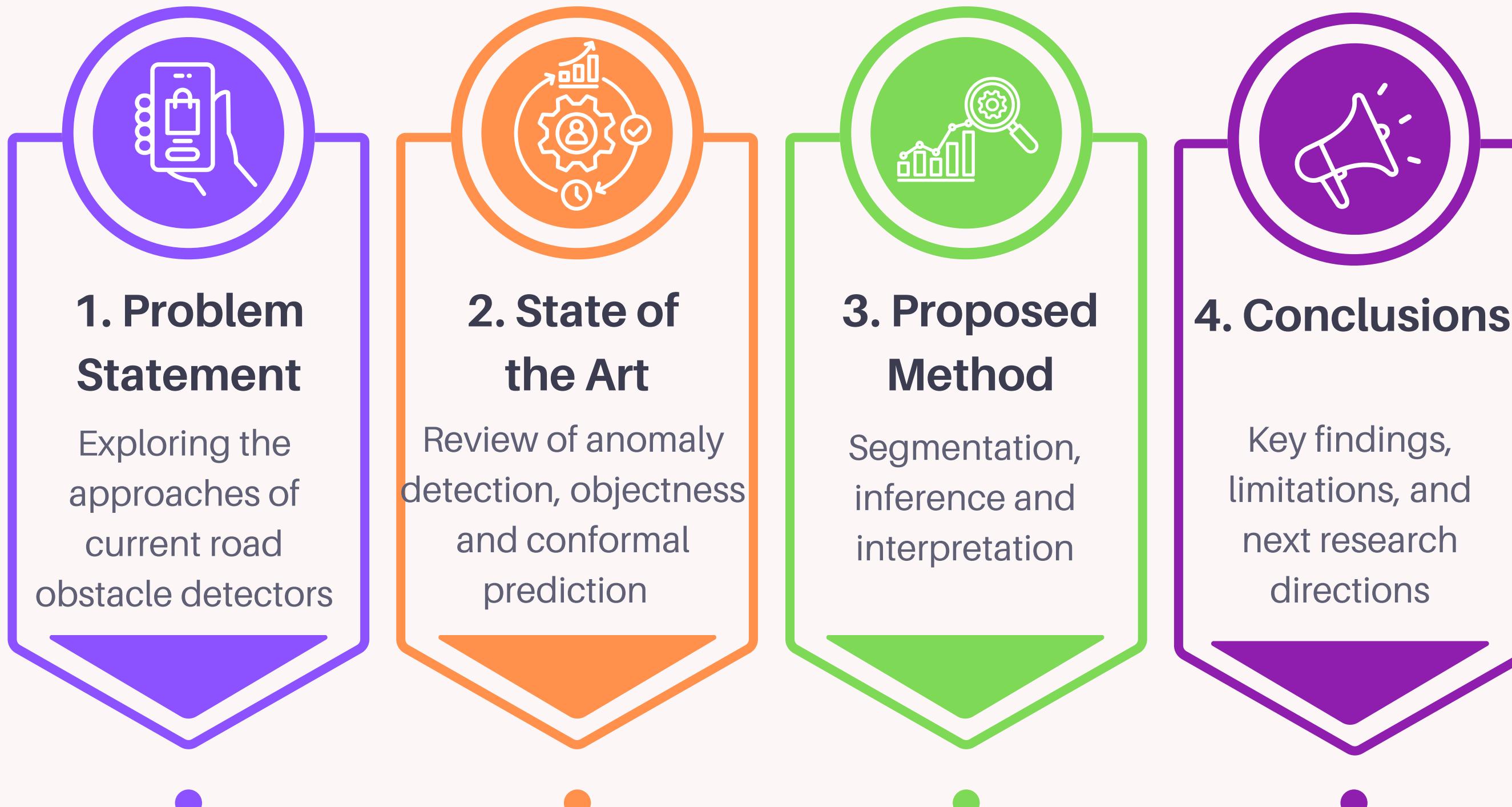


A red Fiat 500 is driving on a paved road. The road is marked with white dashed lines and has orange traffic cones placed along its edge. The background shows a green field and some trees under a clear sky.

Uncertainty-Aware Road Obstacle Identification

FRANCESCO GERMANO
MARTINA LIGORIO

PROJECT OVERVIEW



PROBLEM STATEMENT

The Challenge of Unknown Obstacles

- 1 
- 2 
- 3 

Traditional object detectors are limited to identifying objects belonging to a fixed set of predefined classes.

They are unable to recognize unknown road dangers —like fallen debris, construction materials, or lost cargo.

These unknown obstacles are often misclassified as background, leading to potential safety hazards.

