Title: Deconvolving the Noisy Universe: A machine learning approach to analyze astronomical images

Summary: Inferring physical properties of astrophysical objects such as cluster of galaxies are limited by the quality of observations which include various sources of random and systematic noise from the sky background, the optical system of the telescope, and the detector used to record the data [1,2]. The ability to better recover detailed features through image deconvolution from low-signal-to-noise and low angular resolution imaging data significantly increases our ability to study existing datasets of astrophysical objects as well as future observations with *XMM-Newton* and *Chandra* space telescopes. Traditional deconvolution techniques are limited in their ability to recover features in imaging data by the Shannon-Nyquist sampling theorem [1]. In this project, our goal is to implement a deconvolution algorithm based upon borrowing ideas from Machine Learning techniques. Deep Neural Networks has proven to be a powerful tool to extract features from noisy images [3]. We use large-scale and realistic simulated X-ray images, derived from hydrodynamic simulations or semi-analytical models, to train and test these algorithms [4]. After implementation and testing, the code will become available in an open-source format for the scientific community and will be hosted in a permanent repository, and finally the results will be published in an astronomy journal.

Item	Description
Affiliation	Department of Physics, College of LS&A
Mentor	Arya Farahi, Ph.D student, (aryaf@umich.edu) http://www-personal.umich.edu/~aryaf/
Logistics	4 months for 1 – 2 students Start Date: May 15th or later, Finish Date: September 15th or later It can be extended if there is mutual interest.
Scope	Developing a reproducible algorithm and implementing an open software to deconvolve X-ray astronomical images, and comparing these algorithms with traditional deconvolution algorithms exists in the literature.
Challenge	Building Deep Learning models, working with large scale simulated astronomical images, developing an open source software and documentation, and comparing the results with the literature.
Data	Simulated astronomical images, using template scheme or hydrodynamics simulations (see, Simulating X-ray Observation with Python).
Approach	We will implement few Deep Neural Networks (e.g. Convolutional Neural Network, Residual Neural Network, Generative Adversarial Network) to deconvolve X-ray images and compare them with traditional algorithms (see, Deconvolution in Astronomy: A Review).
Students	Students on this project will desire experience implementing modern ML algorithms, specifically Deep Neural Networks, however having previous experience in Deep learning is not required. They will have programmed in Python before. Prior knowledge of Git is required.
Expectations	Students need to attend weekly meeting and report progress. Students will actively learn telescopes response functions and noise modeling. Students will learn to work with large-scale datasets, potentially running codes on Flux, and hosting codes and dataset on a website.
Products	An open-source code, documentation, visualization, and final report which is intended for publication.
Format	The mentor will meet with the students every week. Students must derive the project (learning, coding, debugging, and documenting), however the mentor will help them throughout the process and will guide the students.
Platform	We use Python and use yt, TensorFlow, and Keras libraries for implementation.
Disclosure	The code will be open source, describe the algorithm, implementation, and results, and be submitted for peer review.