




Improved Robotic Platform to perform Maintenance and Upgrading Roadworks: The HERON Approach

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Improved Robotic Platform to perform Maintenance and Upgrading Roadworks: The HERON Approach




HERON aims to develop an integrated automated system to perform maintenance and upgrading roadworks tasks, such as sealing cracks, patching potholes, asphalt rejuvenation, autonomous replacement of CUD elements and paint markings, but also supporting the pre-/post-intervention phase, including visual inspections and dispensing and removing traffic cones in an automated and controlled manner.


In this magazine: AI networks and tools for recognition, localization, and classification of the **HERON** points of interest.

The road so far: Specific deep learning toolkits have been developed for feature representation of **HERON** maintenance and upgrading tasks, such as:

- Object detection methods for rough localization of:
 - Traffic cones
 - Road signs
 - Various road defects
- Semantic segmentation methods for precise pixel-wise detection of:
 - Road surface
 - Cracks
 - Potholes



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Real-time traffic cone detection

Great changes have taken place in intelligent technology such as object detection in road networks. Despite the technological progress, the demands for driving safety, efficiency, and automated maintenance systems have also increased significantly. There are crucial challenges like the capability to cope with temporary and sudden circumstances such as accidents and road construction. Among the numerous objects, traffic cones need to be recognized since they present spatio-temporal visual appearance periodicity and are constantly replaced and moved in the road network.

To this end, the **HERON** AI component includes a deep learning approach to effectively recognizing traffic cones in roadwork images collected from multiple sources. This application was implemented with the YOLO algorithm which is widely used for object detection problems. A dataset of RGB roadwork images was created and annotated by engineer experts within the framework of the **HERON** project. The traffic cone identification task can be addressed as an on-road object detection problem. The aim, therefore, is to broaden current studies of object detection issues and adapt them to the requirements of contemporary road network issues.



Within the **HERON** project, the aforementioned implementation can contribute to traffic road efficiency and safety development, while in parallel supporting the pre- and post-intervention phases including visual inspections and dispensing and removing traffic cones. Consequently, the **HERON** UGV by utilizing the YOLO algorithm will be able to carry out the dispatching and the removal process of the traffic cones effectively in an automated manner, thus avoiding accidental risks for the personnel and making the maintenance more secure, even under adverse (e.g., weather) conditions.

Real-time road sign detection

In parallel, road signs are an essential component of road infrastructure, serving as visual cues that communicate important information to drivers, pedestrians, and cyclists. They play a crucial role in promoting safe driving practices and reducing the risk of accidents on the road. Road signs provide drivers with critical information about speed limits, traffic signals, and road conditions, enabling them to navigate the road network safely and efficiently.

Regarding the **HERON** project, road signs play a critical role in ensuring efficient and safe operations. In particular, they provide important information about the road network, which is essential for the robotic platform to perform its tasks safely and effectively. Thereby the use of road signs can assist the UGV to plan and execute its operations, enhancing its efficiency and accuracy.

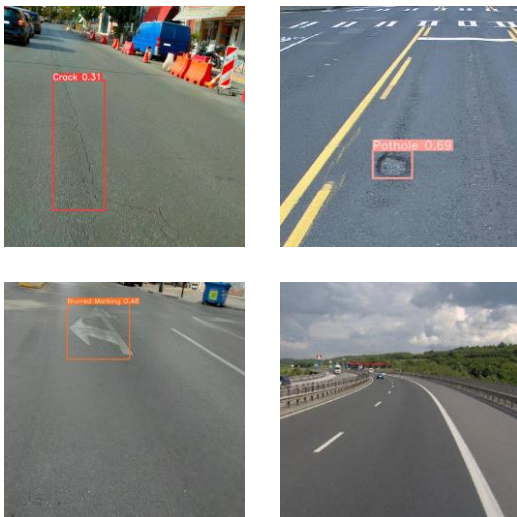
The benefits of road sign detection using deep learning are numerous. Precise and efficient road sign detection systems can improve road safety by providing drivers with timely and accurate information about road conditions and hazards. This technology can also reduce the workload on human operators who are responsible for managing

and maintaining road infrastructure. Another benefit of automated road sign localization is increased safety. Damaged or missing road signs can pose a significant risk to drivers, pedestrians, and cyclists. Thereby, by automating the detection of road signs, we can reduce the risk of accidents and improve overall road safety.