STATE OF THE ART

current landscape of road obstacle detection

Road Obstacle Detection based on Unknown Objectness Scores [1]

introduces Unknown Objectness Score (UOS)

Pixel-wise approach with strong results
Sensitive to boundary noise

Conformal Semantic Image Segmentation [2]

proposed a dual-decoder RGB-D architecture using conformal prediction.

Needs depth sensors and is less effective for irregular obstacles

A Gentle Introduction to Conformal Prediction and Distribution-Free Uncertainty Quantification [3]

conformal prediction for uncertainty estimation with statistical guarantees.

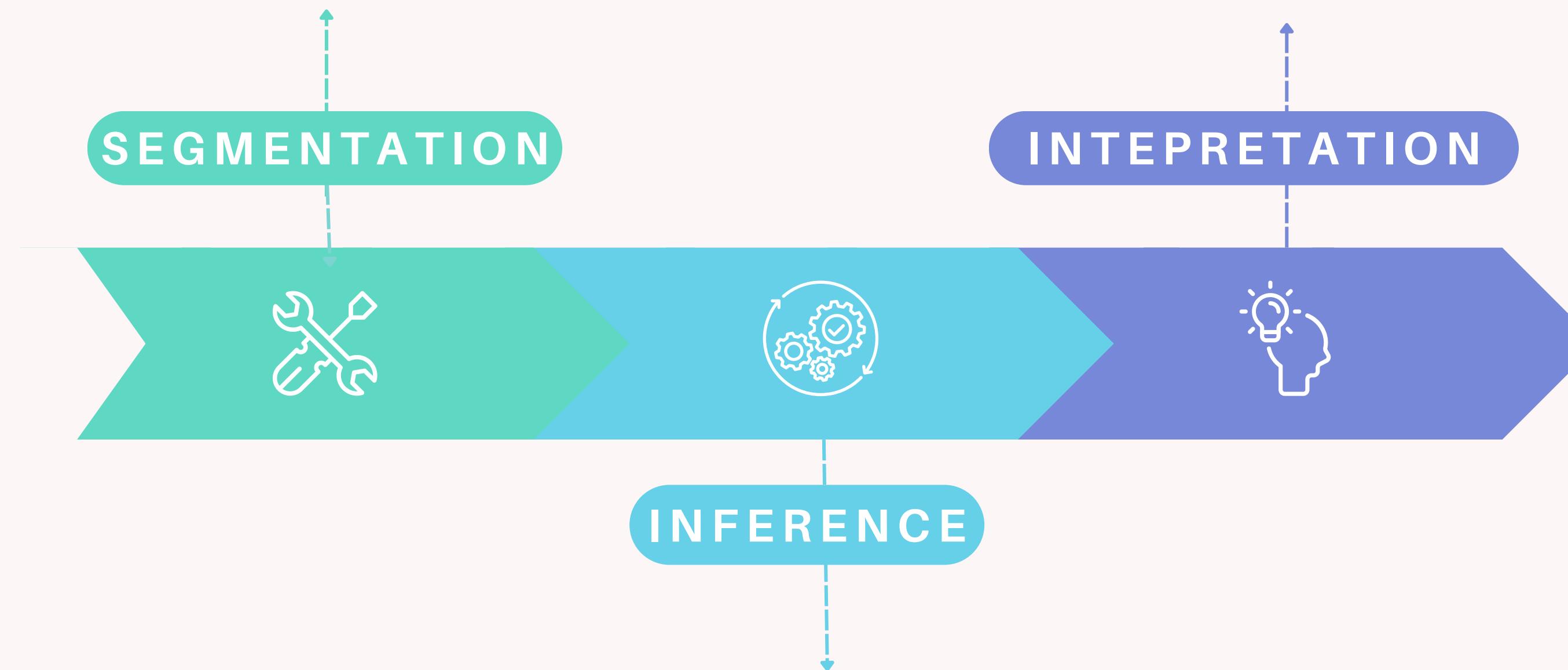
Theory-focused, not directly designed for vision tasks.

