



# ASTROSTATLEARN

## A BEAUTIFUL JOURNEY INTO GALAXIES SEGMENTATION

> A-STRABRUTTI SECRET MISSION



# THE CREW MEMBERS



**CAMILLA  
SAVARESE**  
Spacecraft  
Commander



**GIULIO  
D'ERASMO**  
Mission Specialist



**ARTURO  
GHINASSI**  
Lunar Module Pilot



**ANDREA POTI'**  
Flight Engineer

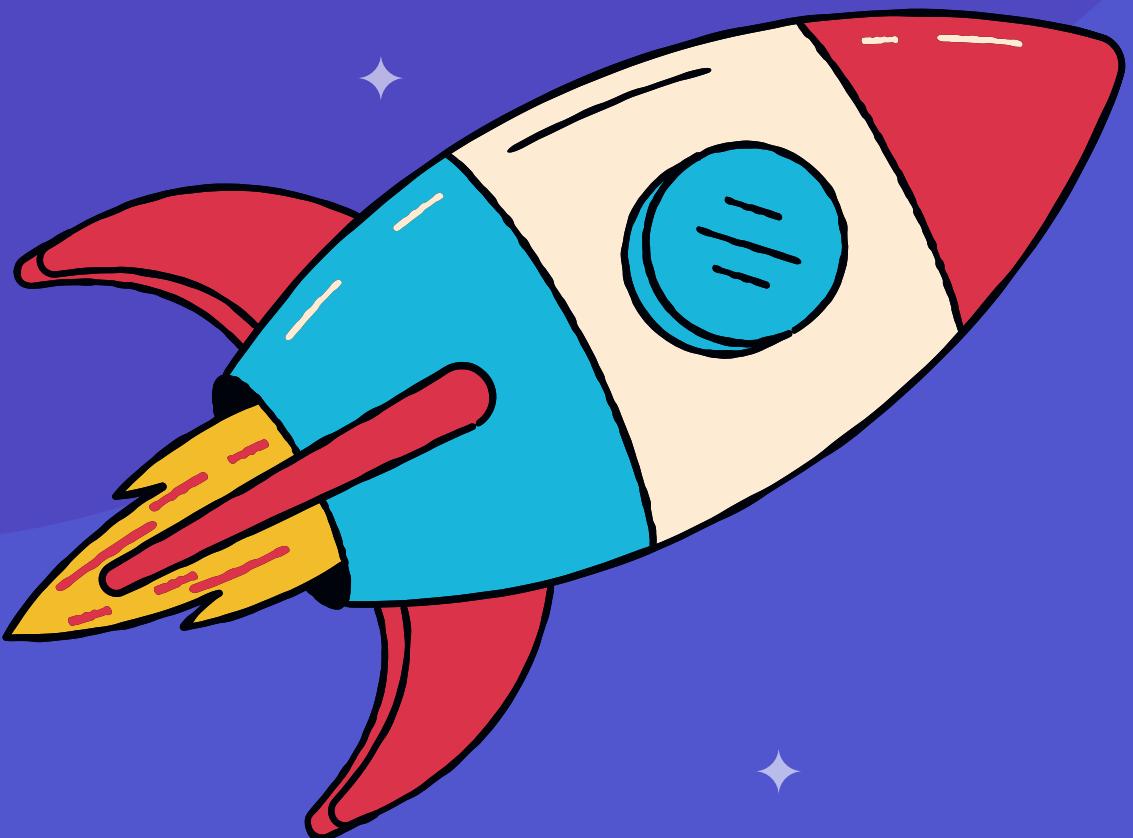


**AMEDEO RANALDI**  
Aerospace Engineer

*SPECIAL AGENT:  
RICCARDO CECCARONI*

A cartoon-style illustration of a white rocket ship with a blue window and red fins, flying through space.

