

Mathematics in Industry 22

The European Consortium for Mathematics in Industry

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Progress in Industrial Mathematics at ECMI 2014

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Photo of Angelo Marcello Anile by courtesy of Giovanni Russo

ISSN 1612-3956 ISSN 2198-3283 (electronic)
Mathematics in Industry
The European Consortium for Mathematics in Industry
ISBN 978-3-319-23412-0 ISBN 978-3-319-23413-7 (eBook)
DOI 10.1007/978-3-319-23413-7

Library of Congress Control Number: 2017950222

Mathematics Subject Classification (2010): 34-xx, 35-xx, 41-xx, 49-xx, 60-xx, 62-xx, 65-xx, 68-xx, 70-xx, 74-xx, 86-xx, 90-xx, 91-xx, 92-xx, 94-xx, 97-xx

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Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Dedication



This book is dedicated to the memory of Professor Angelo Marcello Anile (1948–2007). Worldwide known mathematician, genial scientist, professor dedicated to the creation and spreading of knowledge, gifted with exceptional human qualities, and highest moral. He produced original results in several fields, among which relativistic astrophysics and cosmology, relativistic thermodynamics, mathematical modeling of semiconductors, wave propagation, fuzzy logic, optimization, industrial mathematics. Leader in scientific research, he founded a school of Mathematical Physics with several students. Contributed to support research also with national and international projects, and various forms of contracts. Helped find job opportunities for many young people. Active member of ECMI, created and strengthened relationship between University and Industry in Italy and abroad.

Preface

This volume presents a snapshot of current activities in industrial mathematics in Europe and will be highly relevant for anyone interested in the latest applications of mathematics to industrial problems. It features papers based on contributions to the 18th conference of ECMI, the European Consortium for Mathematics in Industry. The biannual conference has established itself as a *jour fixe* for researchers interested in the applications of mathematical and computational methods to relevant problems in many different areas of social and economic importance. It brings together applied mathematicians and experts from industry, offering them a unique opportunity to exchange ideas, problems, and methodologies and bridging the gap between mathematics and industry to further the advancement of science and technology.

The conference focused on various aspects of industrial and applied mathematics, such as aerospace, information and communication, energy, imaging, medicine and biotechnology, finance, and education.

The event continued for five full days. In addition to the nine plenary speakers, the conference hosted 56 mini-symposia, each of which consisted of one or more 2-h sessions. Six parallel sessions were held at the same time, allowing roughly three hundred and fifty speakers to present the results of their research. A 2-h poster session was also held, offering participants an alternate form of presentation. The participation of young researchers was encouraged by a reduced fee with respect to previous years.

Several topics were discussed at the conference. Specifically, five main topics were addressed by the nine plenary speakers and discussed in several mini-symposia: the life sciences, material science and semiconductors, the environment, design automation, and finance.

Several other interesting mini-symposia on different fields of industrial mathematics enriched the program. A complete list can be found on the conference website.¹

¹<http://www.taosciences.it/ecmi2014/>.

The conference also included an extended mini-symposium organized by EU-Maths-In (European Network of Mathematics for Industry and Innovation),² a recent joint initiative of ECMI and EMS (the European Mathematical Society). In keeping with tradition, this year several prizes and awards were announced during the conference.

Alan Tayler Lecture—This lecture was set up by the ECMI Council to honor Alan Tayler, who passed away on January 28, 1995. Alan was one of the founding members of ECMI and served as its third president in 1989. The Alan Tayler Lecture has been a key feature of the biannual ECMI conferences since 1996 and was delivered this year by Sylvie Méléard.³

*Anile-ECMI Prize for Mathematics in Industry*⁴—This prize is cosponsored by the Associazione Angelo Marcello Anile and ECMI. The prize was established in memory of Angelo Marcello Anile, a brilliant astrophysicist and applied mathematician and a highly active member of ECMI; it is awarded to a young researcher for an excellent PhD thesis in industrial mathematics. This year it has been awarded to Dr. Paolo Pintus, from Scuola Superiore Sant’Anna of Pisa, in recognition of the excellent results achieved in his PhD thesis “Design of silicon based integrated optical devices using the finite element method.”

Hansjörg Wacker Memorial Prize—This prize is cosponsored by ECMI and RICAM (the Johann Radon Institute for Computational and Applied Mathematics⁵) at the Austrian Academy of Sciences (ÖAW). This year it was awarded to Kishan Patel, who completed his MSc in scientific computing and mathematical modeling at the University of Oxford in 2012.

ECMI Honorary Membership—It is a tradition that ECMI, during its biannual conference, offers an honorary lifetime membership to a scientist of the hosting country, in recognition of his or her important contributions to Mathematics in Industry. This year the honorary membership was awarded to Professor Alfio Quarteroni,⁶ in recognition of his important contributions to Mathematics in Industry.

With over four hundred participants, this year was one of the most successful ECMI conferences to date. The number of authors involved in the organization of the mini-symposia and preparation of abstracts and short papers totaled more than 800 people from 41 different countries. The authors came mainly, but not exclusively, from Europe, with the largest group from Germany (167), followed by Italy (152), Spain (79), the UK (69), and France (65).