[1] Noguchi, C., Ohgushi, T., & Yamanaka, M. (2024)

[2] Mossina, L., Dalmau, J., & Andéol, L. (2024)

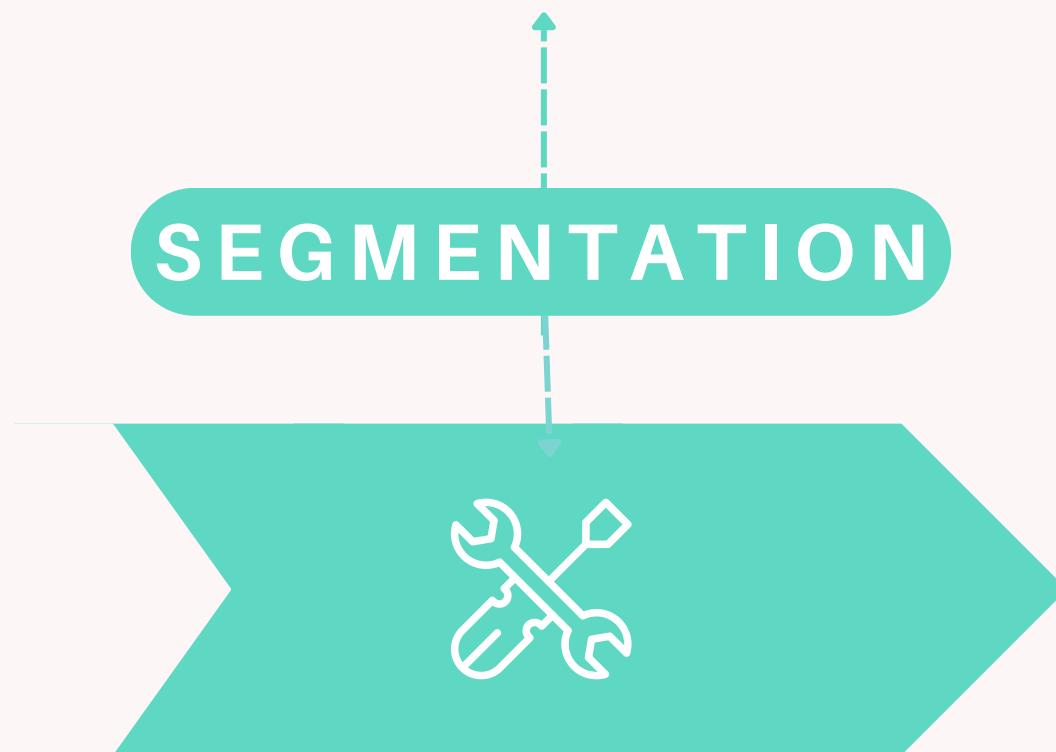
[3] Angelopoulos, A. N., & Bates, S. (2022)

