Today, there are many astronomy datasets provided by various top research groups and companies. Each dataset can be unimodal including images, various natural measures like spectrum, radio waves, redshift, stellar mass, etc, or can be multimodal containing various pairs of unimodal E.g. image-spectrum, image-redshift, etc. Technologies cause datasets to grow drastically, and consequently, working on these datasets is more challenging.

Common deep-learning approaches are based on data that are labeled by humans. This is so time-consuming, and due to the size of the data, it may not be possible to prepare labeled datasets. In this regard, new methods are proposed to take advantage of many available unlabeled datasets. Self-supervised learning tries to generate pseudo-labels from the unlabeled datasets, and train models supervisely. Some self-supervised learning approaches are contrastive learning, mask autoencoders, etc.

Models proposed for astronomy are so task-specific. It means that each of them cannot be utilized for other tasks or data, and they lack generality. Instead of putting time and effort into training task-specific models, we can train a larger model that can be employed for many tasks with only small modifications. This is the main concept of the foundation model, and also the goal that we desire to reach it.

In the proposed foundation model for the galaxy morphology, several tasks like galaxy classification, similarity search, and natural measures prediction like stellar mass, and redshift, applying the foundation model for unseen new data can be employed, and be compared with other proposed foundation models.

Different possible models:

* Propose new foundation models based on unimodal and multi-modal datasets using mask autoencoder, combinations of the mask autoencoder, and contrastive learning, applying some possible modifications to the available methods.
* Propose a larger foundation model using pre-trained models based on ensemble learning methods.
* Applying different fine-tuning approaches to new and previous models and investigating their effectiveness.

**References in astronomy:**

**General Reviews**

[Astronomia ex machina: a history, primer, and outlook on neural networks in astronomy](https://arxiv.org/pdf/2211.03796.pdf) [[1]](https://paperpile.com/c/4U6DSH/zdGk)

[A brief review of contrastive learning applied to astrophysics](https://academic.oup.com/rasti/article/2/1/441/7238495) [[2]](https://paperpile.com/c/4U6DSH/8d88)

Chapters 6, 11, and 12 of AI for Science Book [[3]](https://paperpile.com/c/4U6DSH/A6XU)

Foundation models across disciplines [ScienceFMHub](http://sciencefmhub.org) [[4]](https://paperpile.com/c/4U6DSH/X40f) include related science image applications in remote sensing and climate science.

**Research**

**Datasets** datasets that use imaging surveys

* [Weak Gated Experts (WGE) CNN for deriving photometric redshifts.](https://arxiv.org/abs/1107.3160)

**Astroclip** multi-band imaging and optical spectra.

* [AstroCLIP: Connecting Diverse Observational Modalities in Astrophysics](https://polymathic-ai.org/blog/astroclip/) [[5], [6]](https://paperpile.com/c/4U6DSH/32ku+GBDq)
* AstroCLIP: Cross-Modal Pre-Training for Astronomical Foundation Models, [[7]](https://paperpile.com/c/4U6DSH/s4n0)
* [Self-supervised similarity search for large scientific datasets](https://arxiv.org/pdf/2110.13151.pdf) [[8]](https://paperpile.com/c/4U6DSH/jUbf) analysis that was used by Astroclip for image modality. Uses Contrastive loss

**Radio Galaxy Zoo** ResNet107893 images; 1256 fine-tuning

* [Radio Galaxy Zoo: Towards building the first multi-purpose foundation model for radio astronomy with self-supervised learning.](https://arxiv.org/pdf/2305.16127.pdf) [[9]–[11]](https://paperpile.com/c/4U6DSH/LmeM+kVU4+Nkw8)
* [Self-Supervised Representation Learning for Astronomical Images](https://arxiv.org/pdf/2012.13083.pdf) [[12]](https://paperpile.com/c/4U6DSH/5zgB)
* [Towards Galaxy Foundation Models with Hybrid Contrastive Learning](https://arxiv.org/pdf/2206.11927.pdf) Contrastive Loss, 552K labeled 1.34M not labeled.
* [Transfer learning for galaxy morphology from one survey to another | Monthly Notices of the Royal Astronomical Society | Oxford Academic](https://academic.oup.com/mnras/article/484/1/93/5266389) [[13]](https://paperpile.com/c/4U6DSH/8MWF)
* [Classification of Astronomical Bodies by Efficient Layer Fine-Tuning of Deep Neural Networks](https://ieeexplore.ieee.org/iel7/9672322/9672339/09672430.pdf?casa_token=1ajTnZylzWcAAAAA:r2B7Crg6drIdJ-lTmZK0DWnMWWVOf2z509EfUNVJ_nWgpPHJmlIYD5ovuW8MF_RZz6w4Rxxm) [[14]](https://paperpile.com/c/4U6DSH/2oVw)
* [Galaxy Morphological Classification with Efficient Vision Transformer](https://arxiv.org/abs/2110.01024) [[15]](https://paperpile.com/c/4U6DSH/WpJW)
* [[2205.01677] ASTROMER: A transformer-based embedding for the representation of light curves](https://arxiv.org/abs/2205.01677) [[16]](https://paperpile.com/c/4U6DSH/f89e)

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