# ARTIFICIAL INTELLIGENCE

## DM 630/Teoresi S.p.A. - Anomaly detection for road scene segmentation

| | |
|---|---|
| **Funded By** | TEORESI S.P.A. [P.iva/CF:03037960014]<br>MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584]<br>Politecnico di TORINO [P.iva/CF:00518460019] |
| **Supervisor** | TOMMASI TATIANA - tatiana.tommasi@polito.it |
| **Contact** | TOMMASI TATIANA - tatiana.tommasi@polito.it<br>MASONE CARLO - carlo.masone@polito.it |
| **Context of the research activity** | This research will focus on the development of new machine learning algorithms and methods for precisely detecting and localizing anomalies in visual data, specifically for driving scenes. This task, commonly referred to as “anomaly segmentation”, has potential applications not only in autonomous and assisted driving but also in urban planning for smart cities.<br><br>Progetto finanziato dal PNRR a valere sul DM 630/2024 - CUP: E14D24002330004 |
| | The ability to identify and localise obstacles and anomalous situations in driving and urban scenes is critical for the development of autonomous/assisted driving applications: on one hand, achieving this capability would increase the safety and reliability of these systems; on the other one, it could serve as a way to dynamically filter the data where the perception algorithms are uncertain or have a knowledge gap, and be used later on to improve them.¿¿Anomaly segmentation aims to recognise anomalies at a very fine-grained scale (pixel-wise), and it is the principal algorithmic solution used in this context. However, current anomaly segmentation solutions for driving scenes have a few limitations:<br><br>The current datasets and benchmarks that support the development and assessment of these algorithm generally limit the concept of anomalies to new classes unseen during training [1-3]. Thus, this is more akin to an open-set segmentation problem. However, in reality an anomalous situation could be also having an object category seen by the model during training but in an unusual configuration (e.g., a fallen tree).<br><br>The literature so-far has focused mostly on approaches based on a single |

**Objectives**

modality (RGB images) [4-6], but it could be useful to integrate the data from the various sensors onboard the vehicle to improve the accuracy and reliability of the anomaly detection.

This formulation of the problem considered so far is thus not representative of the real operating conditions of an autonomous/assisted driving vehicle. Moreover, current anomaly segmentation methods [4-6] rely on this limited notion of anomaly (i.e., a new class) to implement supervised learning strategies that leverage the prior knowledge of anomalous categories to boost their scores on current benchmarks, but this solution becomes infeasible when the concept of anomaly is extended.

The goal of this research is to revisit the problem of anomaly segmentation, creating a more general and realistic framework. This framework shall be based on the notion of anomalies not as new classes, but rather as out-of-distribution experiences, i.e., experiences that are outside the normal operations of the system. In this framework we also aim to veer from the current paradigm of supervised algorithms towards methods that are unsupervised and do not require a prior knowledge of the anomalies. We can leverage strategies for out-of-distribution detection [9], but also for uncertainty quantification [7, 8].

The use of multi-modal data for anomaly detection shall also be considered and investigated. This may also inform the development of more reliable anomaly detection algorithms, or solutions to select the best modality depending on the certainty of the prediction.

Lastly, we shall also focus on the development of new metric to assess the uncertainty of predictions, which is crucial to develop more reliable solutions.

This research is part of an industrial collaboration with Teoresi, and it will involve a strict collaboration with their team (including a 6 months internship with them).

[1] Chan, R., Lis, K., Uhlemeyer, S., Blum, H., Honari, S., Siegwart, R., Fua, P., Salzmann, M. and Rottmann, M., “SegmentMeIfYouCan: A Benchmark for Anomaly Segmentation”. NeurIPS 2021
[2] P. Pinggera, S. Ramos, S. Gehrig, U. Franke, C. Rother and R. Mester, "Lost and Found: detecting small road hazards for self-driving vehicles”, IROS 2016
[3] Blum, H., Sarlin, P.E., Nieto, J., Siegwart, R. and Cadena, C., “The Fishyscapes Benchmark: Measuring Blind Spots in Semantic Segmentation”,¿ IJCV 2021
[4] Nayal, N., Yavuz, M., Henriques, J.F. and Güney, F., “Rba: Segmenting unknown regions rejected by all”, ICCV 2023
[5] S. N. Rai, F. Cermelli, D. Fontanel, C. Masone and B. Caputo, "Unmasking Anomalies in Road-Scene Segmentation”, ICCV 2023
[6] M. Grcic, J. Saric, and S. Segvic, “On advantages of mask-level recognition for outlier-aware segmentation”, ICCVW 2023\
[7] Upadhyay, U., Karthik, S., Chen, Y., Mancini, M. and Akata, Z., “BayesCAP: Bayesian identity cap for calibrated uncertainty in frozen neural networks”, ECCV 2022
[8] Mukhoti, J., van Amersfoort, J., Torr, P.H. and Gal, Y., 2021. “Deep deterministic uncertainty for semantic segmentation”.¿ arXiv preprint arXiv:2111.00079.
[9] Djurisic, A., Bozanic, N., Ashok, A. and Liu, R., “Extremely Simple Activation

| | |
|---|---|
| | Shaping for Out-of-Distribution Detection", ICLR 2022 |

| | |
|---|---|
| **Skills and competencies for the development of the activity** | This research is grounded in Deep Learning and Computer Vision, therefore knowledge of calculus, probability, machine learning, computer vision are prerequisite.<br>The candidate is expected to have strong programming skills (Python) and proficiency with the PyTorch framework.<br>The candidate is expected to be proactive and capable of autonomously study and read the most recent literature.<br>English fluency is required.<br>Experience in preparing research plans and writing scientific papers is a plus. |