

POLITECNICO  
MILANO 1863



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2018

AUGUST 3<sup>RD</sup> TO 7<sup>TH</sup>

# 40 YEARS ON GEOMETRY AND GRAPHICS & ICGG2018 POSTERS ON SHOW

OFFICIAL OPENING  
**SUNDAY**  
**August 05 2018**  
**13:40**



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Luigi Cocchiarella

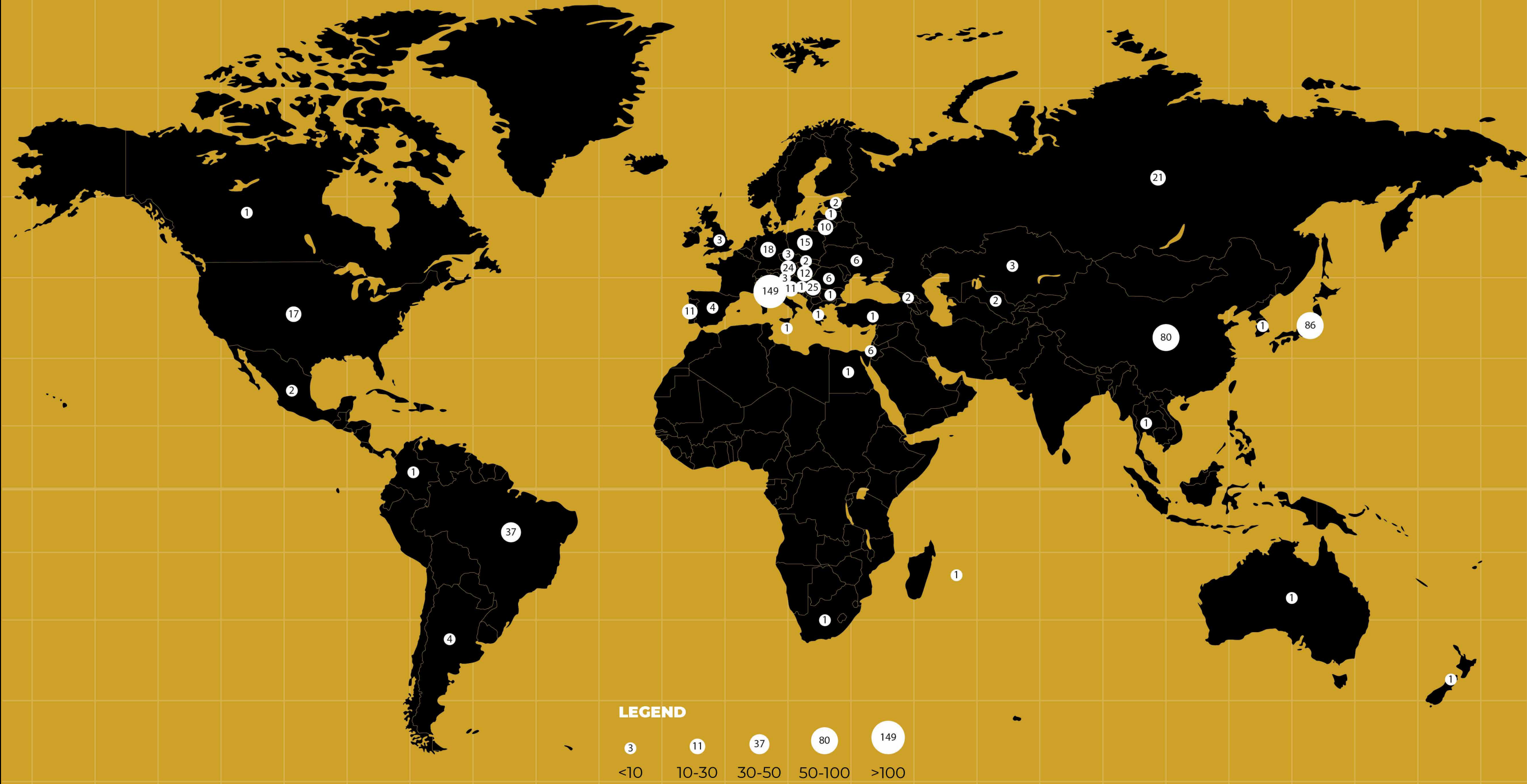
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statistics by country