# 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

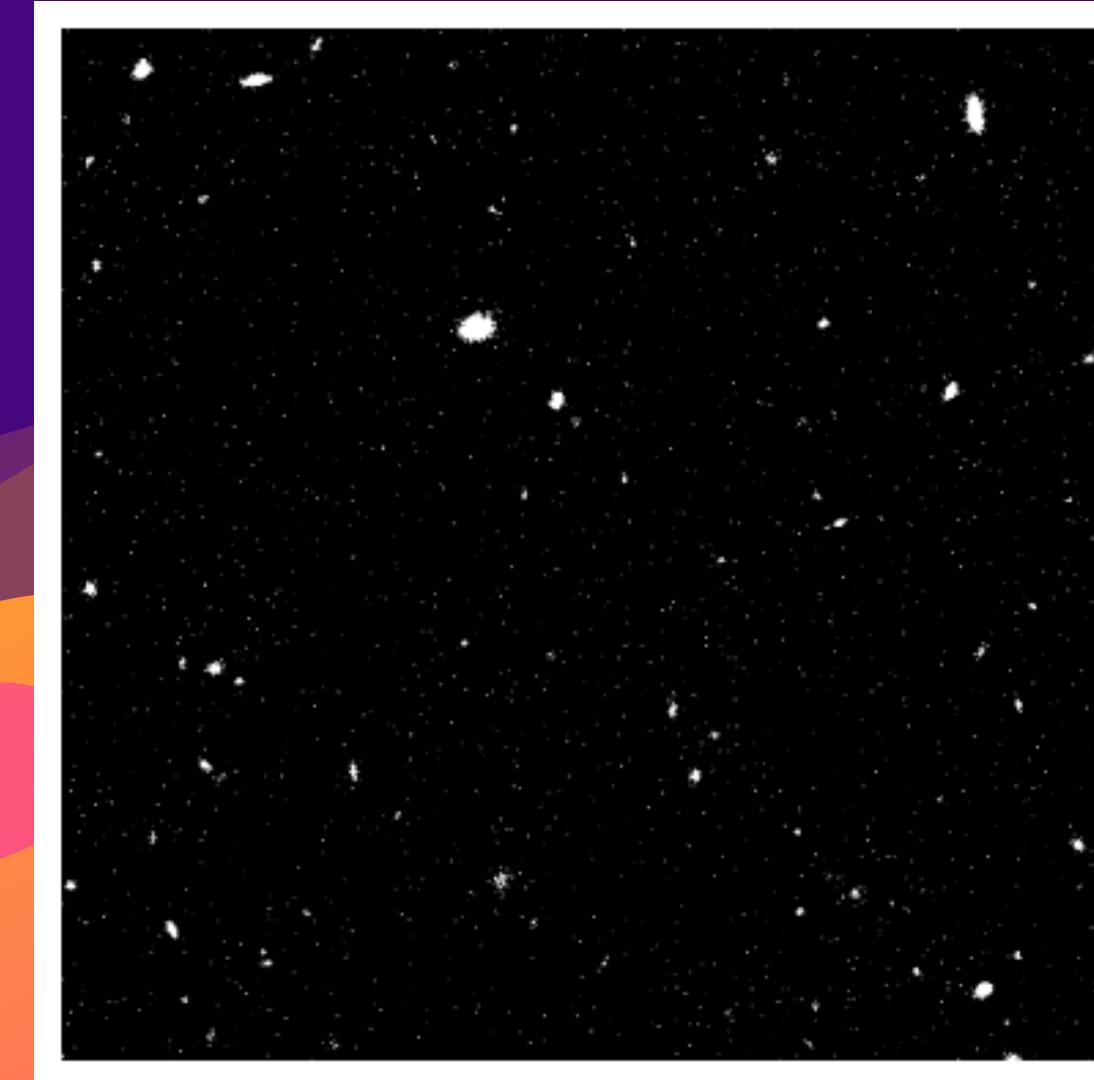
# PREPROCESSING

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:

