USING TRANSFORMERS TO DETECT STAR CLUSTERS

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The amount of data in astrophysics is growing extremely quickly: new large area surveys enable us to gather more and more data about the universe. One of the key problems we hope to solve with machine learning is the automated detection of star clusters. Convolutional Neural Networks have shown great promise in this sphere [1]. However, an alternative architecture based on the self-attention mechanism, so-called Vision Transformers (ViTs) have been shown to perform better with large datasets [2].

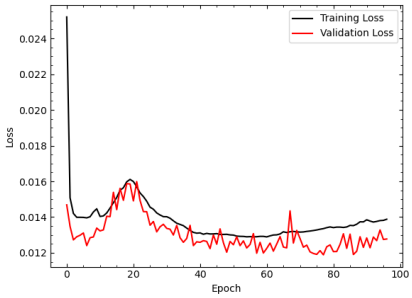

Fig. 1. Training and validation loss of the transformer. We observe a peculiar 'hill' on approximately epoch 20, therefore, we use epoch 50 for further testing.

We have trained a ViT with a single layer of transformer encoders with 16 heads, using an embedded dimension of 128 and a classification head with one layer. We used RMSProp to train the network. The losses are shown in Figure 1; in comparison to our previous work, we obtain far smoother results.

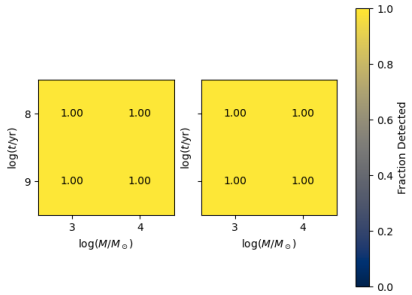

Fig. 2. Results from the artificial star cluster test. The left heatmap shows results with a core radius of 0.1 arcsec, the right – 0.4 arcsec. We notice excellent performance across all parameter ranges.

We have run an artificial cluster test to ensure that the model achieves excellent performance in the test brick. The results, shown in Figure 2, suggest an excellent performance across a wide range of age, mass, and size parameters. Preliminary results also indicate that the transformer is able to detect all of the clusters in the main catalog of Johnson et al. [3]. We also have new detections numbering in the hundreds; most of them are OB associations. The transformers thus successfully located star over-densities in the $F475W$ passband images.

In conclusion, we have developed a new approach to star cluster detection employing transformers using ResNets. Our recall is quite high, however the specificity, especially regarding the separation between background galaxies and clusters, is low. This approach will serve as the first stage of a multi-stage detector for star clusters in Local Universe galaxies. Further work will develop a second stage classifier, which will rectify detections based on other criteria.

Acknowledgements

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[1] B. Zhang et al., "Identification of Star Clusters in M31 from PAndAS Images Based on Deep Learning," 2025, arXiv: arXiv:2503.08130. doi: 10.48550/arXiv.2503.08130.
[2] A. Dosovitskiy et al., "An Image is Worth 16x16 Words: Transformers for Image Recognition at Scale," 2021, arXiv: arXiv:2010.11929. doi: 10.48550/arXiv.2010.11929.
[3] L. C. Johnson et al., "PHAT Stellar Cluster Survey. II. Andromeda Project Cluster Catalog," The Astrophysical Journal, vol. 802, p. 127, 2015, doi: 10.1088/0004-637X/802/2/127.