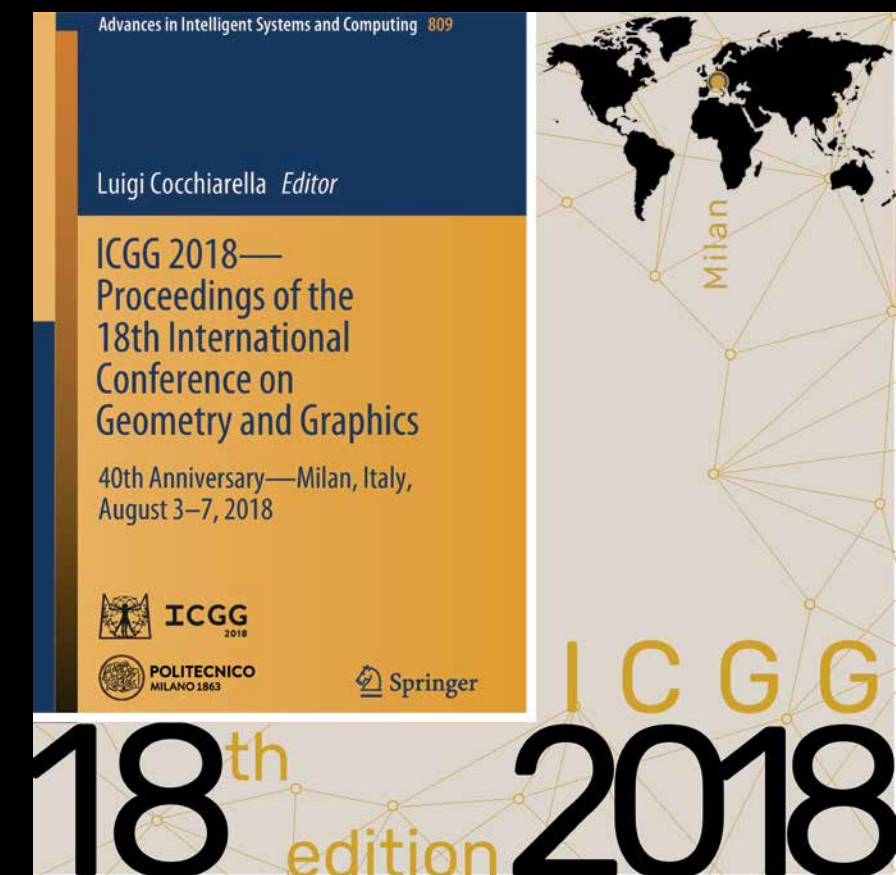
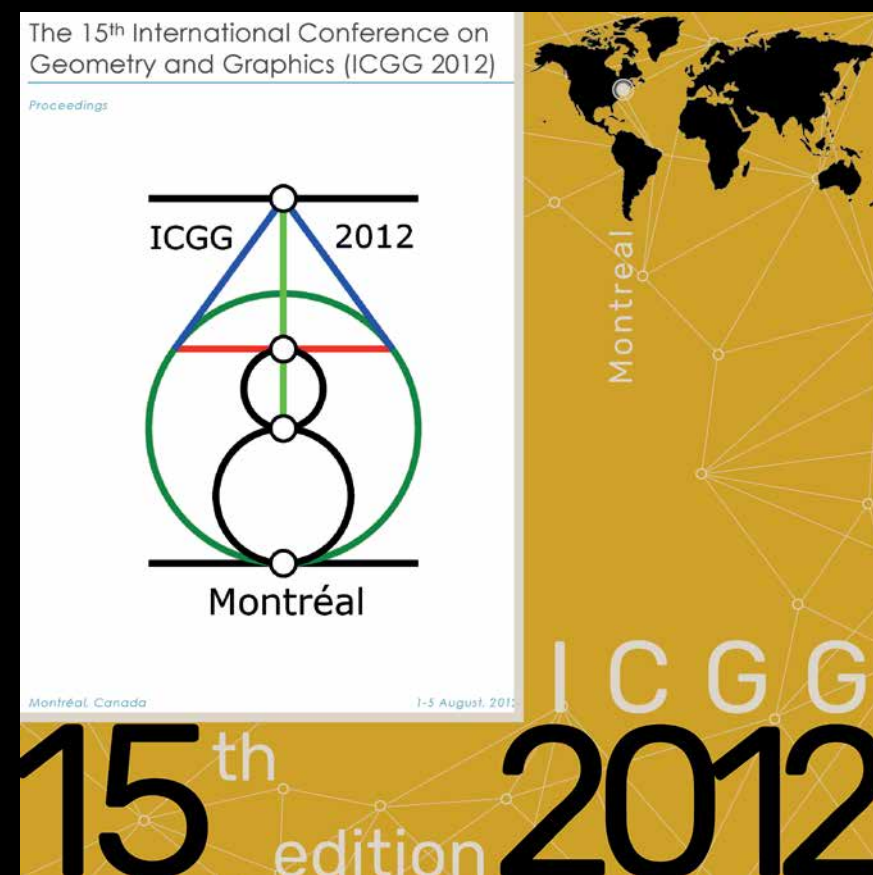
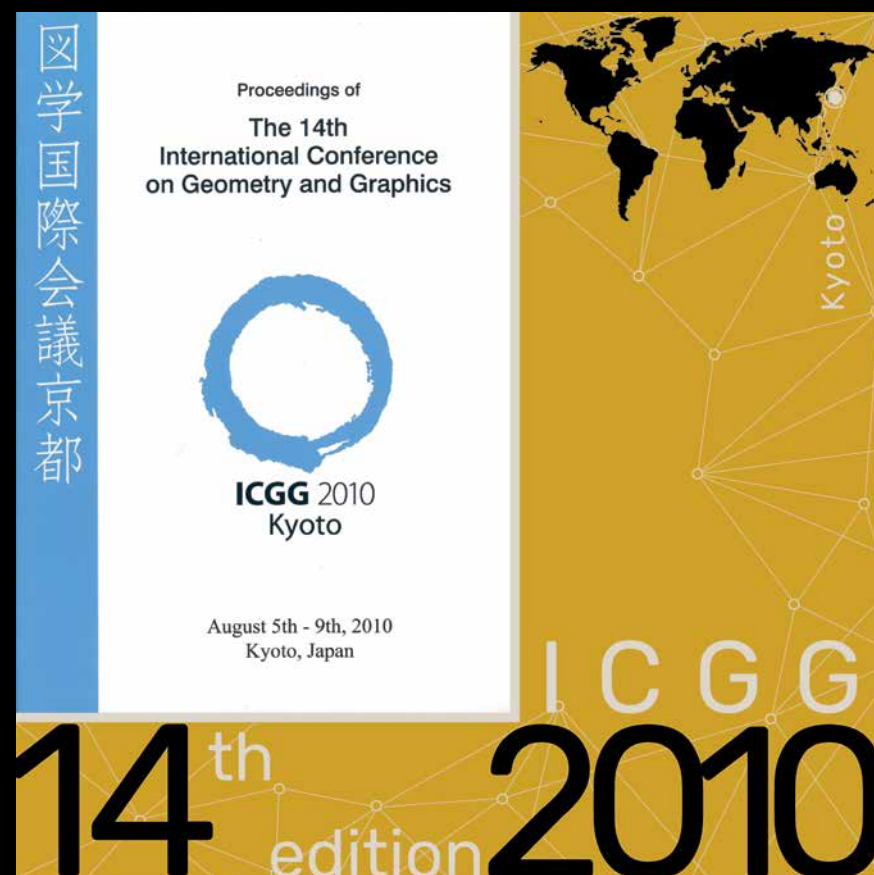
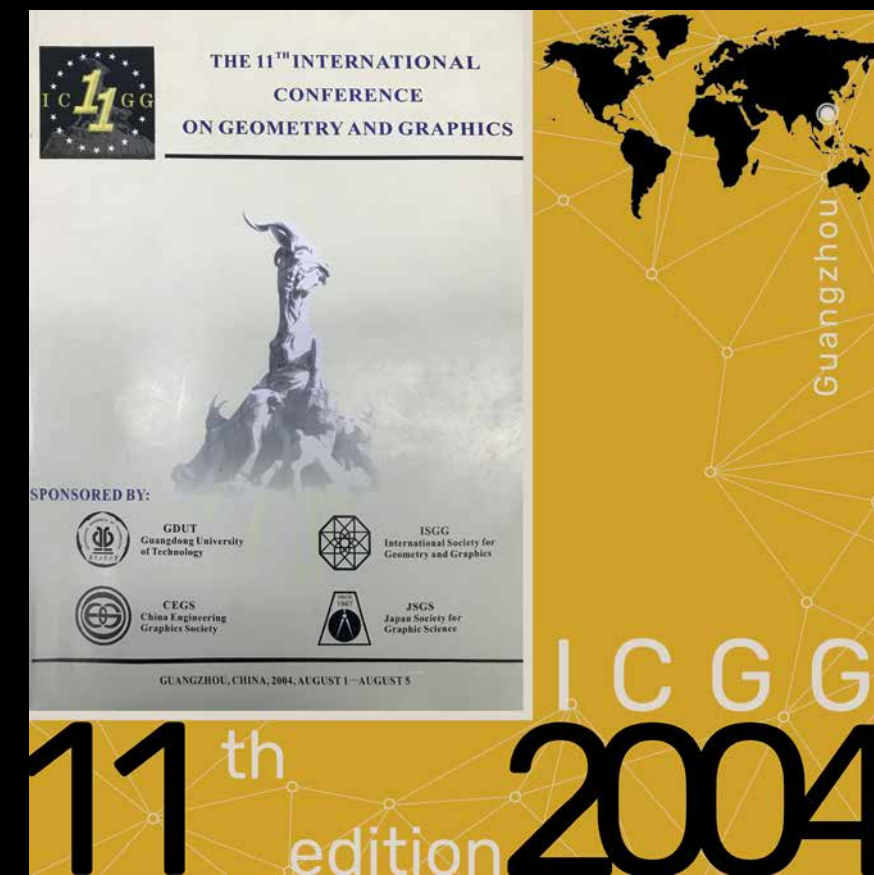
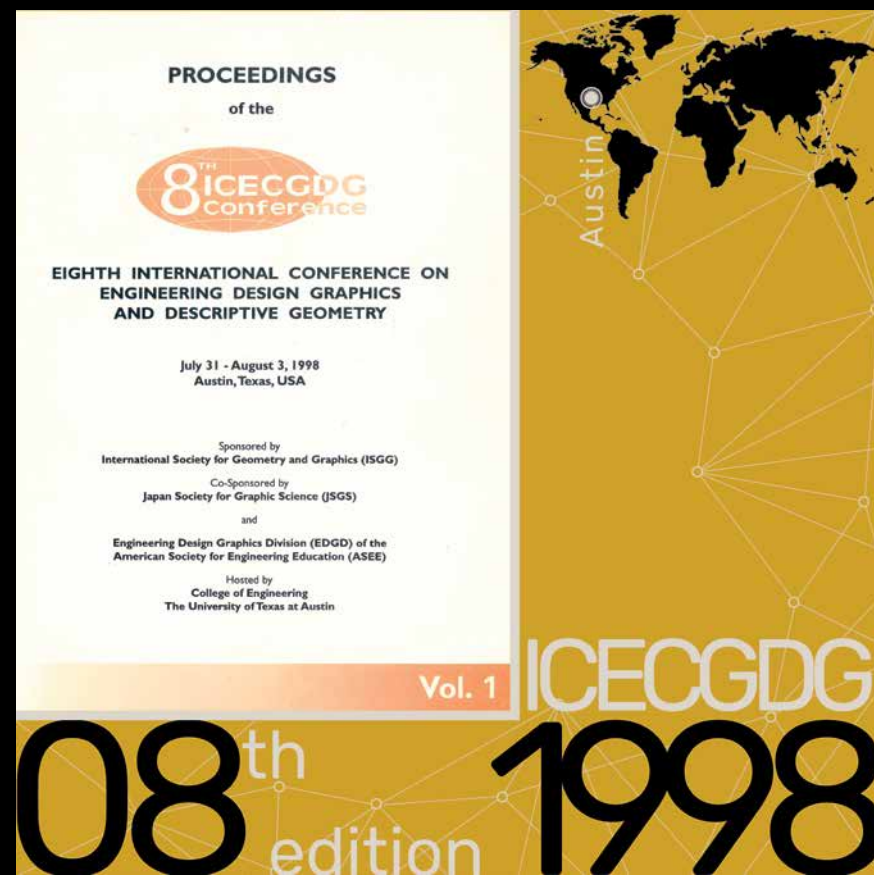