PROPOSED METHOD



PROPOSED METHOD

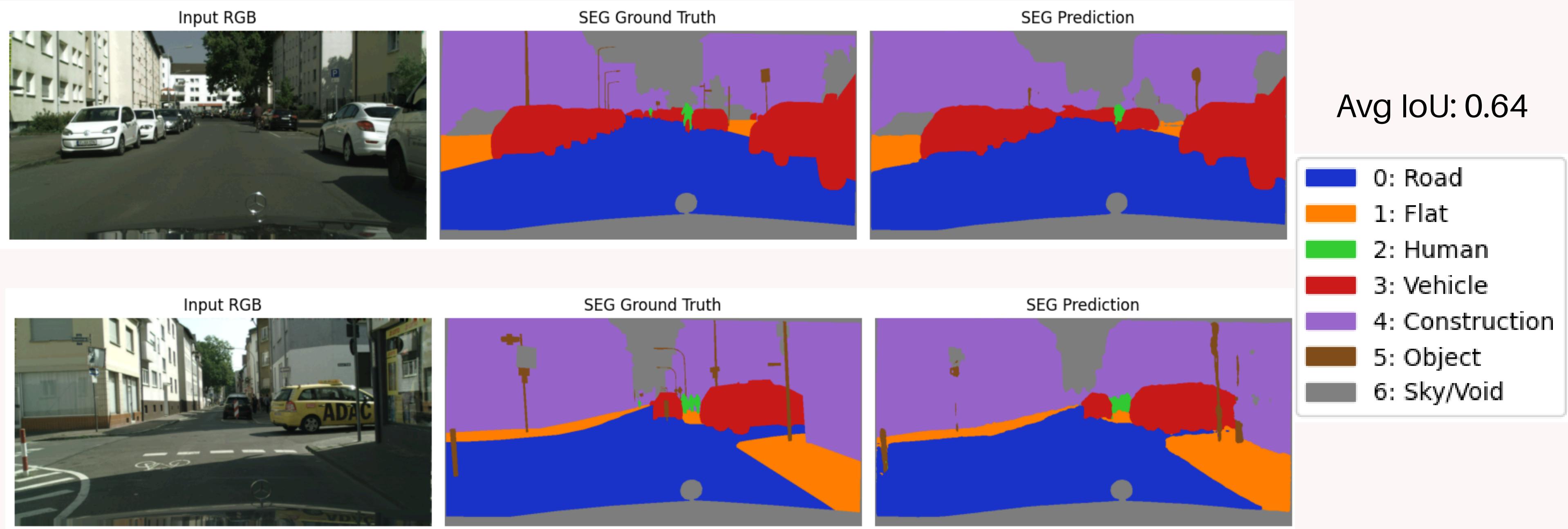
DeepLabV3+ with ResNet50 backbone



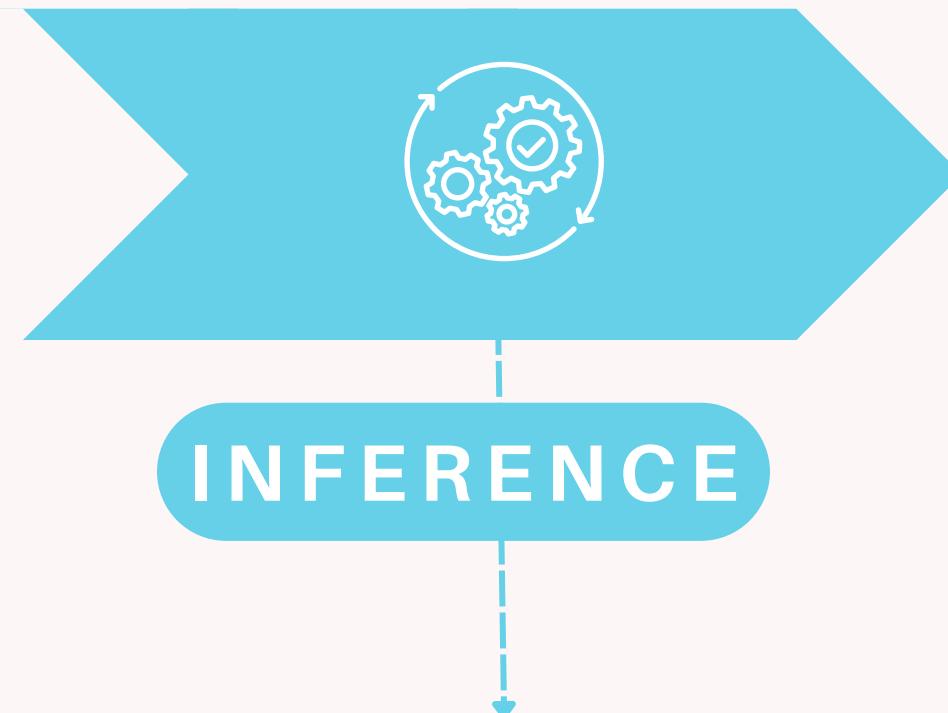
- Dual-Head Model
 - Softmax Head
 - Sigmoid Head
- Training Dataset: CityScapes remapped from 19 to 7 macro-classes*
- Data Augmentation: Horizontal Flip
- Loss functions:
 - CE for segmentation
 - BCE with logits loss for objectness

