COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

Vaishakh Krishnan

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

"Statistical Modeling of Ship Airwakes Including the Feasibility of Applying Machine Learning"

December 3, 2020, 2:00 p.m.
Virtual Dissertation

DEPARTMENT:
Department of Ocean and Mechanical Engineering

ADVISOR:
Gopal Gaonkar, Ph.D.

PH.D. SUPERVISORY COMMITTEE:
Gopal Gaonkar, Ph.D., Chair
Manhar Dhanak., Ph.D.
Davood Moslemian, Ph.D.
James VanZwieten, Ph.D.
Francis Motta, Ph.D.
Jason Mireles-James, Ph.D.

ABSTRACT OF DISSERTATION
Statistical Modeling of Ship Airwakes Including the Feasibility of Applying Machine Learning

Airwakes are shed behind the ship's superstructure and represent a highly turbulent and rapidly distorting flow field. This flow field severely affects pilot's workload and such helicopter shipboard operations. It requires both the one-point statistics of autospectrum and the two-point statistics of coherence (normalized cross-spectrum) for a relatively complete description. Recent advances primarily refer to generating databases of flow velocity points through experimental and computational fluid dynamics (CFD) investigations, numerically computing autospectra along with a few cases of cross-spectra and coherences, and developing a framework for extracting interpretive models of autospectra in closed form from a database along with an application of this framework to study the downwash effects. By comparison, relatively little is known about coherences. In fact, even the basic expressions of cross-spectra and coherences for three components of homogeneous isotropic turbulence (HIT) vary from one study to the other, and the related literature is scattered and piecemeal. Accordingly, this dissertation begins with a unified account of all the cross-spectra and coherences of HIT from first principles. Then, it presents a framework for constructing interpretive coherence models of airwake from a database on the basis of perturbation theory. For each velocity component, the coherence is represented by a separate perturbation series in which the basis function or the first term on the right-hand side of the series is represented by the corresponding coherence for HIT. The perturbation series coefficients are evaluated by satisfying the theoretical constraints and fitting a curve in a least squares sense on a set of numerically generated coherence points from a database. Although not tested against a specific database, the framework has a mathematical basis. Moreover, for assumed values of perturbation series constants, coherence results are presented to demonstrate how coherences of airwakes and such flow fields compare to those of HIT.

Finally, the dissertation focuses on applying the machine learning approaches based on neural networks to an earlier developed algorithm for extracting autospectra in closed form with optimal usage of the database. To this end, in situ airwake flow velocity points measured from the Naval YP676 ship are used for training and testing the neural network. The strengths and weaknesses of this machine learning approach are presented as well.

BIOGRAPHICAL SKETCH
Born in Angamaly, India
B.Tech., National Institute of Technology Trichy, India, 2011

M.Tech., Indian Institute of Technology Madras, Chennai, India, 2015
Ph.D., Florida Atlantic University, Boca Raton, Florida, 2020

CONCERNING PERIOD OF PREPARATION
& QUALIFYING EXAMINATION

Time in Preparation: 2016 - 2020

Qualifying Examination Passed: Spring 2017

Published Papers:

K. A. Schau, G. Gaonkar and V. Krishnan, "On Modelling Wind-Farm Wake Turbulence Autospectra and Coherence from a Database," *Energies,* vol. 12, no. 20, pp. 1-15, 2019.

V. Krishnan and G. Gaonkar , "A Frame-work for Modelling Two-Point Statistics of Coherence from a Database for Airwake with Helicopter Downwash," in *Vertical Flight Society's 75th Annual Forum & Proceedings*, Philadelphia, 2019.