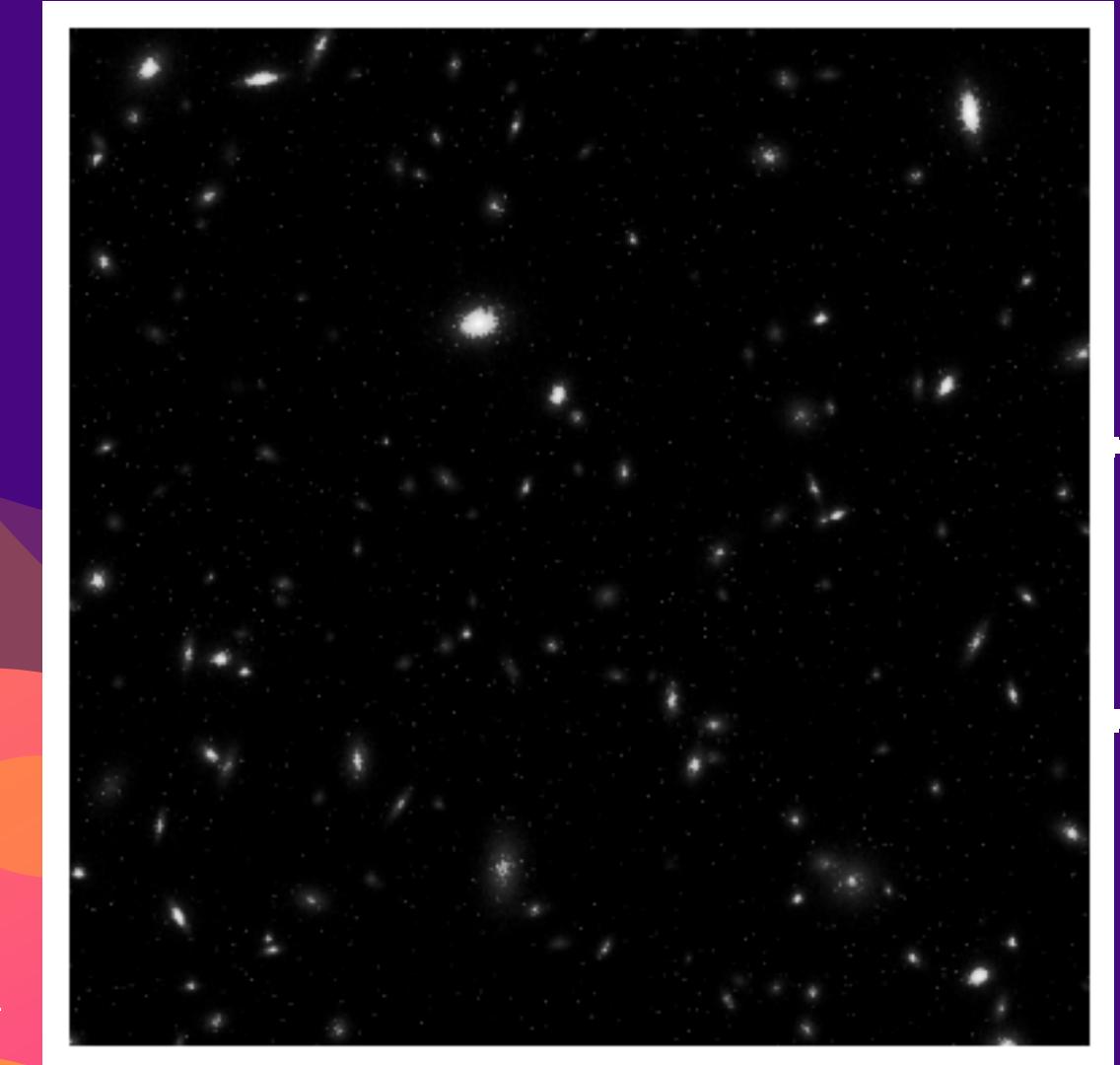
Original Image



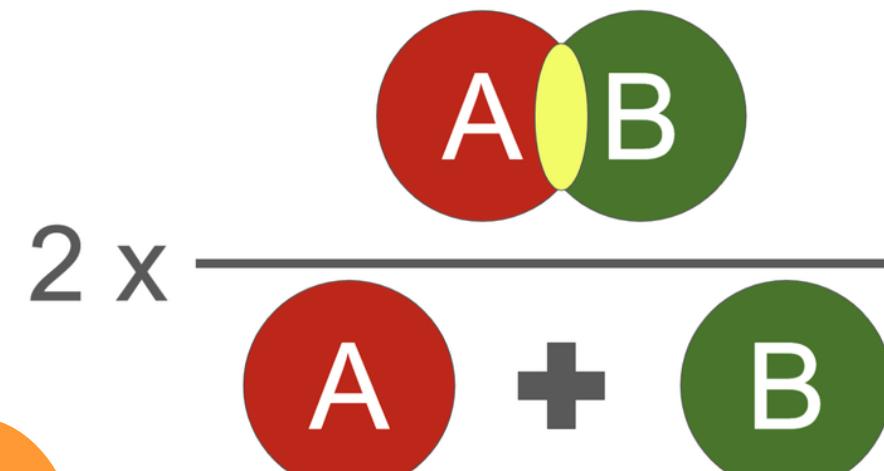
FITS Liberator 3



+ Log stretched RMS

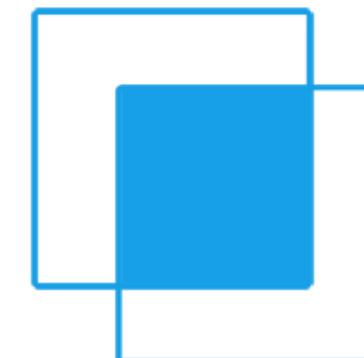


# METRICS TO EVALUATE IMAGE SEGMENTATION PROBLEMS

