Lecture Notes in Computer Science 1953

Edited by G. Goos, J. Hartmanis and J. van Leeuwen

Springer
*Berlin*
*Heidelberg*
*New York*
*Barcelona*
*Hong Kong*
*London*
*Milan*
*Paris*
*Singapore*
*Tokyo*

Gunilla Borgefors  Ingela Nyström
Gabriella Sanniti di Baja (Eds.)

# Discrete Geometry for Computer Imagery

9th International Conference, DGCI 2000
Uppsala, Sweden, December 13-15, 2000
Proceedings

Springer

Series Editors

Gerhard Goos, Karlsruhe University, Germany
Juris Hartmanis, Cornell University, NY, USA
Jan van Leeuwen, Utrecht University, The Netherlands

Volume Editors

Gunilla Borgefors
Swedish University of Agricultural Sciences, Centre for Image Analysis
Lägerhyddvägen 17, 752 37 Uppsala, Sweden
E-mail: gunilla@cb.uu.se

Ingela Nyström
Uppsala University, Centre for Image Analysis
Lägerhyddvägen 17, 752 37 Uppsala, Sweden
E-mail: ingela@cb.uu.se

Gabriella Sanniti di Baja
National Research Council of Italy, Institute of Cybernetics
Via Toiano 6, 80072 Arco Felice (Naples), Italy
E-mail: gsdb@imagm.cib.na.cnr.it

Cataloging-in-Publication Data applied for

Die Deutsche Bibliothek - CIP-Einheitsaufnahme

Discrete geometry for computer imagery : 9th international conference ;
proceedings / DGCI 2000, Uppsala, Sweden, December 13 - 15, 2000.
Gunilla Borgefors . . . (ed.). - Berlin ; Heidelberg ; New York ; Barcelona ;
Hong Kong ; London ; Milan ; Paris ; Singapore ; Tokyo : Springer, 2000
(Lecture notes in computer science ; Vol. 1953)
ISBN 3-540-41396-0

CR Subject Classification (1998):I.3.5, I.4, G.2, I.6.8, F.2.1

ISSN 0302-9743
ISBN 3-540-41396-0 Springer-Verlag Berlin Heidelberg New York

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 New York
a member of BertelsmannSpringer Science+Business Media GmbH
© Springer-Verlag Berlin Heidelberg 2000
Printed in Germany

Typesetting: Camera-ready by author, data conversion by DA-TeX Gerd Blumenstein
Printed on acid-free paper SPIN: 10780979 06/3142 5 4 3 2 1 0

# Preface

This proceedings volume includes papers for presentation at DGCI 2000 in Uppsala, Sweden, 13–15 December 2000. DGCI 2000 is the 9th in a series of international conferences on Discrete Geometry for Computer Imagery. DGCI 2000 is organized by the Centre for Image Analysis (Swedish University of Agricultural Sciences and Uppsala University). It is sponsored by the International Association for Pattern Recognition (IAPR) and by the Swedish Society for Automated Image Analysis (SSAB). This is the first DGCI conference to take place outside France.

The number of researchers active in the field of discrete geometry and computer imagery is increasing. In comparison with the previous editions, DGCI 2000 has attracted a significantly larger number of research contributions from academic and research institutions in different countries. In fact, 62 papers were submitted. The contributions focus on topology, discrete images, surfaces and volumes, shape representation, and shape understanding. After careful reviewing by an international board of reviewers, 40 papers from 16 countries were accepted, leading to a high-quality conference. Of the 40 accepted papers, 28 were selected for oral presentation and 12 for poster presentation. All accepted contributions have been scheduled in plenary sessions. The programme also has been enriched by three invited lectures, presented by three internationally known speakers: Pieter Jonker (Delft University of Technology, The Netherlands), Pierre Soille (ISPRA, Italy), and Jayaram K. Udupa (University of Pennsylvania, USA).

We hope that we have made DGCI 2000 an unforgettable event, especially for researchers from outside Sweden. In fact, the uniquely Swedish Lucia celebration of returning light in the middle of winter has been scheduled in the early morning of 13 December, just before starting the DGCI technical programme. Also, the conference dates were chosen to overlap with the week when the Nobel Prizes are awarded in Stockholm and the Nobel Laureates are giving lectures in Uppsala. In our opinion, these events should be very stimulating for all researchers.

Hereby, we would like to thank the contributors who responded to the call for papers, the invited speakers, all reviewers and members of the Steering, Programme, and Local Committees, as well as DGCI participants. We are also grateful to the sponsoring organizations that provided financial help, indispensable to a successful conference.

September 2000

Gunilla Borgefors
Ingela Nyström
Gabriella Sanniti di Baja

# Organization

DGCI 2000 is organized by the Centre for Image Analysis, Swedish University of Agricultural Sciences, and Uppsala University in Uppsala. The conference venue is the Mathematics and Information Technology campus (MIC) of Uppsala University.

