Application of Industry-Ready Computer Vision Tools to LSST Data

Object Segmentation with Foundation Models

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Introduction

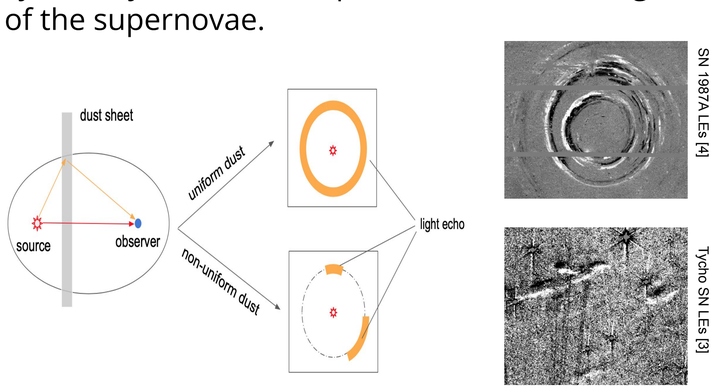
The Legacy Survey of Space and Time holds the promise of revolutionizing astrophysics with unprecedented volumes of data, but this necessitates the development of methods for automated data processing. Foundation models like the Segment Anything Model (SAM, Kirillov+2023)[1] from MetaAI offer a promising solution.

But astrophysical images are inherently out of sample for a model trained on every-day world images.

We tested SAM's performance on astrophysical extended sources in space based galaxy images (GALEX) and ground based galaxy and light echo images (ATLAS, DECAM) testing the potential of its application to data from the LSST.

Data

Light echoes (LEs) are morphologically diverse, continuously evolving phenomena observed when the light from supernovae reflect on interstellar dust. They can provide valuable insight into the study of interstellar dust and symmetry of cosmic explosions, and the origin of the supernovae.



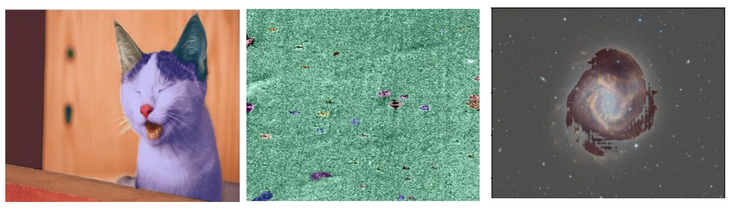
Light Echo(LE) Geometries.[2]
(Left: LE event geometry, Right: Types of LE observations)

The **Rubin FIRST LOOK Galaxy Images** used here are sourced from the Virgo Cluster Treasure Chest. Metadata sourced from Simbad.

Galaxies from FIRST LOOK image.
(Left: M61, Centre: UGC 7513, Right: NGC 4343)

Image Segmentation

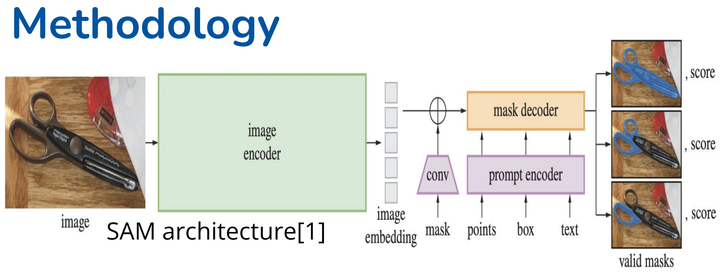
Image segmentation is a computer vision algorithm used to delineate the objects in an image from the background.



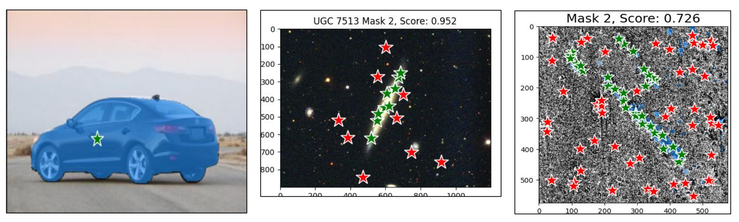
Results from Instance Segmentation with SAM[1], [2], [5].
Each color represents a different segmentation