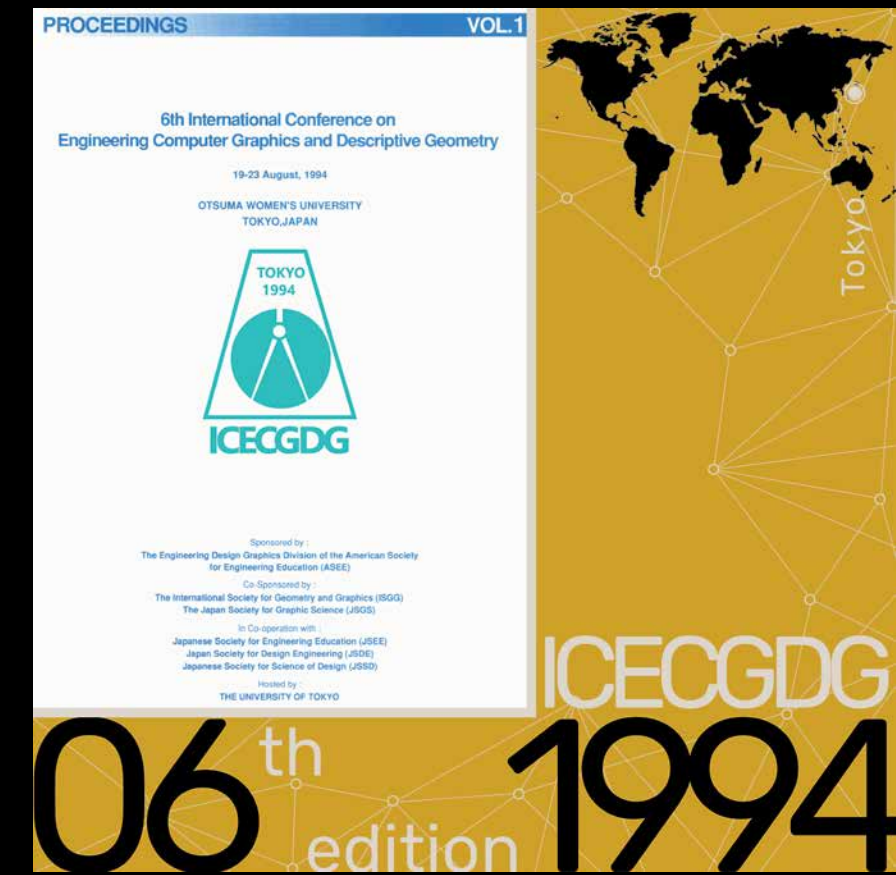
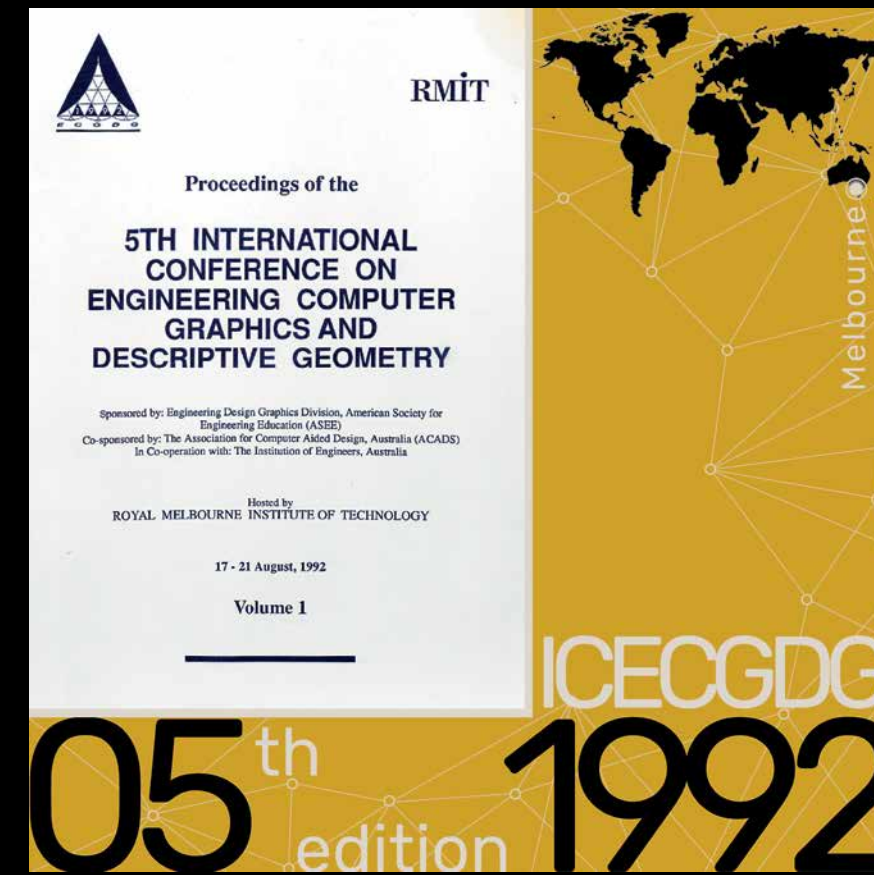
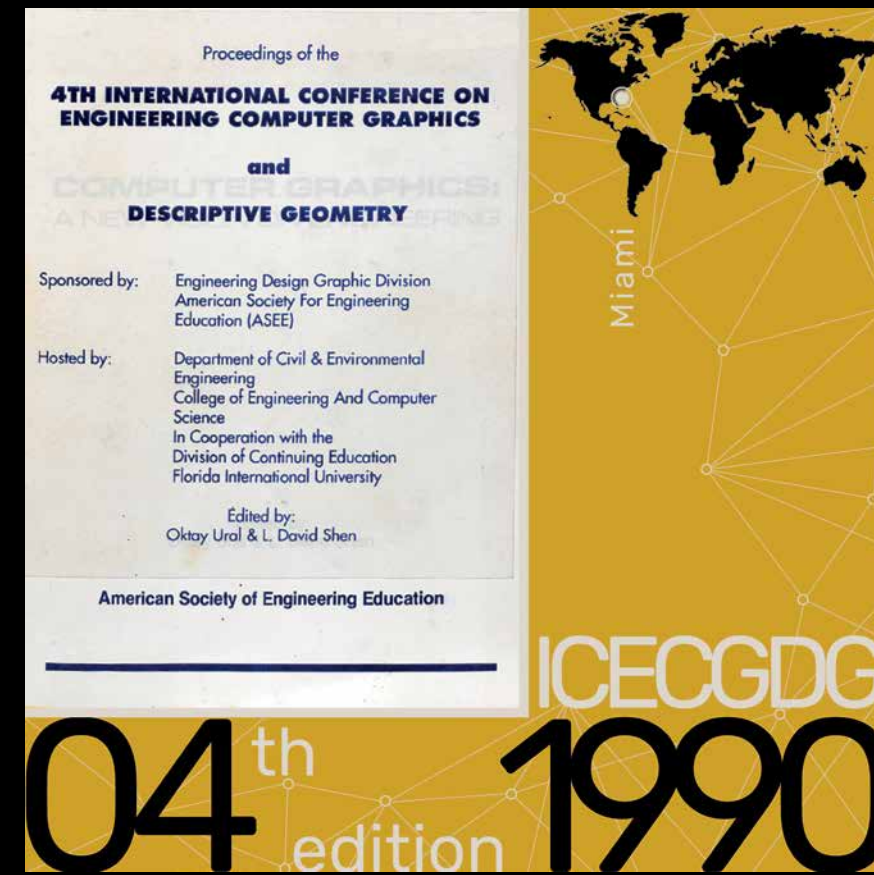
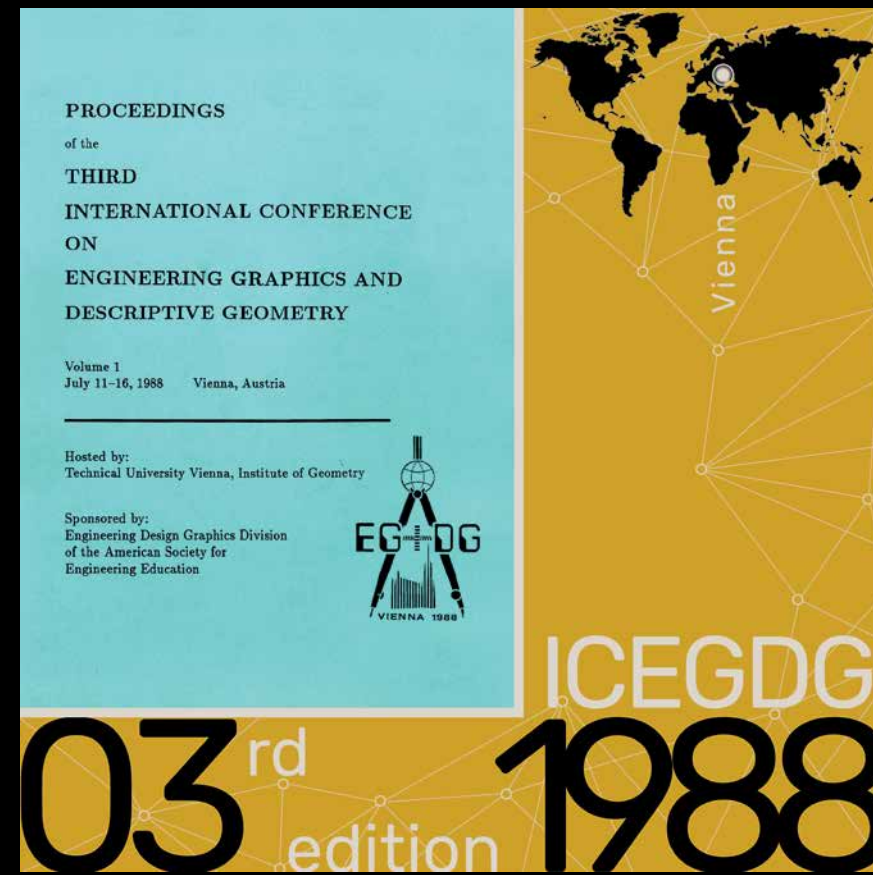


