

# Perspective-Aware Road Obstacle Detection

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**Abstract**—While most obstacle detection techniques have become increasingly effective, they typically ignore the fact that, in practice, the apparent size of the obstacle decreases as their distance to the vehicle increases. In this paper, we account for this by introducing a scale map encoding the apparent size of a hypothetical object at every image location. We then leverage this information to (i) generate training data by filtering existing obstacles, and (ii) incorporate perspective information in the processing part of the detection network to guide the obstacle detection. Our results are evaluated both on standard obstacle detection datasets and on a novel dataset in terms of perspective-aware obstacle detection. We compare our approach to conventional perspective-oblivious methods in terms of performance and model complexity.

## I. INTRODUCTION

Vehicle-based driving assistance systems continuously monitor [1] and predict vehicles to give a path within the predicted obstacle space while avoiding other traffic. Obstacle detection and categorization approaches relying on the road through a ground-truth binary image are either vehicle-based systems or a LiDAR system to detect them in 3D, which offer the benefits from multi-view sensor detection in a structured fashion via learning-based strategies. Such road obstacle detection can also be beneficial for safety in road environments. Given that such objects are non-structured, obtaining reliable datasets of real images associated with such obstacles for training purposes is impractical. Hence, many studies either use deep learning approaches [2], [3], [4], [5], only on synthetically generated training data, for example by cutting out objects and inserting them into individual frames of the Cityscapes dataset.

However, these methods fail to leverage, both when generating training data and performing the actual detection, the perspective perspective transformation in images captured by cameras. Introducing camera tilt as a standard practice [6]–[8], [7] to track objects of arbitrary sizes at any image location in the training data used to detect objects of multiple scales irrespective of where they appear in the image. This does not exploit the rich camera data that more distant objects tend to be smaller and thus gives a calibrated camera, the relationship between real and perceived sizes in frames.

In this work, we show that leveraging the perspective information substantially improves performance. To this end, as shown in Fig. 1, we compare a scale map, where pixel values denote the apparent size of objects of a hypothetical meter-wide object placed at that point on the road. We then replace this information in our complementary steps:

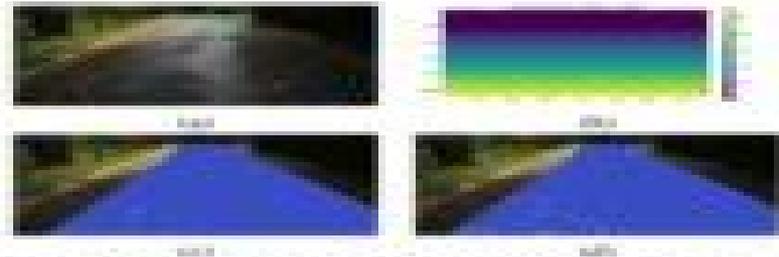


Fig. 1. Our scale method to detect and track cars (green image). The  $1 \times 1$  meters object is red (white) for very small (big)  $1 \times 1$  meters objects (white) for medium sizes. (ii) The perspective map indicates, at each point, the size in pixels of a hypothetical meter-wide object at that location. (iii) Our approach uses the perspective map to distinguish relevant objects from irrelevant ones. It correctly flags in white pixels of the red obstacle while ignoring the nearby car. (iv) When the perspective map (white) is combined with a smaller (red) car, the scale is larger than the car.

- Perspective-Aware Synthetic Object Injection.** Instead of randomly inserting synthetic objects into road scenes to generate training data, as in [4], [6]–[7], we use the perspective map to appropriately cut the projected size of the objects on roads.
- Perspective-Aware Architecture.** We feed the perspective map at multiple levels of a feature pyramid network, enabling it to learn the explicit relationship between distance and size controlled in our training set and in real road scenes.

The bottom portion of Fig. 1 illustrates the benefits of our approach. It not only detects small far-away obstacles but also avoids false alarms arising from small imperfections near the car, such as the fence beam. Because there are no other things located there, our method does not detect them in the white. Our results show that these strategies together contribute to significantly improving the accuracy of road obstacle detection, particularly in terms of perspective-aware detection, which is critical for a self-driving car that needs to identify all potential hazards on the road.

We evaluate our approach on the Highway 101 of the Cityscapes [9] benchmark's obstacle task and the Localized [10] test subset. We demonstrate that it significantly outperforms most of the current approaches that use architectures similar to ours, but without explicit perspective handling. The code of our method and the results publicly available.

# Obstacle Detection Answer Keys

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