International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Review Article)

Astronomical bodies detection with stacking of CoAtNets by fusion of RGB and depth Images

Chinnala Balakrishna [1,*] and Shepuri Srinivasulu [2]

[1] *Department of CSE (AIML and Cyber Security), Guru Nanak Institute of Technology, Telangana, India.*
[2] *Department of CSE (AIML), AVN Institute of Engineering Technology, Telangana, India.*

International Journal of Science and Research Archive, 2024, 12(02), 423–427

Publication history: Received on 28 May 2024; revised on 04 July 2024; accepted on 07 July 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.12.2.1234

Abstract

Space situational awareness (SSA) system requires detection of space objects that are varied in sizes, shapes, and types. The space images are difficult because of various factors such as illumination and noise and as a result make the recognition task complex. Image fusion is an important area in image processing for a variety of applications including RGB-D sensor fusion, remote sensing, medical diagnostics, and infrared and visible image fusion. In recent times, various image fusion algorithms have been developed and they showed a superior performance to explore more information that is not available in single images. In this paper I compared various methods of RGB and Depth image fusion for space object classification task. The experiments were carried out, and the performance was evaluated using fusion performance metrics. It was found that the guided filter context enhancement (GFCE) outperformed other image fusion methods in terms of average gradient, spatial frequency, and entropy. Additionally, due to its ability to balance between good performance and inference speed, GFCE was selected for RGB and Depth image fusion stage before feature extraction and classification stage. The outcome of fusion method is merged images that were used to train a deep assembly of CoAtNets to classify space objects into ten categories. The deep ensemble learning methods including bagging, boosting, and stacking were trained and evaluated for classification purposes. It was found that combination of fusion and stacking was able to improve classification accuracy.

Keywords: Image Fusion; RGB; GFCE; CoAtNets and Stacking

1. Introduction

The near-Earth space environment is known to be utilized for both commercial and scientific purposes. Satellites are launched on a regular basis to aid in space navigation, communication, and weather forecasting [1]. As technology improves, space exploration and satellite launch become more practical, resulting in increasing activity in the near future. The amount of space junk and objects has increased dramatically during the last several decades [2]. Space objects are loosely defined as hardware launched by humans into outer space, whereas debris includes manmade objects that no longer serve a purpose, as well as fragments from collisions and anti-satellite experiments. The majority of the items discovered in space are man-made, with explosions triggered by residual energy in fuel and batteries accounting for the most [4]. These can range from a few meters to many kilometers in size, so while the chances are minimal, continuous tracking is vital. Because of the expanding use of space environments, potential collisions or approaches of various objects should always be monitored to safeguard people's safety and the security of critical space satellites and shuttles. The field of space situational awareness (SSA) comprises themes involving the space environment, including space surveillance and tracking of man-made objects, space weather monitoring and forecasting, and near-Earth object detection. In addition, efforts for space traffic management (STM) are underway for secure outer space missions [9]. The detection, identification, and surveillance of various space objects are critical responsibility for SSA. The application of computational tools to this task may result in more efficient surveillance

* Corresponding author: Chinnala Balakrishna

systems, as well as impact risk assessment and mitigation [7]. The documentation of the space environment and activity provides valuable data for analysis and study. Digital sky surveys are an important source of data in astronomy [10]. These are terabytes of visual data with specified properties spanning a wide variety of wavelengths.

Currently, such models are being used in a variety of initiatives, including space navigation, astronaut aid, and Earth observatory data processing, with more projects in progress [11]. With numerous existing applications of recognition tasks in the healthcare and commercial industries, machine learning for space object recognition is a significant prospect that can help manage the increasing use of satellites and space shuttles [8].

2. Related work

Chanussot [1], X. Wu, D. Hong, Z. Huang, and others found small in size and easily absorbed by a complex and changing background are characteristics of infrared objects that are obtained from a long distance. Space navigation missions heavily rely on space situational awareness (SSA) technologies.

A. C. Rabeendran and L. Denneau discovered a sophisticated approach to distinguishing between real solar system objects and various types of noise or artifacts in astronomical data. This is particularly important for the Asteroid Terrestrial-impact Last Alert System (ATLAS), which is designed to detect Near-Earth Objects (NEOs) that could potentially pose a threat to Earth.

Y. Liu, X. Chen, R. K. Ward, and Z. J. Wang discovered sparse representation (SR) model named convolutional sparsity based morphological component analysis (CS-MCA) which introduced for pixel-level medical image fusion. Unlike the standard SR model, which is based on single image component and overlapping patches. The CS-MCA model can simultaneously achieve multi-component and global SRs of source images.