STATISTIC DATA

Authors	Country
4	Argentina
1	Australia
24	Austria
1	Bosnia and Herzegovina
37	Brazil
1	Bulgaria
1	Canada
80	China
1	Colombia
11	Croatia
3	Czechia
1	Egypt
2	Estonia
2	Georgia
18	Germany
1	Greece
12	Hungary
6	Israel
149	Italy
86	Japan
3	Kazakhstan
1	Latvia
10	Lithuania
1	Malta
1	Mauritius
2	Mexico
1	New Zealand
15	Poland
11	Portugal
6	Romania
21	Russia
25	Serbia
2	Slovakia
3	Slovenia
1	South Africa
1	South Korea
4	Spain
1	Thailand
1	Turkey
6	Ukraine
3	United Kingdom
17	United States
2	Uzbekistan
8	Unknown

587 Total











# UP TO NOW...

Advances in Intelligent Systems and Computing 809

Luigi Cocchiarella Editor

ICGG 2018—  
Proceedings of the  
18th International  
Conference on  
Geometry and Graphics  
40th Anniversary—Milan, Italy,  
August 3–7, 2018



Springer

## The 18th International Conference on Geometry and Graphics 3–7 August 2018 40th Anniversary BOOK OF ABSTRACTS

Edited by  
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## FORWARD

The International Conference on Descriptive Geometry provided the opportunity for geometers all over the world to meet, exchange ideas, and discuss new developments and applications of descriptive geometry. Historically, the Conference commemorated the Engineering Design Graphics Division's fiftieth year of providing significant leadership in engineering education. Attendees convened from 11 countries, 6 Canadian provinces and 30 states thus enhancing the international atmosphere. There were a total of 115 registrants and 53 spouses and guests.

The PROCEEDINGS are designed to provide a permanent document of the paper presentations and other events of the Conference. The papers and events are chronologically organized in the PROCEEDINGS in much the same order that they occurred at the Conference. Names and addresses as well as a photograph of each author are given with his paper. In addition, more complete address information is given for all registrants in the Appendix.

The editor is most grateful for the cooperation and assistance of all persons who made the publication of the PROCEEDINGS possible. He is especially indebted to Professors Amogene F. DeVaney, Conference Chairman, Amarillo College and Clarence E. Hall, Program Chairman, Louisiana State University who coordinated the gathering of papers, pre-edited much of the copy, and who gave the editor moral support to see the task through. Dr. William J. VanderWall, Associate Editor, North Carolina State University, deserves special credit for much of the final editing and copy-fitting. The Editor's daughter, Deborah, is also to be commended for the patience and perseverance in typing the final copy for publication. Professor Robert H. Hammond, Director of Freshman Engineering and Student Services, North Carolina State University, deserves a special thanks for allowing the editor time from his other duties to undertake this project.



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## GROUP PHOTO

The photograph below is the same as the one that appears on the cover and shows 68 of the attendees who gathered for a group picture on the steps of the Conference Center. Names and addresses of other registrants are in the Appendix.



ROW ONE (left to right): W. F. Street, Clara Street, Arthur Loeb, Leo Altling, Maynard Roberts, Mary Ann Roberts, Ken Meek, Art Carlson, Klaus Kroner, Gene Pare, William Elwood, Amogene DeVaney

ROW TWO: Hugh R. Gilliland, Larry D. Goss, Harry Osers, Ming H. Land, Robert J. Beil, Wally Reynolds, Ksenija Horvatic, Victor Janze, Kenneth Perry, Jack C. Brown

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ROW FOUR: Claude DeGuise, Jack Rollins, Phil Sell, Warren White

ROW FIVE: Anna Hall, Mary Copeland, Eva Kuhn, Hans Seybold, Tom Foster, Eric Haffner, Lionel March, John Reddaway, Norm Metz, William W. Hunt

ROW SIX: John Biggers, Paul Zsombor-Murray, Robert Christianson, Harold Ekern, Louis Vroomer, Clayton Wrenshall

ROW SEVEN: Fryderyk Gorczyca, Clarence E. Hall, Abe Rotenberg, Eric Chappell, Marc Sauvageau, Neil Harrison, William Harrison, Takashi Nagata, Akira Nannichi, Jay Abramowitz, Robert Kennedy, David Gunderson, David Webb, Fred Almgreen, Frank Croft

## PREFACE



STEVE M. SLABY  
Princeton University  
Princeton, New Jersey



The Proceedings of the First International Conference of Descriptive Geometry represent concrete evidence of the fact that Descriptive Geometry, the "Queen" of the Engineering Disciplines is alive and thriving in the intellectual and applied arenas. The range of papers presented demonstrates the "harmony among disciplines" that is possible and so necessary in the continuing search for truth and for a proper understanding and respect for our physical world. The role of Descriptive Geometry was succinctly expressed by the great mathematician C. F. Gauss in his review of "Geometri Descriptive" by Gaspard Monge in 1813. In writing about the review, Dr. Fritz Hohenberg, the eminent descriptive geometer of the University of Graz in Austria quotes Gauss as follows:

"We must especially praise 'Geometri Descriptive' by G. Monge for its clearness and conciseness, for its well-ordered transition from easy to difficult topics, for its richness of new aspects and developments. So we must recommend

the study of this book as a substantial intellectual nourishment, capable of contributing to enliven and preserve the genuine geometric spirit, a spirit which is missed sometimes in the mathematics of our time. Besides this pure scientific aspect of investigations one has also to take into consideration their use in all human work which is concerned with spatial relations ..."