## Conference Chairs

| | |
|---|---|
| General Chair: | Gunilla Borgefors<br>Centre for Image Analysis, Swedish University of Agricultural Sciences, Uppsala, Sweden |
| Programme Chair: | Gabriella Sanniti di Baja<br>Istituto di Cibernetica, National Research Council of Italy, Arco Felice (Napoli), Italy |
| Local Arrangements Chair: | Ingela Nyström<br>Centre for Image Analysis, Uppsala University, Uppsala, Sweden |

## Steering Committee

| | | |
|---|---|---|
| Ehoud Ahronovitz | LIRMM, Montpellier | France |
| Gilles Bertrand | ESIEE, Marne-la-Vallée (Paris) | France |
| Jean-Marc Chassery | TIMC-IMAG, Grenoble | France |
| Annick Montanvert | ENSIEG-LIS, Grenoble | France |
| Maurice Nivat | LIAFA-Paris VI | France |
| Denis Richard | LLAIC1, Clermont-Ferrand | France |

## Programme Committee

| | | |
|---|---|---|
| Yves Bertrand | IRCOM-SIC, Poitiers | France |
| Alberto Del Lungo | Università di Siena | Italy |
| Ulrich Eckhardt | Universität Hamburg | Germany |
| Christophe Fiorio | LIRMM, Montpellier | France |
| Richard W. Hall | University of Pittsburgh | USA |
| T. Yung Kong | City University of New York | USA |
| Vladimir Kovalevsky | Universität Rostock | Germany |
| Walter Kropatsch | Technische Universität Wien (Vienna) | Austria |
| Attila Kuba | József Attila University, Szeged | Hungary |
| Rémy Malgouyres | LLAIC1, Clermont-Ferrand | France |
| Serge Miguet | ERIC, Université Lyon 2 | France |
| Ingemar Ragnemalm | Linköping University | Sweden |
| Gabor Szekely | ETH, Zürich | Switzerland |
| Mohamed Tajine | ULP, Strasbourg | France |

## Local Organizing Committee

Stina Svensson
Lena Wadelius

## Referees

Ehoud Ahronovitz
Eric Andres
Dominique Attali
Jean-Pierre Aubert
Emese Balogh
Gilles Bertrand
Yves Bertrand
Gunilla Borgefors
Sara Brunetti
Jean-Marc Chassery
David Coeurjolly
Michel Couprie
Guillaume Damiand
Alain Daurat
Alberto Del Lungo
Marianna Dudásné
Jean-François Dufourd
Ulrich Eckhardt
Christophe Fiorio
Sébastien Fourey
Yan Gerard
Michel Habib
Richard W. Hall
Christer Kiselman
T. Yung Kong
Vladimir Kovalevsky
Walter Kropatsch
Attila Kuba
Christophe Lohou
Rémy Malgouyres
Serge Miguet
Annick Montanvert
Antal Nagy
Phillippe Nehlig
Maurice Nivat
Ingela Nyström
Kálmán Palágyi
Ingemar Ragnemalm
Denis Richard
Christian Ronsé
Gabriella Sanniti di Baja
Pierre Soille
Gabor Szekely
Mohamed Tajine
Larue Tougne
Jayaram K. Udupa

## Sponsors

City of Uppsala
Swedish Foundation for Strategic Research (SSF)
through the Visual Information Technology (VISIT) programme
Swedish Research Council for Engineering Sciences, TFR
Faculty of Forestry, Swedish University of Agricultural Sciences
Faculty of Information Technology, Uppsala University
Faculty of Science and Technology, Uppsala University

Swedish Society for Automated Image Analysis, SSAB
International Association for Pattern Recognition, IAPR

# Table of Contents

## Topology

Homotopy in Digital Spaces ..... 3
*Rafael Ayala, Eladio Domínguez, Angel R. Francés and Antonio Quintero*

Tesselations by Connection in Orders ..... 15
*Michel Couprie and Gilles Bertrand*

A Concise Characterization of 3D Simple Points ..... 27
*Sébastien Fourey and Rémy Malgouyres*

Digital $n$-Pseudomanifold and $n$-Weakmanifold
in a Binary $(n+1)$-Digital Image ..... 37
*Mohammed Khachan, Patrick Chenin and Hafsa Deddi*

Digital Jordan Curve Theorems ..... 46
*Christer O. Kiselman*

A New Means for Investigating 3-Manifolds ..... 57
*Vladimir Kovalevsky*

Nearness in Digital Images and Proximity Spaces ..... 69
*Pavel Pták and Walter G. Kropatsch*

Morphological Operators with Discrete Line Segments ..... 78
*Pierre Soille*

Hausdorff Discretizations of Algebraic Sets and Diophantine Sets ..... 99
*Mohamed Tajine and Christian Ronse*

