

DEEP LEARNING FOR PRECISION AGRICULTURE

INJECTING FREQUENCY ANALYSIS AS A PRIOR IN DETR FOR WHEAT HEAD DETECTION

1. INTRODUCTION

- Wheat head detection for field management improvement
 - Challenging image characteristics
- DETR - Detection Transformer
 - (+) end-to-end | anchor-free | set prediction
 - (-) long training time | bad on small objects



Fig. 1: Image from the Wheat Head training dataset

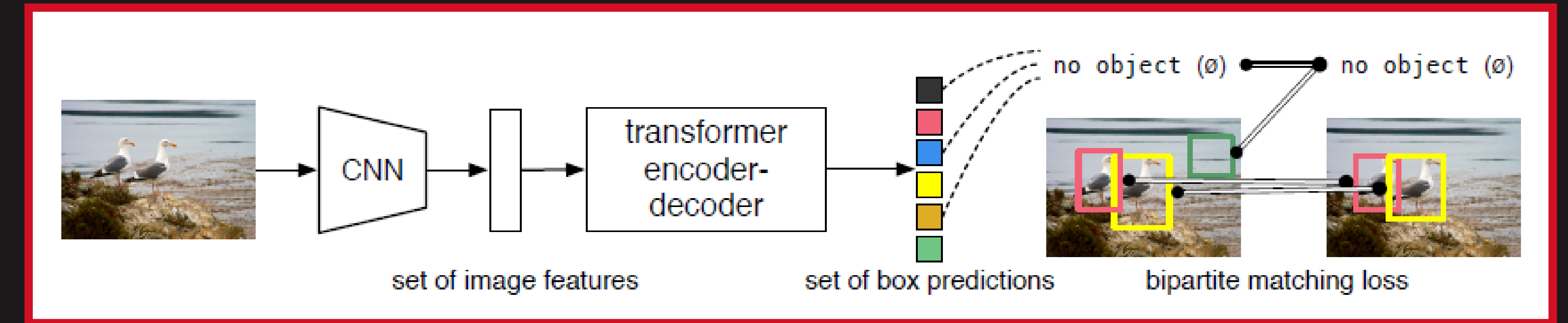


Fig 5: DETR Neural Network

2. RESEARCH QUESTIONS

DETR

- Optimal configuration for wheat head detection?
- Performance analysis?
- DETR VS FFT-based DETR
- _ VS other models used in the competition? (YOLO, Faster R-CNN)

