

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.

1. Introduction

Vehicle-based driving assistance is now 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 individual frames of the Cityscapes dataset.

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

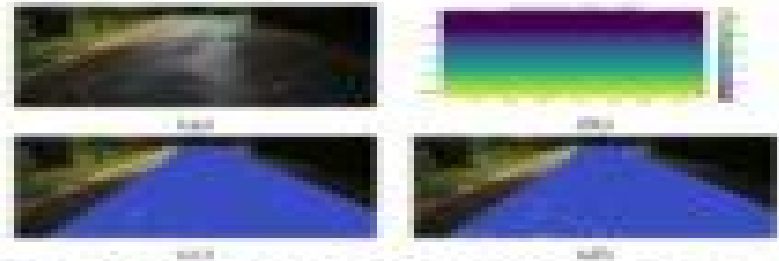


Fig. 1: **Real and virtual in close and faraway, car (green) and truck (red).** Obstacle is real obstacle (the car), and the red (green) reference depicts the synthetic object. (a) The perspective map indicates, at each point, the size in pixels of a hypothetical meter-wide object at that location. (b) Our approach scale the perspective map to distinguish synthetic objects from landmarks ones. It correctly flags in red the pixels of the real obstacle while ignoring the faraway car. (c) Without the perspective aware insertion, car is wrongly scale a smaller reference than truck (d).

1. **Perspective-Aware Synthetic Object Injection.** Instead of uniformly inserting 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 reflected 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 real scale on the lower lane. 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 Argoverse 1B [8] Far Case [9] benchmark’s obstacle task and the Lyft/Pose2 [6] 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 will be made publicly available.

Obstacle Detection Answer Keys

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include cluster analysis 3D vision of dynamic objects speech recognition computer vision in food handling and video content analysis and retrieval This second edition is extensively revised to describe progress in the field since 1993 Chen is affiliated with the electrical and computer engineering department at the University of Massachusetts Dartmouth Annotation copyrighted by Book News Inc Portland OR Department of Transportation and Related Agencies Appropriations for Fiscal Year 1998 United States. Congress. Senate. Committee on Appropriations. Subcommittee on Transportation and Related Agencies,1998

Frontiers in Cancer Research Carlo C. Maley,Mel Greaves,2016-11-21 This is the ideal book for anyone contemplating starting a career in or shifting their career to studying the dynamics that drive cancer progression and its response to therapy Topics include the theory and population genetics of cancers genetic diversity within tumors intra tumor heterogeneity understanding how mutant clones expand in tissues the role of cancer stem cells in the dynamics of tumors the evolution of metastasis and how to improve cancer therapy by addressing the evolution of cancers in response to our interventions There are also chapters on the patterns of cancer susceptibility in humans due to a mismatch between our modern environment and the environment in which our ancestors evolved as well as a chapter on the evolution of cancer suppression mechanisms that have evolved in different species particularly the large long lived animals like elephants and whales that are better at suppressing cancers than humans This book serves as a primer on the evolutionary and ecological theory of cancer the framework upon which all the details of cancer may be hung It is ideal for oncologists and cancer researchers interested in evolutionary theory and evolutionary biologists and ecologists interested in gaining insights into cancer development and prevention

Spoken Natural Language Dialog Systems Ronnie W. Smith,D. Richard Hipp,1995-02-02 As spoken natural language dialog systems technology continues to make great strides numerous issues regarding dialog processing still need to be resolved This book presents an exciting new dialog processing architecture that allows for a number of behaviors required for effective human machine interactions including problem solving to help the user carry out a task coherent subdialog movement during the problem solving process user model usage expectation usage for contextual interpretation and error correction and variable initiative behavior for interacting with users of differing expertise The book also details how different dialog problems in processing can be handled simultaneously and provides instructions and in depth result from pertinent experiments Researchers and professionals in natural language systems will find this important new book an invaluable addition to their libraries

Self Driving Cars Demystified StoryBuddiesPlay,2024-10-28 This chapter delves into the intricate world of path planning for autonomous vehicles highlighting the critical algorithms and techniques that enable self driving cars to navigate safely and efficiently Covering everything from global and local planning to behavioral decision making it addresses the challenges posed by dynamic environments and complex scenarios like intersections and merging As technology evolves we explore how machine learning and real time data enhance path planning capabilities ensuring that autonomous vehicles can adapt to changing conditions