*road, flat, human, vehicle, construction, object, and background

SEGMENTATION PREDICTIONS



PROPOSED METHOD

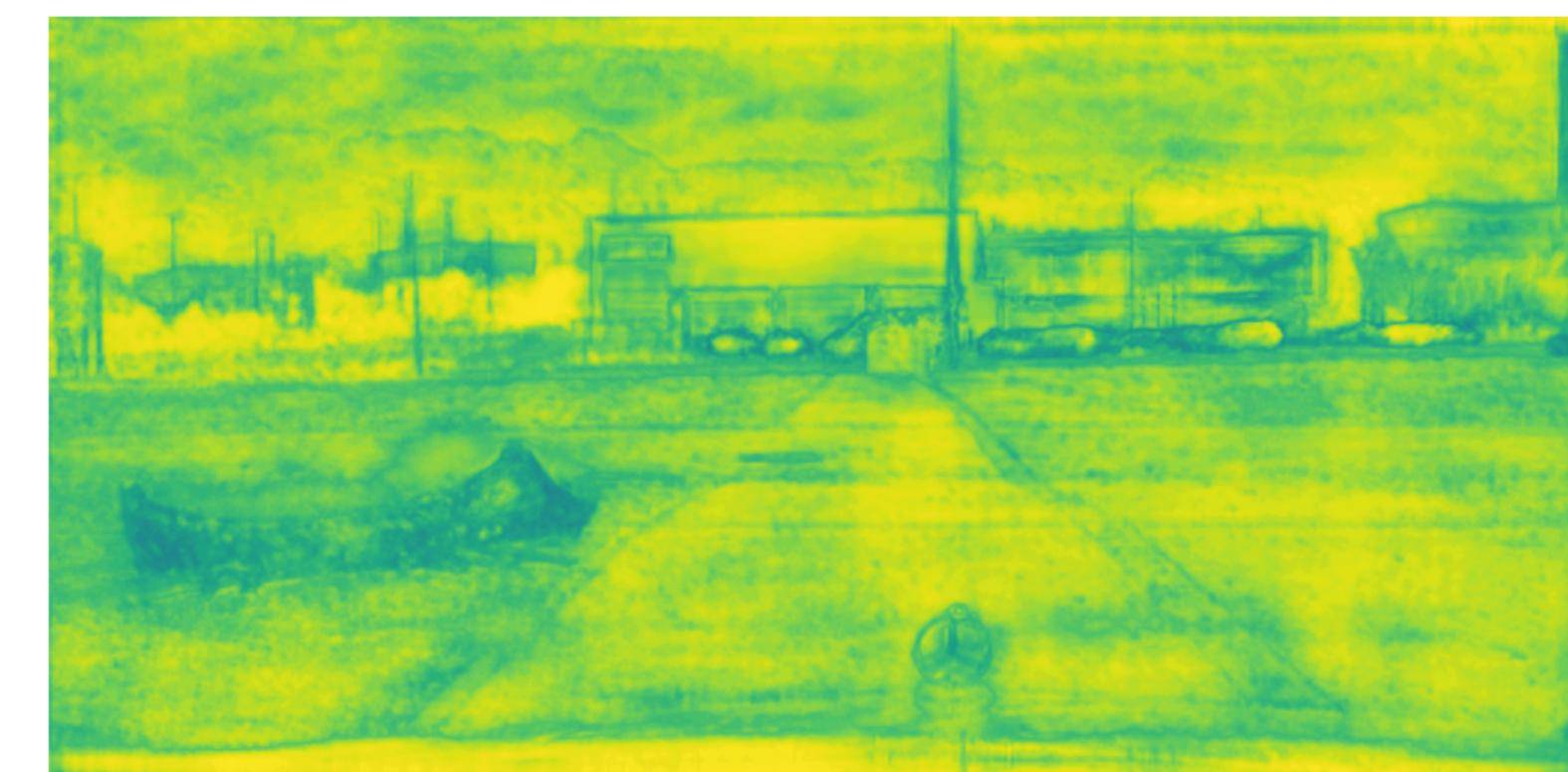
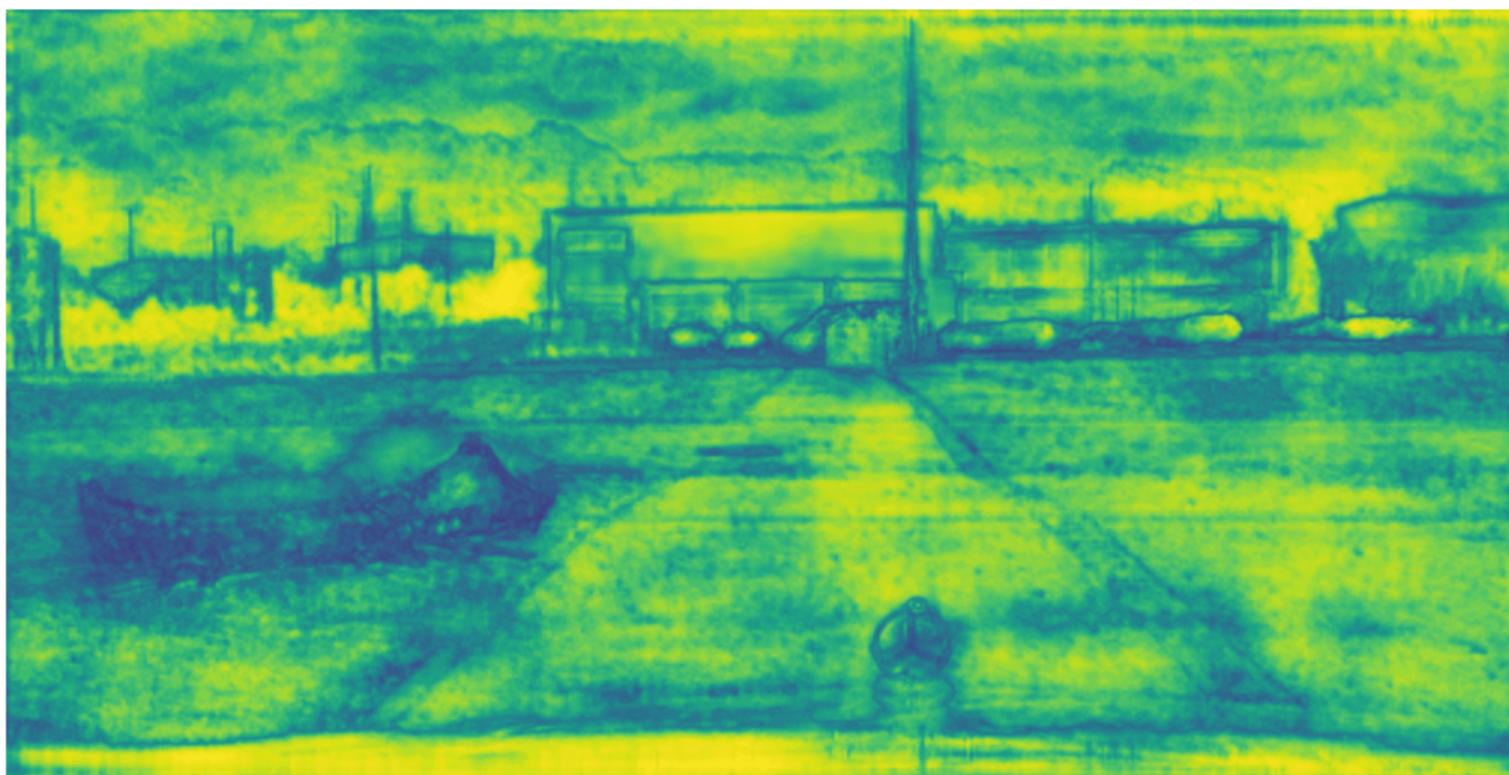


