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Autonomous Inland & Short Sea Shipping

Resilient Vessel Perception: Progress and Open Question

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Abstract

A fully autonomous ship requires resilient self-localization and environmental perception that enable risk-free decision-making and safe maneuvering. However, surface vehicles operate in challenging environments where rough conditions for perceptual algorithms can be expected. For instance, the waterway often displays a large-scale, unstructured environment where several yet-to-be-recognized objects are dispersed across a broad area and captured by camera in small sizes. Due to these challenging conditions, traditional perceptual algorithms for autonomous driving degrade, especially in lengthy runs, leading to inaccurate environmental understanding. In this abstract, we outline our most recent efforts to strengthen the accuracy of small-scale object recognition and object detection in challenging conditions, as well as our detailed proposals addressing open questions.

For the visual perception system, small objects merely occupy a few sets of pixels in an entire image. The state-of-the-art object detector's performance deteriorates on small objects as compared to medium and large objects. Due to the large number of layers in the feature extractor, the features of small objects become difficult to learn. One solution is to divide the image into multiple parts and feed them to the detector [1]. However, this would increase the runtime. To improve the runtime performance, the maritime data is analysed. Our research found that 95% of small objects are found on the horizon. Region Of Interest is then systematically selected for the images before feeding them into the object detector. Our method enhances small object detection performance by 4% while slightly increasing the runtime, making it appropriate for real-time applications.

The various weather conditions were one of the earliest difficulties. Weather-related variations in perception system performance are common. Due to the necessity for further research, we have divided the data into categories such as sunny, partly sunny, cloudy, rainy, snowy, and foggy. Such situations are less frequent in a general dataset, which leads to an unbalanced set of data. To counter data imbalances, models were trained and evaluated using data augmentation techniques. Figure 1 illustrates how object detection performs better with trained models in a variety of weather scenarios, including difficult situations like sunlight reflection from a sea surface. Our method not only detects the objects in challenging conditions, but does so with high confidence.

Our learning-based detector can classify 48 different classes with 85% accuracy after gathering a wide range of data in various lightning conditions. Despite achieving accuracy over 90%, or about half of the classes, there are some classes with detection accuracy less than 50%. This low accuracy is largely caused by the high similarity rates between the classes, and at the same time, these classes have fewer samples than their similar counterparts.

These efforts are a part of several of our inland waterways-related projects, including DataSOW, DAVE, MuSEAS and projects with industrial partners. While the MuSEAS project is a collaboration between TITUS Research and RWTH Aachen University, the aim is to develop tools to automatically annotate 3D objects in point clouds and robust vessel localization in challenging environments by fusing multiple sensor observations. Above all, challenges and research gaps remain as an extension of this work, especially in object tracking and runtime constraints.

Figure 1: General purpose object detector trained on general dataset tends to fail in detecting objects highly reflected sunlight from water surface (top-left image), in foggy condition (botoom-left image) whereas object detector trained with our approach able to detect the same objects with high confidence in their respective condition (top-right, bottom-right).

Literature

[1] Akyon, Fatih Cagatay, Sinan Onur Altinuc, and Alptekin Temizel. "Slicing aided hyper inference and fine-tuning for small object detection." 2022 IEEE International Conference on Image Processing (ICIP). IEEE, 2022.