

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. 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 [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 need to be smaller and thus, given a calibrated camera, the relationship between real and perceived sizes in images.

In this work, we show that leveraging the perspective information substantially increases 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:

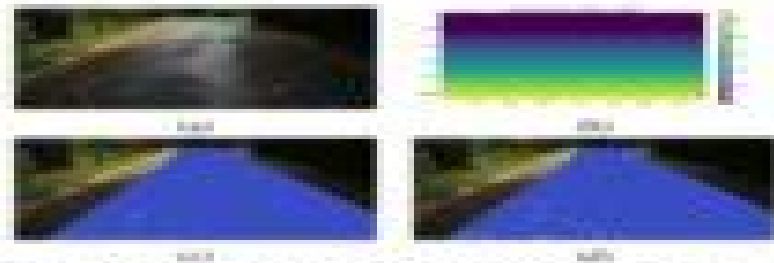


Fig. 1: **Real and virtual in close and faraway, car (top) images.** The **green** denotes a real obstacle (car) and the **red** **scale** indicates specific far locations (near). (a) The perspective map indicates, at each point, the size in pixels of a hypothetical meter-wide object at that location. (b) Our approach scale the perspective map to distinguish relevant objects from irrelevant ones. It correctly flags as relevant pixels of the real obstacle while ignoring the faraway car. (c) When the perspective aware (proposed) net is trained with a smaller architecture (less than 9M).

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 inferring between distance and size combined to our training set and to 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 car, such as the fence fence. Because there are at this image location there are much less of 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 100** [9] & **Car** [10] benchmarks’s obstacle task and the **LongRange** [11] test subset. We demonstrate that it significantly outperforms most of the art techniques 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

Lei Huang

A red circular graphic with a gradient, appearing as a semi-circle or a partial circle, located to the right of the author's name.

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Handbook of Deep Learning Applications Valentina Emilia Balas,Sanjiban Sekhar Roy,Dharmendra Sharma,Pijush Samui,2019-02-25 This book presents a broad range of deep learning applications related to vision natural language processing gene expression arbitrary object recognition driverless cars semantic image segmentation deep visual residual abstraction brain computer interfaces big data processing hierarchical deep learning networks as game playing artefacts using regret matching and building GPU accelerated deep learning frameworks Deep learning an advanced level of machine learning technique that combines class of learning algorithms with the use of many layers of nonlinear units has gained considerable attention in recent times Unlike other books on the market this volume addresses the challenges of deep learning implementation computation time and the complexity of reasoning and modeling different type of data As such it is a valuable and comprehensive resource for engineers researchers graduate students and Ph D scholars

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Assistive Technology Solutions for Aging Adults and Individuals With Disabilities Pandey, Rajiv, Maurya, Pratibha, Prajapati, Jigna Bhupendra, Halder, Raju, Tyagi, Kanishka, 2025-01-15 Assistive technology solutions enhance the quality of life for aging adults and individuals with disabilities These innovative tools and devices support daily activities improve independence and promote social engagement From mobility aids like walkers and wheelchairs to advanced communication devices and smart home technologies assistive technologies cater to a wide range of needs Continued research into this technology may help create more inclusive environments ensuring aging adults and those with disabilities can participate in their communities Assistive Technology Solutions for Aging Adults and Individuals With Disabilities addresses the challenges faced by adults and individuals with disabilities through exploration of effective assistive tools Various devices and technologies are examined including their usefulness in creating a more inclusive community for those with disabilities and specialized healthcare needs This book covers topics such as communication devices mobility aids and visual assistance and is a useful resource for psychologists sociologists healthcare professionals computer engineers academicians and researchers

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