COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

# Dennis Estrada

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

## "Machine Learning Methods for Image Enhancement in Degraded Visual Environments"

June 24, 2022, 10:00 a.m.
Virtual Dissertation

Zoom Meeting
Meeting ID: 883 1214 0283
Passcode: 376463

---

DEPARTMENT:
Electrical Engineering and Computer Science

ADVISORS:
Yufei Tang, Ph.D.
Bing Ouyang, Ph.D.

PH.D. SUPERVISORY COMMITTEE:
Yufei Tang, Ph.D., Co-Chair
Bing Ouyang, Ph.D., Co-Chair
Fraser Dalgleish, Ph.D.
Hanqi Zhuang, Ph.D.
Xingquan Zhu, Ph.D.

ABSTRACT OF DISSERTATION
Significant reduction in space, weight, power, and cost (SWAP-C) of imaging hardware has induced a paradigm shift in remote sensing where unmanned platforms have become the mainstay. However, mitigating the degraded visual environment (DVE) remains an issue. DVEs can cause a loss of contrast and image detail due to particle scattering and distortion due to turbulence-induced effects. The problem is especially challenging when imaging from unmanned platforms such as autonomous underwater vehicles (AUV) and unmanned ariel vehicles (UAV). While single-frame image restoration techniques have been studied extensively in recent years, single image capture is not adequate to address the effects of DVEs due to under-sampling, low dynamic range, and chromatic aberration. Significant development has been made to employ multi-frame image fusion techniques to take advantage of spatial and temporal information to aid in the recovery of corrupted image detail and high-frequency content and increasing dynamic range. In this dissertation, a supervised multi-frame image enhancement technique is proposed and evaluated to restore images distorted by DVEs. This approach utilizes a generative adversarial network (GAN) framework to predict the optimal weight maps in a balanced fusion technique that can reduce image distortion, recover crisp image detail, and reduce the overall noise figure. The proposed algorithm is designed based on the analysis of several key research topics in image degradation modeling, single image enhancement, and multi-frame image fusion. A key contribution of this paper is the adoption of an image loss function that incorporates an innovative combined correntropy and Fourier space loss function to reinforce the network in both the spatial and frequency domain. The correntropy loss function allows for the reduction of non-gaussian noise caused by detector noise, whereas the Fourier space loss enforces the correction of geometric distortion caused by turbulence. The performance of the proposed algorithm is then evaluated against images captured by the Unobtrusive Multi-static Serial LiDAR Imager (UMSLI) in the test tank and field experiments and turbulence images captured from experiments conducted at the Naval Research Lab's Simulated Turbulence and Turbidity Environment (NRL-SS SiTTE).

BIOGRAPHICAL SKETCH
Born in West Palm Beach, Florida, USA
B.S., Florida Atlantic University, Boca Raton, Florida 2017
M.S., Florida Atlantic University, Boca Raton, Florida 2019
Ph.D., Florida Atlantic University, Boca Raton, Florida, 2022

CONCERNING PERIOD OF PREPARATION & QUALIFYING EXAMINATION

**Time in Preparation:** Fall 2019 – Summer 2022

**Qualifying Examination Passed:** Spring 2020

**Published Papers:**

Estrada, Dennis C., Fraser R. Dalgleish, Casey J. Den Ouden, Brian Ramos, Yanjun Li, and Bing Ouyang. "Underwater LiDAR Image Enhancement Using a GAN Based Machine Learning Technique." *IEEE Sensors Journal* 22, no. 5 (2022): 4438-4451.

Estrada, Dennis, Fraser Dalgleish, Casey Den Ouden, and Bing Ouyang. "Multi-frame GAN-based machine learning image restoration for degraded visual environments." In *Big Data III: Learning, Analytics, and Applications*, vol. 11730, p. 1173004. International Society for Optics and Photonics, 2021.

Den Ouden, Casey, Dennis Estrada, Fraser Dalgleish, and Bing Ouyang. "Evaluation of a technique to simulate LiDAR image datasets for training a machine learning-based image enhancement algorithm." In *Big Data III: Learning, Analytics, and Applications*, vol. 11730, pp. 154-161. SPIE, 2021.

Estrada, Dennis, Susanne Lee, Fraser Dalgleish, Casey Den Ouden, Madison Young, Caitlin Smith, Joseph Desjardins, and Bing Ouyang. "DeblurGAN-C: image restoration using GAN and a correntropy based loss function in degraded visual environments." In *Big Data II: Learning, Analytics, and Applications*, vol. 11395, p. 1139507. International Society for Optics and Photonics, 2020.

Ouyang, Bing, Dennis Estrada, Yanjun Li, and Fauzia Ahmad. "Human activity monitoring using a compressive active sensing electro-optical sensor." In *Big Data: Learning, Analytics, and Applications*, vol. 10989, p. 109890H. International Society for Optics and Photonics, 2019.

Estrada, Dennis, Weilin Hou, Silvia Matt, and Bing Ouyang. “Multi-Frame Image Fusion using a Machine Learning based Weight Mask Predictor for Turbulence-Induced Image Degradation.” *SPIE Journal of Applied Remote Sensing*. Submitted.