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


2 x —————

A + B





**ASTROPY**

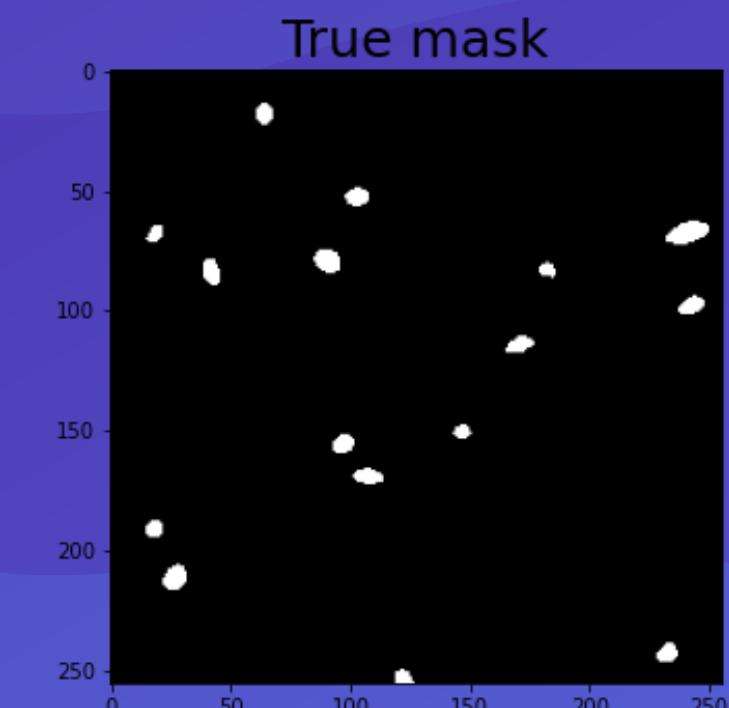
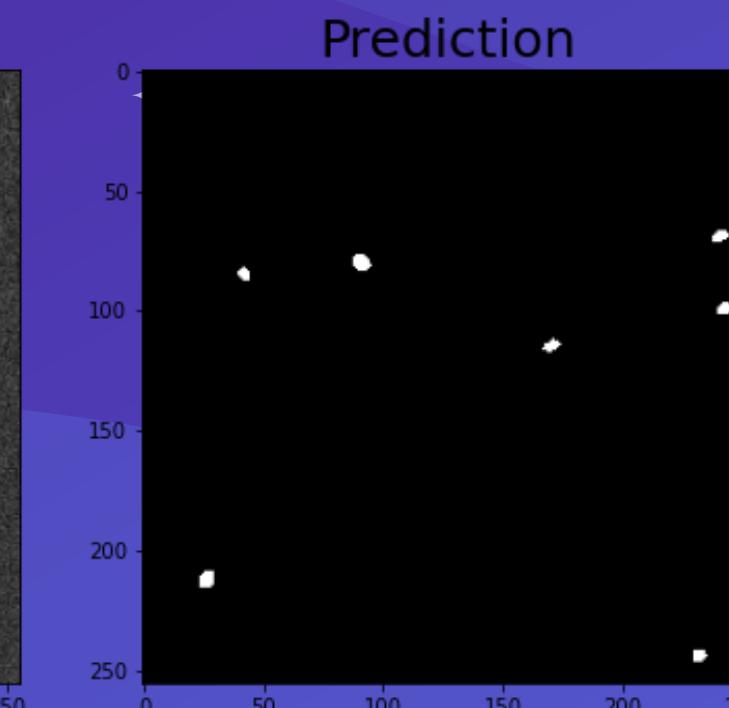
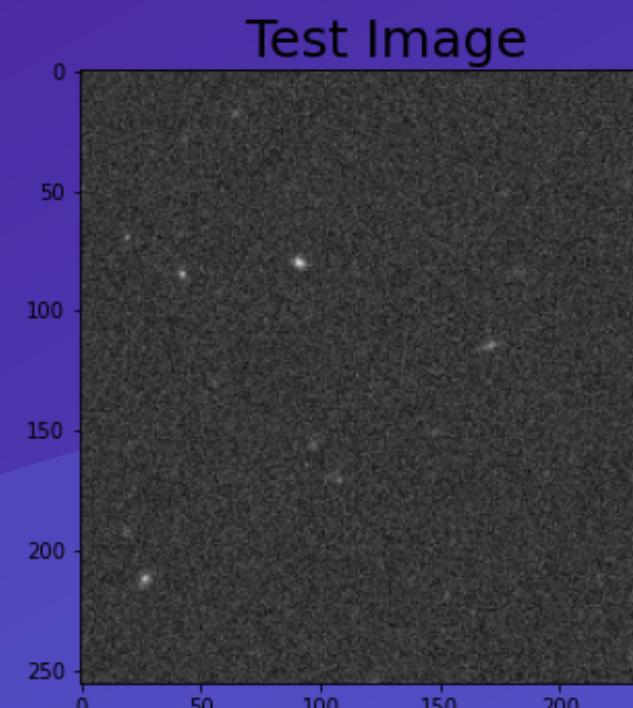
**K-MEANS**