Real-time road defect detection

Similarly, various object detection models were analyzed and compared for the task of road defect detection. The focus was to automate the detection of three main types of road damage (potholes, cracks, and blurred markings) by exploiting the state-of-the-art and computationally efficient deep learning algorithms, on images captured from various RGB sensors.



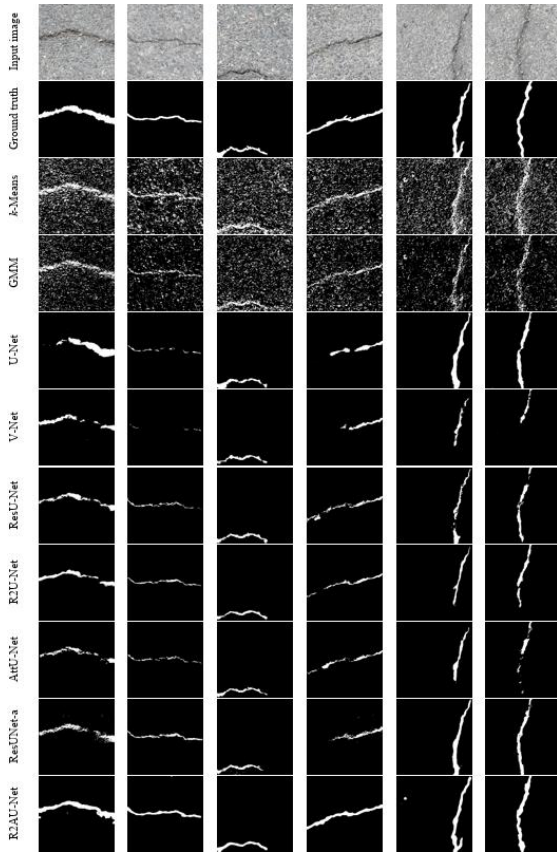
Real-time road defect detection

Also, the use of drones favors the monitoring of RI that are difficult to access, and in the case of road maintenance, they will allow having a current model of defects to plan automated actions for the next day's maintenance tasks, avoiding visual inspection of the personnel (driving vehicles and walking on the road) and, thus, possible accidents. Drone technology will make it possible to reduce the overall cost of these costly interventions. Consequently, the use of aerial drones within the **HERON** system, in conjunction with novel and efficient deep learning methods, can provide the bigger picture of the area under maintenance or/and upgrading intervention procedure.



Pixel-level crack segmentation

AI-driven crack identification is a computer vision problem that can be addressed as a (i) classification, (ii) object detection, or (iii) semantic segmentation task. In the first process, the model returns a binary output, where a positive result implies the presence of cracks on the pavement, and a negative result entails that the image depicts a non-deteriorated road surface. In the second approach, the algorithm provides bounding boxes that precisely localize and indicate the dimensions of the distress. The last procedure involves pixel-wise classification methods, which generate segmentation masks that provide a granular understanding of the contour of the crack region.



Although the first two concepts can be suitable for an image-based automatic pavement surface distress survey system, as they indicate the presence or absence of defects in real-time of the road infrastructure, they cannot be useful for automated maintenance since they are not able to precisely localize the crack areas. On the other hand, pixel-based semantic segmentation provides meticulous information on a variety of metrics and properties that are critical for the automated maintenance process, such as geometry, type, orientation, length, density, and shape of the cracks.



3D localization of the points of interest

To achieve effective recognition and localization of the various road defects and objects of interest, real-time 2D and 3D visual information will be needed. The developed deep learning models use as input 2D RGB images, thus they need to be combined with depth information to deduce the relevant position of a detected object or PoI to the UGV's frame of reference, so it can proceed with the mending tasks.

To this end, for data capturing, **HERON** will use off-the-self cameras capable to fuse multiple technologies of visual capturing such as Time of Flight, Stereo Depth, and Inertial Measurement Unit on top of the typical optical sensors to provide enhanced image stabilization, advanced operation in sub-optimal illumination environment and high-quality depth data. All data collected by the **HERON** sensing interface will be processed by the various state-of-the-art integrated deep learning algorithms.

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