The intimate relationship between the theory and application of Descriptive Geometry was recognized and appreciated by Gauss. It is a relationship which is natural and mutually supporting and offers a continuing means to extend the frontiers of Descriptive Geometry beyond the Mongean limits.

Many new spatial Worlds exist and await to be discovered and the First International Conference on Descriptive Geometry has given us some glimpses of these new worlds and has demonstrated the continuing vitality of the "genuine geometric spirit."

Professor Slaby received his BSME from Lawrence Institute of Technology and his MA in Economics from Wayne State University. He has done postgraduate work in Multi-dimensional descriptive geometry, has served as a Visiting Scholar in Technology & Society at the University of Michigan and at the University of Stockholm, Sweden. He has written numerous papers and has had a number of books published in the area of Engineering Geometry, Statics, and Strength of Materials. Mr. Slaby is presently Associate Professor and Director of Technology at Princeton University.



# PROCEEDINGS INTERNATIONAL CONFERENCE ON ENGINEERING AND COMPUTER GRAPHICS

Aug. 27—Sept. 1, 1984  
Beijing, China

Co-Editors  
Professor Zhu Yuwan  
Professor Steve M. Slaby



## FOREWORD

The International Conference on Engineering and Computer Graphics is the second International Conference in the area of Engineering Graphic Science — the first being the International Conference on Descriptive Geometry held in Vancouver, Canada in June, 1978 and sponsored by the Engineering Design Graphics Division of the American Society for Engineering Education.

The International Conference on Engineering and Computer Graphics in Beijing, China is co-sponsored by the China Engineering Graphics Society and the Engineering Design Graphics Division of the American Society for Engineering Education. This is a "first" international co-sponsorship of such a Conference and has extremely positive implications for developments in our field of intellectual and practical endeavor.

The basic goals of this Conference are to establish direct and enduring contacts between scholars and experts in the area of Engineering and Computer Graphics, to further promote development in the fields to the mutual advantages of all, to promote international academic exchange and friendship, and to further strengthen academic cooperation among the organizations in this field all over the world.

These proceedings contain 82 papers presented by the authors from 11 countries in the world. The majority of the papers contained in these proceedings deal with computer graphics. In addition, there are a number of papers pertaining to theoretical graphics, applied graphics, graphics development, techniques of drawing as well as graphics education. The papers are compiled in accordance with these group classifications and the sequence of their presentation at the Conference.

The invited lectures to be presented at the plenary sessions by specialists from China, USA, etc., as well as the list of Conference participants and those who pre-registered will be published in a separate booklet as a supplement to these proceedings.

We thank the members of the respective Organizing Committees of the China Engineering Graphics Society and the Engineering Design Graphics Division of the American Society for Engineering Education for their support and cooperation in making preparations for this Conference and the China Association for Science and Technology and all others who made contributions toward this end. We especially want to recognize the participants in the Conference and those who prepared and presented papers. Finally we express our appreciation to all participants and people who made this Conference possible and we look forward to the Third International Conference in our field in the not too distant future.

### Co-Editors

Zhu Yuwan

Steve M. Slaby

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Foreword

It is our honor to write the foreword to the Proceedings of the "Third International Conference on Engineering Graphics and Descriptive Geometry" which is being hosted by the Institute for Geometry of the Technical University of Vienna, Austria. The sponsorship of this conference is shared by the Institutes and Departments of Geometry at the Austrian University in Graz, Innsbruck, Leoben, and Vienna; and the Engineering Design Graphics Division of the American Society for Engineering Education (ASEE).

We thank the members of the Austrian Organizing Committee and the United States Organizing Committee for their support and cooperation in making preparations for this conference.

The First International Conference on Descriptive Geometry which took place in Vancouver, Canada in 1978 was sponsored by the Engineering Design Graphics Division of the American Society for Engineering Education on its 50th Anniversary. The Second International Conference on Engineering and Computer Graphics was held in 1984 in the People's Republic of China and was sponsored by the China Engineering Graphics Society and the Engineering Design Graphics Division of the American Society for Engineering Education. The conferences in Canada and China were extremely successful in bringing together teachers and scholars in descriptive geometry, engineering and computer graphics from various parts of the world to share their knowledge and experiences. The intellectual and social interactions that resulted were outstanding and academic/professional relationships among the participants continued beyond the conferences themselves.

The fact that these International Conferences attract large numbers of outstanding professional educators, scholars, and implementers in and of our discipline indicates that descriptive geometry, and engineering/computergraphics are vital, exciting, intellectually active and productive areas of scholarly research and teaching. The continual development of our discipline to enhance the "visualization" of physical as well as socio-economic phenomena is a testament to its vitality and validity as a scientific discipline.

We look forward to the Vienna Conference to be part of the continuum that is geometry and to a collegiality among the participating geometers and graphicicians which not only promotes the development and new discoveries in our field but also, in its own way, contributes to the promotion of peaceful cooperation and mutual understanding among the diverse peoples on our planet earth.

Prof. Hellmuth Stachel  
Chairman, Austrian Organizing Committee

Prof. Steve M. Slaby  
Chairman, United States of  
America Organizing Committee

This conference is being held as a living memorial to Professor Dr. Fritz Hohenberg, of the University of Graz, Austria. He was a leading Descriptive Geometer of our era and continues to be so through his publications. Prof. Hohenberg was scheduled to appear at this conference to offer some insights into our field as well as to welcome all participants - but fate planned it otherwise. Professor Dr. Fritz Hohenberg died on December 16, 1987. He was 81 years old and was an eminent "elder statesman" of our discipline.

We express our sympathy and condolences to his family, students and colleagues. We are forever indebted to Prof. Hohenberg for his major achievements and contributions to the continuing development of the science of Descriptive Geometry.

Steve M. Slaby

PREFACE

The 6th International Conference on Engineering Computer Graphics and Descriptive Geometry is a continuation of the International Conferences in this series held in Vancouver in 1978, Beijing in 1984, Vienna in 1988, Miami in 1990 and Melbourne in 1992. In a broad sense, this series is the only setting for international exchange of information on the results of both academic and industrial researches which would involve the application of geometry, computational methods in modern technology and education in related fields.

The themes and issues of this 6th International Conference in Tokyo include the following subjects:

1. Theoretical Graphics and Applied Geometry
2. Engineering Computer Graphics
3. Graphics Education

165 contributed papers from 24 different countries are included in the Conference Proceedings. Papers in Category 1, "*Theoretical Graphics and Applied Geometry*", discuss on the development of descriptive geometry, kinematic geometry and computational geometry. Numerous applications of geometry in arts and sciences are also included. Papers in Category 2, "*Engineering Computer Graphics*", discuss innovative use of computational methods and computer-aided design(CAD) not only in mechanical engineering but also architectural or civil engineering. Mathematical theories and their applications to the development of algorithms and software are also presented. Papers in Category 3, "*Graphics Education*", discuss innovative and effective ways to educate Engineering Computer Graphics and Descriptive Geometry. Evaluation and enhancement of students' spatial abilities are also discussed. In addition, four invited papers by renowned authors give keynote addresses on the various themes of the Conference. For the special forum -Modernization of Graphics Education- held during the Conference, a position paper and three papers by eminent graphic educators from various countries are presented. With its diverse coverage of topics, this publication becomes a valuable source of reference in the field of engineering computer graphics and descriptive geometry.

