

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 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.

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 rendered frames of the Cityscapes dataset.

However, these methods fail to leverage the benefit of generating training data and performing the actual detection, the perspective perspective back-projecting 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 frames.

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:

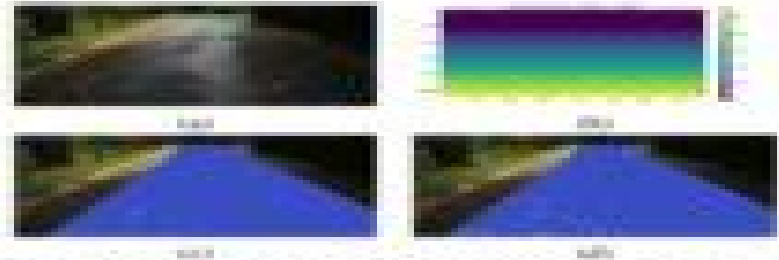


Fig. 1: **Real and virtual in close and landmark, car (top-left) image.** The **green** obstacle is real obstacle the **orange** and the **red** obstacles appear far because they are far. The perspective map indicates, at each point, the size in pixels of a hypothetical meter-wide object at that location. (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 far ones. (iii) Within the perspective aware decoder, we correlate with a smaller receptive-field than the gt.

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 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 EuRoC [9] benchmark’s obstacle task and the Lund/Finnish [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 and the results publicly available.

Obstacle Detection Answer Keys

Karin Nielsen-Saines



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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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Bond,Douglas Vickers,Joseph P Forgas,J. Michael Innes,Ronald C King,Barry J. Fallon,Philip L Smith,Adrienne F Bennett,H. Peter Pfister,John Brebner,Kevin M McConkey,John A Keats,David A. T Siddle,Mary A Luszcz,Ted Nettelbeck,John K Collins,Peter F Lovibond,Peter H Wilson,1989

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 was to unify the picture of contemporary intelligent computing techniques as an integral concept that highlights the trends in advanced computational intelligence and bridges theoretical research with applications Therefore the theme for this conference was Advanced Intelligent Computing Technology and Applications

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

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 while prioritizing safety and passenger

comfort Whether you re a developer engineer or enthusiast this chapter provides valuable insights into the future of autonomous navigation path planning autonomous vehicles self driving cars obstacle avoidance motion planning behavioral planning navigation algorithms traffic rules machine learning dynamic environments 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 *Handbook of Pattern Recognition & Computer Vision* Chi-hau Chen,Louis-Fran ois Pau,1999 Annotation Presents the latest research findings in theory techniques algorithms and major applications of pattern recognition and computer vision as well as new hardware and architecture aspects Contains sections on basic methods in pattern recognition and computer vision nine recognition applications inspection and robotic applications and architectures and technology Some areas discussed 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 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 *Advances in Social Computing and Multiagent Systems* Fernando Koch,Christian Guttman,Didac Busquets,2015-11-14 This book constitutes thoroughly revised selected papers of the proceedings of the 6th International Workshop on Collaborative Agents Research and Development CARE 2015 and the Second International Workshop on Multi agent Foundations of Social Computing MFSC 2015 held in Istanbul Turkey on May 4 2015 Both Workshops were held in conjunction with AAMAS 2015 The 5 revised full papers of CARE and the 7 full papers of MFSC presented were carefully selected from 14 CARE and 10 MFSC submissions Both workshop address issues in relevant areas of social computing such as smart societies social applications urban intelligence intelligent mobile services models of

teamwork and collaboration *IoT Security* SK Hafizul Islam, Debabrata Samanta, Arup Kumar Pal, Ummer Iqbal, 2025-10-15