Given the large variety of subjects, it has been difficult to classify the contributions into broader topics. Therefore, we decided to merely draw a distinction between short papers related to talks at the mini-symposia (chapter “MS 1 Minisymposium: Advanced Imaging for Industrial Application”), and short papers from

²<http://www.eu-maths-in.eu>.

³<http://www.cmap.polytechnique.fr/spip.php?rubrique61>.

⁴<http://asso-ama.dmi.unict.it/en>.

⁵<http://www.ricam.oew.ac.at/>.

⁶<http://http://cmcs.epfl.ch/people/quarteroni>.

the contributed sessions (chapter “A Customized System for Vehicle Tracking and Classification”).

The mini-symposia are ordered alphabetically by title, as are the corresponding papers.

The last chapter contains the paper related to the Anile prize lecture.

The 18th ECMI conference, managed by the organizing committee, with the collaboration of ECMI and Tao Sciences Research Center, took place in Taormina, Sicily, on the beautiful premises of the Hotel Villa Diodoro, conveniently located near the Villa Comunale of Taormina and the Teatro Greco, offering a gorgeous view of Taormina Bay.

Acknowledgments

Many people contributed to the success of the conference, and it is impossible to list them all in a limited space. First of all, we would like to thank Mrs. Marisa Lappano Anile, who helped us a lot for all organizational, administrative, and practical problems, with professionalism and enthusiasm. Even more, with a strong motivation behind, which bears the name of our friend and mentor Marcello Anile, she was one of the inspirers of the event. We thank all the members of the Scientific Committee, who determined the selection of the plenary speakers. In particular, we thank the past presidents of ECMI, such as L. Bonilla, and M. Guenther, and W. Schilders, for valuable practical advices about the organization of the conference. A thank goes to the Board of ECMI, for valuable advices and, even more, for trusting our actions and leaving us a large autonomy both at a scientific and organizational level. A special thank goes to the rest of the organizing committee and in particular the young volunteers: Alice, Armando, Gianluca, Gianni, Ivano, Leonardo, Mario, Riccardo, Sergio, and Silvia: they worked hard on virtually all organizational aspects of the conference. We warmly thank all the plenary speakers for accepting the invitation and delivering such interesting talks. Many thanks to the sponsors of the event, namely, the Associazione Angelo Marcello Anile, the Office of Naval Research Global, and European Patent’s Office, for their generous contributions. We would like to thank all the mini-symposia organizers, all the contributors, and all the participants, who determined the success of the event and contributed to the pleasant general atmosphere of the conference. We all thank our wives for the patience and support during the several months the organization of the conference kept us busier than usual. We thank Prof. Nicole Marheineke for help in the management of the final version of the proceedings. Last, but not least, we would like to express our

gratitude to Ruth Allewelt, from Springer, for her help, patience, and competence granted us during the preparation of the present book of proceedings.

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Part I
Minisymposia

MS 1

MINISYMPOSIUM: ADVANCED IMAGING FOR INDUSTRIAL APPLICATION

Organizers

Sebastiano Battiato¹, Giovanni Gallo² and Filippo Stanco³

Speakers

Marco Leo⁴ and Cosimo Distante⁵

Iris Segmentation: A New Strategy for Real Biometric Applications

Giovanni Maria Farinella⁶, Sebastiano Battiato¹, Giovanni Giuffrida⁷ and Davide Moltisanti⁸

Web Scraping of Online Newspapers Via Image Matching

Sebastiano Battiato¹, Giovanni Maria Farinella⁶, Antonino Furnari⁹, Giovanni Puglisi¹⁰

A Customized System for Vehicle Tracking and Classification

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Keywords

Computer vision

Image matching

Segmentation

Tracking

Short Description

The aim of this mini-symposium is to provide an overview of state of the art methods for imaging applications in different industrial contexts (consumer devices, e-health, digital signage, forensics, Cultural Heritage, etc.) to stimulate the creation of appropriate benchmark dataset to be used as reference for the development of novel algorithms.

A Customized System for Vehicle Tracking and Classification

Sebastiano Battiato, Giovanni Maria Farinella, Antonino Furnari,
and Giovanni Puglisi

Abstract We present a customized system for vehicle tracking and classification. The main purpose of the system is tracking the vehicles in order to understand lane changes, gates transits and other behaviors useful for traffic analysis. The classification of the vehicles into two classes (short vehicles vs. tall vehicles) is also performed for electronic truck-tolling as well as to optimize the performances of the tracker module. The whole system has been developed through a data driven approach based on video sequences acquired by QFree. (Q-Free (www.q-free.com) is a global supplier of solutions and products for Road User Charging and Advanced Transportation Management having applications mainly within electronic toll collection for road financing, congestion charging, truck-tolling, law enforcement and parking/access control.) The sequences are acquired by wide angle cameras from the top of the road and are preprocessed in order to obtain a normalized, low-resolution representation of the scene where the distance between neighboring pixels is constant in the real world. The sequences exhibit high variability in terms of lighting changes, contrast changes and distortion. We assume that the vehicle detection is performed by an external module for plate recognition.