FFT + DETR

FAST FOURIER TRANSFORM FILTER

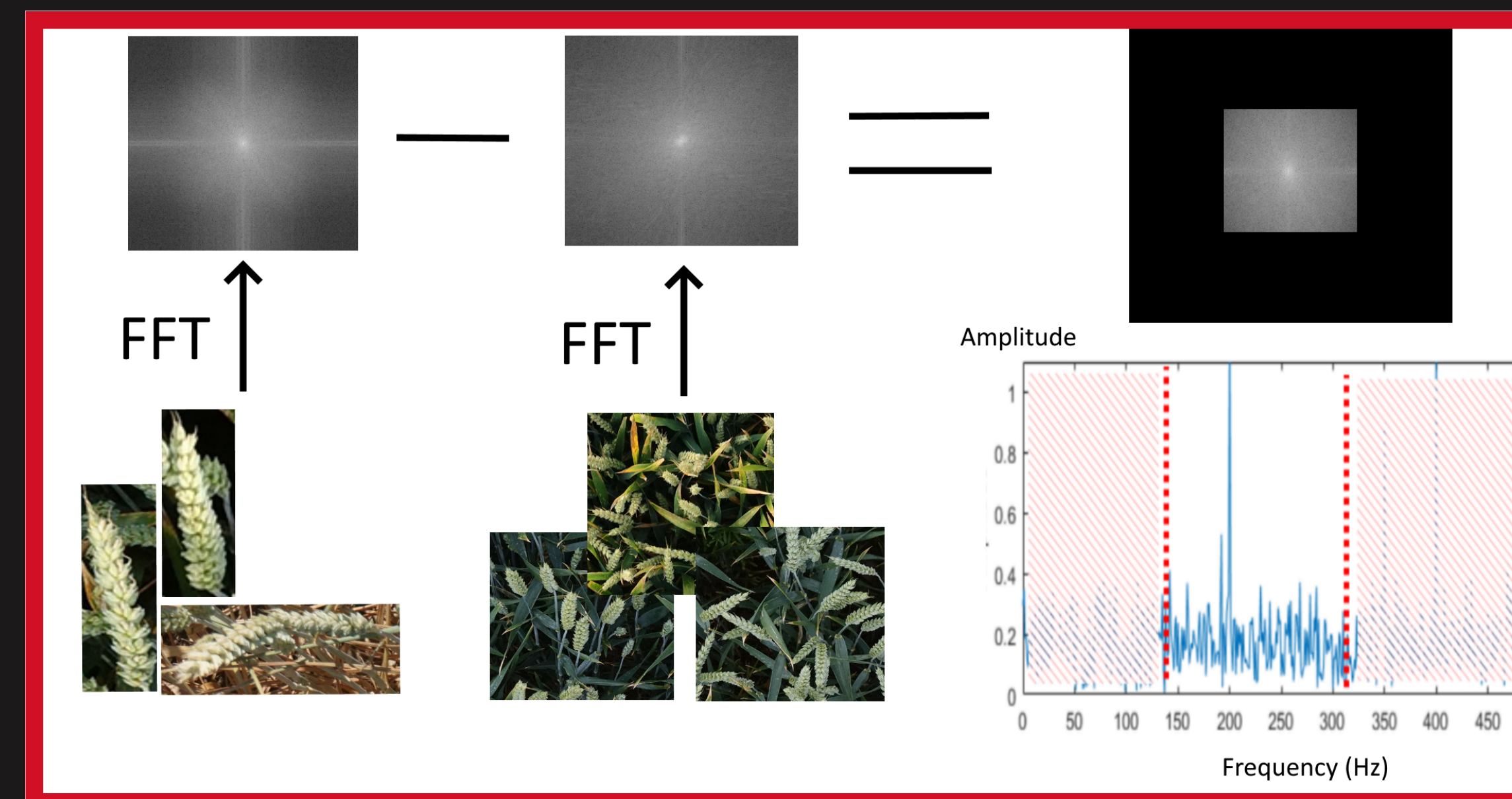


Fig. 2: FFT mask creation proces. In the end, it is a band-pass frequency filter

PREDICTION

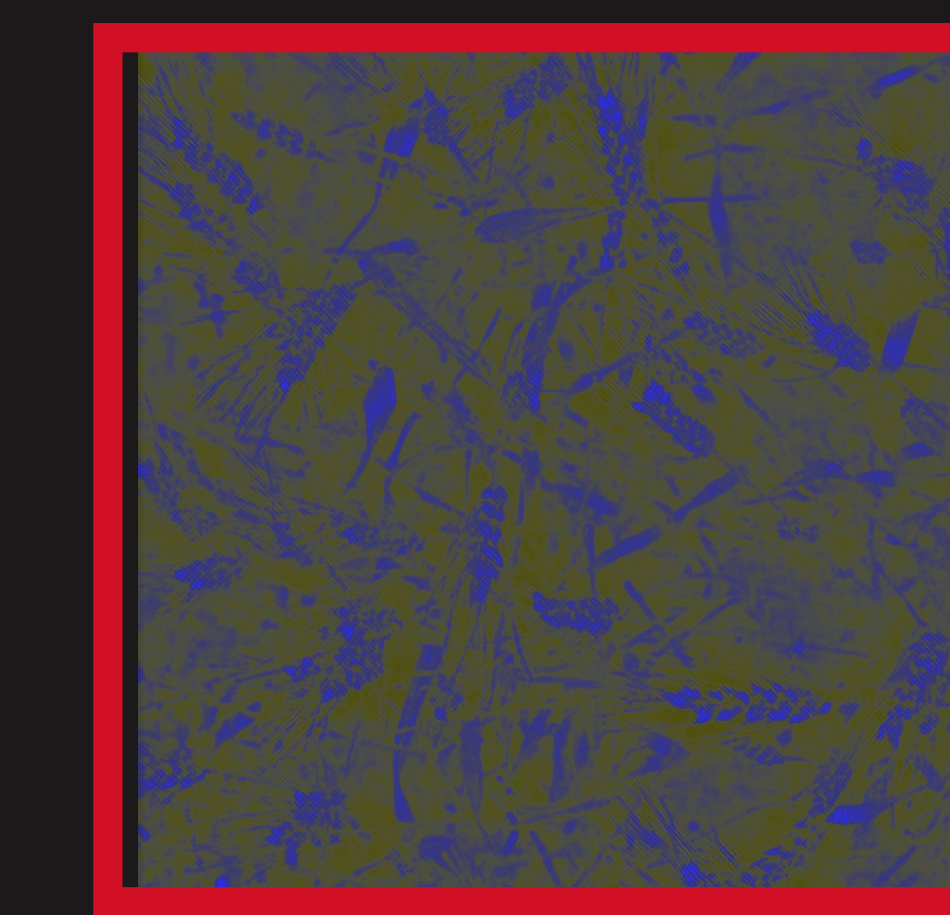


Fig. 3: Training image filtered in frequency domain



Fig. 4: Final prediction of wheat heads

3. METHOD

Pre-processing in the frequency domain

- Creation of the FFT-based mask:
 - threshold for the filter's range
 - exclude for the high-pass noise reduction

