FAU COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

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for the degree of Doctor of Philosophy (Ph.D.)

“Modeling, Path Planning, and Control Co-Design of Marine Current Turbines”

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DEPARTMENT:
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ABSTRACT OF DISSERTATION
Marine and hydrokinetic (MHK) energy systems, including marine current turbines and wave energy converters, could contribute significantly to reducing reliance on fossil fuels and improving energy security while accelerating progress in the blue economy. However, technologies to capture them are nascent in development due to several technical and economic challenges. For example, for capturing ocean flows, the fluid velocity is low, but density is high, resulting in early boundary layer separation and high torque. This dissertation addresses critical challenges in modeling, optimization, and control co-design of MHK energy systems, with a specific case study of a variable buoyancy-controlled marine current turbine (MCT). Specifically, this dissertation presents (a) comprehensive dynamic modeling of the MCT, where data recorded by an acoustic Doppler current profiler are used as the real ocean environment. Numerical simulations results of the turbine performance for normal, hurricane, and fault conditions are presented and discussed; (b) vertical path planning of the MCT, where the problem is formulated as a novel spatial-temporal optimization problem to maximize the total harvested power of the system in an uncertain oceanic environment. Reinforcement learning-based method is designed to explore the optimal control actions, and results are quantitatively compared with a model predictive control-based strategy; (c) control co-design of the MCT, where the physical device geometry and turbine path control are optimized simultaneously. Bi-directional coupling between plant design and path control is formulated and optimized in a nested co-optimization framework to maximize key performance index, e.g., the power-to-weight ratio. Evaluations are carried out using field-collected ocean current data and simulation in the Matlab/Simulink. Comparative studies with baseline designs validate the superiority of our proposed innovations.

BIOGRAPHICAL SKETCH
Born in Tehran, Iran

B.S., Amirkabir University of Technology, Tehran, Iran, 2012
M.S., Amirkabir University of Technology, Tehran, Iran, 2014
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CONCERNING PERIOD OF PREPARATION & QUALIFYING EXAMINATION

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Published Papers:

A. Hasankhani, J. VanZwieten, Y. Tang, B. Dunlap, A. De Luera, C. Sultan, and N. Xiros, "Modeling and numerical simulation of a buoyancy-controlled ocean current turbine," International Marine Energy Journal, vol. 4, no. 2, pp. 47-58, 2021.

A. Hasankhani, A. De Leura, J. VanZwieten, B. Dunlap, Y. Tang, C. Sultan, and N. Xiros, "Numerical Simulation of A Buoyancy-Controlled Ocean Current Turbine," 2021 International Conference on Ocean Energy (ICOE), 2021.

A. Hasankhani, Y. Tang, J. VanZwieten and C. Sultan, "Ocean Current Turbine Active Depth Optimization for Maximum Power Production," 2021 International Conference on Ocean Energy (ICOE), 2021.

A. Hasankhani, Y. Tang, J. VanZwieten, and C. Sultan, "Comparison of deep reinforcement learning and model predictive control for real-time depth optimization of a lifting surface-controlled ocean current turbine," in 2021 IEEE Conference on Control Technology and Applications (CCTA). IEEE, 2021, pp. 301–308.

A. Hasankhani, Y. Tang, J. VanZwieten and C. Sultan, "Spatiotemporal Optimization for Vertical Path Planning of an Ocean Current Turbine," IEEE Transaction on Control Systems Technology, 2022. (Conditionally Accepted).

A. Hasankhani, E. Ondes, Y. Tang, C. Sultan, and J. VanZwieten, "Integrated Path Planning and Tracking Control of Marine Current Turbine in Uncertain Ocean Environments," 2022 American Control Conference (ACC), Accepted.

A. Hasankhani, Y. Tang, A. Snyder, J. VanZwieten and W. Qiao, "Control Co-Design for Buoyancy-Controlled MHK Turbine: A Nested Optimization of Geometry and Spatial-Temporal Path Planning," 2022 Conference on Control Technology and Applications (CCTA), Accepted.

A. Hasankhani, Y. Tang, Y. Huang, and J. VanZwieten, "Real-Time Vertical Path Planning Using Model Predictive Control for an Autonomous Marine Current Turbine," 2022 Conference on Control Technology and Applications (CCTA), Accepted.

A. Hasankhani, Y. Tang, and J. VanZwieten, "Reinforcement Learning for Underwater Spatiotemporal Path Planning, with Application to an Autonomous Marine Current Turbine," IEEE Robotics and Automation Letters, Submitted.

A. Hasankhani, J. VanZwieten, Y. Tang, C. Sultan, and N. Xiros, "Modeling and Numerical Simulation of a Lifting Surface Controlled Ocean Current Turbine," Renewable Energy Journal. (Under preparation and will be submitted soon).

A. Hasankhani, Y. Tang, and J. VanZwieten, "Integrated Path Planning and Tracking Control using Reinforcement Learning, with Application to a Marine Current Turbine," IEEE Transactions on Vehicular Technology. (Under preparation and will be submitted soon).

A. Hasankhani, Y. Tang, and J. VanZwieten, "Control Co-design of Physical Design and Integrated Path Planning and Tracking for Marine Current Turbine," IEEE Transactions on Control Systems Technology. (Under preparation and will be submitted soon).