

# Using multiple-hypothesis disparity maps and image velocity for 3-D motion estimation

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## Abstract

*In this paper we explore a multiple hypothesis approach to estimating rigid motion from a moving stereo rig. More precisely, we introduce the use of Gaussian mixtures to model correspondence uncertainties for disparity and image velocity estimation. We show some properties of the disparity space and show how rigid transformations can be represented. An algorithm derived from standard random sampling-based robust estimators, that efficiently estimates rigid transformations from multi-hypothesis disparity maps and velocity fields is given.*

## 1. Introduction

Estimation of rigid motion from a moving stereo rig is an important problem in computer vision. To solve it, one must both identify correspondences across viewpoint, i.e., disparity, and across time, i.e., displacement. Searching for the joint set of disparity and displacement estimates that obey the equations of rigid motion is the fundamental step in rigid-body motion stereo.

Unfortunately, it is well known that estimation of both disparity (stereo) and displacement (optical flow) correspondences is often extremely ambiguous. Many common image structures do not offer unique correspondence: *repetitive textures, low textures regions, ...*

One approach to this problem is to identify a core set of image features which are likely to have unique matches. An operator which selects "good features to track", e.g., [15] can locate points whose local contrast constrains tracking in both the horizontal and vertical direction. But many scenes will not have a sufficient number of such features, or they may be difficult to track over longer time periods. And to only use points at the image which pass such an interest operator ignores the constraints offered by the partially ambiguous points which could in some cases improve the estimation.

Indeed, the success of parametric optical flow estima-

tion shows that reliable estimates of global motion can be obtained even when the local measurements are almost everywhere ambiguous [1, 13, 2]. Such gradient-based methods are appealing because they integrate locally linear constraints, rather than single point estimates of image displacement. Gradient-based motion-stereo has been demonstrated [9, 10], but requires coarse-to-fine processing with 3-D warping when motion yields greater than sub-pixel displacements.

We would like to capture displacement/disparity information at partially ambiguous points, but without requiring a coarse-to-fine method. Our approach is to develop a rigid motion stereo estimator that uses non-unimodal input representations. In most rigid motion stereo estimation algorithms, the input representation is an optical flow and disparity map. These representations capture only the mean estimate (and sometimes variance) of the displacement or disparity. In this paper we explore a multiple hypothesis approach to estimating rigid motion from a moving stereo rig. We use a disparity and displacement space representation in which a Gaussian mixture model represents the match surface over the range of possible offsets.

## Organization

The paper is organized as follow. In Section 2, we introduce the use of Gaussian mixtures to model correspondence uncertainties for disparity and velocity (optical flow) estimation. An algorithm to estimate them is given in Section 3. In Section 4 we show some properties of the disparity space and show how rigid transformations can be represented. An algorithm, derived from standard random sampling-based robust estimators that efficiently estimates rigid transformations from multi-hypothesis disparity maps and velocity fields, is given in Section 5. Finally Section 6 shows some experiments with real data and the approach is discussed in Section 7.

# Stereo And Multi Baseline Vision Smbv 2001 Proceedings

**Kostas Daniilidis, Petros  
Maragos, Nikos Paragios**



## **Stereo And Multi Baseline Vision Smbv 2001 Proceedings:**

**Stereo and Multi-Baseline Vision (SMBV 2001): Proceedings of the 2001 IEEE Workshop ,2001 IEEE Workshop on Stereo and Multi-Baseline Vision ,2001 Proceedings of the Fourth International Conference on Signal and Image Processing 2012 (ICSIP 2012)** Mohan S,S Suresh Kumar,2013-01-11 The proceedings includes cutting edge research articles from the Fourth International Conference on Signal and Image Processing ICSIP which is organised by Dr N G P Institute of Technology Kalapatti Coimbatore The Conference provides academia and industry to discuss and present the latest technological advances and research results in the fields of theoretical experimental and application of signal image and video processing The book provides latest and most informative content from engineers and scientists in signal image and video processing from around the world which will benefit the future research community to work in a more cohesive and collaborative way