Models:	ext-DETR	FFT-DETR	Proj-FFT-DETR
Threshold for difference	0.2	0.8	0.8

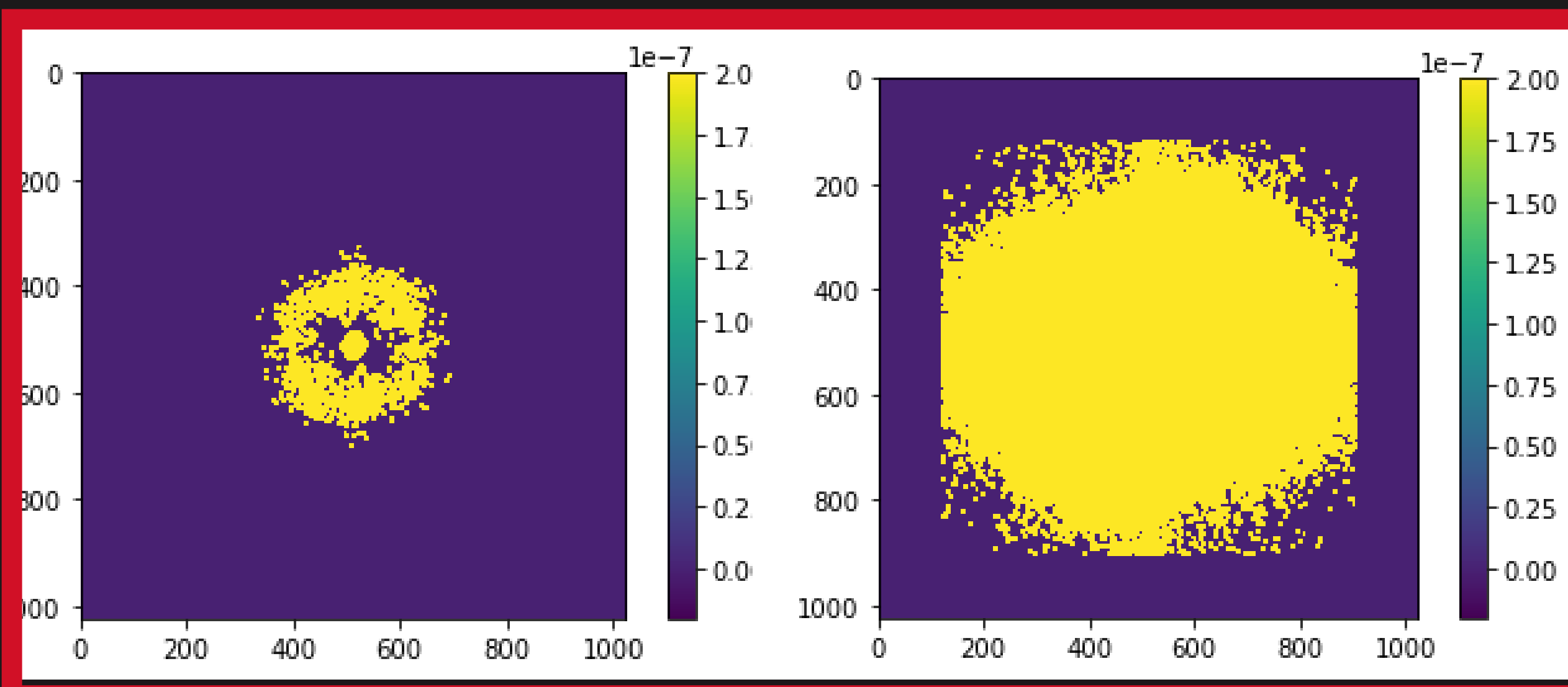


Fig. 6: Amount of filtered frequencies depending on the threshold

4. RESULTS

- YOLO/Faster R-CNN: 0.70 AP
- ext-DETR: 0.60 AP
- Proj-FFT-DETR: 0.56 AP
- FFT-DETR: 0.55 AP

Fig. 7: Attention map visualization



5. CONCLUSIONS & LIMITATIONS

Minimum extra config on pre-trained DETR - 0.47 S

Add FFT-based filter in 2 ways:

- Directly feed to DETR
- Concatenate with the original image => 6 channels
 - convolutional projection 6 -> 3 channels

Slight performance decrease be 4 S & 5 AP

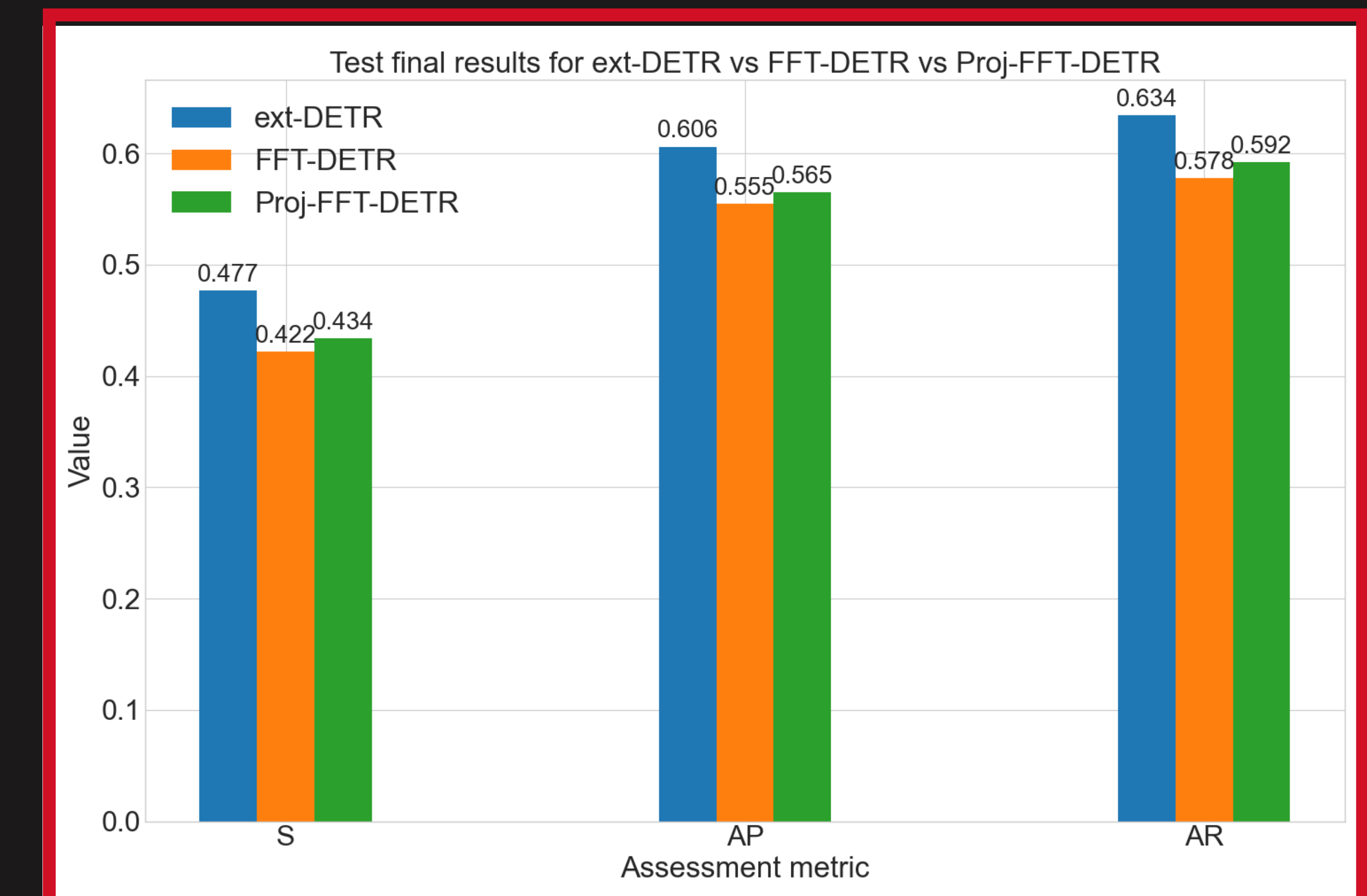


Fig. 8: Final results achieved by ext-DETR, FFT-DETR and Proj-FFT-DETR on the test set. S - score; AP - average precision; AR - average recall

References:

Nicolas Carion, Francisco Massa, Gabriel Synnaeve, Nicolas Usunier, Alexander Kirillov, and Sergey Zagoruyko. End-to-end object detection with transformers, 2020.