Each of the papers included in the proceedings has been reviewed and accepted for publication by the editors of the proceedings. However, the responsibility for the contents of these papers rests upon the authors and not the organisers of this conference. Data presented and conclusions developed by the authors are for information only and are not intended for use without independent substantiating investigation on the part of the potential user.

Finally the editors would like to express their appreciation and thanks to ASEE Engineering Design Graphics Division members, Japan Society for Graphic Science members, and ISGG Steering Committee members for their continuous effort for the Conference to be held in Tokyo. Sincere thanks are also expressed to the staff at The University of Tokyo and Otsuma Women's University for the preparation of the program and proceedings. The authors should be congratulated for their excellent and scholarly contributions which made this conference possible.

Prof. Kenjiro SUZUKI and Prof. Katsuyuki YOSHIDA, Editors  
1 August 1994



ABSTRACT

Engineering education is becoming more and more computer oriented. It appears that as computer graphics expands in capability and availability, the ties between engineering graphics skills, educational practices, design and manufacturing processes strengthen. As a result, it is becoming a trend to introduce engineering students to some Computer Aided Design and Drafting (CADD) packages, such as AutoCAD, DigicAD, CADKEY, OrCAD, etc. Many innovative uses of engineering computer graphics are discussed and various computer graphics hardware/software systems are presented in the Proceedings. In addition, different strategies to improve the visualization ability of engineering students are also discussed. With its diverse coverage on theoretical graphics, engineering computer graphics, graphics teaching and other application of descriptive geometry, this volume becomes a valuable source of reference in the field of engineering design graphics.

KEYWORDS

1. Theoretical Graphics
2. Engineering Computer Graphics
3. Graphics Teaching
4. Descriptive Geometry
5. Visualization
6. Computer Aided Design (CAD)
7. Surface Modeling
8. Computer Animation
9. Computer Software
10. Computer Application
11. Spatial Ability
12. Curriculum
13. Visual-Perception
14. Engineering Education
15. Engineering Graphics

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PREFACE

The Fourth International Conference on Engineering Computer Graphics and Descriptive Geometry is a continuation of the International Conferences on Engineering Computer Graphics and Descriptive Geometry held in Vancouver in 1978, in Beijing in 1984, and in Vienna in 1988.

The themes and issues of the Fourth International Conference on Engineering Computer Graphics and Descriptive Geometry include the following subjects:

1. Theoretical Graphics
2. Engineering Computer Graphics
3. Graphics Teaching
4. Other Applications of Geometry

Ninety two papers from 20 different countries are included in the Conference Proceedings which discusses new and innovative ways to teach theoretical graphics. Innovative use of Computer Aided Design (CAD) in engineering graphics is also discussed. Graphics teaching and numerous other applications of descriptive geometry are also presented. Each of the papers included in the proceedings has received two positive peer reviews and has been accepted for publication by the editors of the proceedings.

Finally, the editors would like to express their appreciation to Professors Steve Slaby, Merwin Weed, Luis Prieto-Portar, and ASEE Engineering Design Graphics Division members; FIU secretaries, Lillian Stein, Rebeca Ramos, Nestor Gomez, and Nancy Spenst for their continuous support for the preparation of the program and proceedings. The authors should be congratulated for their excellent and scholarly contributions which made this conference possible.

Oktaý Ural  
L. David Shen  
March 22, 1990



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PREFACE

The 5th International Conference on Engineering Computer Graphics and Descriptive Geometry is a continuation of the International Conferences in this series held in Vancouver in 1978, Beijing in 1984, Vienna in 1988 and Miami, USA in 1990. The themes and issues of this 5th International Conference on Engineering Computer Graphics and Descriptive Geometry include the following subjects:

1. Theoretical Graphics and Applied Geometry
2. Engineering Computer Graphics and Computer Aided Design
3. Scientific and Technical Visualisation
4. Graphics Teaching
5. Manufacturing and Other Applications

114 papers from 20 different countries are included in the Conference Proceedings which discuss new and innovative ways to teach Engineering / Computer Graphics and Descriptive Geometry. Innovative use of computational methods and computer-aided design (CAD) in Engineering is also discussed. The inclusion of a separate category of papers on the area of "Visualization" of physical phenomena would be of interest to teachers and researchers on computer-aided engineering. Papers on theoretical graphics discuss the mathematical theories and their applications to the development of algorithms and software for computer-aided design and manufacturing (CAD / CAM). Numerous applications of kinematic geometry and descriptive geometry are also presented. With its diverse coverage of topics on geometry and computer graphics, this publication becomes a valuable source of reference in the field of engineering design, graphics and manufacturing.

Each of the papers included in the proceedings has been reviewed and accepted for publication by the editors of the proceedings. However, the responsibility for the contents of these papers rests upon the authors and not the organisers of this conference. Data presented and conclusions developed by the authors are for information only and are not intended for use without independent substantiating investigation on the part of the potential user.

Finally the editors would like to express their appreciation and thanks to Prof. Steve Slaby of Princeton University, Mr Martin Jones of ACADS, Dr John Browne of Swinbourne Institute of Technology for their assistance and the Faculty of Engineering staff at RMIT, Jillian Wyatt and Linda Code for their continuous support for the preparation of the programme. It has been a pleasure to be associated with the Institution of Engineers, Australia and their assistance is gratefully acknowledged. Sincere thanks are also expressed to the staff at RMIT Communication Services Unit for the production of the proceedings. The authors should be congratulated for their excellent and scholarly contributions which made this conference possible.

V.O. Thomas and W.P. Lewis, Editors  
15 June 1992

MESSAGE FROM THE CHAIRMEN

Welcome to the 5th International Conference on Engineering Computer Graphics and Descriptive Geometry.

Since their inception in 1978, the ECGDG conferences have been successful in bringing together many scholars and educators in Geometry, Engineering and Computer Graphics from various parts of the world with the aim of sharing their knowledge and experiences. The intellectual and social interactions that resulted were outstanding and the academic/professional relationships among the participants continued beyond the conferences themselves.

Engineering Education is becoming more and more computer oriented. Educational institutions in general, and engineering departments in particular, should be prepared to respond to the normal processes of technological change and the demands of industry. This technological change in terms of computers has markedly affected engineering design and manufacturing. The processes involved in the design and manufacturing of components and systems can be visualised and produced on a computer screen using the mathematical and geometrical relationships. Engineering students are now expected to have some understanding of computer aided design and drafting and computer aided manufacturing methods (CAD / CAM). As a result it is becoming a trend to introduce engineering students to some computer aided design and drafting packages and visualization techniques. The 5th International Conference on Engineering Computer Graphics and Descriptive Geometry in Melbourne, Australia, 17-21 August 1992 addresses these and other related issues of engineering education and technological research. Many innovative uses of engineering computer graphics and descriptive geometry are described and various computer graphics hardware/software systems are presented in the proceedings.

We hope that the 5th International Conference in Melbourne, Australia will provide a valuable forum for the discussion of both academic and industrial research which would involve the application of geometry and computational methods to modern technology.

We would like to express our thanks to the Australian and Western Hemisphere Organising Committees for their support and co-operation in making the preparation for this conference, and thank the authors and delegates for their efforts in making the conference a success.