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Automatic Control, Mechatronics and Industrial Engineering Yigang He,Xue Qing,2019-03-20 Engineering technology development and implementation play an important role in making the industry more sustainable in an increasingly competitive world This book covers significant recent developments in both fundamental and applied research in the engineering field Domains of application include but are not limited to Intelligent Control Systems and Optimization Signal Processing Sensors Systems Modeling and Control Robotics and Automation Industrial and Electric Engineering Production and Management This book is an excellent reference work to get up to date with the latest research and developments in the fields of Automation Mechatronics and Industrial Engineering It aims to provide a platform for researchers and professionals in all relevant fields to gain new ideas and establish great achievements in scientific development Interplay of Artificial General Intelligence with Quantum Computing C. Kishor Kumar Reddy,Shenson Joseph,Herat Joshi,Mariya Ouaisa,Marlia Mohd Hanafiah,2025-08-12 This book investigates the dynamic relationship between artificial general intelligence AGI and quantum computing AGI refers to a form of AI capable of performing any intellectual task that a human can while quantum computing utilizes quantum mechanics principles to process information in fundamentally different ways compared to classical computing This interplay explores how quantum computing might enhance AGI by accelerating complex computations and optimizing learning algorithms potentially enabling AGI systems to solve problems beyond the reach of traditional computers It also examines the challenges and opportunities presented by combining these technologies including theoretical implications and practical applications in advancing AI capabilities This book examines the groundbreaking intersection of artificial general intelligence AGI and quantum computing The book explores how AGI which aims to replicate human like cognitive abilities can be enhanced by quantum computing s unique processing capabilities It delves into theoretical foundations practical applications and potential synergies illustrating how quantum computing could tackle complex computational challenges inherent in AGI development By integrating these advanced technologies the book provides a comprehensive analysis of their combined impact offering insights into future advancements and the transformative potential of merging AGI with quantum computing **Advanced Intelligent Computing Technology and Applications** De-Shuang Huang,Qinhu Zhang,Chuanlei Zhang,Wei Chen,2025-07-17 The 12 volume set CCIS 2564 2575 together with the 28 volume set LNCS LNAI LNBI 15842 15869 constitutes the refereed proceedings of the 21st International Conference on Intelligent Computing ICIC 2025 held in Ningbo China during July 26 29 2025 The 523 papers presented in these proceedings books were carefully reviewed and selected from 4032 submissions This year the conference concentrated mainly on the theories and methodologies as well as the emerging applications of intelligent computing Its aim

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Innovations in Smart Cities Applications Volume 5 Mohamed Ben Ahmed,Anouar Abdelhakim Boudhir,İsmail Rakıp Karaş,Vipul Jain,Sehl Mellouli,2022-03-03 This book sets the innovative research contributions works and solutions for almost all the intelligent and smart applications in the smart cities The smart city concept is a relevant topic for industrial governments and citizens Due to this the smart city considered as a multi domain context attracts tremendously academics researchers and practitioners who provide efforts in theoretical proofs approaches architectures and in applied researches The importance of smart cities comes essentially from the significant growth of populations in the near future which conducts to a real need of smart applications that can support this evolution in the future cities The main scope of this book covers new and original ideas for the next generations of cities using the new technologies The book involves the application of the data science and AI IoT technologies and architectures smart earth and water management smart education and E learning systems smart modeling systems smart mobility and renewable energy It also reports recent research works on big data technologies image processing and recognition systems and smart security and privacy **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

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Computational Intelligence Techniques for 5G Enabled IoT Networks Mohit Kumar, Sukhpal Singh Gill, Vijay Kumar, Prabal Verma, 2025-07-26 This book explores emerging interdisciplinary themes and applications reflecting advancements in Computational Intelligence CI for IoT and 5G networks It is divided into four sections Section 1 introduces Computational Intelligence and Sustainability Solutions for Next Gen IoT Networks Section 2 covers Optimization and Resilience Strategies for 5G Enabled IoT Networks Section 3 delves Intelligent Resource Allocation and Service Optimization in 5G IoT Networks Section 4 presents Case studies on Applied Computational Intelligence and 5G IoT Innovations for Industry 4.0 This comprehensive work is essential for researchers and professionals interested in leveraging CI IoT and 5G technologies across diverse applications

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