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Supervised machine learning-based solutions for Space Situational Awareness

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Introduction

Space Situational Awareness (SSA) knowledge represents a pivotal component in ensuring the safe execution of space operations. A Key challenge in SSA is the increasing number of objects requiring continuous surveillance and monitoring. Integrating fully autonomous optical systems, powered by Machine Learning (ML) models to detect Resident Space Objects (RSOs) emerges as a promising solution to overcome this challenge[1]. This research has led to the development of supervised models, both trained from scratch and employing transfer learning methodologies. These models utilize data sourced from RMIT University's Robotic Optical Observatory (ROO) to detect RSOs within the Geosynchronous Earth Orbit (GEO).

Aims

- Investigate the utilisation of transfer learning approaches, including pretrained models, for deep learning-based GEO RSO detection.
- Systematically optimize the training process of Convolutional Neural Network (CNN) models from scratch, ensuring precision and efficiency.
- Evaluate the impact of data augmentation techniques on the training and performance of Feature Pyramid Network [2] models for RSO detection.
- Explore the classification of detected RSOs as either active satellites or space debris to enhance SSA knowledge for better decision-making.
- Integrate and deploy the trained models into ROO's routine operations.

Methodology

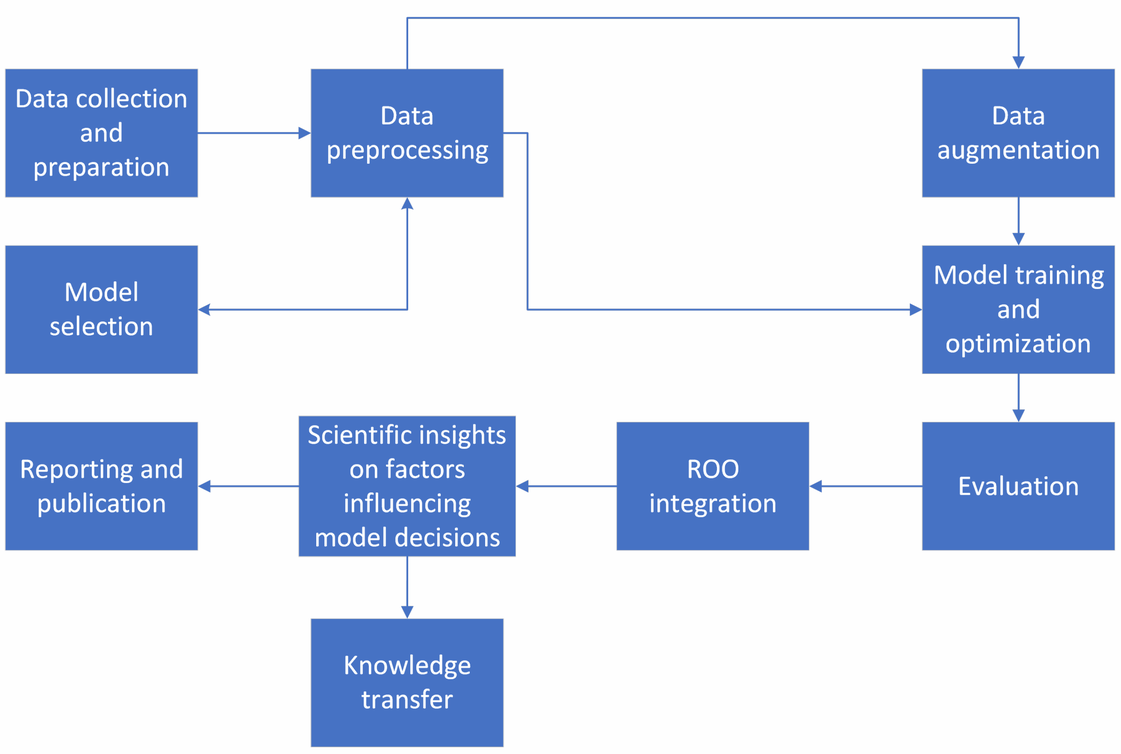

Fig 1: Research methodology flowchart

Discussion and Results

- A deep learning model specifically utilizing semantic segmentation and the Feature Pyramid Network architecture along with the EfficientNet-B7 encoder pre-trained on ImageNet weights has been developed [3].
- Conducted a systematic investigation into the influence of expanding available data through data augmentation techniques on the training of feature pyramid network models, subsequently leading to enhanced performance in RSO detection.
- The initial training of CNN models trained from scratch has been successfully completed, and the optimization phase is currently in progress to ensure precision and efficiency.
- An offset has been observed in the predicted position of satellites in a few instances. This is anticipated to be due to a larger mask generated during the data pre-processing stages and will be investigated further.
- Detections from the current models have been acquired, initiating the subsequent classification phase into active satellites or space debris. This contributes to enhancing Space Situational Awareness (SSA) knowledge for improved decision-making.
- Utilized independent datasets for evaluation, closely emulating real-world scenarios in preparation for ROO integration, achieving an impressive detection rate of 95.12% and an F1 score of 0.71.

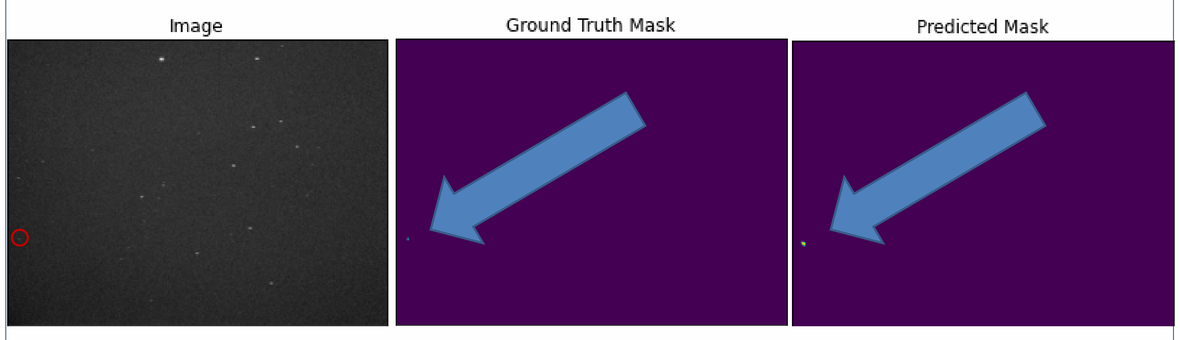

Fig 2: Machine learning model result evaluation using Original Image vs Ground-truth mask vs Predicted mask

References

[1] Abay, R. and Gupta, K., 2021, April. GEO-FPN: A convolutional neural network for detecting GEO and near-GEO space objects from optical images. In Proceedings of the 8th European Conference on Space Debris (virtual).

[2] Lin, Tsung-Yi, et al., 2017. Feature pyramid networks for object detection. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp.2117-2125).

[3] Vallapureddy, S., et al., 2022. A Deep Learning approach for Geosynchronous Earth Orbit resident space object detection using RMIT's Robotic Optical Observatory imagery. In Proceedings of the 20th Australian Space Research Conference

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