computational Image Analysis and Physical-informed Machine Learning – fast Inverse solutions from experimental observations: Developed image analysis tools to reconstruct extract real 3D geometries from 2D optical microscopic images for helical filaments and soft-objects interacting with surrounding flow. Dynamics and mechanical properties are solved using physical-based machine learning and inverse simulations.

Graduate Research Assistant
Department of Mechanical Engineering, University of Utah and University of Nevada, Reno — 2012-2018

- **Numerical/analytical methods to simulate fluid flow in biological systems:** Developed GPU-based parallel algorithms to study hydrodynamics, flexibility, and fluid-structure interactions in biological systems.
- **The hydrodynamic interactions of microorganisms with complex environments:** Demonstrated how fluctuations in swimming velocities can arise from the interaction of swimmers with spatially varying microstructural heterogeneity, and that the forces on microstructure are physically related to changes in swimming velocities.
- **An optimal computational method for swimming and pumping:** Provided a guide for the proper choice of numerical methods for obtaining accurate results in modeling microswimmers by comparing the accuracy of different boundary element methods (BEM) and resistive force theory (RFT).
- **A novel numerical approach to investigate the flexibility of the flagellar filament:** A three-dimensional mathematical procedure was developed to solve full hydrodynamic interactions of flexible objects in Stokes fluids for biophysical applications.

- **Dynamic instability of monoflagellated microorganisms:** Found that the dynamic instability in hook/flagellum system initiates flick motility and reorientation in swimming directions which is a new concept from previous believes.
- **Bacterial swimming strategies with multiple modes of motility:** Created efficient numerical models based on experimental observations to study various patterns of motility of H. suis and found that wrapping flagellum around the cell body adds other degrees of freedoms to the flagellar filaments which enable the bacterium to swim and maneuver in any directions
- **Magnetization directions and optimal geometries of artificial microswimmers:** Investigated which magnetic dipoles and helical geometries optimally lead to linear velocity-frequency response, which is desirable for the precise control and positioning of artificial microswimmers.
- **Viscous constraints on microorganisms approach and interactio**n: Found analytical solutions to study hydrodynamic interactions of organisms with localized and distributed propulsions with other passive particles in a Stokes fluid with applications in biological systems, e.g. feeding, mating, and conjugations to transfer DNS properties.

Research Scientist
Thermal and Heat Transfer Research Group, ISRC (Iranian Space Research Center), Tehran, Iran 2011 – 2012

- Designed required thermal tests for a satellite prototype that recreate conditions satellites meet in space
- Analyzed experimental data to the computational models and improved them to achieve the desired temperature of the structure and component subsystems.

Production Manager and Design Consultant
ESS (Ebtekar Sanate Sharif group), Tehran, Iran 2009 – 2011

- Designed High-Low temperature/ humidity test chamber (-75 to +140°C) with controllability of 1°C.
- Designed a salt-spray corrosion chamber to test the corrosion-erosion resistance of marine products.
- Designed and fabricated thermal-vacuum-chambers to test the ground-based satellite prototypes.
- Prototyped a high-pressure hydraulic testing system to test pressure gauges, valves, pipes, and joints.

Graduate Research Assistant
Department of Mechanical Engineering, Sharif University of Technology, Tehran, Iran 2006-2009

Near-field model for underwater acoustic noise sources

- **Machinery noise simulation:** Created a FEM-model to study and optimize vibrations and machinery noises of floating vessels using ANSYS software.
- **Hydrodynamic noise:** Carried out large-eddy simulations (LES) running custom user define functions under the parallel mode of FLUENT to predict unsteady flow fluctuations around rotating a propeller and moving objects.

Underwater acoustics wave propagation: Developed and coupled boundary element method (BEM) with exciting sources calculated form mechanical and hydrodynamic noises to study underwater wave propagations with different absorbing and reflecting boundary conditions.

Other significant contributions: Contributed to some additional projects as an active member of the Control and Mechatronic Division. The most significant contributions included

- Designed, analyzed, and dynamically controlled a Snake Robot as a course project.
- Designed and manufactured a motion controller circuit for a stepper motor for Mechatronic course.
- Designed and Manufactured RC (Remote Control) Boat for International Competition in Iran.
- Conducted underwater modal analysis of propellers to determine natural frequencies – Industrial project.
- Created an experimental procedure to measure ship maneuvering – Industrial project in Marine Lab.

Summer (2007 and 2008) Internship at Iran Shipbuilding & Offshore Industries Complex (ISOICO):

- Towing and Wave Tank model tests are performed to determine resistance and loads on submerged objects.
- An offshore platform analysed under dynamic free-surface waves (Airy wave theory) and current loads.
- Performed hydrostatic and stability analysis of surface vessels for their loading and damaged stabilities.

