

Lecture Notes in Computer Science

Edited by G. Goos and J. Hartmanis

825

Advisory Board: W. Brauer D. Gries J. Stoer



Joseph L. Mundy Andrew Zisserman
David Forsyth (Eds.)

Applications of Invariance in Computer Vision

Second Joint European – US Workshop
Ponta Delgada, Azores, Portugal
October 9-14, 1993
Proceedings

Springer-Verlag

Berlin Heidelberg New York
London Paris Tokyo
Hong Kong Barcelona
Budapest

Series Editors

Gerhard Goos
Universität Karlsruhe
Postfach 69 80
Vincenz-Priessnitz-Straße 1
D-76131 Karlsruhe, Germany

Juris Hartmanis
Cornell University
Department of Computer Science
4130 Upson Hall
Ithaca, NY 14853, USA

Volume Editors

Joseph L. Mundy
The General Electric Corporate Research and Development Laboratory
P. O. Box 8, Schenectady, NY 12309, USA

Andrew Zisserman
Department of Engineering Science, University of Oxford
Parks Road, Oxford OX1 3PJ, United Kingdom

David Forsyth
University of Iowa, Department of Computer Science
Iowa City, Iowa 52242, USA

CR Subject Classification (1991): I.3-5, I.2.9-10

ISBN 3-540-58240-1 Springer-Verlag Berlin Heidelberg New York
ISBN 0-387-58240-1 Springer-Verlag New York Berlin Heidelberg

CIP data applied for

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag. Violations are liable for prosecution under the German Copyright Law.

© Springer-Verlag Berlin Heidelberg 1994
Printed in Germany

Typesetting: Camera-ready by author
SPIN: 10472584 45/3140-543210 - Printed on acid-free paper

Preface

This book is the proceedings of the Second Joint European-US Workshop on “Applications of Invariance in Computer Vision”, held in Ponta Delgada, Azores during October 1993.

The First Workshop, held in Reykjavik, Iceland 1991, and subsequent proceedings, demonstrated the fruitfulness of using projective geometry and geometric invariance in computer vision. At that time, some areas, such as projective geometry and the classical theory of algebraic invariance, were well understood, while other issues such as invariants of 3D structures and recognition using invariants were only just emerging. Consequently, study and implementation initially focused on the planar case, since many invariants for the projective plane were known. Invariants then were primarily for sets of points, lines and conics in the plane, and their derivation largely based on geometric constructions. Ideas on 3D curved objects were sketchy and there was a lack of statistical analysis, except for a few empirical studies.

Now, a host of single view invariants for non-algebraic curves and 3D smooth surfaces are available. A sophisticated algebraic structure has developed, complementing geometric constructions, for modelling and partitioning camera projections, and the projective relationships among sets of cameras. New areas and applications, particularly the use of uncalibrated stereo in robotic navigation and surveillance, have proven feasible. These significant advances since the Reykjavik Workshop are extensively documented in this volume.

We are extremely grateful for workshop funding for European participants provided by ESPRIT (Working Group 76096) administered originally by Michel Bosco and subsequently Jakub Wejchert. European research in invariance is supported primarily by ESPRIT Project 6448 ‘VIVA’, coordinated by Luc Van Gool. US participants were supported by NSF grant no. IRI 93-11050, with substantial ARPA participation in the award.

We particularly acknowledge Jennet Batten for her efficient and thoughtful organization of both the Azores Workshop and the assembly of the manuscripts into the final form for this book. Jennet provided the necessary gentle pressure which causes authors to yield their manuscripts to press. Richard Offer and Andrew Wildenberg solved our Latex problems.

May 1994

Joseph L. Mundy
Andrew Zisserman
David Forsyth

Contents

Introduction and Chapter Summary	3
<i>Joseph L. Mundy, Andrew Zisserman and David Forsyth</i>	

Foundations

Cartan's Moving Frame Method and Its Application to the Geometry and Evolution of Curves in the Euclidean, Affine and Projective Planes.....	11
<i>Olivier Faugeras</i>	
Representation of Three-Dimensional Object Structure as Cross-Ratios of Determinants of Stereo Image Points	47
<i>Eamon Barrett, Gregory Gheen and Paul Payton</i>	
A Case Against Epipolar Geometry	69
<i>Andrew Zisserman and Stephen J. Maybank</i>	
Repeated Structures: Image Correspondence Constraints and 3D Structure Recovery.....	89
<i>Joseph L. Mundy and Andrew Zisserman</i>	
How to Use the Cross Ratio to Compute Projective Invariants from Two Images.....	107
<i>Patrick Gros</i>	
On Geometric and Algebraic Aspects of 3D Affine and Projective Structures from Perspective 2D Views.....	127
<i>Amnon Shashua</i>	
The Double Algebra: An Effective Tool for Computing Invariants in Computer Vision	145
<i>Stefan Carlsson</i>	
Matching Perspective Views of Parallel Plane Structures.....	165
<i>Luc Van Gool, Theo Moons, Marc Van Diest and Eric Pauwels</i>	
Invariants for Recovering Shape from Shading	185
<i>Isaac Weiss</i>	
Fundamental Difficulties with Projective Normalization of Planar Curves.....	199
<i>Kalle Åström</i>	
Invariant Size Functions.....	215
<i>Alessandro Verri and Claudio Uras</i>	

Recovery

Euclidean Reconstruction from Uncalibrated Views	237
<i>Richard I. Hartley</i>	
Accurate Projective Reconstruction	257
<i>Roger Mohr, Boubakeur Boufama and Pascal Brand</i>	
Applications of Motion Field of Curves	277
<i>Theo Papadopoulos and Olivier Faugeras</i>	
Affine Reconstruction from Perspective Image Pairs Obtained by a Translating Camera	297
<i>Theo Moons, Luc Van Gool, Marc Van Diest and Eric Pauwels</i>	
Using Invariance and Quasi-Invariance for the Segmentation and Recovery of Curved Objects	317
<i>Mourad Zerroug and Ramakant Nevatia</i>	
Representations of 3D Objects that Incorporate Surface Markings	341
<i>David Forsyth and Charlie Rothwell</i>	
Model-based Invariant Functions and Their Use for Recognition	359
<i>Daphna Weinshall</i>	

Recognition

Integration of Multiple Feature Groups and Multiple Views into a 3D Object Recognition System	381
<i>Jianchang Mao, Anil K. Jain and Patrick J. Flynn</i>	
Hierarchical Object Description Using Invariants	397
<i>Charles A. Rothwell</i>	
Generalizing Invariants for 3-D to 2-D Matching	415
<i>David W. Jacobs</i>	
Recognition by Combinations of Model Views: Alignment and Invariance	435
<i>Ronen Basri</i>	

Statistics

Classification Based on the Cross Ratio.....	453
<i>Stephen J. Maybank</i>	
Correspondence of Coplanar Features Through P^2 -Invariant Representations.....	473
<i>Peter Meer, Sudhir Ramakrishna and Reiner Lenz</i>	
Integrating Algebraic Curves and Surfaces, Algebraic Invariants and Bayesian Methods for 2D and 3D Object Recognition.....	493
<i>Daniel Keren, Jayashree Subrahmonia and David B. Cooper</i>	