N. AlDahoul, H. A. Karim, and M. A. Momo initiate Spacecraft recognition is a significant component of space situational awareness (SSA), especially for applications such as active debris removal, on-orbit servicing, and satellite formation.

3. Methodology

This unique approach aims to create a robust space object recognition system using CoatNets, sophisticated neural network architectures. The goal is to improve recognition accuracy by integrating RGB and depth images. Its goal is to collect and preprocess a wide dataset of space images, build and fine-tune CoatNets for RGB and depth data, and investigate fusion strategies for optimal information combining. The trained model will be tested to determine its performance by comparing it to models that solely use RGB or depth information [3]. The ultimate goal is to develop a reliable recognition system with applications in satellite monitoring, space debris tracking, and autonomous space exploration. It also tries to identify issues, address constraints, and provide opportunities for future research in the topic. To distinguish spatial objects in photos, this work proposes a mix of image fusion and ensemble learning models [10]. Twenty picture fusion algorithms were tested using metrics to see which one provided the best balance of performance and runtime speed [5]. The image fusion block produces fused images, which are then fed into ensemble learning models to learn patterns from. Several ensemble approaches, including bagging [6], boosting, and stacking, were implemented and tested.

3.1. System architecture

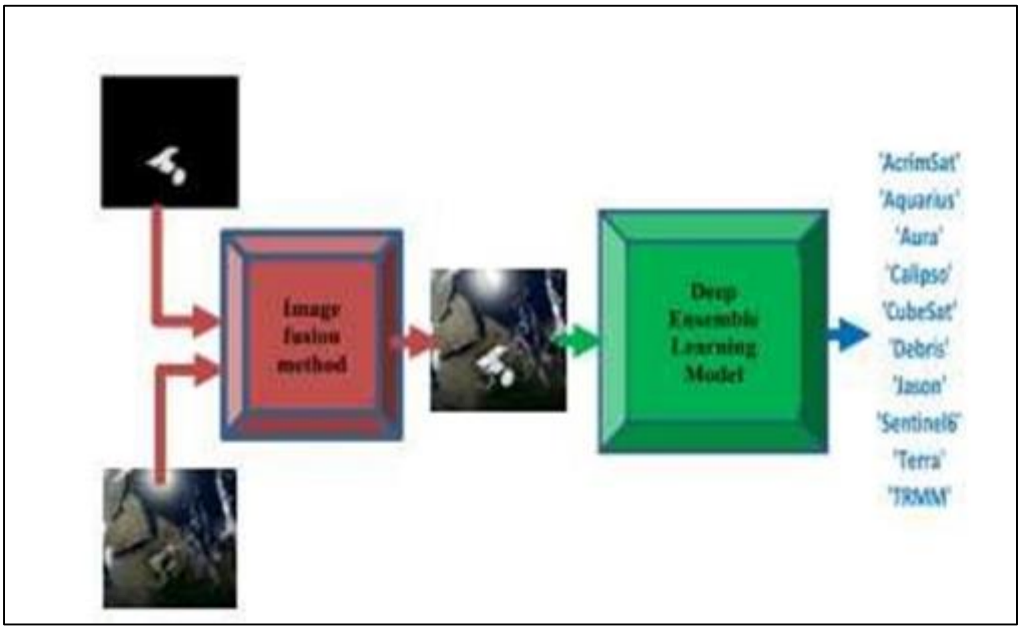


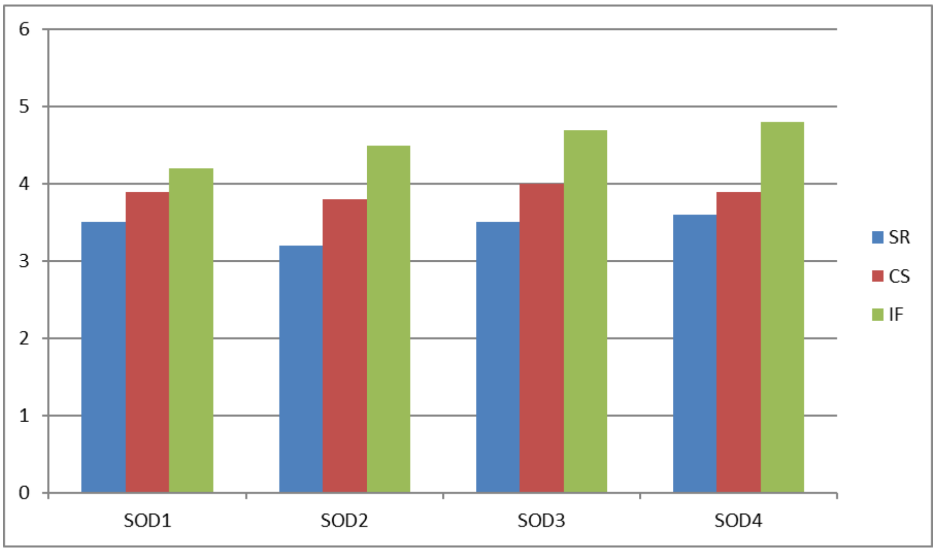
Figure 1 Image Fusion method to detect objects

4. Experimental results

Combining different models or data types to improve overall accuracy,

Fusion methods understanding of complex patterns or relationships within the information.