Professor William Carroll  
Chairman,  
Australian Organising Committee  
Dean, Faculty of Engineering  
Royal Melbourne Institute of Technology  
Melbourne, Australia

Professor Larry D Goss  
Chairman,  
Western Hemisphere Organising Committee  
University of Southern Indiana  
Evansville, Indiana, USA



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## MESSAGE FROM THE CHAIRMEN

It is a great pleasure for us to extend our warmest welcome to the participants of the "Sixth International Conference on Engineering Computer Graphics and Descriptive Geometry" which is being hosted by the College of Arts and Sciences of the University of Tokyo, Japan. The sponsorship of this conference is shared by the Japan Society for Graphic Science(JS GS), the Engineering Design Graphics Division of the American Society for Engineering Education(ASEE) and the International Society for Geometry and Graphics(ISGG).

Since the First International Conference on Descriptive Geometry in Vancouver 1978, this series of international conferences has been extremely successful in bringing together many scholars and educators in geometry, engineering and computer graphics from various parts of the world with the aim of exchanging and sharing their knowledge and experiences. It has played an essential role in activating the intellectual and social interactions as well as the academic and professional relationships among the participants.

Graphic representation, such as drawings, diagrams, figures, illustrations or pictures, be they still or animated, serves as the most fundamental and easiest way of cognition for human beings, and it is the most important means of communication of geometric information. The importance of graphic representation and visualization will be even greater in the highly computerized multimedia era. Science and technology of geometry and graphics are, therefore, vital, exciting, intellectually stimulating and productive areas for scholarly research and teaching. Reflecting such a situation, a variety of research works are being conducted all over the world not only on the long-established manual methods of Descriptive Geometry and Engineering Drawing but also on the newly developed and rapidly expanding methods of Computer Graphics and Computer Aided Design, or even on Computer Assisted Instruction and Computer Assisted Learning in geometry and graphics. Quite a number of new and innovative proposals and trials have been conducted on the teaching methods and programs of graphic courses where educationally essential parts of DG/ED, CG/CAD and CAI/CAL are integrated in order to gain a synergistic effect.

The Sixth International Conference on Engineering Computer Graphics and Descriptive Geometry in Tokyo 1994 addresses these and other related issues of graphic education and scientific/technological research. Many innovative uses of DG and CG are described and various CG/CAD/CAI systems are presented in the proceedings. We hope that the Tokyo Conference will provide a valuable forum for the discussion of science, technology and education on geometry and graphics.

We would like to express our gratitude to the Japan and Western Hemisphere Organizing Committees and the Japan Executive Committee for their support and cooperation in making the preparations for this conference, and to the authors and delegates for their efforts in making the conference a success.

Professor Saburo Nagano  
Chairman  
Japan Organizing Committee  
College of Arts and Sciences  
University of Tokyo  
Meguro, Tokyo 153, Japan

Professor Ronald D. Jenison  
Chairman  
Western Hemisphere Organizing Committee  
Division of Engineering Fundamentals  
Iowa State University  
Ames, IA 50011-2150, USA





## Notes on The 7th International Conference on Engineering Computer Graphics and Descriptive Geometry Organisers



### ANDRZEJ WYŻYKOWSKI

Chairman, D.Sc., Ph.D, Architect is an Associate Professor of the Cracow University of Technology, head of the Division of Urban Renewal and Development. Large teaching and professional experience, including: Visiting Professor at the University of Tennessee, California State Polytechnic University, Iowa State University; Guest Lecturer in Copenhagen, Aarhus, Berlin, Athens, London; Scholarship Holder of Greece and Norwegian Government, also Senior Designer in Kuwait. He is a winner of 24 architectural and town planning competitions, designer of numerous apartment blocks and individual houses. Main interest: planning and designing of residential areas, urban renewal, revitalization and development. Author and co-author of many articles and papers published in various professional magazines. Member of Polish Architects Association, Polish Town Planner Society, Salzburg Congress on Urban Planning and Development.



### MARIAN PALEJ

Vice-Chairman, Chairman of The Polish Scientific Committee. Full Professor at The Silesian University of Gliwice, organizer and long-time director of The Descriptive Geometry Institute of Gliwice and president of The Polish Society for Geometry and Engineering Graphics:  
*„we must work more swiftly and more efficiently to prepare young men for the world of complicated technology, in order to understand technical language - the language, the basis of which is the domain of engineering geometry and graphics. The 7th Conference can and ought to help in the realisation of this challenge”.*



### LIDIA ŻAKOWSKA

Vice-Chairman, Programme Coordinator. Ph.D. in 1994, graduated from the Civil Engineering, Road Design at the Cracow University of Technology, and works at the Division of Descriptive Geometry and Engineering Graphics of the Department of Architecture. Her main research and scientific interests are employing methods of geometry in engineering practice (especially in highway design), visual road design, drivers' perception, road view and environmental studies, road safety and aesthetics. She is the author of 27 scientific publications and two research GRANT projects and is a member of Polish Society for Geometry and Engineering Graphics PTGiG, International Society for Geometry and Graphics ISGG Board Member and Transport Psychology Research Group, International Association for Applied Psychology in Traffic IAAP.

### TADEUSZ DYDUCH

Vice-Chairman, Head of the Organising Office. Ph.D. in 1981 at the Faculty of Automatics of the St. Staszic Technical University of Cracow. He is an author or co-author of 28 published scientific papers. Combines disciplines of geometry, where he has over 20 years of teaching experience with his origin education - computer science. The main areas of his scientific research are image processing and artificial intelligence methods - namely neural network theory.



### RENATA GÓRSKA

Secretary of the Organising Office. Ph.D. in 1990, graduated from the Civil Engineering Faculty, Theory of Constructions, Cracow University of Technology, works at the Division of Descriptive Geometry and Engineering Graphics of the Department of Architecture. Scientific research areas: descriptive geometry and its applications into the civil engineering constructions, computer aided design and modelling. Member of the board of Polish Society for Geometry and Engineering Graphics. She specialises in CAD methods' application in designing work and works on the development of new didactics curriculae. She leads research works on spatial abilities recognition and measurement in international co-operation.



### LESZEK PIEKARSKI

Secretary Assistant of the Organising Office. M.Sc. in 1989, graduated from Pedagogical University of Cracow, and works at the Division of Descriptive Geometry and Engineering Graphics. His scientific research areas are: synthetic and descriptive geometry, computer graphics, applications in design, modelling and visualisation. He is a student at the Academy of Mining and Metallurgy, Cracow Institute of Automatics. He is involved in the frame of research programme on the computer simulation of discrete deterministic processes



## Letter from the Conference Chairman

This is my personal welcome to those, who have decided to attend 7th ICECGDG, and participate in that great scientific event.

I feel very honored and happy to welcome you here in Cracow, former capital of Poland, where newly born democracy is responsible for enormous changes, including the impact of computerization and access to information. As the scope of conference is to provide a forum for the discussion of both academic and industrial research, I am sure that the place of the conference has been well chosen, offering you a unique ambiance and atmosphere of and old medieval city in conjunction with polish hospitality.

Even though the conference is oriented toward strictly professional exchange of ideas in the field of Engineering Computer Graphics and Descriptive Geometry - it is my intention to include in our discussion a wide range of different disciplines. Let us discover new possibilities and advantages which that scope of interest might offer to other professions. I do also expect, that the conference will proof, that its main concerns reflect not only an advanced technology, but an art, which enriches our civilization and culture.

Welcome you in Cracow

Andrzej Wyżykowski





## MESSAGE FROM THE HONORARY CONFERENCE CHAIRMAN



I am happy and honored to present greetings to you on the occasion of 8th International Conference of Engineering Computer Graphics and Descriptive Geometry sponsored by the International Society for Geometry and Graphics, the Japan Society for Graphic Science, and the Engineering Design Graphics Division of the American Society for Engineering Education. The conference is hosted by our good colleagues at the University of Texas at Austin.

This conference is very special since it marks the 20th anniversary since the first International Conference on Descriptive Geometry which took place in 1978 at the University of British Columbia in Vancouver, Canada.

