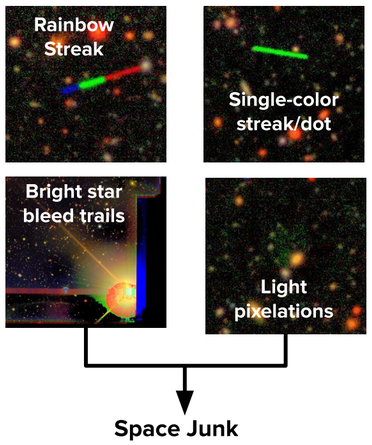
Finding Space Junk with the World's Biggest Telescopes

Rebecca Bell, Pavani Jairam, Jiayue Xu

What is Space Junk?

Astronomers use images of deep space to study the universe. These images are polluted with "space junk" that obstructs their view.

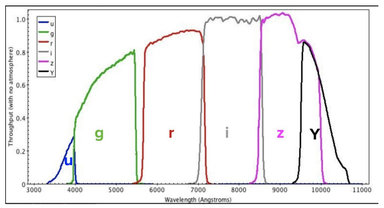


Data: The Dark Energy Survey

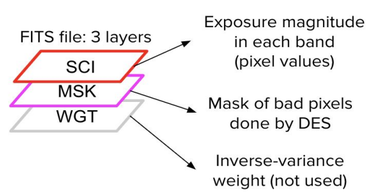
DES Data

- International effort to map galaxies, detect supernovae, and reveal patterns of dark energy
- 6 deep fields, 363 4200x2200 images

Each image consists of 6 bands

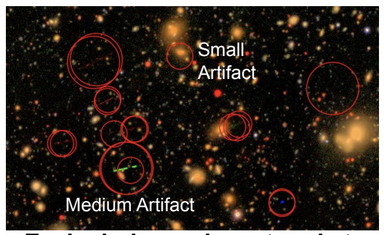


Each band stored in FITS file



Manual Mask Data

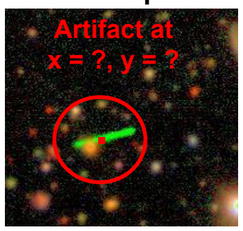
- Artifact location identified by volunteers
- 231 images contain small and medium masks



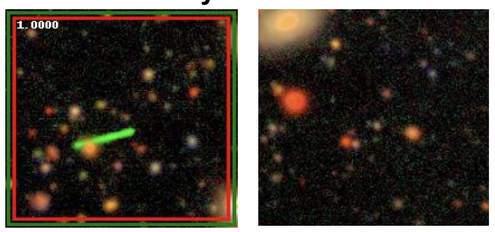
Each circle mask centered at x,y coordinates of artifacts

Deep Convolutional Models to Find Space Junk

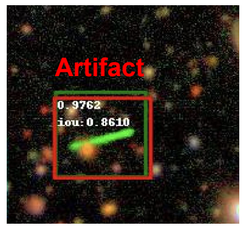
Current Process: Manual Inspection



Approach 1: Binary Classification



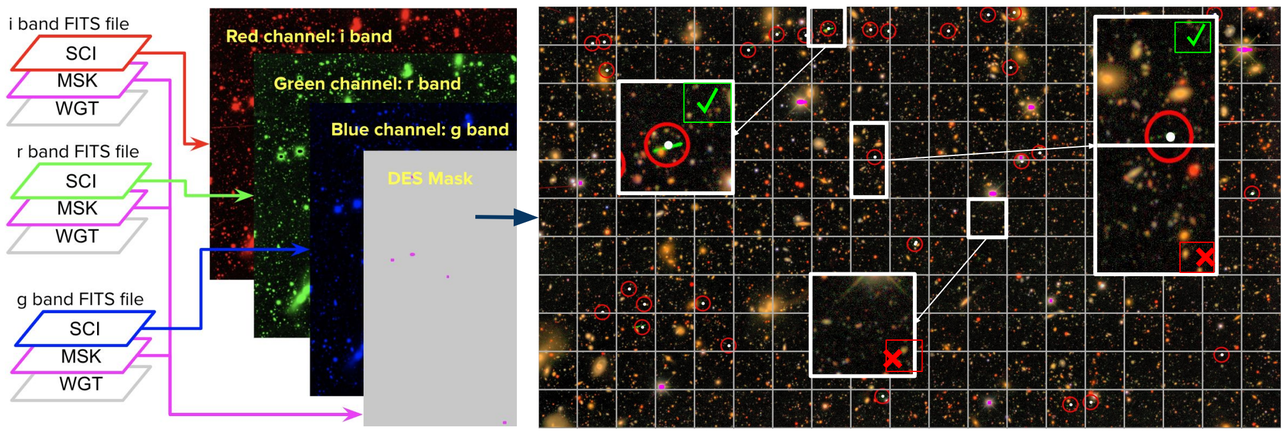
Approach 2: Object Detection



Manually detecting space junk is time consuming, inefficient, and leaves room for human error. Our mission was to build an algorithm that would automate this detection process.