**RANDOM  
FOREST**

**THE BASELINE METHODS**

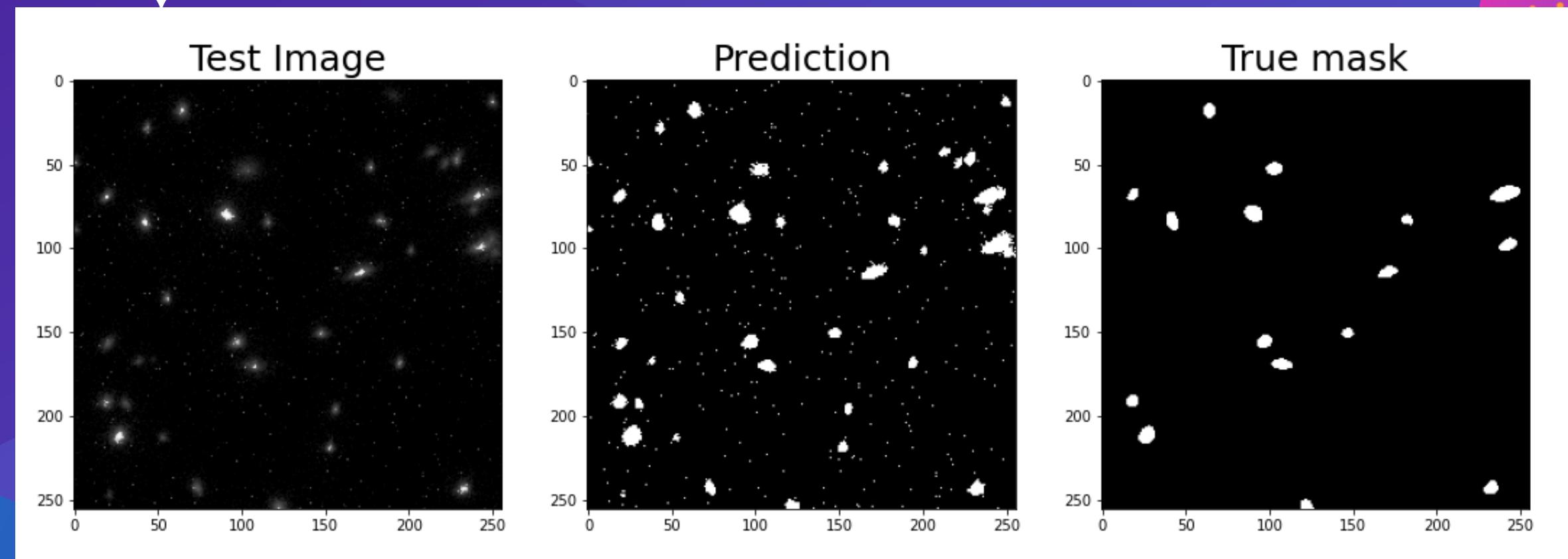
# ASTROPY MAIN RESULTS

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 ★

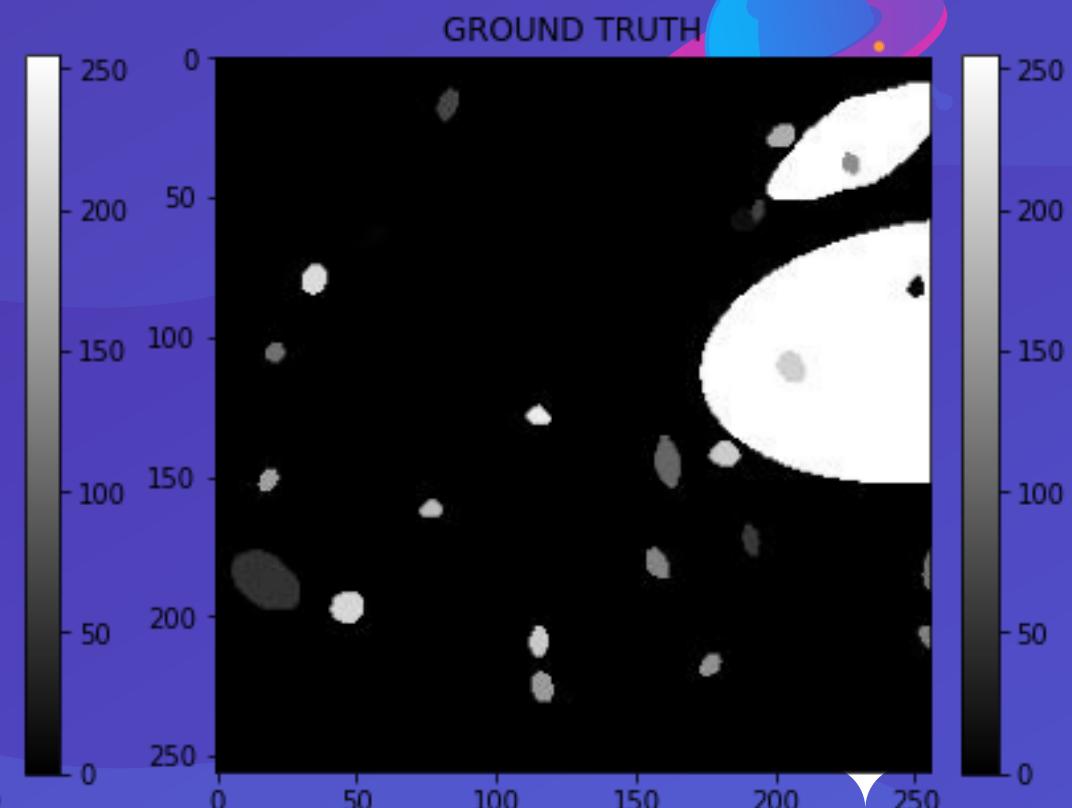
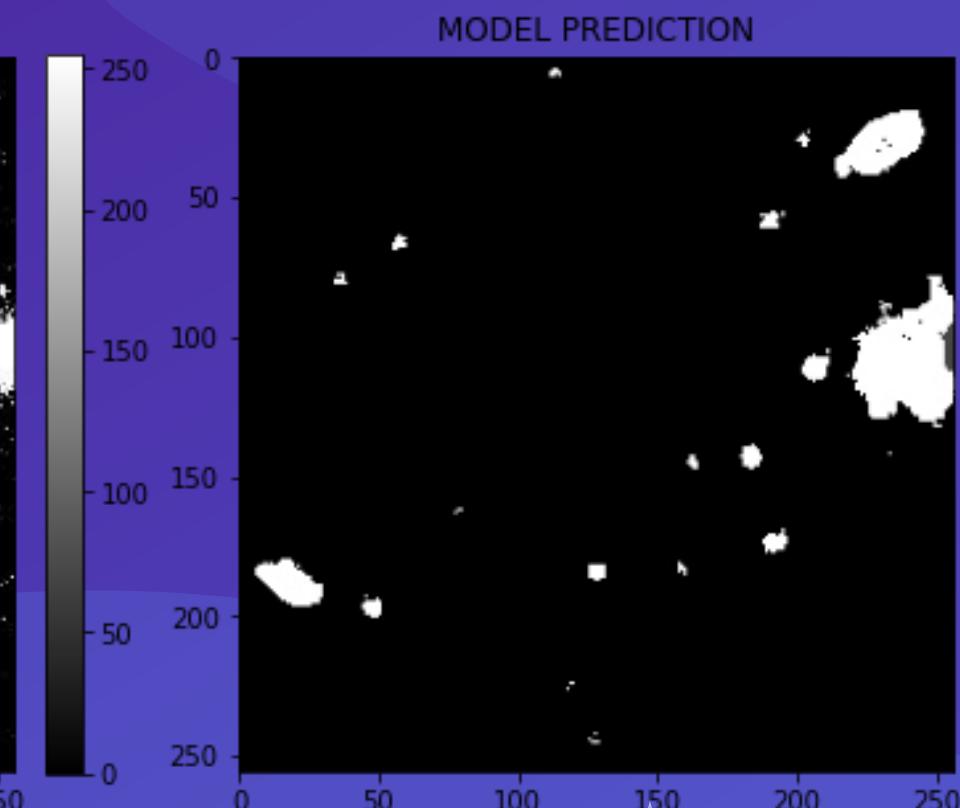
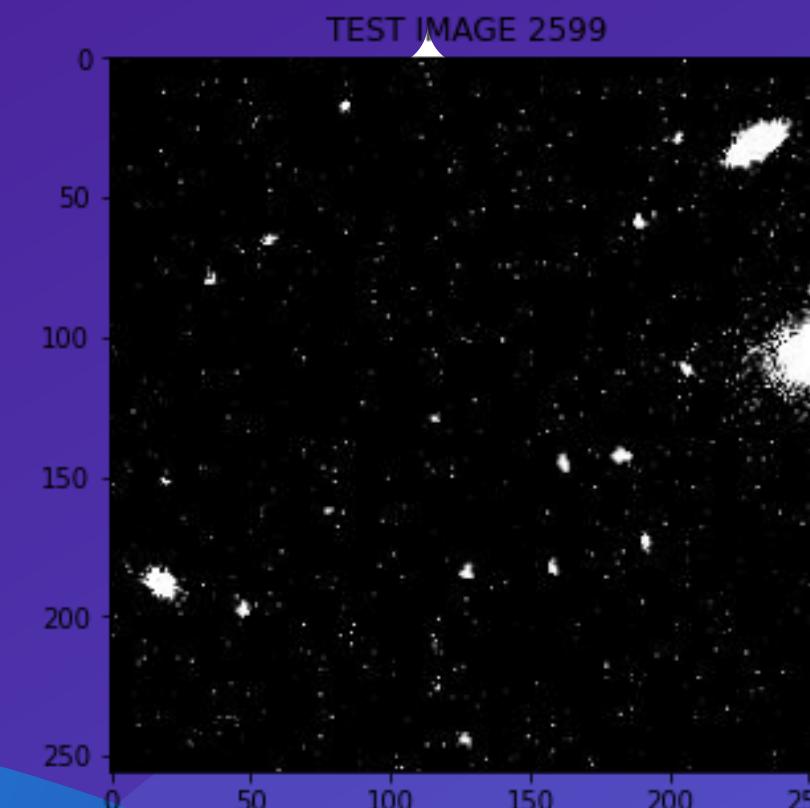
RESULTS	
PRECISION	12.59%
RECALL	44.34%
ACCURACY	76.61%
F1 SCORE	18.73%

