
ASTROSTATLEARN
A BEAUTIFUL JOURNEY INTO
GALAXIES SEGMENTATION
> A-STRA-BRUTTI SECRET MISSION
NASA

THE CREW MEMBERS

CAMILLA SAVARESE
Spacecraft Commander

GIULIO D'ERASMO
Mission Specialist

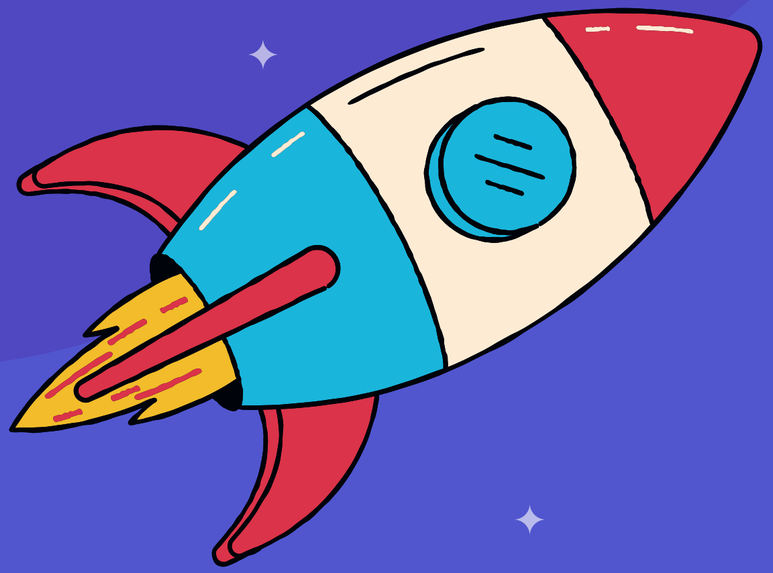
ARTURO GHINASSI
Lunar Module Pilot

ANDREA POTI'
Flight Engineer

AMEDEO RANALDI
Aerospace Engineer

SPECIAL AGENT: RICCARDO CECCARONI

THE DATASET



IMG.FITS

A RAW 25000x25000 PIXEL SATELLITE IMAGE

RMS.FITS

A 25000X25000 PIXEL

TRUE.FITS

A 25000X25000 PIXEL IMAGE REPRESENTING THE MASK OR THE TRUE SEGMENTED IMAGE LOCALIZING THE SINGLE GALAXIES

THE MODELS

ASTROPY

K-MEANS

RANDOM FOREST

U-NET

MASK -RCNN

DETR

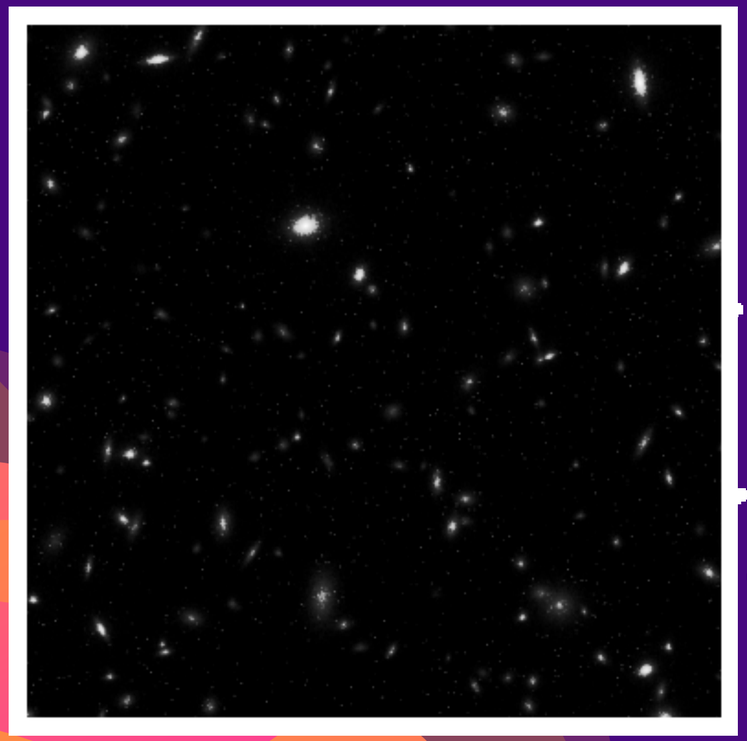
PREPROCESSING

Before passing the dataset to the models we apply different preprocessing techniques on the primary image in order to enhance the contrasts and see galaxies better. Below the results:

Original Image

FITS Liberator 3

+ Log stretched RMS



METRICS TO EVALUATE IMAGE SEGMENTATION PROBLEMS

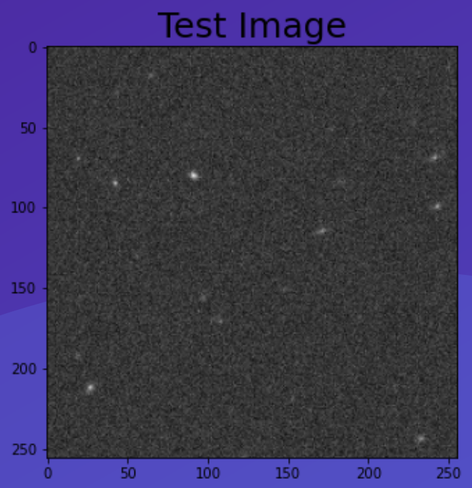
$$2 \times \frac{A \cap B}{A + B}$$

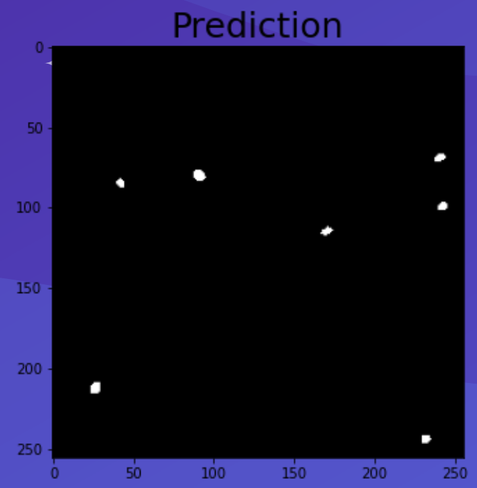
$$IoU = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$

THE BASELINE METHODS

ASTROPY MAIN RESULTS

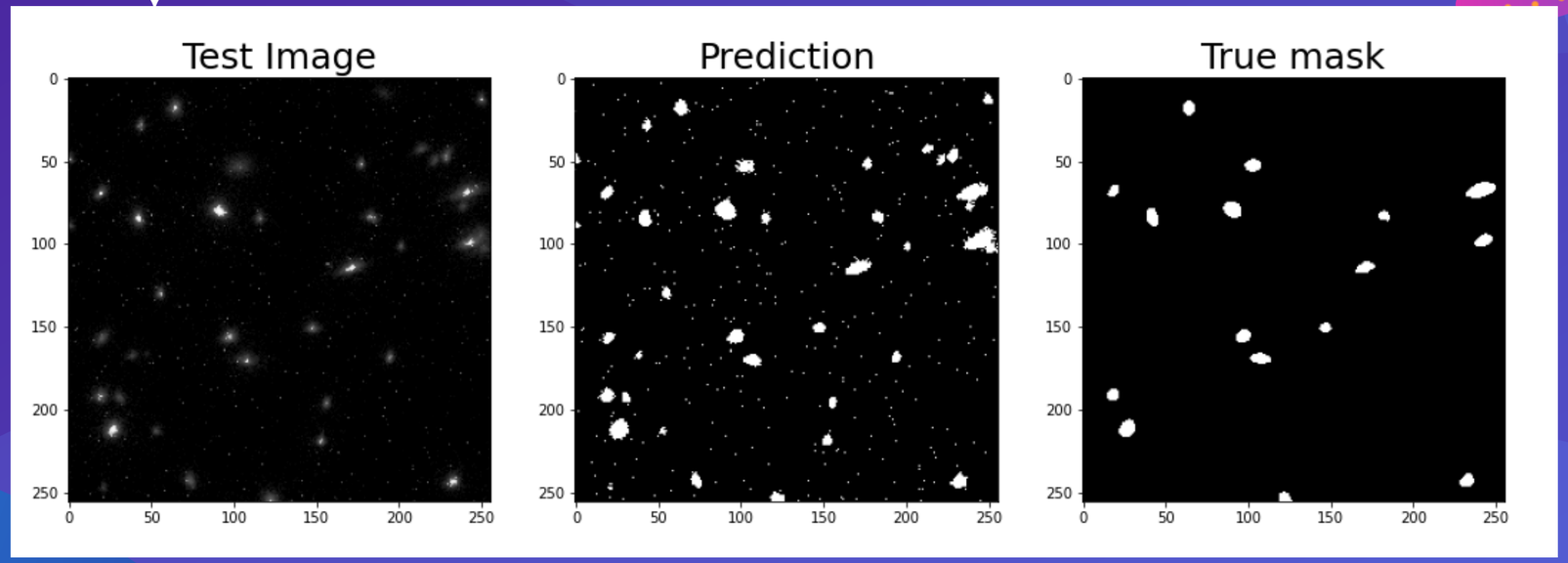
IMAGES	IoU	RECALL	DICE	ACC.CY
Normalized Image	25.09%	99.42%	39.71%	96.12%
Software + Normalized Image	11.25%	12.35%	19.80%	74.63%
Software + RMS + Normalized Image	7.95%	9.18%	14.15%	46.69%
Software + RMS + Normalized + Stretch Image	10.63%	11.81%	17.83%	53.20%