Data Pre-Processing

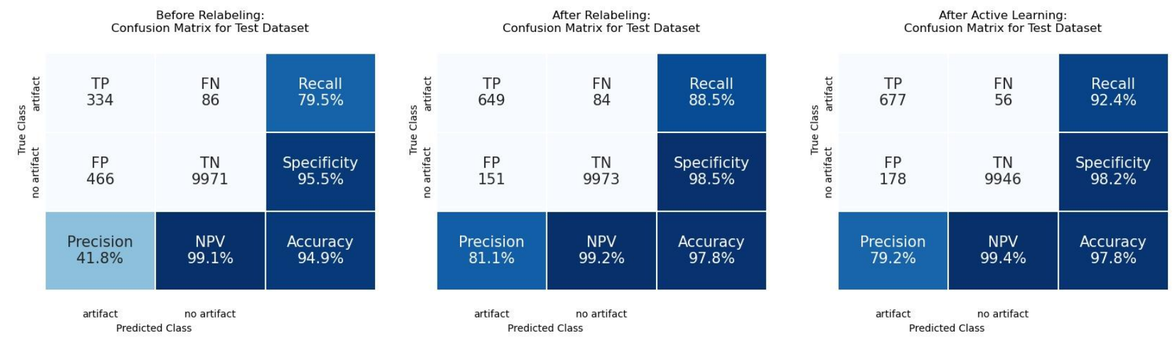
- To transform FITS files into JPEGs, we extracted the SCI layer of the *i, r, g*-bands and mapped them to red, green, and blue channels. Then, each of the MSK layers are combined into a single array, which, when applied to the RGB array, shows magenta colored masks.
- We located the artifacts using x,y coordinates. After dividing the image into tiles (200x200 for classification, 600x600 for detection), we classified each by the percentage of tile that is masked.



Binary Classification: Methods & Results

small artifacts with 50:50 training class balance	Included data augmentations	Finetune optimizer and learning rate scheduler	Included medium artifacts	Change to 20:80 training class balance
Validation Recall: 0.872 Val. Precision: 0.377	Validation Recall: 0.946 Val. Precision: 0.362	Validation Recall: 0.967 Val. Precision: 0.350	Validation Recall: 0.953 Val. Precision: 0.391	Validation Recall: 0.930 Val. Precision: 0.432

Active Learning With a 95% threshold

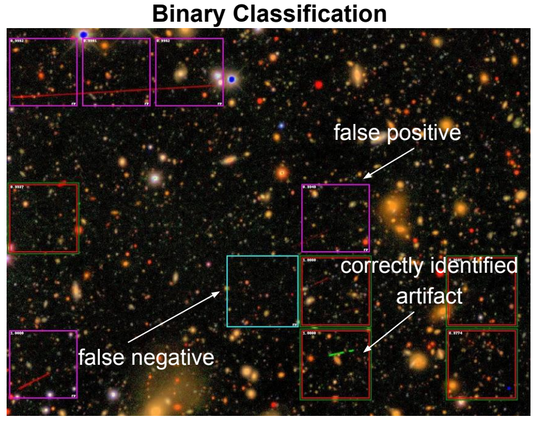


Object Detection: Methods & Results

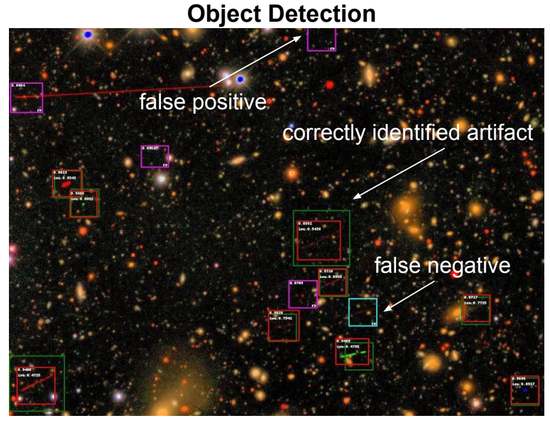
Torch Vision Faster RCNN R50 FPN	Detectron2 Faster RCNN R50 FPN	Detectron2 Faster RCNN R101 FPN	Detectron2 Faster RCNN X101 FPN	Detectron2 Retinanet R50 FPN	Detectron2 Retinanet R101 FPN
Average Recall: 0.539 Avg. Precision: 0.380	Average Recall: 0.563 Avg. Precision: 0.389	Average Recall: 0.558 Avg. Precision: 0.387	Average Recall: 0.575 Avg. Precision: 0.407	Average Recall: 0.582 Avg. Precision: 0.391	Average Recall: 0.602 Avg. Precision: 0.399

Comparison of Results

Binary Classification



Object Detection



When the results of our two models are stitched together, they generate the full-sized images above.

Next Steps

We plan on continuing our work into the semester. We hope to extend our models into all 6 channels, apply active learning to object detection, fine tune, and package the software for DES researchers.

Acknowledgements

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