Fusion techniques can handle missing or noisy data better by integrating information from multiple sources.



SR model- sparse representation; IF-Image fusion; CS-convolutional sparsity; SOD-Space Object Detection

Figure 2 Comparison of Space Object Detection model with SR and IF models

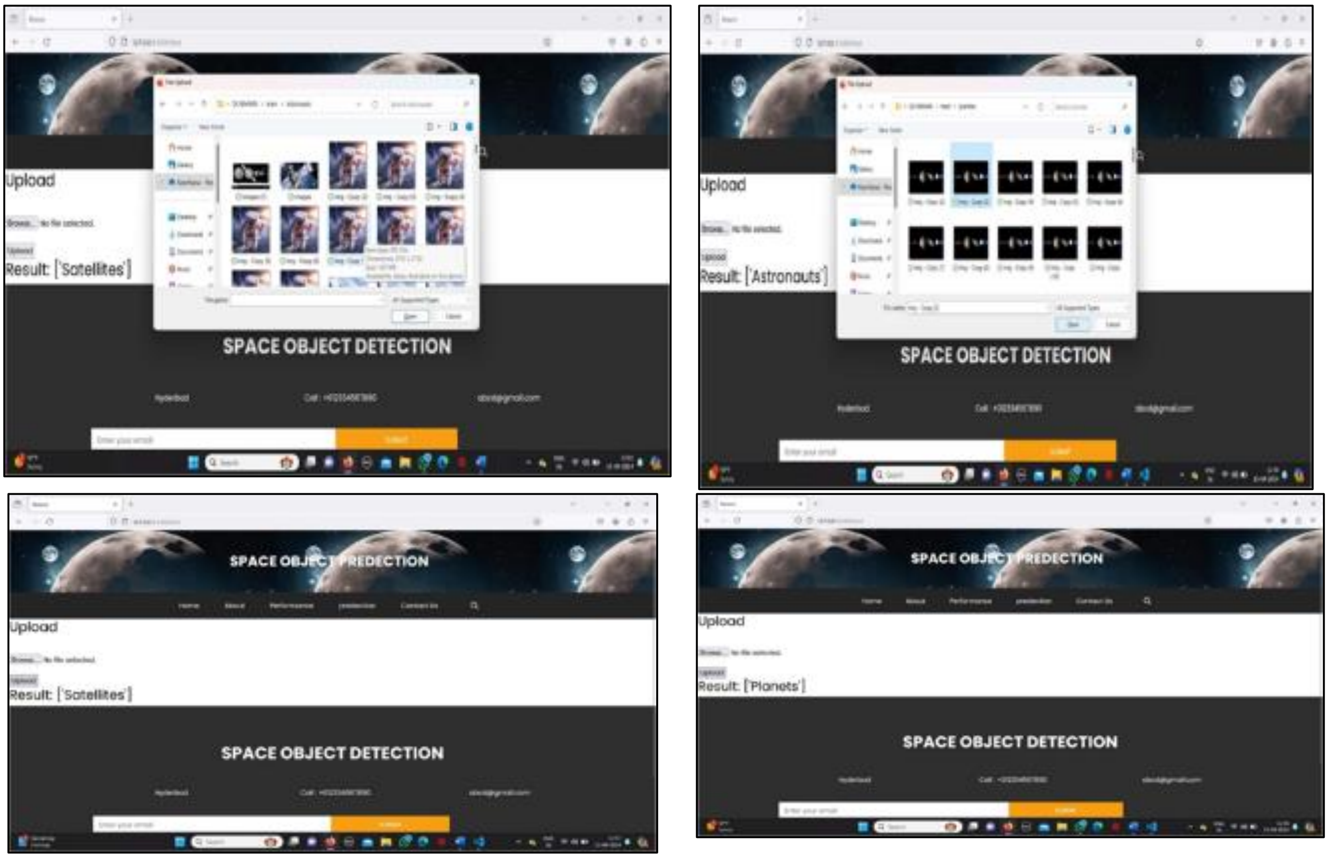


Figure 3 Different types of Space Objects detected like Satellites, Astronauts and Planets