- Obstacle detection rule:
 - softmax confidence is low for every class
 - objectness score is above a threshold
- Uncertainty estimation via conformal prediction
 - $$1 - [\max(\text{softmax outputs})]$$
- Calibration
- Threshold
- Datasets: LostAndFound, RoadAnomaly

LOST AND FOUND INTERPRETATION



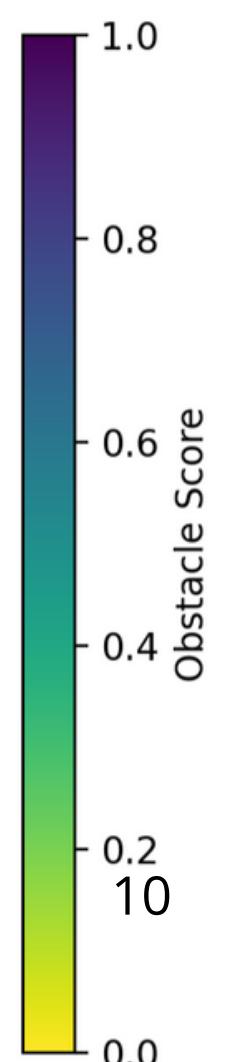
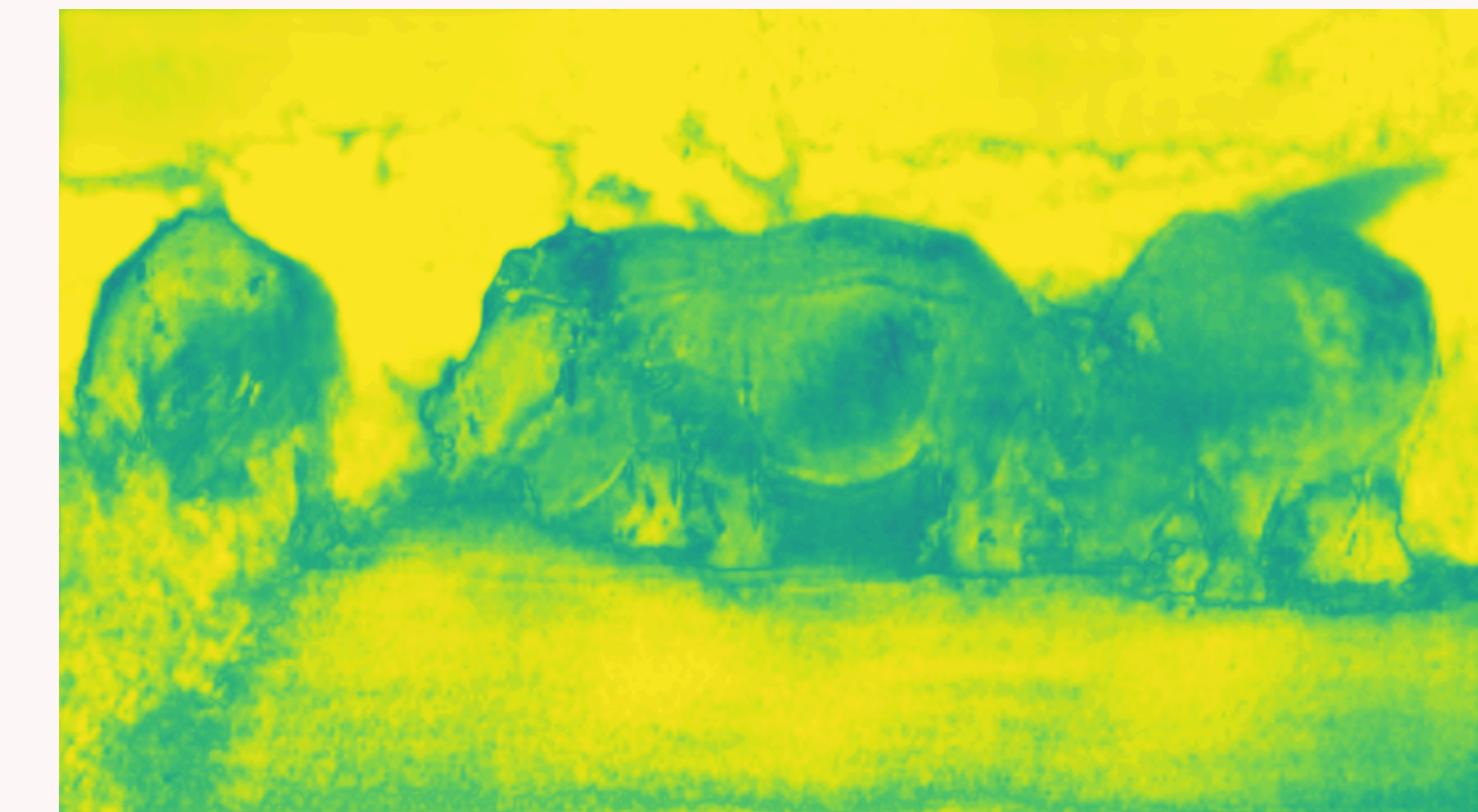
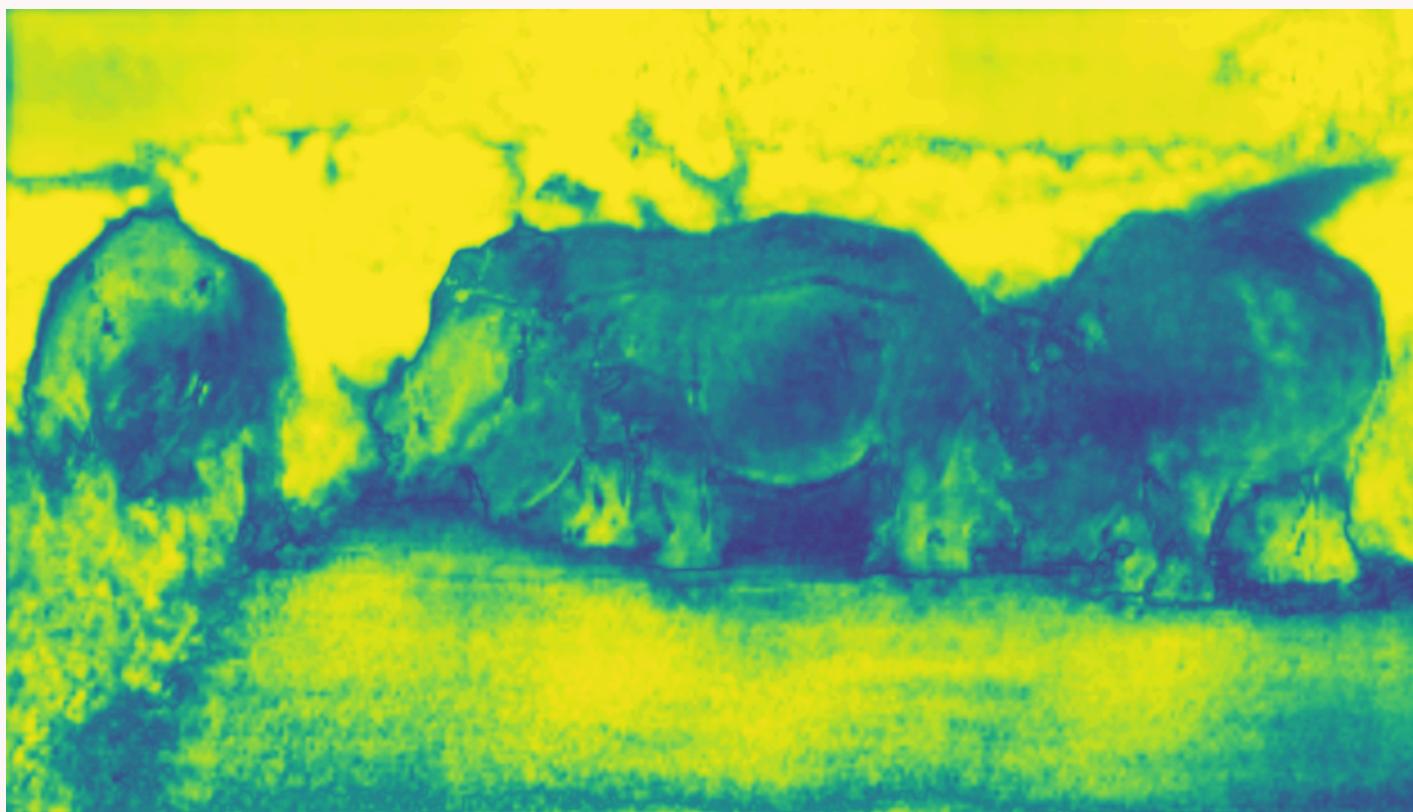
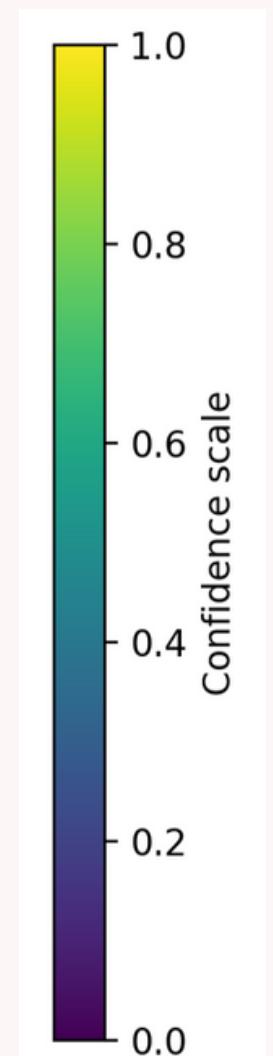
Metric	Avg
Precision	0.297769
Recall	0.492834
F1 Score	0.317349
IoU	0.198677
AUROC	0.6812
FP@95TPR	81.29%