## TEST SIZE:

- ◆ 5 images

## NEGATIVE ASPECTS:

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



# THE PLANET OF NEURAL NETWORKS

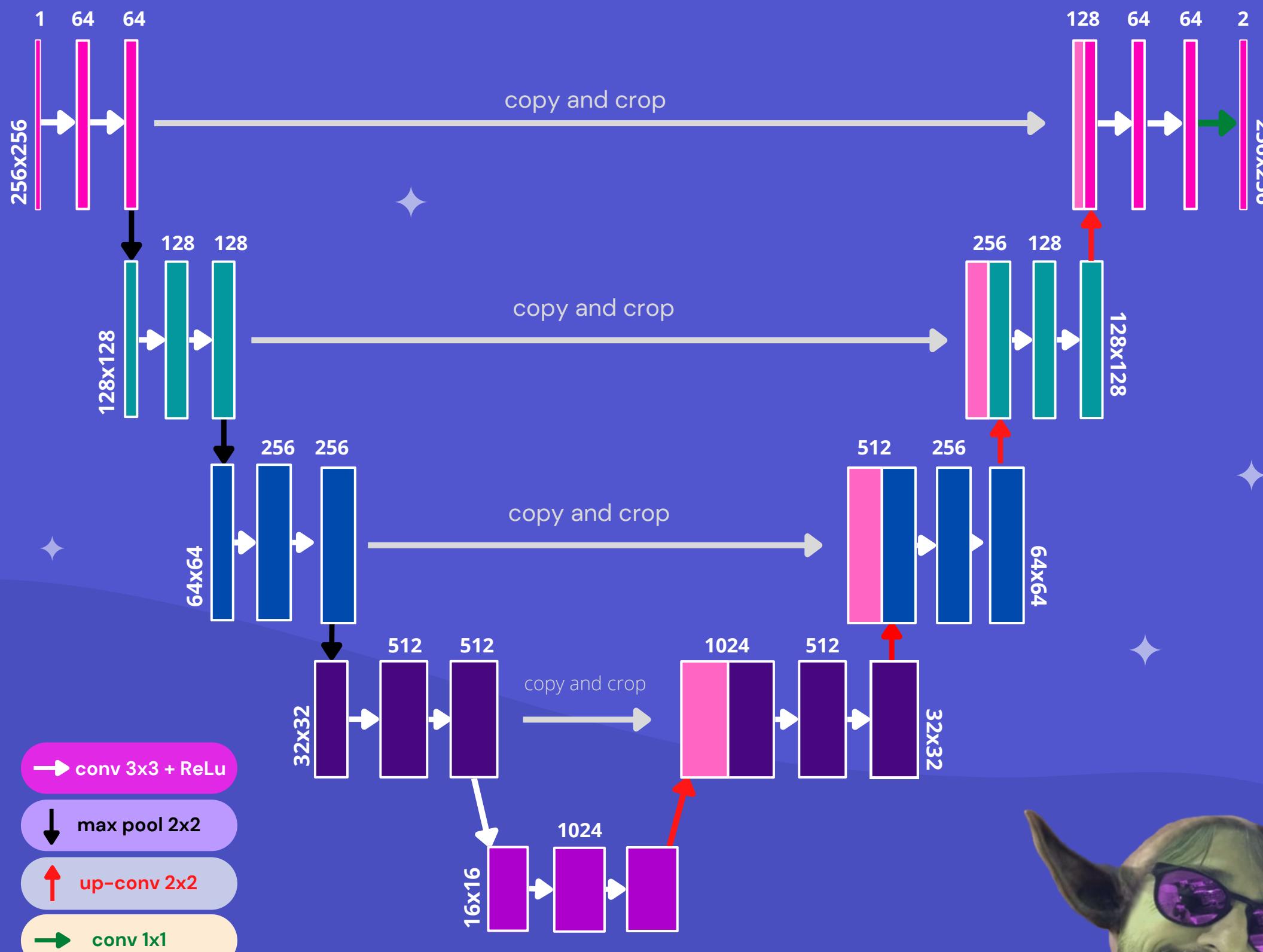
MASK-  
RCNN

U-NET

DETR



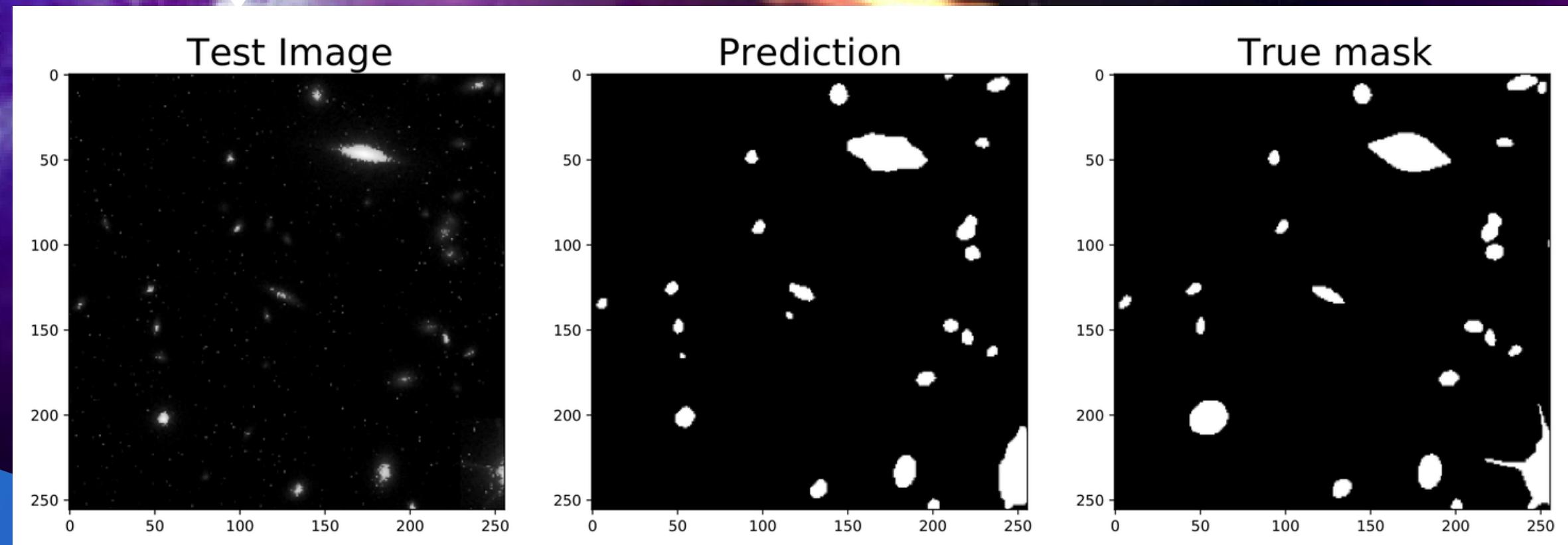
# MAY THE FORCE BE WITH U-NET



- input/output size (256x256x1)
  - added padding at each convolution
  - no cropping, just concatenating  
  - almost 2000 patches (256x256)
  - binarized mask (1 galaxy, 0 background)
  - 30 epochs + early stop  
  - Drop-out layer for regularization
  - Data augmentation
  - More epochs and train samples
  - Switching to COLAB PRO