5. Conclusion

In this study, various image fusion algorithms were evaluated for the task of RGB-D image fusion, and they demonstrated superior performance in exploring more information that is not available in single images. We also investigated numerous fusion methods to fuse RGB and depth images that include space objects for recognition purposes. The trials were completed, and the performance was assessed using 13 fusion performance measures. The fusion method produces fused images, which are used to train a deep learning model to classify space objects into ten categories. Several models trained on the SPARK dataset are included in the deep ensemble approaches, such as bagging, boosting, and stacking.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] J. A. Dennerley, ‘‘State liability for space object collisions: The proper interpretation of ‘fault’ for the purposes of international space law,’’ Eur. J. Int. Law, vol. 29, no. 1, pp. 281–301, May 2018, doi: 10.1093/ ejil/chy003

[2] X. Wu, D. Hong, Z. Huang and J. Chanussot, "Infrared Small Object Detection Using Deep Interactive U-Net," in IEEE Geoscience and Remote Sensing Letters, vol. 19, pp. 1-5, 2022, Art no. 6517805, doi: 10.1109/LGRS.2022.3218688.

[3] P. Rajyalakshmi, C. Balakrishna, E. Swarnalatha, B. S. Swapna Shanthi and K. Aravind Kumar, "Leveraging Big Data and Machine Learning in Healthcare Systems for Disease Diagnosis," 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2022, pp. 930-934, doi: 10.1109/ICIEM54221.2022.9853149.

[4] AlDahoul, N., Karim, H.A., De Castro, A. et al. Localization and classification of space objects using EfficientDet detector for space situational awareness. Sci Rep 12, 21896 (2022). https://doi.org/10.1038/s41598-022-25859-y

[5] Balakrishna, C. ., Sapkal, A. ., Chowdary, B., Rajyalakshmi, P., Kumar, V. S. ., & Gupta, K. G. . (2023). Addressing the IoT Schemes for Securing the Modern Healthcare Systems with Block chain Neural Networks. International Journal on Recent and Innovation Trends in Computing and Communication, 11(7s), 347–352. https://doi.org/10.17762/ijritcc.v11i7s.7009

[6] Ravi, C., Raghavendran, C. V. ., Satish, G. N. ., Reddy, K. V. ., Reddy, G. . K. ., & Balakrishna, C. . (2023). ANN and RSM based Modeling of Moringa Stenopetala Seed Oil Extraction: Process Optimization and Oil Characterization. International Journal on Recent and Innovation Trends in Computing and Communication, 11(7s), 329–338. https://doi.org/10.17762/ijritcc.v11i7s.7007

[7] G. Wang, N. Lei and H. Liu, "Improved-YOLOv3 network for object detection in simulated Space Solar Power Systems images," 2020 39th Chinese Control Conference (CCC), Shenyang, China, 2020, pp. 7177-7181, doi: 10.23919/CCC50068.2020.9189240.

[8] C. B. . Koushik Reddy Chaganti, C. Sasikala, G.Sirisha, Shravani Amar, Ravindra Changala, Koppuravuri Gurnadha Gupta, "Improved Plant Phenotyping System Employing Machine Learning Based Image Analysis", Int J Intell Syst Appl Eng, vol. 12, no. 3, pp. 2415–2421, Mar. 2024.

[9] S. Aydın, M. S. Atar, M. A. Arabaci, M. Gökçe and T. M. Lahaçlar, "Determination of Space Object Size in LEO using Measurement of Brightness," 2023 10th International Conference on Recent Advances in Air and Space Technologies (RAST), Istanbul, Turkiye, 2023, pp. 1-6, doi: 10.1109/RAST57548.2023.10197958.

[10] Balakrishnaa, Chinnala, and Tryambak Hirwarkarb. "Hybrid Broadcast Encryption and Group Key Agreement Protocol with Precise Cipher Texts." Turkish Journal of Computer and Mathematics Education Vol 12.5 (2021): 984-988.

[11] S. Li et al., "A Multitask Benchmark Dataset for Satellite Video: Object Detection, Tracking, and Segmentation," in IEEE Transactions on Geoscience and Remote Sensing, vol. 61, pp. 1-21, 2023, Art no. 5611021, doi: 10.1109/TGRS.2023.3278075.

[12] BALAKRISHNA, CHINNALA. "SYSTEMATIC REVIEW OF CONTRIBUTORY BROADCAST ENCRYPTION WITH EFFICIENT ENCRYPTION AND SHORT CIPHER TEXTS." (2020).

[13] Huan Zhang, Yang Zhang, Qingjuan Feng, Kebei Zhang, "Review of Machine-Learning Approaches for Object and Component Detection in Space Electro-optical Satellites", International Journal of Aeronautical and Space Sciences, 2023.