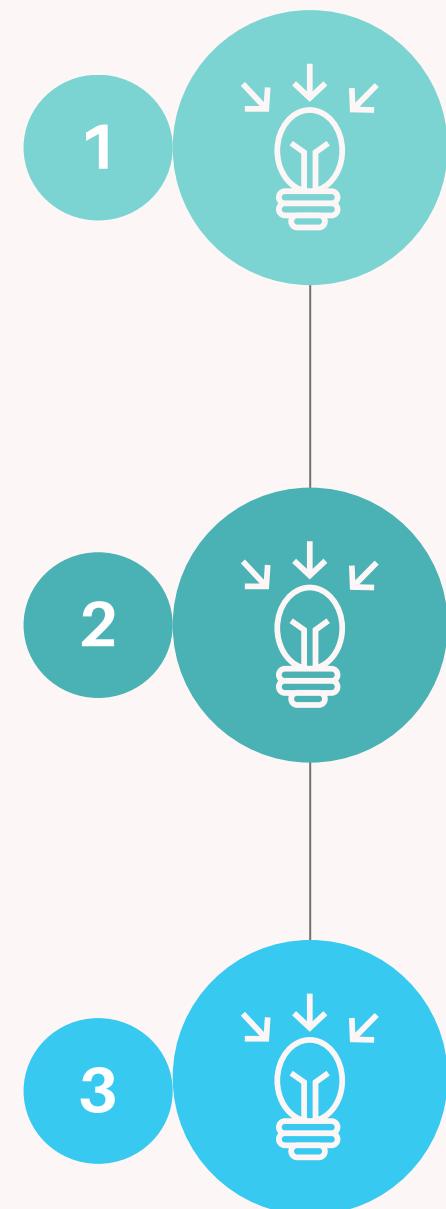
ROAD ANOMALY INTERPRETATION



Metric	Avg
Precision	0.007024
Recall	0.700488
F1 Score	0.013409
IoU	0.006931
AUROC	0.8421
FP@95TPR	54.11%



CONCLUSIONS



Custom traits introduced
(segmentation head override, data augmentation attempts)

Segmentation-independent approach achieved

However, directly shifting domains comes with drawbacks
Precision drops, false positives rise, instability on unseen data



Thanks for your attention!