COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

Raymond Colucci

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

"Optimization of Battery Operation Using Artificial Intelligence to minimize the electricity cost in a microgrid with renewable energy sources and electric vehicles"

October 24, 2024, 3:45 p.m.
Building Engineering East, Room # 405
777 Glades Road
Boca Raton, FL

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ABSTRACT OF DISSERTATION

The increasing integration of renewable energy sources (RES) and electric vehicles (EVs) into microgrids presents both opportunities and challenges in terms of optimizing energy use and minimizing electricity costs. This dissertation explores the development of an advanced optimization framework using artificial intelligence (AI) to enhance battery operation in microgrids. The proposed solution leverages AI techniques to dynamically manage the charging and discharging of batteries, considering fluctuating energy demands, variable electricity pricing, and intermittent RES generation.

By employing a fuzzy logic-based control algorithm, the system intelligently allocates energy from solar power, grid electricity, and battery storage to reduce peak demand charges. The optimization framework integrates predictive modeling for energy consumption and generation and electricity markets to make informed decisions. Additionally, the approach considers the trade-off between maximizing renewable energy usage and minimizing reliance on costly grid power during peak hours.

A critical element of this framework is the accurate prediction of solar irradiance, which provides essential input for battery operation optimization. This research investigates various machine learning algorithms for predicting solar power availability, including Random Forest (RF), Extreme Gradient Boosting (XGBoost), Support Vector Regression (SVR), Kernel Ridge Regression (KRR), and Linear Regression. Ensemble methods such as voting, stacking, and bagging are utilized to further enhance prediction accuracy. Among these, stacking demonstrated superior performance. The model was validated using cross-validation techniques and generalized to predict solar irradiance across different geographical locations. Accurate solar predictions improve the system's ability to optimize energy storage decisions and ensure efficient operation under fluctuating solar conditions.

Our evaluation results show that the AI-driven optimization of battery operation in the microgrid significantly reduces electricity costs while improving the overall efficiency of energy usage. This work contributes to the field by demonstrating how AI can enhance the sustainability and economic viability of microgrids with RES and EVs. The findings have practical implications for microgrid operators, policymakers, and the broader push towards greener, smarter energy systems.

BIOGRAPHICAL SKETCH
Born in New York, New York
B.S., Hofstra University, Hempstead, New York, 1983

M.S., Florida Atlantic University, Boca Raton, Florida, 2001
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CONCERNING PERIOD OF PREPARATION
& QUALIFYING EXAMINATION

Time in Preparation: 2016 - 2024

Qualifying Examination Passed: Fall 2018

Published Papers:

1. Colucci, R., Mahgoub, I., Yousefizadeh, H., & Al-Najada, H. (2024). Survey of strategies to optimize battery operation to minimize the electricity cost in a microgrid with renewable energy sources and electric vehicles, IEEE Access journal, 2024 Jan 10.

2. Colucci, R., & Mahgoub, I. (2024, February). Solar Irradiance Prediction with Ensemble Learning Method as Input for Battery Operation Optimization. In 2024 IEEE Texas Power and Energy Conference (TPEC) (pp. 1-6), IEEE.

3. Intelligent Fuzzy Logic-Based Scheme for Battery Operation Optimization in Solar Energy Systems – submitted to IEEE Transactions on Smart Grid journal

4. Generalizable Solar Irradiance Prediction for Battery Operation Optimization in a Microgrid Environment – submitted to Journal of Sensor and Actuator Networks