K-MEANS MAIN RESULTS

IMAGES	IoU	RECALL	DICE	ACC.CY
Normalized Image	3.15%	27.11%	5.94%	25.54%
Software + Normalized Image	15.26%	56.96%	26.24%	95.34%
Software + RMS + Normalized Image	15.31%	62.02%	26.33%	95.42%
Software + RMS + Normalized + Stretch Image	28.74%	70.08%	42.54%	94.52%



RANDOM FOREST MAIN RESULTS

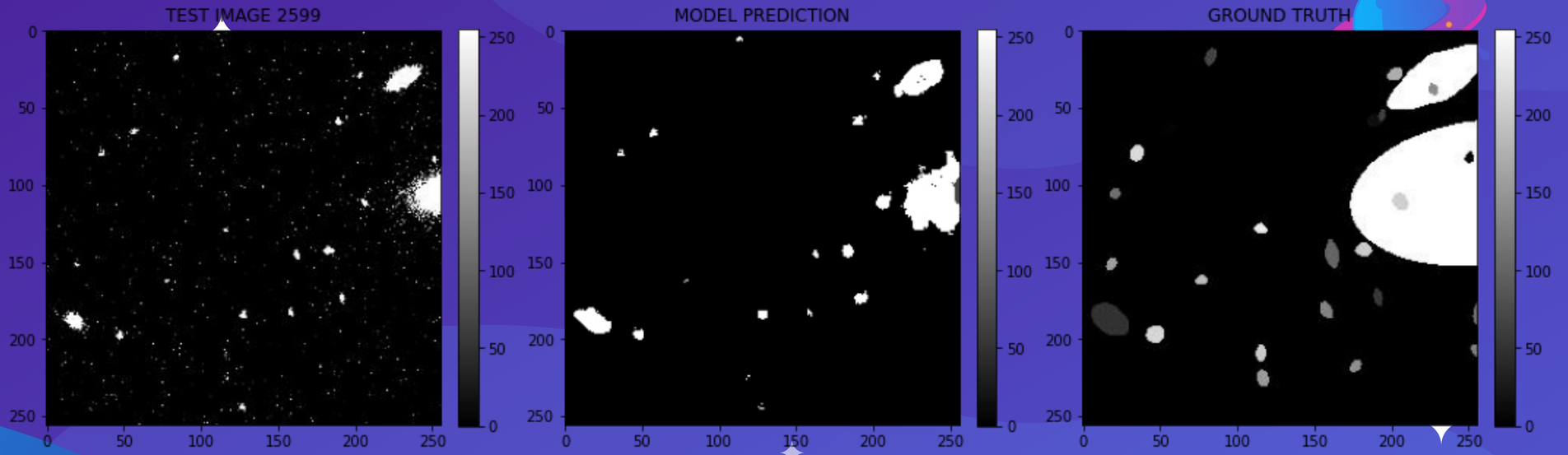
RESULTS	
PRECISION	12.59%
RECALL	44.34%
ACCURACY	76.61%
F1 SCORE	18.73%

TEST SIZE:

- 5 images

NEGATIVE ASPECTS:

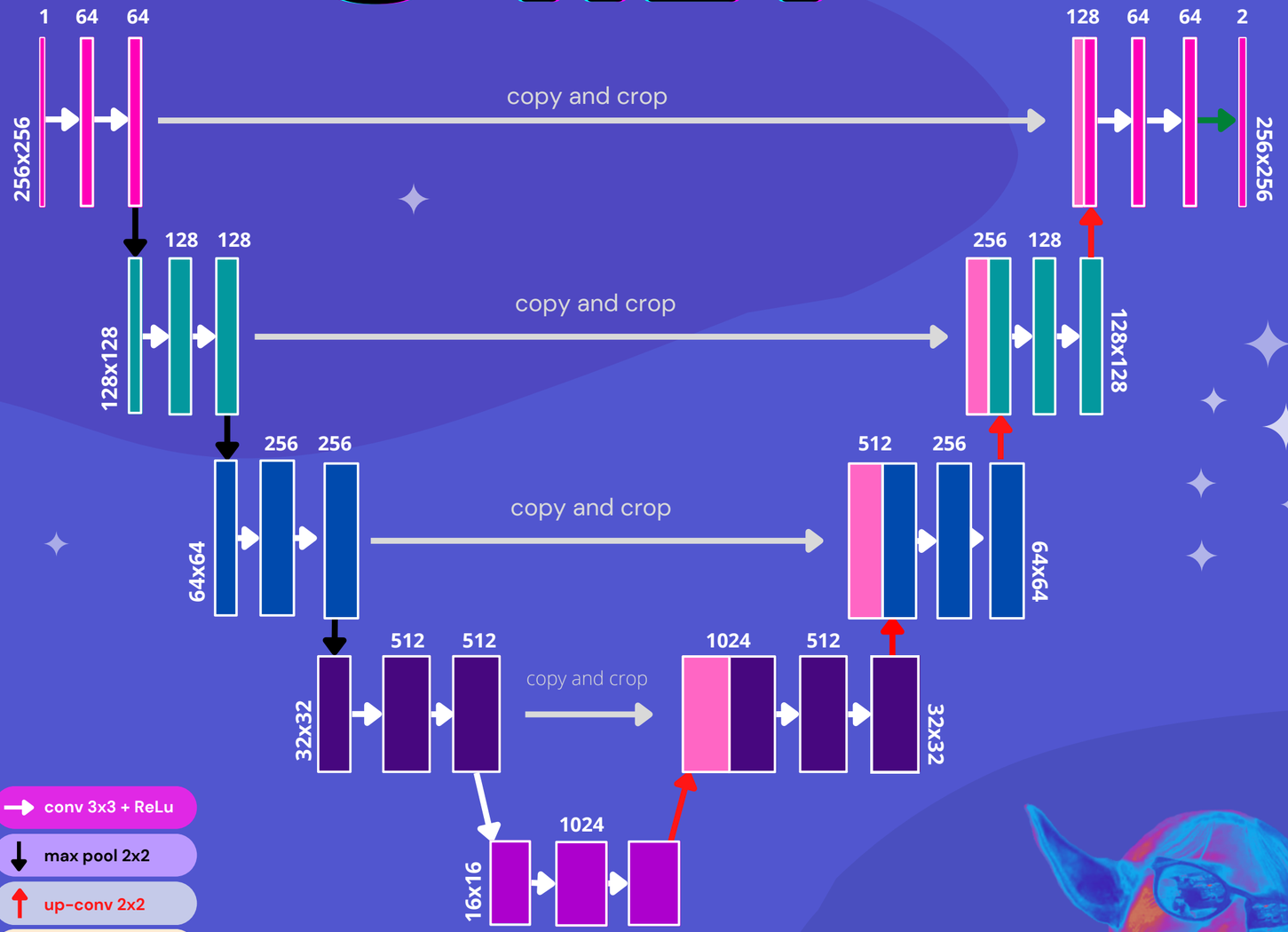
- Bad prediction for segmentation
- Not the right algorithm for this task