## Discrete Images

An Algorithm for Reconstructing Special Lattice Sets
from Their Approximate X-Rays ..... 113
*Sara Brunetti, Alain Daurat and Alberto Del Lungo*

A Question of Digital Linear Algebra ..... 126
*Yan Gérard*

Reconstruction of Discrete Sets with Absorption ..... 137
*Attila Kuba and Maurice Nivat*

Some Properties of Hyperbolic Networks ..... 149
*Christophe Papazian and Eric Rémila*

The Reconstruction of the Digital Hyperbola Segment from Its Code .....159
*Nataša Sladoje*

Determining Visible Points in a Three-Dimensional Discrete Space .....171
*Grit Thürmer, Arnault Pousset and Achille J.-P. Braquelaire*

**Surfaces and Volumes**

Extended Reeb Graphs for Surface Understanding and Description .....185
*Silvia Biasotti, Bianca Falcidieno and Michela Spagnuolo*

Euclidean Nets: An Automatic and Reversible Geometric Smoothing of Discrete 3D Object Boundaries .....198
*Achille J.-P. Braquelaire and Arnault Pousset*

Object Discretization in Higher Dimensions .....210
*Valentin E. Brimkov, Eric Andres and Reneta P. Barneva*

Strong Thinning and Polyhedrization of the Surface of a Voxel Object .... 222
*Jasmine Burguet and Rémy Malgouyres*

Deformable Modeling for Characterizing Biomedical Shape Changes .....235
*Matthieu Ferrant, Benoit Macq, Arya Nabavi and Simon K. Warfield*

Naive Planes as Discrete Combinatorial Surfaces .....249
*Yukiko Kenmochi and Atsushi Imiya*

Surface Digitizations by Dilations Which Are Tunnel-Free .....262
*Christoph Lincke and Charles A. Wüthrich*

Delaunay Surface Reconstruction from Scattered Points .....272
*Angel Rodríguez, José Miguel Espadero, Domingo López and Luis Pastor*

Go Digital, Go Fuzzy .....284
*Jayaram K. Udupa*

Recognition of Digital Naive Planes and Polyhedrization .....296
*Joëlle Vittone and Jean-Marc Chassery*

**Shape Representation**

Topological Encoding of 3D Segmented Images ..... 311
*Yves Bertrand, Guillaume Damiand and Christophe Fiorio*

Some Weighted Distance Transforms in Four Dimensions .....325
*Gunilla Borgefors*

Representing 2D Digital Objects .....337
*Vito Di Gesù and Cesare Valenti*

Plane Embedding of Dually Contracted Graphs .....348
*Roland Glantz and Walter G. Kropatsch*

A New Visibility Partition for Affine Pattern Matching ..... 358
*Michiel Hagedoorn, Mark Overmars and Remco C. Veltkamp*

Morphological Operations on 3D and 4D Images:
From Shape Primitive Detection to Skeletonization ..... 371
*Pieter P. Jonker*

Efficient Algorithms to Implement the Confinement Tree ..... 392
*Julian Mattes and Jacques Demongeot*

A 3D 3–Subiteration Thinning Algorithm for Medial Surfaces ..... 406
*Kálmán Palágyi*

Computing 3D Medial Axis for Chamfer Distances ..... 418
*Eric Remy and Edouard Thiel*

Multiresolution Modelling of Polygonal Surface Meshes
Using Triangle Fans ..... 431
*José Ribelles, Angeles López, Inmaculada Remolar, Oscar Belmonte and Miguel Chover*

Detecting Centres of Maximal Geodesic Discs
on the Distance Transform of Surfaces in 3D Images ..... 443
*Gabriella Sanniti di Baja and Stina Svensson*

The Envelope of a Digital Curve Based on Dominant Points ..... 453
*David E. Singh, María J. Martín and Francisco F. Rivera*

**Shape Understanding**

Minimum-Length Polygons in Simple Cube-Curves ..... 467
*Reinhard Klette and Thomas Bülow*

Planar Object Detection under Scaled Orthographic Projection ..... 479
*Julián Ramos Cózar, Nicolás Guil Mata and Emilio López Zapata*

Detection of the Discrete Convexity of Polyominoes ..... 491
*Isabelle Debled-Rennesson, Jean-Luc Rémy and Jocelyne Rouyer-Degli*

An Efficient Shape-Based Approach to Image Retrieval ..... 505
*Ioannis Fudos and Leonidas Palios*

Towards Feature Fusion – The Synthesis of Contour Sections
Distinguishing Contours from Different Classes ..... 518
*Dag Pechtel and Klaus-Dieter Kuhnert*

Parallel Line Grouping Based on Interval Graphs ..... 530
*Peter Veelaert*

**Author Index** ..... 543