**Proceedings of the International Conference on Aerospace System Science and Engineering 2022** Zhongliang Jing,Xingqun Zhan,Christopher Damaren,2023-02-25 The book collects selected papers presented at the 6th International Conference on Aerospace System Science and Engineering ICASSE 2022 organized by Shanghai Jiao Tong University China and hosted by University of Toronto Canada in July 2022 It provides a forum for experts in aeronautics and astronautics to share new ideas and findings ICASSE conference has been organized annually since 2017 and host in Shanghai Moscow and Toronto in turn where the three regional editors of journal Aerospace Systems are located This book presents high quality contributions in the subject area of Aerospace System Science and Engineering including topics such as Trans space vehicle systems design and integration Air vehicle systems Space vehicle systems Near space vehicle systems Opto electronic system Aerospace robotics and unmanned system Aerospace robotics and unmanned system Communication navigation and surveillance Dynamics and control Intelligent sensing and Information fusion Aerodynamics and aircraft design Aerospace propulsion Avionics system Air traffic management Earth observation Deep space exploration Bionic micro aircraft spacecraft

*Stereo vision-based road condition monitoring* Brunken, Hauke,2021-05-12 When planning road construction measures it is essential to have up to date information on road conditions If this information is not to be obtained manually it is currently obtained using laser scanners mounted on mobile mapping vehicles which can measure the 3D road profile However a large number of mobile mapping vehicles would be necessary to record an entire road network on a regular basis Since 2D road damages can be found automatically on monocular camera images the idea was born to use a stereo camera system to capture the 3D profile of roads With stereo camera systems it would be possible to equip a large number of vehicles and regularly collect data from large road networks In this thesis the potential applications of a stereo camera system for measuring road profiles which is mounted behind the windshield of a vehicle are investigated Since this requires a calibration of the stereo camera system but the effort for the user should be kept low the camera self calibration for this application is also examined 3D reconstruction from stereoscopic images is a well studied topic but its

application on road surfaces with little and repetitive textures requires special algorithms. For this reason a new stereo method was developed. It is based on the plane sweep approach in combination with semi global matching. It was tested with different measures for pixel comparison. Furthermore the plane sweep approach was implemented in a neural network that solves the stereo correspondence problem in a single step. It uses the stereoscopic images as input and provides an elevation image as output. A completely new approach was developed for the self calibration of mono cameras and stereo camera systems. Previous methods search for feature points in several images of the same scene. The points are matched between the images and used for the calibration. In contrast to these methods the proposed method uses feature maps instead of feature points to compare multiple views of one and the same plane. To estimate the unknown parameters the backpropagation algorithm is used together with the gradient descent method. The measurements obtained by stereoscopic image processing were compared with those obtained by industrial laser scanners. They show that both measurements are very close to each other and that a stereoscopic camera system is in principle suitable for capturing the surface profile of a road. Experiments show that the proposed self calibration method is capable of estimating all parameters of a complex camera model including lens distortion with high precision.

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anstelle von Merkmalspunkten Feature Maps um mehrere Ansichten derselben Ebene zu vergleichen Zur Schätzung der unbekannten Parameter wird der Backpropagation Algorithmus zusammen mit dem Gradientenabstiegsverfahren verwendet Die durch stereoskopische Bildverarbeitung erhaltenen Messungen wurden mit Messungen von industriellen Laserscannern verglichen Sie zeigen dass beide sehr nahe beieinander liegen und dass ein Stereokamerasystem für die Erfassung des Oberflächenprofils einer Straße grundsätzlich geeignet ist Experimente zeigen dass die neue Selbstkalibrierungsmethode in der Lage ist alle Parameter eines komplexen Kameramodells einschließlich der Linsenverzerrung mit hoher Präzision abzuschätzen

**Stereo Vision** Asim Bhatti, 2008-11-01 The book comprehensively covers almost all aspects of stereo vision In addition reader can find topics from defining knowledge gaps to the state of the art algorithms as well as current application trends of stereo vision to the development of intelligent hardware modules and smart cameras It would not be an exaggeration if this book is considered to be one of the most comprehensive books published in reference to the current research in the field of stereo vision Research topics covered in this book makes it equally essential and important for students and early career researchers as well as senior academics linked with computer vision