Keywords Image matching • Tracking

The tracking algorithm is based on Template Matching [1, 2] and the Normalized Cross Correlation is used as similarity measure. The vehicle template is updated at each frame to cope with the vehicles' changes of appearance. In order to deal with the main variabilities, four modules are designed: a multicorrelation module to deal with the appearance of artifacts on the vehicles; a refinement module to deal with the change of the vehicle horizontal scale due to distortion (see Fig. 1a–c); a background subtraction module to deal with perspective issues on tall vehicles; a

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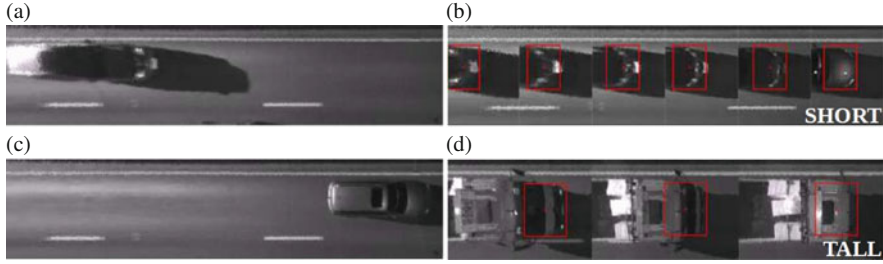


Fig. 1 Some sample images from the developed system. (a), (b) Vehicle deformation. (c) Tracking results. (d) Classification results

selective update module to avoid the propagation of a wrong template in the slow scenes. A controller has been realized to switch on or off the modules depending on the vehicle estimated speed and the vehicle estimated class. Two measuring methods are defined to assess the performances of the proposed tracker with respect to other standard tracking pipelines [3–6] in a supervised way. The performance analysis points out that the vehicles are correctly tracked for nearly the 99 % of the scene. Fig. 1b shows some tracking results.

The classification is performed when the vehicle approaches the central part of the scene, where the variabilities are less significant. The image patches are extracted from the frame taking into account the estimated vehicle bounding box. The training set is built considering the image patches extracted from the input sequences. To make the learning procedure more robust, the training set is augmented generating artificial patches tailored to introduce alignment, perspective, rotation and photometric variabilities. The patches are normalized to the training set mean patch size and the HOG (Histogram of Oriented Gradients) features are extracted [7]. The feature vectors dimensionality is reduced through the Principal Component Analysis (PCA) [8]. The labeled samples are then projected through the Linear Discriminant Analysis (LDA) [9] to the most discriminant dimension. This unidimensional feature is aggregated to the patch height in pixels, obtaining a two-dimensional vector. A new LDA projection is hence performed on the two-dimensional samples and the two projected populations are modeled as unidimensional Gaussian distributions. In the classification step, the sample is projected using the previously learned PCA and LDA bases. The Mahalanobis distances [10] are computed between the projected sample and the Gaussian distributions related to the two classes (short vs. tall vehicles). The sample is assigned to the class giving the smallest distance. The classification performances are evaluated with the Leave One Out strategy and the overall classification accuracy is over the 98 %. Fig. 1d shows some classification results.

This work has been performed in the project PANORAMA, co-funded by grants from Belgium, Italy, France, the Netherlands, and the United Kingdom, and the ENIAC Joint Undertaking.

References

1. Maggio, E., Cavallaro, A.: Video Tracking: Theory and Practice. Wiley, New York (2011)
2. Yilmaz, A., Javed, O., Shah, M.: Object tracking: a survey. *ACM Comput. Surv.* **38**(4), 13-es (2006)
3. Lucas, B.D., Kanade, T.: An iterative image registration technique with an application to stereo vision. *Imaging* **130**, 674–679 (1981)
4. Baker, S., Gross, R., Ishikawa, T., Matthews, I.: Lucas-kanade 20 years on: a unifying framework: Part 2. *Int. J. Comput. Vis.* **56**(3), 221–255 (2004)
5. Comaniciu, D., Ramesh, V., Meer, P.: Kernel-based object tracking. *IEEE Trans. Pattern Anal. Mach. Intell.* **25**, 564–577 (2003)
6. Bradski, G.R.: Computer vision face tracking as a component of a perceptual user interface. In: *IEEE Workshop on Applications in Computer Vision* (1998)
7. Dalal, N., Triggs, B.: Histograms of oriented gradients for human detection. *IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recogn.* **1**, 886–893 (2005)
8. Hotelling, H.: Analysis of a complex of statistical variables into principal components. *J. Educ. Psychol.* **24**(6), 417 (1933)
9. Fisher, R.A.: The use of multiple measurements in taxonomic problems. *Ann. Eugen.* **7**(2), 179–188 (1936)
10. Mahalanobis, P.C.: On the generalized distance in statistics. *Proc. Natl. Inst. Sci.* **2**, 49–55 (1936)