

OBJECT DETECTION OF HORIZONTAL ROAD MARKINGS FOR ADAS

*Joanna Kulawik*¹

¹*Faculty of Computer Science and Artificial Intelligence, Department of Computer Science,
Czestochowa University of Technology, Czestochowa, Poland*

¹*joanna.kulawik@pcz.pl*

Keywords: classification, horizontal road markings, image analysis, YOLOv7, YOLOv8, YOLOv9

Road traffic safety and the development of Advanced Driver Assistance Systems are largely dependent on the reliable recognition of road markings. Contemporary ADAS systems are primarily based on camera data and deep learning methods, which have replaced classical image processing approaches in object detection and classification tasks; however, most research still focuses on vertical signs, while horizontal markings [1][2] – apart from lane markings [3] and automated parking scenarios [4] – are analyzed much less frequently. Their recognition is particularly challenging due to high visual variability, material degradation, and differences in scale and perspective in images.

In the study, a dataset of 6,250 color digital images containing 13,360 labeled objects belonging to nine classes was used [5]. The objects represent examples of the most common horizontal road markings, including pedestrian crossings and eight types of directional arrows. The dataset was divided into three subsets intended for training, validation, and testing of CNN models.

Deep learning detectors of the YOLO family [6][7] have become a standard solution for real-time object recognition. In this work, the YOLOv7, YOLOv8n, and YOLOv9t models were applied to the task of detection and classification of horizontal markings in color images, and were adapted to the defined nine object classes. The training process was conducted over 300 epochs, using a training set of 5,000 images and 750 validation images. Standard data augmentation techniques were applied in order to improve robustness and generalization capability. All networks were trained on images with a resolution of 416×416 pixels. The YOLOv7, YOLOv8n, and YOLOv9t models differ in the number of parameters and the level of complexity. In the experiments, the models were trained using default training settings, and the implementations were conducted in the Python and PyTorch environment. The training results of all models show initial fluctuations of the loss function values, followed by stable convergence. The use of the DFL component (in newer YOLO variants) improves localization accuracy and the stability of the training process.

All three YOLO models (YOLOv7, YOLOv8n, and YOLOv9t) were evaluated on an independent test dataset consisting of 500 images. The conducted experiments confirm effective detection and classification of horizontal markings under real-time conditions. The analysis of the confusion matrix indicates high performance of all models with a minimal number of errors. For each class, precision, recall, and F1-score were calculated as functions of the confidence threshold, and performance was further analyzed using the `ap_per_class` method, which computes class wise Average Precision and evaluates metrics across different confidence thresholds. Quality metrics such as precision, $mAP@0.5$, and $mAP@0.5:0.95$ were also computed, assessing both classification and localization accuracy.

The results indicate that YOLOv7 achieves the highest recall and $mAP@0.5$, whereas YOLOv8n and YOLOv9t provide higher precision and better performance at more restrictive IoU thresholds. All models meet real-time requirements, achieving high processing speeds, which confirms their applicability in Advanced Driver Assistance Systems. Additionally, qualitative tests show that partially occluded horizontal markings are correctly recognized, confirming robustness to limited visibility. Supplementary experiments also demonstrate effective performance in the case of heavily worn and low contrast markings, indicating stability of the models under challenging environmental conditions.

References

- [1] Agarwal, M.; Seth, D. The Enhancement in Road Safety using Different Image Detection and Recognition Techniques: A State of Art. In Proceedings of the 2023 International Conference on Device Intelligence, Computing and Communication Technologies (DICCT), Dehradun, India, 17–18 March 2023; pp. 69–74.
- [2] Valiente, R.; Chan, D.; Perry, A.; Lampkins, J.; Strelnikoff, S.; Xu, J.; Ashari, A.E. Robust perception and visual understanding of traffic signs in the wild. *IEEE Open J. Intell. Transp. Syst.* 2023, 4, 611–625.
- [3] Zakaria, N.J.; Shapiai, M.I.; Abd, Ghani, R.; Yassin, M.N.M.; Ibrahim, M.Z.; Wahid, N. Lane detection in autonomous vehicles: A systematic review. *IEEE Access* 2023, 11, 3729–3765.
- [4] Kaushik, P. Enhanced cloud car parking system using ML and Advanced Neural Network. *Int. J. Res. Sci. Technol.* 2023, 13, 73–86.
- [5] Kulawik J., Kubanek M., Garus S., The Verification of the Correct Visibility of Horizontal Road Signs Using Deep Learning and Computer Vision. *Applied Sciences*. 2023, 13(20), 11489.
- [6] Jocher, G.; Qiu, J.; Chaurasia, A. Ultralytics YOLO, Version 8.0.0; 2023. Available online: <https://github.com/ultralytics/ultralytics> (accessed on 2 October 2025).
- [7] Wang, C.-Y.; Liao, H.-Y.M. YOLOv9: Learning What YouWant to Learn Using Programmable Gradient Information. *arXiv* 2024, arXiv:2402.13616.