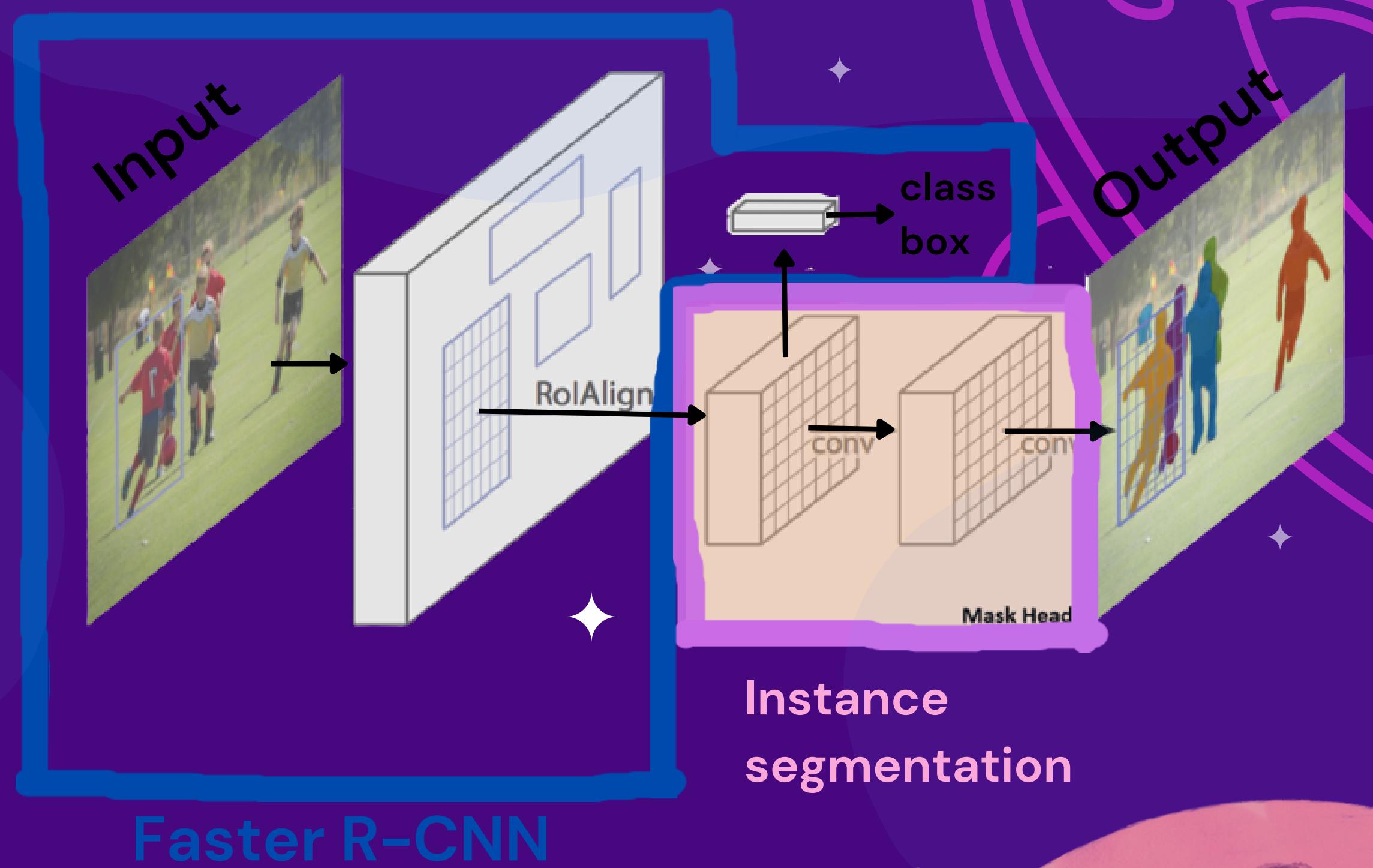
# MAIN RESULTS

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%





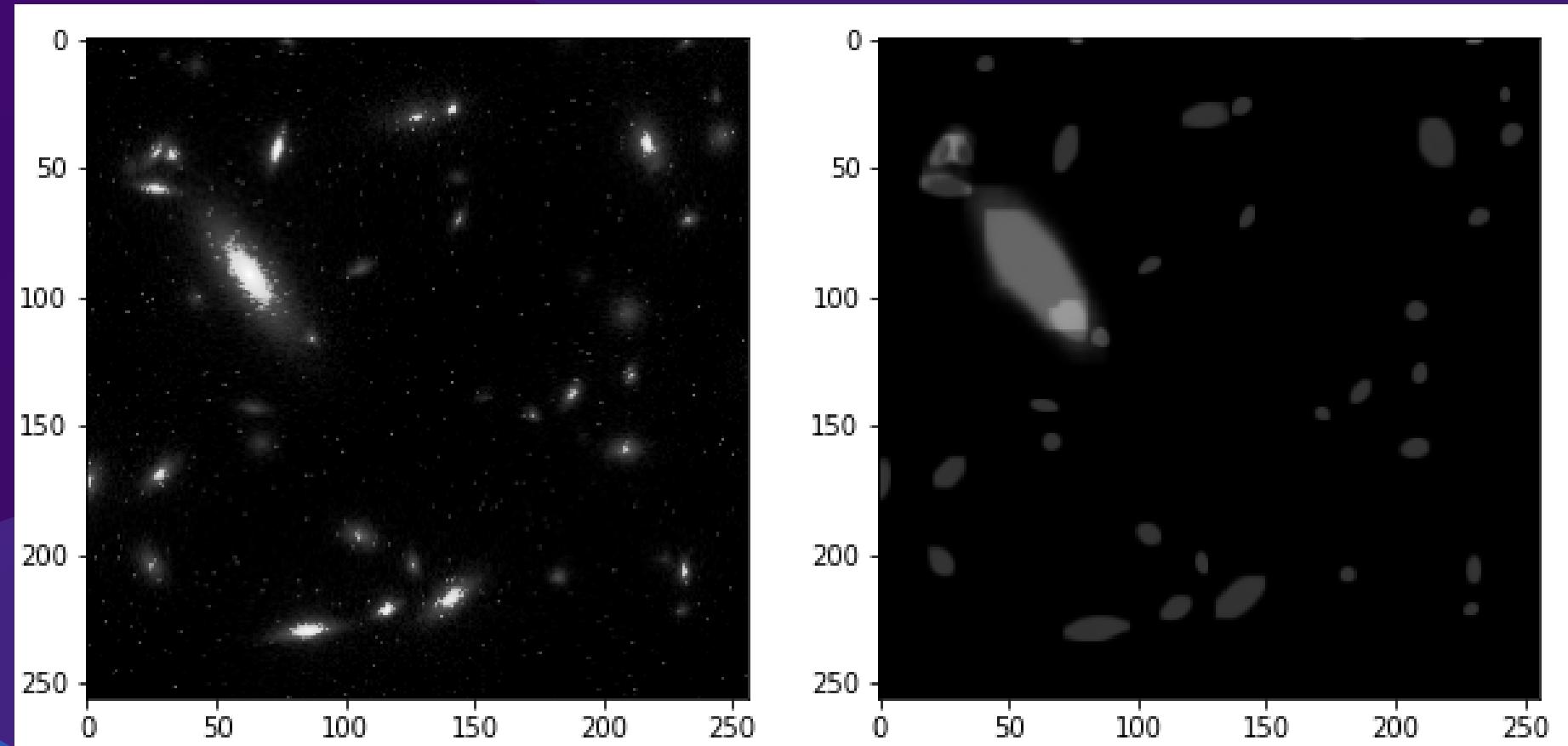
- ◆ Improved version of Faster R-CNN used for both image segmentation and object detection
- ◆ COCO dataset format in order to use the model containing the following items:
  - dataset folder with images and ground truth
  - annotation file
- ◆ Training:
  - input size: 256x256 with ~1300 samples
  - train/val/test split (75/15/15)
  - 20 epochs
  - Adam optimizer w/ learning rate adaptor
  - batch size of 8



