

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 according the apparent size of a hypothetical object at every image location. We then leverage this perspective map to (i) generate training data by labeling synthetic objects onto the road in a more realistic fashion than existing methods, and (ii) incorporate perspective information in the detection part of the detection network to guide the 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.

I. INTRODUCTION

Vehicle-based driving assistance is more commercially available [1] 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. 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 [2], [3], [4], [5] rely on synthetically generated training data, for example by creating real objects and inserting them into individual frames of the Cityscapes dataset.

However, these methods fail to leverage the scale while generating training data and performing the actual detection, the predictable perspective foreshortening in images captured by cameras’ front-facing cameras. It is a standard practice [6]–[8], [7] 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 objects of a hypothetical meter-wide object placed at that point on the road. We then integrate this information in two straightforward steps:

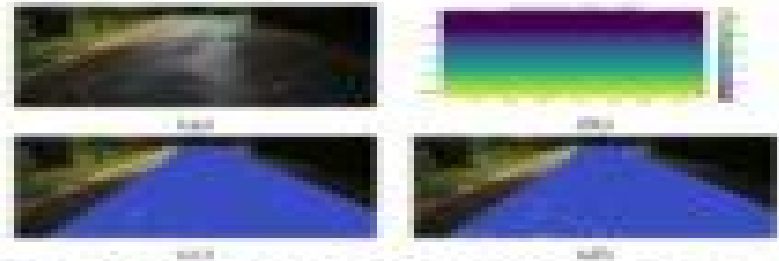


Fig. 1: **Real and virtual in close and landmarks**, our proposed images. The **original** image is real obstacle-free image, and the **real** and **virtual** images are the synthetic images. The perspective map indicates, at each point, the size in pixels of a hypothetical meter-wide object at that location. **Real** and **virtual** images are the images that are generated by inserting objects from landmarks onto it, correctly taking into account the size of the real obstacle while ignoring the location. **Virtual** image perspective map is generated with a smaller resolution than the **real** one.

1. **Perspective-Aware Synthetic Object Injection**. Instead of uniformly inserting synthetic objects into road scenes to synthesized training data, as in [4], [6], [7], 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 between the real distance and size perceived 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 faraway obstacles but also avoids false alarms arising from small irregularities near the road, such as the fence fence. Because there are no other image locations that are much closer to real objects in the image, 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 **Waymo 015** [9] **Real Case** [9] benchmark’s obstacle task and the **LocalForest** [6] test 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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