Constellation Generation & Detection

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Problem Definition

- Apparent **lack of annotated astronomical data.**
- **Applications:**
  1. Satellite positioning
  2. Telescope Detection
  3. Astronomy Research
- Proposing detection method that can be extended beyond just constellations.

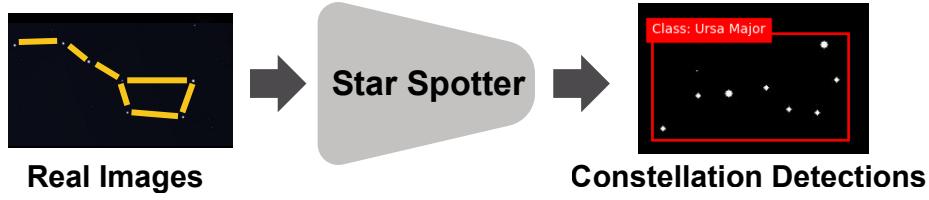
Objectives

- Create generative **cGAN** model (**dots2stars**) to make realistic, synthetic astronomy data.
- Create finetuned detection model (**Star Spotter**) to validate synthetic images.
- Comparative constellation detection (procedural vs. generative dataset curation).

Final Design

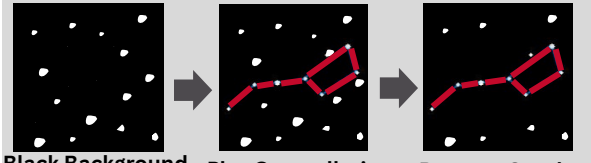
#1. Constellation Generation

#2. Constellation Detection



Design Calculations & Analysis

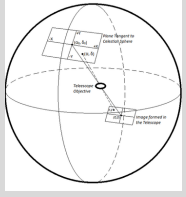
Procedural Constellation Generation



Real-Images Dataset

- Online-Sourced
- 1750 Img, 6130 Instances
- 14 Constellation Classes

3D Coordinates to 2D Coordinates



$$x = \cos(\theta)\cos(\phi)$$

$$y = \sin(\theta)\cos(\phi)$$

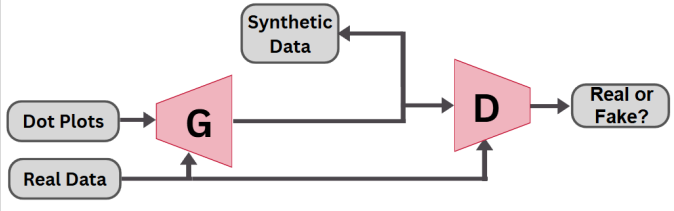
Balancing cGAN Loss

- Generator **maximizes making realistic images.**
- Discriminator **minimizes mistaking synthetic images for real images.**
- Adjustable Parameter λ

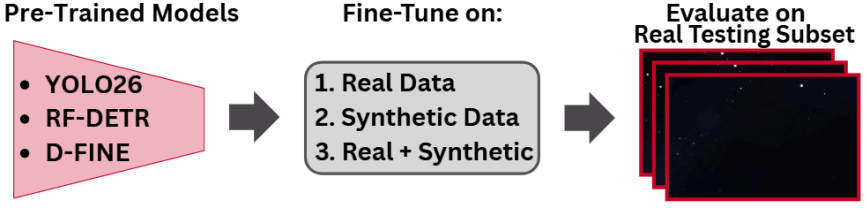
$$\mathcal{L} = \mathcal{L}_{\text{GAN}}(G, D) + \lambda \mathcal{L}_{L_1}(G)$$

Conditional GAN

- **G**enerator
- **D**iscriminator
- Compares the synthetic images against real images



Prototype & Test Results



	Nano		Small	
Model	mAP50	mAP50-95	mAP50	mAP50-95
YOLO26+Real	81.08	48.10	92.29	57.07
YOLO26+Dots	0.04	0.01	1.86	0.93
YOLO26+Real+Dots	11.7	4.46	22.09	10.09
YOLO26+GanGen	0.37	0.06	0.11	0.04
YOLO26+Real+GanGen	6.50	1.91	10.28	4.30