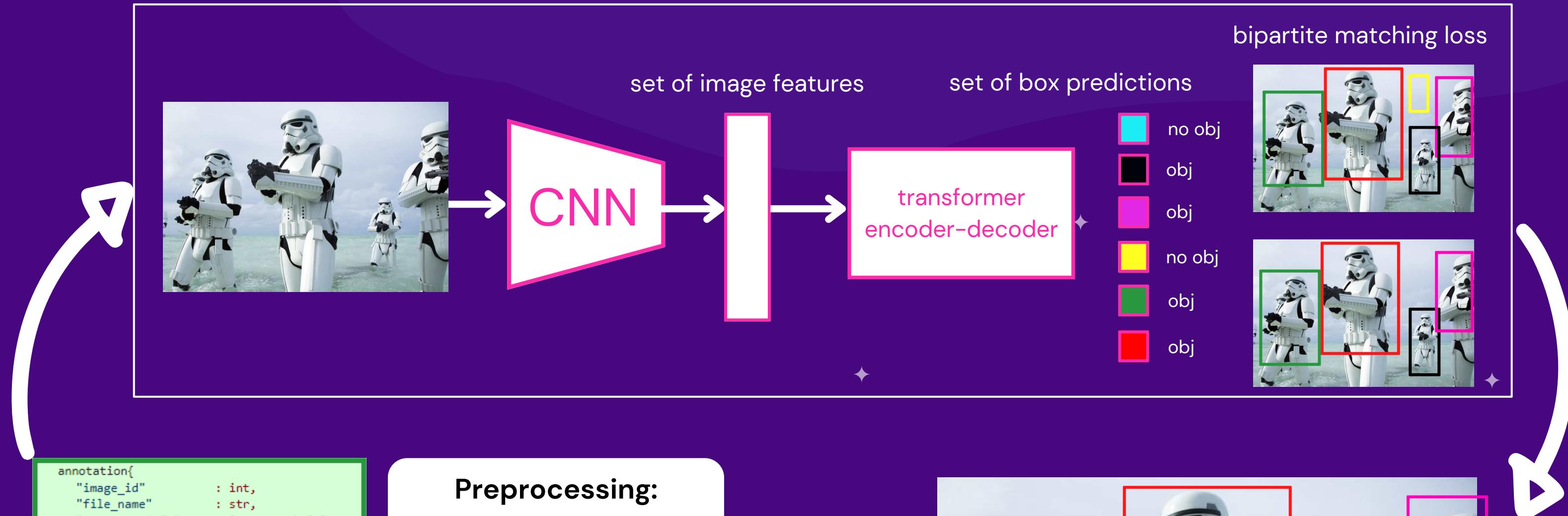
**Neural  
Networks**

# MAIN RESULTS

IMAGES	AP@[IoU=0.5:0.95]	AP@[IoU=0.5]	AP@[IoU=0.75]	AR@[IoU=0.5:0.95]
Normalized 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%

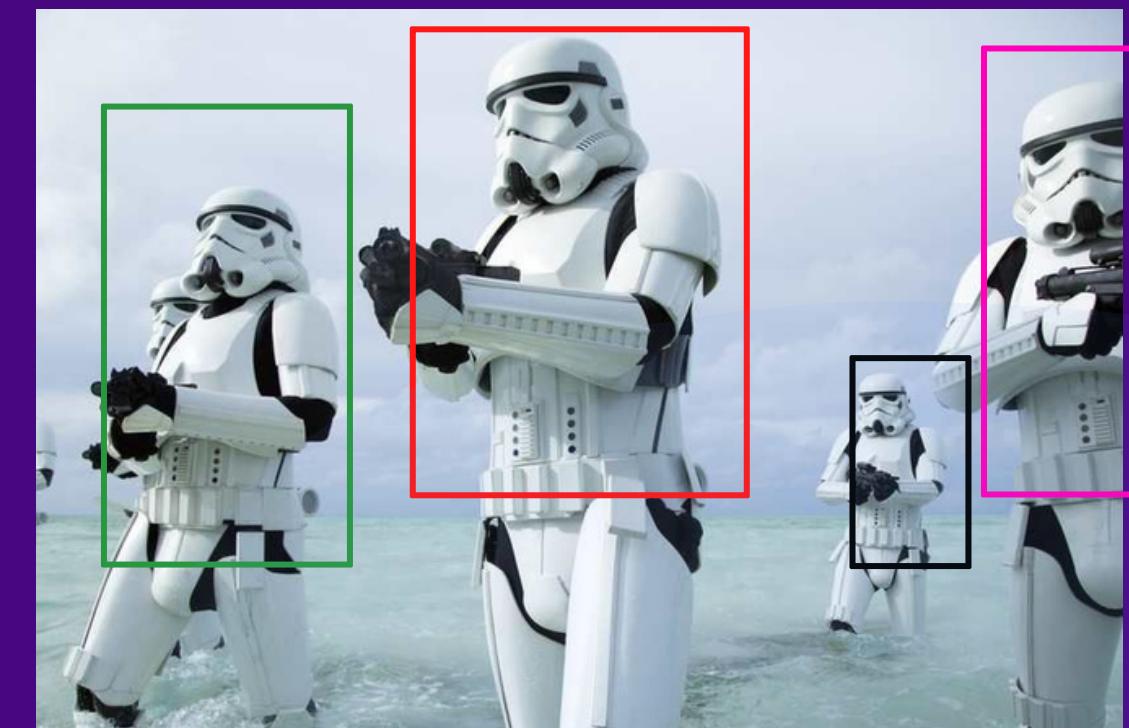


# DETR: END-TO-END OBJECT DETECTION WITH TRANSFORMERS



```
annotation{  
    "image_id"      : int,  
    "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	?	?	?

