

Perspective-Aware Road Obstacle Detection

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Abstract. While road obstacle detection techniques have become increasingly effective, they typically ignore the fact that, in practice, the apparent size of the obstacles decreases as their distance to the vehicle increases. In this paper, we account for this by computing a scale map encoding the apparent size of a hypothetical object at every image location. We then leverage this perspective map to (i) generate training data by injecting synthetic objects onto the road in a scene-specific fashion (thus avoiding overfitting) and (ii) incorporate perspective information in the decoding part of the detection network to guide the obstacle detection. Our results are standard benchmarks show that, together, these two strategies significantly boost the obstacle detection performance, allowing our approach to consistently outperform state-of-the-art methods in terms of instance-level obstacle detection.

1. Introduction

Vehicle-based driving assistance is more commercially available [3] and enables vehicles to plan a path within the predicted obstacle space while avoiding other traffic. However, missed and unexpected obstacles lying on the road remain a potential danger. Since not every vehicle has access to a LiDAR sensor to detect them in 3D, much effort has recently been made to achieve detection in a monocular fashion via learning-based strategies. Such road obstacle detection can also be beneficial for vehicles in rural environments. Given that such objects are under-represented obtaining sufficient datasets of real images associated with such obstacles for training purposes is impractical. Hence, many state-of-the-art deep learning approaches [24, 17, 34, 17] rely on synthetically generated training data, for example by creating real objects and inserting them into rendered frames of the Cityscapes dataset.

However, these methods fail to leverage the wealth of generating training data and performing the actual detection, the ground-truth perspective back-projecting in images captured by cameras’ monocular cameras. It is a standard practice [34–36, 17] to insert objects of arbitrary sizes at any image location in the training data used to detect objects at multiple scales irrespective of where they appear in the image. This does not exploit the well-known fact that more distant objects tend to be smaller and thus, given 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 compute a scale map, where pixel values denote the apparent size of pixels of a hypothetical meter-wide object placed at that point on the road. We then exploit this information in two straightforward steps:

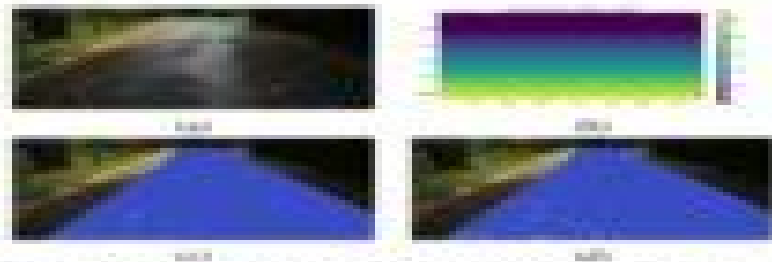


Fig. 1: **Size and distance in close and landmark, car (green) images.** The **green** denotes a real obstacle (the car), and the **red** **scale** indicates specific size features known for the perspective map inference, as each point on the map is given off a hypothetical meter-wide object at that location. (ii) Our approach uses the perspective map to distinguish relevant objects from irrelevant ones. It correctly flags as relevant pixels of the real obstacle while ignoring the background. Without the perspective aware inference, we observe much a smaller performance drop than this.

- 1. **Perspective-Aware Synthetic Object Injection.** Instead of uniformly injecting synthetic objects into road scenes to synthesized training data, as in [34, 36, 17], we use the perspective map to appropriately set the projected size of the objects in pixels.
- 2. **Perspective-Aware Architecture.** We feed the perspective map at multiple levels of a feature pyramid network, enabling it to learn the relation inferring between distance and size embedded 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 irregularities near the road, such as the fence here. Because there are at this image location there are much less of real objects in the vehicle. Our results show that these strategies together contribute to significantly improving the accuracy of road obstacle detection, particularly in terms of instance-level detection, which is critical for a self-driving car that need to identify all potential hazards on the road.

We evaluate our approach on the Segment 3D of Car (Car 3D) benchmark’s obstacle task and the Localized (L) task subset. We demonstrate that it significantly outperforms most of the state-of-the-art methods that use architectures similar to ours, but without explicit perspective handling. The code of our method will be made publicly available.

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