Synthetic galaxies with chained deep learning models

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Why would we even need that?

(1) Training sets for budding deep learning applications

- Morphological classification of galaxies ^{1,2,3,4}
- ► Finding galaxy-galaxy strong lensing effects ⁵
- Deblending overlapping galaxies in images ⁶
- Recovering features in degraded images ⁷

(2) Calibration of shape measurements in weak lensing ⁸

^[1] Dieleman et al. (2015), MNRAS, 450:1441 / arXiv:1503.07077

^[2] Huertas-Company et al. (2018), ApJ, 858:2 / arXiv:1804.07307

^[3] Khalifa et al. (2018), ICCSE 2018 Proceedings / arXiv:1709.02245

^[4] Domínguez Sánchez et al. (2018), MNRAS, 476:3661 / arXiv:1711.05744

^[5] Lanusse et al. (2017), MNRAS, 473:3895 / arXiv:1703.02642

^[6] Reiman & Göhre (2018), working paper / arXiv:1810.10098

^[7] Schawinski et al. (2017), MNRAS, 467:L110 / arXiv:1702.00403

^[8] Ravanbaksh et al. (2017), AAAI-17 Proceedings / arXiv:1609.05796

An undergraduate research success story

Background

- Began as an undergraduate summer research project
- ► Worked well enough to continue and make it a paper

Student

- Levi Fussell (deservedly the paper's first author)
- Now a PhD student at the School of Informatics

Generative adversarial networks (GANs) ⁹

(1) Discriminator

- ► Input: Image, either an original or a forgery
- Output: Classification w.r.t. the input's nature
- Gets ever-better at classifying originals and forgeries

(1) Generator

- (Usually) Gaussian noise as a random variable
- Output: Image, following the originals' distribution
- Gets ever-better at creating more convincing forgeries

Building a galaxy-creating generative model

Generator network



Discriminator network

Results of just throwing dropout at problems



Closest-match analysis



Testing physical realism for 64×64 images



Maxing out at a resolution of 64×64



Solution: Second-stage resolution enhancement



Testing physical realism for 128×128 images



Generating synthetic galaxies



Thank you!

Paper

Fussell, L. & Moews, B. (2018), "Forging new worlds: High-resolution synthetic galaxies with chained generative adversarial networks", submitted to MNRAS

Preprint

www.arxiv.org/abs/1811.03081

<u>Code</u>

www.github.com/moews/ganaxies