THE PLANET OF NEURAL NETWORKS

MAY THE FORCE BE WITH

U-NET

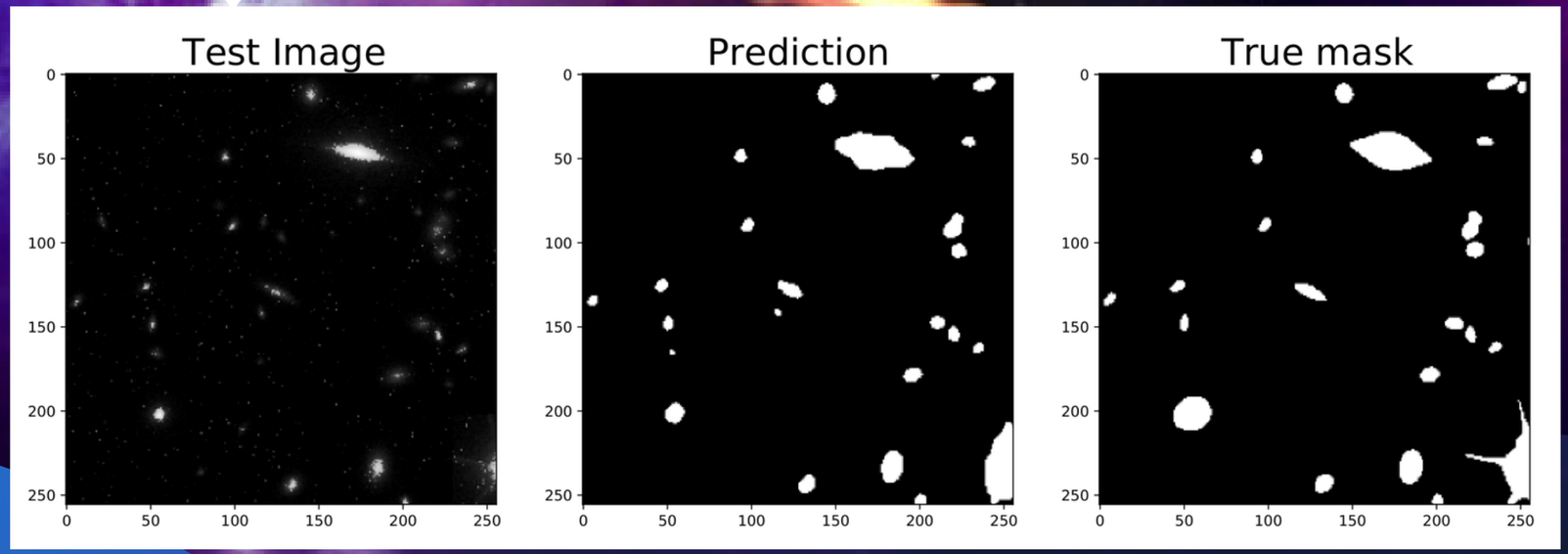


POINTS

- **modifications to the original model :**
  - input/output size (256x256x1)
  - added padding at each convolution
  - no cropping, just concatenating
- **training:**
  - almost 2000 patches (256x256)
  - binarized mask (1 galaxy, 0 background)
  - 30 epoques + early stop
- **possible improvements:**
  - Drop-out for regularization
  - Batch normalization
  - More epoques and train samples
  - Switching to COLAB PRO

MAIN RESULTS

IMAGES	Loss	IoU@0.3	IoU@0.5	RECALL	DICE	ACC.CY
Normalized Image	7.57%	58.71%	58.55%	65.87%	56.86%	97.63%
Software + Normalized Image	6.94%	60.77%	61.64%	61.64%	61.20%	97.81%
Software + RMS + Normalized Image	6.56%	62.76%	66.23%	66.23%	59.84%	98.06%
Software + RMS + Normalized + Stretch Image	3.93%	71.16%	70.76%	70.76%	74.93%	98.38%

