Pattern identification for the inspection of steel structures

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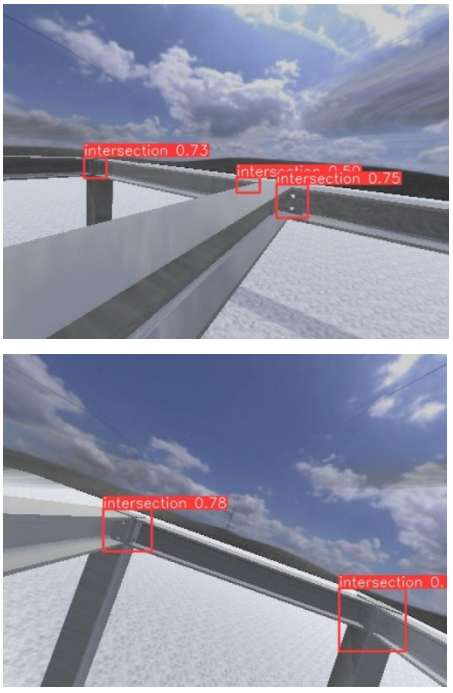
Community-critical steel infrastructure, such as energy transmission and telecommunication lines, steel bridges, offshore rigs, etc… require regular inspection, in order to guarantee the integrity of the structure and good operation. The main interest is to identify fatigue signs within a structure, without requiring to stop its usage. Drones are potentially good candidate to achieve this goal.

This project aims at evaluating how a drone can identify key points, such as beam intersections where stress tends to accumulate within a steel structure.

The first step of this project consisted in designing a realistic model in AutoCAD that was then imported in Webots. In this simulation world, two solutions were then evaluated: Classical computer vision algorithms and Deep Learning.

For classical computer vision algorithms, several methods were tested: edge detection (Canny and Hough transform), segmentation algorithms and Fourier feature descriptors for object detection. However, these methods were too specific and did not generalize well.

For Deep Learning, the latest YOLOv5 (You Only Look Once) implementation developed by Ultralytics was used. To train our model, we used transfer learning on the generic COCO pre-trained yolov5m weights. In fact, since our dataset is relatively small (550 images), transfer learning is expected to produce better results than training from scratch. The model's performance was then assessed with different metrics: Precision, Recall and mean Average Precision over different IoU thresholds (mAP). It was fine-tuned by adjusting the hyperparameters and validated on test data and on a recorded video. The detections were good, although some false positive detections on some frames of the video were still happening. To reduce these, it was necessary to train on a larger dataset and especially to have more background images.



Detection results on the test dataset

To conclude, compared to classical computer vision algorithm, deep learning provide better results and superior flexibility because CNN models and frameworks can be re-trained using a custom dataset for any use case, contrary to computer vision algorithms, which tend to be more domain-specific. Overall, the results obtained are very encouraging and motivate the future implementation and testing of the drone-based inspection of steel structures.