(Left: MetaAI Image, Centre: ATLAS LE Image, Right: NGC 4378)

Methodology



Prompting SAM works well on every-day images off the shelf but also allows the use of point and box input prompting methods which identifies relevant area of an image to improve performance. We tested the use of single points, multi-points, and box prompts for astrophysical objects

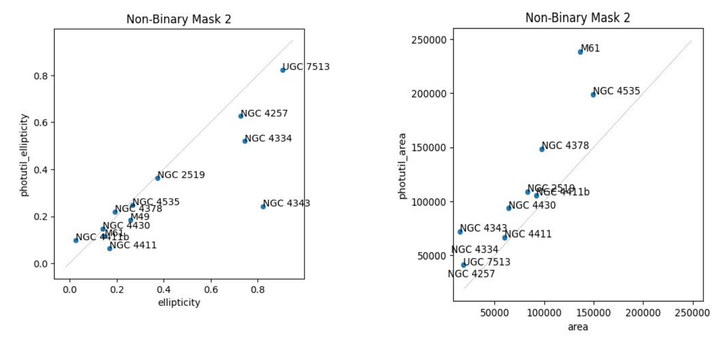


Point Prompting Results
Left: SAM sourced Image[1], Centre: ATLAS LE Image Right: UGC 7513,

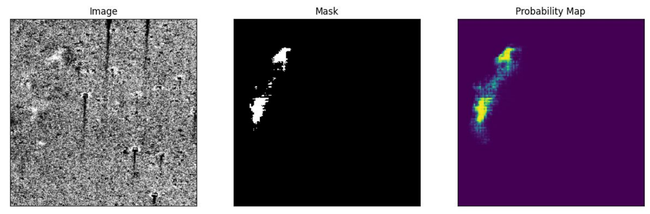
Transfer learning is a technique that helps a model trained on one task to learn a new related task. Since SAM does not perform well in instance segmentation, transfer learning was used to isolate the "mask decoder" for efficient retraining (10). We retrain SAM on small sets of LEs to improve performance

Results

Galaxies: well resolved low redshift galaxies can be segmented effectively by SAM when point prompts are provided. Morphological parameters derived from the SAM masks, like ellipticity and angle are comparable with parameters derived with ellipsoidal isophot fitting (with astropy.photutils).



Light Echoes: light echoes are studied in difference imaging, they are faint and morphologically diverse. Point or box prompt alone is not enough. They require transfer learning, but using a small amount of data for fine tuning and box prompting, e.g. as provided by AILE, a Neural Network for the *detection* of LE in image samples [12],



Conclusion

For well resolved extended astrophysical sources zero-shot learning with prompts SAM can derive effective morphological parameters.
For challenged targets, like Light Echoes, combination of transfer learning and drawing a bounding box around the ground truth mask enables SAM to make highly accurate predictions masks.

Although SAM relies on user generated input prompts to segment astrophysical objects, it is still a useful tool as it significantly reduces the computational resources needed to build a model from scratch.

References

[1] Kirillov, Alexander, *et al.* 2023 *arXiv:2304.02643*.
[2] Li, Xiaolong, *et al.* 2022 *ApJ* 164, no. 6: 250.
[3]Tonry J., Denneau L., Heinze A. *et al.* 2018 *PASP* 130 064505
[4]Rest, A., Suntzeff, N., Olsen, K. *et al.* Nature 438, 1132–1134 (2005).
[5]Conselice, The Astrophysical Journal Supplement Series, 147:1-28, 2003 July
[6]Ryan Hausen, Brant E. Robertson 2020 *ApJS* 248 20
[7]Alexander Gagliano, V. Ashley Villar(2023), arXiv:2312.16687
[8]H. Farias et al.(2020), Astronomy and Computing, Volume 33, 2020.
[9]Duo Xu, Ye Zhu(2024) arXiv:2405.14238
[10]BotPenguin(2023), https://botpenguin.com/glossary/transfer-learning
[11]Li et al.(2020) The Astronomical Journal 164.6 (2022): 250.
[12]Larry Bradley et al. (2025). astropy/photutils: 2.2.0 (2.2.0). Zenodo. https://doi.org/10.5281/zenodo.14889440

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