A Holistic Approach for Autonomous Marine Surface Vessels

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Abstract:
Autonomous marine surface vessels aim at eliminating human errors in ship navigation and lead to an efficient operation of ships in harsh environmental conditions. The challenges associated with autonomous vessels arise from nonlinearities in ship dynamics, structured and unstructured uncertainties, under-actuated configuration of ships and unpredictable environmental disturbances induced by wind, sea-current and wave excitations. A holistic approach encompassing a guidance system, nonlinear robust controllers and observers has been devised to address this problem. The simulation results demonstrate the robust performance and accurate tracking characteristic of the system in the presence of significant modeling imprecision and environmental disturbances. These results were validated by an experimental study conducted on an under-actuated 16 ft. tracker boat in a completely uncontrolled real-world setting of the open-water in Lake St. Clair, Michigan. Moreover, two additional scenarios will be discussed. The first one focuses on the enhanced capabilities of the guidance system by incorporating a collision avoidance scheme based on the velocity obstacles (OV) approach while accounting for the rules of maritime navigation specified in the International Regulations for Prevention of Collisions at Sea (COLREGS). The second scenario deals with the autonomous operation of a two-vessel system involving a disabled ship.

Biography:
Dr. Nabil G. Chalhoub received his BSME and MSME from the Mechanical Engineering Department at Wayne State University (WSU) and his Ph.D. from the Mechanical Engineering Department at the University of Michigan (UoM), Ann Arbor. He has been serving as the DeVlieg Chairman of the Mechanical Engineering Department at WSU since 2014. He was elected to the grade of ASME Fellow in 2012. His research interest is in modeling and active control of flexible structures, robotics, IC engine dynamics and tribology, guidance and control of marine vessels, nonlinear robust controllers and observers and self-tuning fuzzy controllers. He gave the keynote presentation for the 22nd IASTED International Symposia on Modelling and Simulation in 2011, Calgary, Canada. He co-chaired the International Conference on Advanced Research and Applications in Mechanical Engineering (ICARAME’11), served as the Registration Chair for the 2014 ASME DSC conference and was the Chair of the Model Identification and Intelligent Systems (MIIS) Technical Committee in the ASME DSC Division. He has also served on the editorial boards of the ASME Journal of Dynamic Systems, Measurement and Control (JDSMC), the Journal of Vibration and Control
(JVC) and on the Local Committee for the *International Symposium on Vibro-Impact Dynamics of Ocean Systems and Related Problems*. His research has been funded by NSF, ONR, ARO, U.S. Army TARDEC, ARC, Ford Motor Company and FCA.