IoT Security Fundamentals and Key Enabling Technologies explores the complex interactions between Internet of Things IoT and the pressing need for effective cyber security solutions Diving into real world case studies to provide insights into implementing efficient security measures that safeguard against online dangers this book comprehensively analyzes the challenges and possibilities presented by intelligent technologies fueling transformational change emphasizing the crucial role cybersecurity plays in defending networks data and user privacy in an increasingly interconnected digital ecosystem Coverage includes cryptographic methods communication networks device identity and access data governance and privacy as well as regulatory frameworks and standards for IoT security Computer science researchers and engineers will benefit from this compilation of cutting edge research and practical case studies learning how to minimize risks for IoT and intelligent technologies Covers emerging application areas in IoT and possible applications of cybersecurity solutions Presents cutting edge blockchain enabled applications for smart cities cyber physical systems cloud computing intelligent transportation systems and network security Offers both theoretical insights and applications of blockchain edge computing machine learning AI penetration testing and collaborative security approaches *Application And Service Integration Specialist - 400+ Interview Questions & Answers | Perfect Guide for Success* CloudRoar Consulting Services, 101-01-01 Are you aiming to progress into a leadership role in IT service management particularly aligned with strategy transformation and governance 350 Interview Questions Answers for ITIL 4 Strategic Leader PeopleCert AXELOS ITIL 4 Strategic Leader Certification Referenced by CloudRoar Consulting Services is your definitive guide This book is tailored to help you build confidence and depth in the skills that organisations expect from strategic IT leadership without being a pure exam cram guide ITIL 4 Strategic Leader SL a designation by PeopleCert AXELOS recognizes professionals who lead in digitally enabled services and demonstrates how IT directs shapes and supports business strategy peoplecert org 2 axelos com 2 While this book does not replace official training or exams its Q A sets reflect knowledge areas from the SL stream especially the two modules Strategist Direct Plan Improve DPI and Leader Digital IT Strategy DITS peoplecert org 1 Inside you ll find 350 expertly crafted questions with model answers covering Digital IT Strategy Alignment How to translate business goals into IT strategy defining digital visions handling disruption innovation and emerging technologies Direct Plan Improve Practices Continual improvement governance risk management decision making structures strategic planning metrics performance measurement Governance Risk Compliance Establishing governance frameworks balancing risk and opportunity regulatory legal compliance audit trails Value Streams Service Value System SVS Understanding the four dimensions of service management value streams service value chain integration of practices to deliver value Leadership Change Culture Leading organisational change influencing culture stakeholder engagement communication coaching future leaders Strategic Decision Making Metrics Key performance indicators balanced scorecards risk quantification prioritizing initiatives

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Modernizing Global Health Security to Prevent, Detect, and Respond Scott J.N. McNabb, Affan T. Shaikh, Carol J. Haley, 2023-10-19 *Modernizing Global Health Security to Prevent Detect and Respond* explores through thoughtful thorough and diverse scientific review and analyses factors that have led to recent public health emergencies and offers a vision for a better protected global environment The authors consider the history of global health security governance and legal structures with an eye toward novel approaches for the present and future The book presents a vision for a more protected and safer global public health future with the actions needed to achieve it to prevent detect and respond to re emerging threats Its aim is to chart a way forward with the understanding that future pandemics must and can be prevented Major topics examined from a public health perspective include global health security the growing concept of One Health epidemic and pandemic prevention detection and response reviews of past e g Ebola MERS CoV Zika and COVID 19 public health emergencies of international concern roles of information and communication technology humanmade public health threats and legal and ethical issues e g viral sovereignty trust and transparency *Modernizing Global Health Security to Prevent Detect and Respond* provides the academic substance and quality for researchers and practitioners to deeply understand the why of health emergencies and most importantly what we can and should do now to prepare Highlights re emerging past and future threats to public health e g climate change antibiotic resistance failures of societal sectors to work together Discusses new visions for global health security in each chapter Considers how to leverage technological innovations to advance public health Includes practical examples through case studies from around the world [SKILLFUL MINDS CBSE AI, Coding, Robotics Class 6 Computer Book with ICT Fundamentals \(Edition 2\) for Academic Year 2025-26 | Lab Activities| Block Coding](#)

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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

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Nicholas Clifford, Meghan Cope, Thomas Gillespie, Shaun French, 2016-05-21 Practical accessible careful and interesting this revised volume brings the subject up to date and explains in bite sized chunks the how's and why's of modern day geographical study It brings together physical and human approaches again in a new synthesis Danny Dorling Professor of Geography University of Oxford Key Methods in Geography is the perfect introductory companion providing an overview of qualitative and quantitative methods for human and physical geography This Third Edition Features 12 new chapters representing emerging themes including online virtual and digital geographical methods Real life case study examples Summaries and exercises for each chapter Free online access to full text of Progress in Human Geography and Progress in Physical Geography Progress Reports The teaching of research methods is integral to all geography courses Key Methods in Geography Third Edition explains all of the key methods with which geography undergraduates must be conversant

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