**Creating Autonomous Vehicle Systems** Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot, 2022-11-10 This book is the first technical overview of autonomous vehicles written for a general computing and engineering audience The authors share their practical experiences of creating autonomous vehicle systems These systems are complex consisting of three major subsystems 1 algorithms for localization perception and planning and control 2 client systems such as the robotics operating system and hardware platform and 3 the cloud platform which includes data storage simulation high definition HD mapping and deep learning model training The algorithm subsystem extracts meaningful information from sensor raw data to understand its environment and make decisions about its actions The client subsystem integrates these algorithms to meet real time and reliability requirements The cloud platform provides offline computing and storage capabilities for autonomous vehicles Using the cloud platform we are able to test new algorithms and update the HD map plus train better recognition tracking and decision models This book consists of nine chapters Chapter 1 provides an overview of autonomous vehicle systems Chapter 2 focuses on localization technologies Chapter 3 discusses traditional techniques used for perception Chapter 4 discusses deep learning based techniques for perception Chapter 5 introduces the planning and control subsystem especially prediction and routing technologies Chapter 6 focuses on motion planning and feedback control of the planning and control subsystem Chapter 7 introduces reinforcement learning based planning and control Chapter 8 delves into the details of client systems design and Chapter 9 provides the details of cloud platforms for autonomous driving This book should be useful to students researchers and practitioners alike Whether you are an undergraduate or a graduate student interested in autonomous driving you will find herein a comprehensive overview of the whole autonomous vehicle technology stack If you are an autonomous driving practitioner the many practical techniques introduced in this book will be of interest to you Researchers will also find plenty

of references for an effective deeper exploration of the various technologies      Proceedings of 3rd International Conference on Computer Vision and Image Processing Bidyut B. Chaudhuri, Masaki Nakagawa, Pritee Khanna, Sanjeev Kumar, 2019-10-31 This book is a collection of carefully selected works presented at the Third International Conference on Computer Vision Image Video Formation and Display Image Video Filtering Restoration Enhancement and Super resolution Image Video Coding and Transmission Image Video Storage Retrieval and Authentication Image Video Quality Transform based and Multi resolution Image Video Analysis Biological and Perceptual Models for Image Video Processing Machine Learning in Image Video Analysis Probability and uncertainty handling for Image Video Processing and Motion and Tracking      *Creating Autonomous Vehicle Systems, Second Edition* Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot, 2022-05-31 This book is one of the first technical overviews of autonomous vehicles written for a general computing and engineering audience The authors share their practical experiences designing autonomous vehicle systems These systems are complex consisting of three major subsystems 1 algorithms for localization perception and planning and control 2 client systems such as the robotics operating system and hardware platform and 3 the cloud platform which includes data storage simulation high definition HD mapping and deep learning model training The algorithm subsystem extracts meaningful information from sensor raw data to understand its environment and make decisions as to its future actions The client subsystem integrates these algorithms to meet real time and reliability requirements The cloud platform provides offline computing and storage capabilities for autonomous vehicles Using the cloud platform new algorithms can be tested so as to update the HD map in addition to training better recognition tracking and decision models Since the first edition of this book was released many universities have adopted it in their autonomous driving classes and the authors received many helpful comments and feedback from readers Based on this the second edition was improved by extending and rewriting multiple chapters and adding two commercial test case studies In addition a new section entitled Teaching and Learning from this Book was added to help instructors better utilize this book in their classes The second edition captures the latest advances in autonomous driving and that it also presents usable real world case studies to help readers better understand how to utilize their lessons in commercial autonomous driving projects This book should be useful to students researchers and practitioners alike Whether you are an undergraduate or a graduate student interested in autonomous driving you will find herein a comprehensive overview of the whole autonomous vehicle technology stack If you are an autonomous driving practitioner the many practical techniques introduced in this book will be of interest to you Researchers will also find extensive references for an effective deeper exploration of the various technologies      **Computer Vision -- ECCV 2010** Kostas Daniilidis, Petros Maragos, Nikos Paragios, 2010-09-24 The 2010 edition of the European Conference on Computer Vision was held in Heraklion Crete The call for papers attracted an absolute record of 1 174 submissions We describe here the selection of the accepted papers Thirty eight area chairs were selected coming from Europe 18 USA and Canada 16 and Asia 4 Their selection was

based on the following criteria 1 Researchers who had served at least two times as Area Chairs within the past two years at major vision conferences were excluded 2 Researchers who served as Area Chairs at the 2010 Computer Vision and Pattern Recognition were also excluded exception ECCV 2012 Program Chairs 3 Minimization of overlap introduced by Area Chairs being former student and advisors 4 20% of the Area Chairs had never served before in a major conference 5 The Area Chair selection process made all possible efforts to achieve a reasonable geographic distribution between countries thematic areas and trends in computer vision Each Area Chair was assigned by the Program Chairs between 28 32 papers Based on paper content the Area Chair recommended up to seven potential reviewers per paper Such assignment was made using all reviewers in the database including the conflicting ones The Program Chairs manually entered the missing conflict domains of approximately 300 reviewers Based on the recommendation of the Area Chairs three reviewers were selected per paper with at least one being of the top three suggestions with 99

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