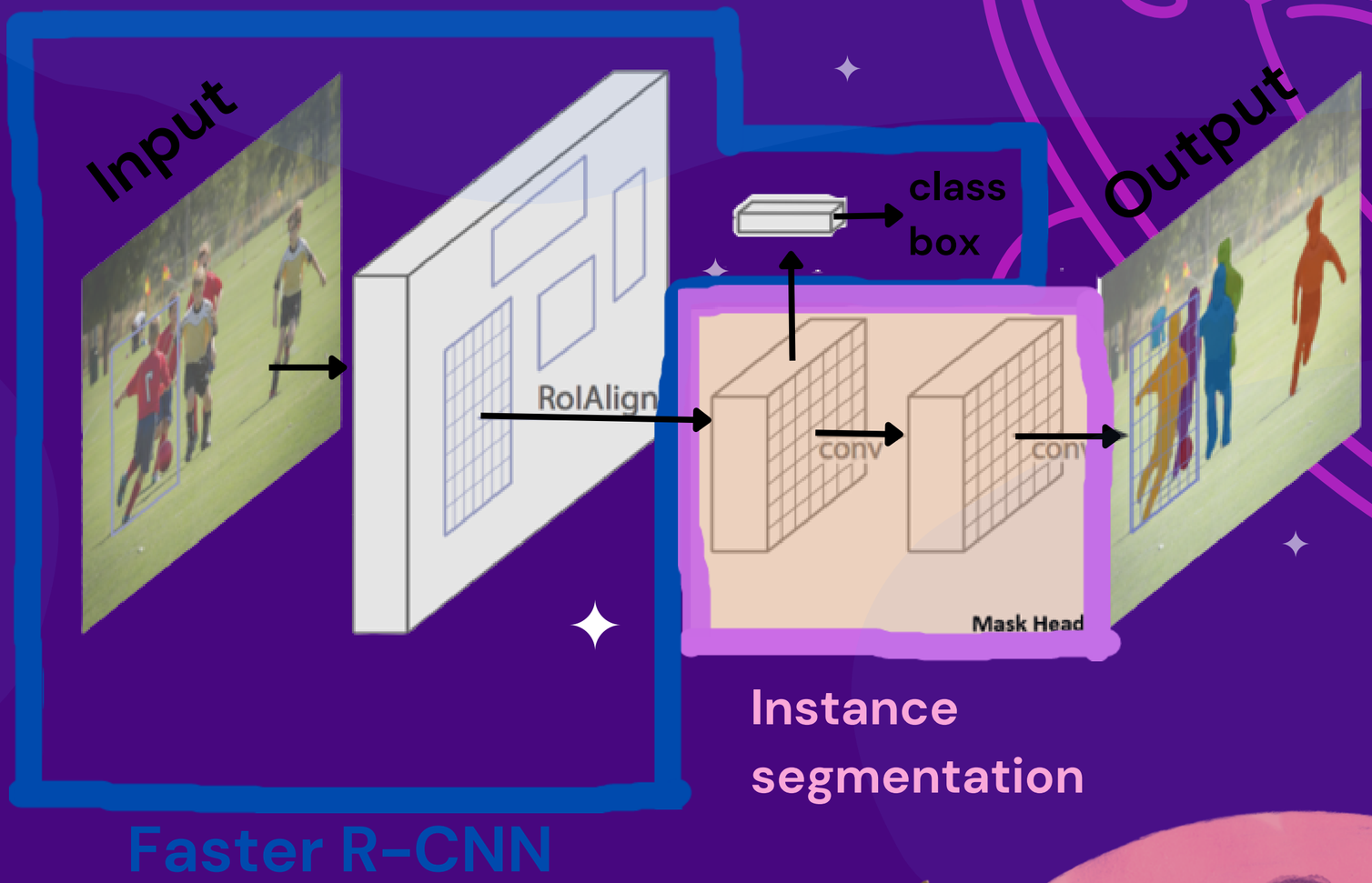


MASK R-CNN

- Improved version of Faster R-CNN used for both image segmentation and object detection

- COCO dataset format in order to use the model containing the following items:
  - dataset folder with images and ground truth
  - annotation file

