COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

Hamid Akbarian

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

"DEEP LEARNING BASED ANOMALY DETECTION IN SPACE SYSTEMS AND OPERATIONS"

March 26, 2024, Time 3:00 p.m.
Building EE96, Room #405
777 Glades Road
Boca Raton, FL

DEPARTMENT:
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ABSTRACT OF DISSERTATION
Dissertation Title: Deep Learning Based Anomaly Detection in Space Systems and Operations.

Abstract: The relentless expansion of space exploration necessitates the development of robust and dependable anomaly detection systems (ADS) to safeguard the safety and efficacy of space missions. Conventional anomaly detection methods often falter in the face of the intricate and nuanced dynamics of space systems, resulting in a proliferation of false positives and/or false negatives. In this study, we delve into cutting-edge techniques in deep learning (DL) to tackle the challenges inherent in ADS. This research offers an in-depth examination of recent breakthroughs and hurdles in deep learning-driven anomaly detection tailored specifically for space systems and operations. A key advantage of deep learning-based anomaly detection lies in its adaptability to the diverse data encountered in space missions. For instance, Convolutional Neural Networks (CNNs) excel at capturing spatial dependencies in high-dimensional data, rendering them well-suited for tasks such as satellite imagery analysis. Conversely, Recurrent Neural Networks (RNNs), with their temporal modeling ability, excel in identifying anomalies in time-series data generated by spacecraft sensors. Despite the potential of deep learning, several challenges persist in its application to anomaly detection in space systems. The scarcity of labeled data presents a formidable hurdle, as acquiring labeled anomalies during space operations is often prohibitively expensive and impractical. Additionally, the interpretability of deep learning models remains a concern, particularly in mission-critical scenarios where human operators need to comprehend the rationale behind anomaly predictions. Addressing these challenges necessitates innovative approaches, such as the fusion of diverse deep learning techniques and methodologies to grapple with unlabeled data, high-dimensional datasets, and imbalanced data distributions to enhance model performance. To confront the aforementioned challenges inherent in space systems and operations, this dissertation proposes novel deep learning-based schemes leveraging Autoencoder (AE), Long Short-Term Memory (LSTM), and K-means. AE architectures are employed to harness their dimension reduction capabilities for pertinent feature extraction, while LSTM models are utilized to capture and learn long-term dependencies. Additionally, K-means clustering techniques are employed to adapt to varied data structures. The performance of the proposed schemes is evaluated in terms of F1-score, demonstrating their accuracy and efficiency in detecting anomalies within space systems and operations.

BIOGRAPHICAL SKETCH

Born in Tehran, Iran (US Citizen)

B.S., Florida Atlantic University, Boca Raton, Florida, 1999

M.S., Florida Atlantic University, Boca Raton, Florida, 2001

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CONCERNING PERIOD OF PREPARATION
& QUALIFYING EXAMINATION

Time in Preparation: 2020 – 2024

Qualifying Examination Passed: Semester Spring 2011

Published Papers:

• A Survey of Machine Learning Based Schemes in Space Communications, 16th International Conference on Space Operations, 3-5 May 2021. Vol 4, ISBN: 9781713855538

• Autoencoder-LSTM Algorithm for Anomaly Detection”. In proceedings of the 2023 IEEE 20th International Conference (HONET), pp. 1-6. DOI: 10.1109/HONET59747.2023.10374710

• “Autoencoder-K-Means Algorithm for Efficient Anomaly Detection to Improve Space Operations” in 2024 International Conference on Smart Applications, Communications and Networking (SmartNets). (Submitted)

• “Autoencoder-LSTM-K-Means Algorithms for Efficient Anomaly Detection in Space Systems” Journal of IEEE Transactions on Aerospace and Electronic Systems. (Submitted)