Mechanical Engineer I
Teva Darya Company, Tehran, Iran 2005 – 2006

- Developed user-friendly software (MATLAB GUI) to calculate ship manoeuvring.
- Experimentally measured the hydrodynamic coefficients from the model test of high-speed crafts for maneuvering applications.
- Conducted a Cavitation Tunnel test to measure propulsion and thrust force of propellers.

AWARDS/HONORS

2017 – 2018	University Of Utah, The Outstanding Graduate Researcher of the Year Award, Department of Mechanical Engineering
2013 – 2016	University of Nevada, Reno, Graduate school association travel award for APS DFD conference
2014 – 2015	University of Nevada, Reno, College of Engineering annual fellowship
2013 – 2015	University of Nevada, Reno, International Student Award
2014 – 2015	University of Nevada, Reno, Grant Access Scholarships
2009	Conceptual Design Award for RCBC (Remote Control of Boat Competition) among 68 teams
2006	Iranian University Entrance Exam (Konkur), Ranked 1st among +5000 participants, Marin Engineering
2006	Iranian University Entrance Exam, Ranked 29th among +10000 participants, Mechanical Engineering
2006	Outstanding Thesis Award, Marine Engineering Department, AUT
2004	The Top Student award in the Marine Engineering Department, AUT
2009 – Present	Member of Iran's National Elites Foundation

TEACHING EXPERIENCES

- Graduate Teaching Assistant, Aerodynamics and Matlab, University of Nevada, Reno, Fall 2012 and Fall 2013
- Vibration and Mechanism Design Lab, Sharif University of Technology, Spring 2010
- Machine Design and Fundamentals of Vibration, Nokhbeghan e Sharif Institute, Spring 2008
- Teaching Assistant, Fundamentals of Vibration, AUT, Naval Architecture and Marine Engineering, Spring 2005
- Teaching Assistant, Dynamics, AUT, Naval Architecture and Marine Engineering, Spring 2005
- Teaching Assistant, Strength of Material, AUT, Naval Architecture and Marine Engineering, Fall 2004
- Teaching Assistant, Statics, AUT, Naval Architecture and Marine Engineering, Fall 2004

PUBLICATIONS

Peer-reviewed Journal Publications

11 **M. Jabbarzadeh** and H. C. Fu, "A numerical method for inextensible elastic filaments in viscous fluids", *Journal of Computational Physics Phys.* (2019) – *Accepted*.

10 Ahmadvand, Seyedsaeid; Elahifard, Mohammadreza; **M. Jabbarzadeh,** Mirzanejad, Amir; Pflughoeft, Kathryn; Abbasi, Behrooz; Abbasi, Bahman, "Bacteriostatic Effects of Apatite-Covered Ag/AgBr/TiO_2 Nanocomposite in the Dark: Anomaly in Bacterial Motility." *The Journal of Physical Chemistry B* 123.4 (2019): 787-791.

9 Maira A. Constantino, **Mehdi Jabbarzadeh**, Henry C. Fu, Zeli Shen, James G. Fox, Freddy Haesebrouck, Sara K. Linden & Rama Bansil, "Bipolar lophotrichous Helicobacter suis combine extended and wrapped flagella bundles to exhibit multiple modes of motility." *Scientific Reports* 8.1 (2018): 14415.

8 **M. Jabbarzadeh** and H. C. Fu, "Viscous constraints on microorganism approach and interaction." *Journal of Fluid Mechanics* 851 (2018): 715-738.

7 **M. Jabbarzadeh** and H. C. Fu, "Dynamic instability in the hook/flagellum system that triggers bacterial flicks", *Phys. Rev. E*, 97, 012402 (2017).

6 J. Ali, U. K. Cheang, J. D. Martindale, **M. Jabbarzadeh**, H. C. Fu, and M. J. Kim. "Bacteria inspired nanorobots with flagellar polymorphic transformations and bundling." *Scientific Reports* 7, 14098 (2017).

5 M. A. Constantino, **M. Jabbarzadeh**, H. C. Fu, R. Bansil, "Helical and rod-shaped bacteria swim in helical trajectories with little additional propulsion from helical shape." *Science Advances* 2, e1601661. (2016).
Highlighted as Science Advances Editor's Selection
Media: Article in BUToday website,
http://www.bu.edu/today/2017/physicists-uncover-swimming-secrets-of-hpylori-bacteria/

4 J. D. Martindale, **M. Jabbarzadeh**, H. C. Fu, "Choice of computational method for swimming and pumping with nonslender helical filaments at low Reynolds number." *Phys. Fluids* 28, 021901, (2016).

3 H. C. Fu, **M. Jabbarzadeh**, F. Meshkati, "Magnetization directions and geometries of helical microswimmers for linear velocity-frequency response." *Phys. Rev. E*, 91, 043911 (2015).