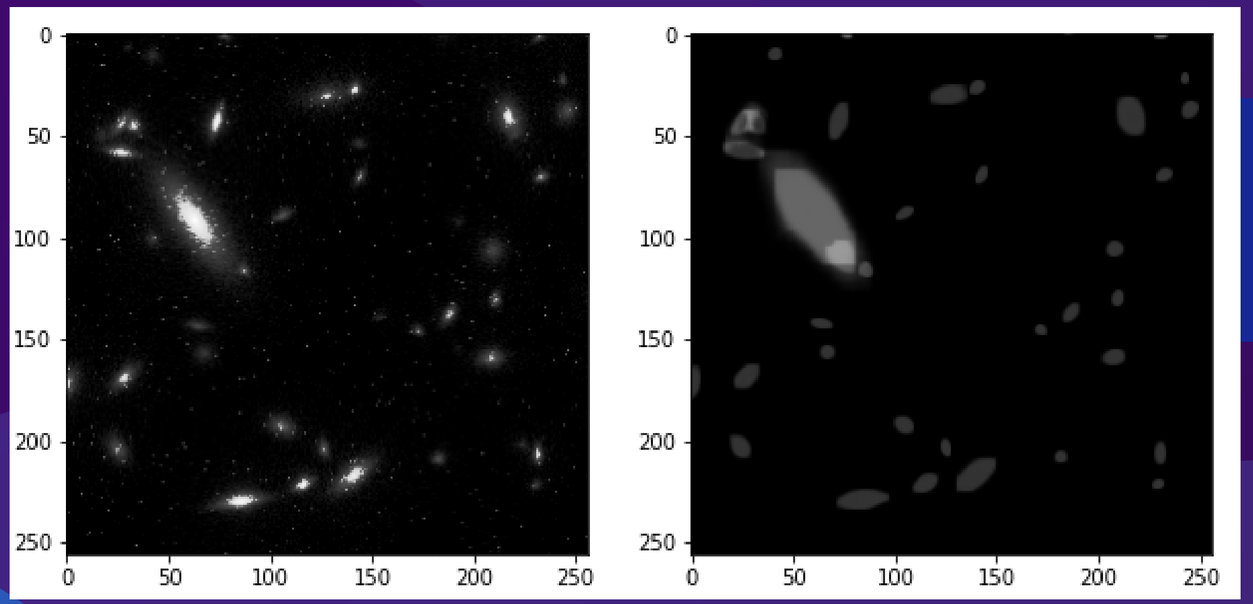
- Training:
  - input size: 256x256 with ~1300 samples
  - train/val/test split (75/15/15)
  - 20 epoques
  - Adam optimizer w/ learning rate adaptor
  - batch size of 8



Neural Networks

MAIN RESULTS

IMAGES	AP@[IoU=0.5:0.95]	AP@[IoU=0.5]	AP@[IoU=0.75]	AR@[IoU=0.5:0.95]
Image	0.5%	1.6%	0.2%	3.6%
Software + Normalized Image	1.12%	42.2%	2.5%	55.9%
Software + RMS + Normalized Image	1.07%	35.6%	4.1%	51.0%
Software + RMS + Normalized + Stretch Image	2.45%	71.8%	8.6%	58.1%



DETR: END-TO-END OBJECT DETECTION WITH TRANSFORMERS

CNN

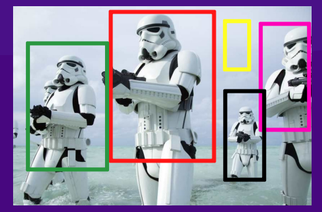
set of image features

transformer
encoder-decoder

set of box predictions

- no obj
- obj
- obj
- no obj
- obj
- obj

bipartite matching loss



```
annotation{
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   "file_name"         : str,
   "segments_info"     : [segment_info],
}

segment_info{
   "id"                : int,
   "category_id"       : int,
   "area"              : int,
   "bbox"              : [x,y,width,height],
   "iscrowd"           : 0 or 1,
}

categories[{
   "id"                : int,
   "name"              : str,
   "supercategory"     : str,
   "isthing"           : 0 or 1,
   "color"             : [R,G,B],
}]
```
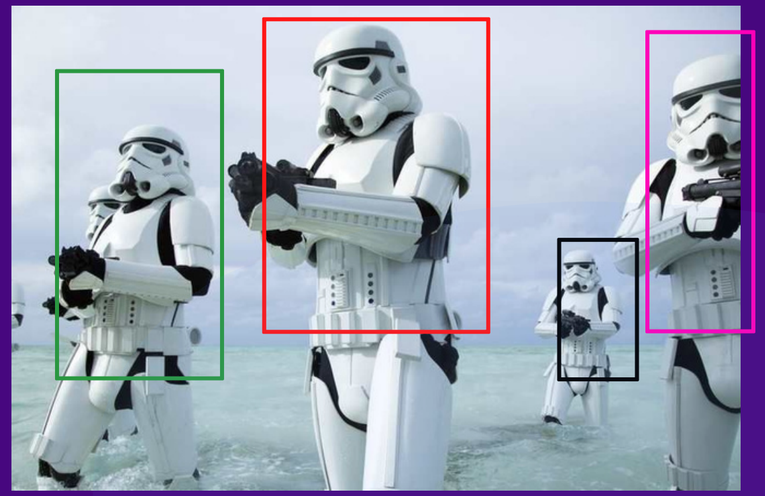

Preprocessing:
Panoptic segmentation



MAIN RESULTS

IMAGES	PQ	SQ	RQ
ALL	?	?	?
Class void	?	?	?
Class Galaxy	?	?	?