2 S. A. Mirbagheri, E. Ceniceros, **M. Jabbarzadeh**, Z. McCormick, H. C. Fu, "Sensitively photoelastic biocompatible gelatin spheres for investigation of locomotion in granular media." Experimental Mechanics, 55, 427-438 (2015).

1 **M. Jabbarzadeh**, Y. Hyon, H. C. Fu, "Swimming fluctuations of micro-organisms due to heterogeneous microstructure." *Phys. Rev. E*, 90, 043021 (2014).

CONFERENCE PRESENTATIONS

Time-dependent hook flexibilities in run-reverse-flick motility.
M.Jabbarzadeh, American Physical Society Division of Fluid Dynamics Meeting, Seattle, WA, 11/20/2019

Deformations in the hook and flagellum during bacterial run-reverse-flick motility.
M.Jabbarzadeh, Society for Engineering Science, Washington University in St. Louis, MO, 10/15/2019

Deformations in the hook and flagellum during bacterial flick motility
M.Jabbarzadeh, American Physical Society Division of Fluid Dynamics Meeting, Boston, MA, 03/06/2019

The dynamic instability in the hook/flagellum system that triggers bacterial flicks
M.Jabbarzadeh, American Physical Society Division of Fluid Dynamics Meeting, Denver, CO, 11/20/2017

The dynamic instability in the hook/flagellum system that triggers bacterial flicks
M.Jabbarzadeh, Society for Engineering Science, Northeastern University, Boston, MA, 7/27/2017

Instability of hooks during bacterial flagellar swimming
M.Jabbarzadeh, American Physical Society Division of Fluid Dynamics Meeting, Portland, OR, 11/20/2016

Viscous constraints on squirmer microswimmers approaching suspended particles
M.Jabbarzadeh, American Physical Society Division of Fluid Dynamics Meeting, Boston, MA, November 23, 2015

Viscous constraints on predator:food size ratios in microscale feeding
M.Jabbarzadeh, American Physical Society Division of Fluid Dynamics Meeting, San Francisco, CA, November 25, 2014

The signatures of microstructure in swimming properties of microorganisms in heterogeneous media
M.Jabbarzadeh, American Physical Society Division of Fluid Dynamics Meeting, Pittsburgh, PA, November 26, 2013

Poster: Bacterial flick are triggered by a dynamic instability in the hook/flagellum system,
Modeling Complex Fluids and Gels for Biological Applications, University of Utah, UT, 5/4/2017

Scientific Presentations as Co-Author

Helical and Rod-shaped Bacteria Swim in Helical Trajectories with Little Additional Propulsion from Helical Shape
H. Fu, M. Constantino, **M. Jabbarzadeh**, R Bansil, APS, Division of Fluid Dynamics Meeting, Denver, CO, 2017

Magnetic Actuation of Self-assembled Bacteria Inspired Nanoswimmers
J. Ali, U. K. Cheang, J. D. Martindale, **M. Jabbarzadeh**, H. Fu, M. J. Kim, APS, Division of Fluid Dynamics Meeting, Denver, CO, 2017

Helical and Rod-shaped Bacteria Swim in Helical Trajectories with Little Additional Propulsion from Helical Shape
H. Fu, M. Constantino, **M. Jabbarzadeh**, R Bansil, SES, Northeastern University, Boston, MA, 2017

Helicobacter pylori displays spiral trajectories while swimming like a cork-screw in solutions
M. A. Constantino, J. M. Hardcastle, R. Bansil, **M. Jabarzadeh**, H. C. Fu, 2016 APS March Meeting, Baltimore, MD 2016.

Optimal computational methods for swimming and pumping with helical filaments at Low Reynolds number
J. Martindale, **M. Jabbarzadeh**, H. Fu, 2015 APS Division of Fluid Dynamics Meeting, Boston, MA, 2015

Photoelastic gelatin spheres for investigation of locomotion in granular media
H. Fu, **M. Jabbarzadeh**, APS, Division of Fluid Dynamics, Volume 59, Number 20, San Francisco, CA, November 24, 2014

Design of helical magnetically rotated microswimmers for controllability
H. Fu, F. Meshkati. **M. Jabbarzadeh**, APS, Division of Fluid Dynamics Meeting, San Francisco, CA, 2014

Microscale swimming through heterogeneous networks
H. Fu, **M. Jabbarzadeh**, APS March Meeting 2014, Volume 59, Number 1, Denver, Colorado, March 3, 2014

Swimming through heterogeneous networks
H. Fu, **M. Jabbarzadeh** "Active Fluids: Bridging Complex Fluids and Biofluids, Aspen, CO, 2014