Since then our subsequent conference sites have spanned a large section of the earth including the South China Institute of Technology in Beijing, China, in 1984; the Technical University of Vienna - Institute for Geometry in Vienna, Austria, in 1988; the Florida International University in Miami, Florida, USA, in 1990; the Royal Melbourne Institute of Technology in Melbourne, Australia, in 1992; the University of Tokyo in Tokyo, Japan, in 1994; the Cracow University of Technology in Cracow, Poland, in 1996 and today the University of Texas at Austin, Texas, USA. We are truly extending our global reach and hopefully having a positive influence on our field and our human relations.

I wish to you all, as key participants in this conference, very successful intellectual and collegial experiences.

Professor Emeritus Steve M. Slaby  
Princeton University  
Honorary Conference Chairman

## MESSAGE FROM THE PRESIDENT, INTERNATIONAL SOCIETY FOR GEOMETRY AND GRAPHICS



It is a great pleasure for me to extend my warmest welcome to the participants of the "Eighth International Conference on Engineering Computer Graphics and Descriptive Geometry". Its main sponsor, the International Society for Geometry and Graphics, was established to "...foster international collaboration and stimulate scientific research and teaching methodology in the fields of geometry and computer graphics." This series of conferences represents the main instrument used to accomplish that objective.

A graphic expression, such as drawings, either still or animated, serves as the most fundamental and easiest means in cognition of human beings. The importance of graphic representation and visualization is even greater in the current, highly computerized multimedia era. Since geometry is the basis of scientific aspects of graphics, the areas of both geometry and graphics are vital, exciting, intellectually stimulating, and productive for scholarly research and teaching. As a result, a variety of research work is being conducted involving the long-established, traditional methods as well as rapidly expanding methods based on Computer Graphics.

I trust that the Austin Conference will provide a valuable forum for the discussion on science, technology and education aspects of geometry and graphics. I also hope that the Conference will contribute to the promotion of peaceful cooperation and mutual understanding among diverse peoples.

I would like to express my gratitude to the Local Organizing Committee and to Professor D. Juricic for their efforts in organizing this conference, as well as to the authors and conference delegates for their scholarly contributions and productive participation in the work of the conference.

Professor Kenjiro Suzuki  
The University of Tokyo  
President, International Society for Geometry and Graphics

## PREFACE

These proceedings have been assembled from camera-ready copies of papers submitted by the authors. No attempt was made to edit the papers except that some pages had to be reduced in size to fit the available page space.

There are more than 150 papers prepared by authors from 30 countries. The papers are assembled in three volumes. All papers with registered speakers submitted by the printer's deadline have been assembled in Volumes 1 and 2. Volume 1 contains papers to be presented on Friday and Saturday morning; Volume 2 contains papers to be presented on Saturday afternoon and Monday morning. Volume 3 – to be printed and distributed after the conference – will contain all other papers that will be presented at the conference.

Each volume has three parts titled: (1) Theoretical Graphics and Applied Geometry, (2) Engineering Computer Graphics, and (3) Graphics Education. Inside each part, the papers are arranged in order of presentation. The plenary-session papers are given at the beginning of Volume 1.

All papers included in these proceedings have been reviewed by the International Program Committee for their content and the Local Program Committee for their format. The opinions expressed by the authors in their papers are not necessarily the opinions of the conference organizers or the International Society for Geometry and Graphics.

Many persons deserve credit for organizing the conference and recording its work in the conference proceedings. However, the most deserving are the authors that contributed their research papers and made this conference a success.

Professor Davor Juricic  
The University of Texas at Austin  
For Local Program Committee



## MESSAGE FROM THE HONORARY CONFERENCE CHAIRMAN



It is indeed a great honor and pleasure to greet members, colleagues and friends of the International Society for Geometry and Graphics at our 9<sup>th</sup> International Conference here at RAND AFRIKAANS UNIVERSITY in Johannesburg, Republic of South Africa.

Our meeting here in the year 2000, the new millennium, is a testament to the fact that geometry and graphics is alive and continuing its onward development at the theoretical, application and educational levels. These areas of research and teaching continue to make their positive impact on science and technology.

I convey my appreciation and thanks to Mr. Johann Pretorius and his colleagues for all the hard work they have dedicated to the preparation of this Conference. We owe all of them a great deal of thanks for their contribution in furthering the integrated fields of Geometry and Graphics.

LONG LIVE GEOMETRY AND GRAPHICS

Professor Emeritus Steve M. Slaby  
Princeton University  
Honorary Conference Chairman

## MESSAGE FROM THE PRESIDENT, INTERNATIONAL SOCIETY FOR GEOMETRY AND GRAPHICS



It is a great pleasure for me to extend my warmest welcome to the participants of the Ninth International Conference on Geometry and Graphics. Its main sponsor, the International Society for Geometry and Graphics, has been established to "... foster international collaboration and stimulate scientific research and teaching methodology in the fields of geometry and graphics". This series of conferences represent the main instrument used to accomplish that objective.

A graphic expression, either line drawings or photo-realistic computer graphics, either still or animated, serve as the most fundamental and easiest means in cognition of human beings. The importance of graphic representation and visualization is even greater in the current, highly computerized multimedia era. Since geometry is the basis of scientific aspects of graphics, the areas of both geometry and graphics are vital, exciting, intellectually stimulating, and productive for scholarly research and teaching. As a result, a variety of research work is being conducted involving the long-established, traditional methods as well as rapidly expanding method bases on computer graphics.

I trust that the Johannesburg Conference will provide a valuable forum for the discussion on science, technology and education aspects of geometry and graphics. I also hope that the Conference will contribute to the promotion of peaceful cooperation and mutual understanding among diverse peoples from all over the world.

Finally, I would like to express my gratitude to the Local Organizing Committee and to Mr. Johann Pretorius for their efforts in organizing this conference, as well as to the authors and conference delegates for their scholarly contributions and productive participation in the work of the Conference.

Professor Kenjiro Suzuki  
The University of Tokyo  
President, International Society for Geometry and Graphics

## PREFACE

The papers contained in this volume represent the Proceedings of the Ninth International Conference for Geometry and Graphics. This series of conferences provides a forum for the discussion of both academic and industrial research that involves the application of theoretical, constructive and computational geometry and extends to educational issues in the related fields.

These proceedings include papers by various researchers in the fields of geometry and graphics and aim to afford both the layman and the specialist alike the opportunity to get acquainted with some of the latest developments. There are more than 80 papers prepared by authors from 35 countries. These papers are assembled in two volumes. All papers with registered speakers submitted by the printers' deadline have been assembled in Volume 1. Volume two will be printed and distributed after the conference, containing all other papers that will be presented at the conference.

Each volume has four parts titled: (1) Theoretical Graphics and Applied Geometry, (2) Engineering Computer Graphics, (3) Graphics Education and (4) Other Topics of Interest. Papers are arranged in alphabetical order within each section. The plenary session papers are given at the beginning of Volume 1.

The editor extends his sincere thanks to all the authors of papers who have contributed to the success of this conference by keeping to the various deadlines and who have done a great job in sharing their knowledge. A special word of thanks goes to all the sponsoring organisations whose contributions made this conference possible.

A final word of appreciation goes to the students and staff of the faculty of Engineering at the Rand Afrikaans University who helped in the organising of the conference and the preparation of this publication.

Johann Pretorius  
Editor



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**International Society for Geometry and Graphics (ISGG)  
Ukrainian Association of Applied Geometry (UAAG)**

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**Address from  
International Society for Geometry and Graphics (ISGG)  
President  
Prof. Gunter Weiss**



It is a well established tradition that the International Society for Geometry and Graphics ISGG biannually holds an International Conference on Geometry and Graphics and that the president of that Society expresses a warm welcome to all the participants of these conferences.

In spite of modern media including increased possibilities to communicate and to contact each other and to present one's own ideas and scientific results on web pages, personal meetings will remain crucial. Watching and listening to a researchers presentation and to take part in discussions are still an effective and important way to gain and spread knowledge, ideas and discoveries. Herein lies the importance of conferences and they will never come to be superfluous.

The increasing needs of visualisation make scientists and technicians to customers and users of geometrical knowledge and graphics tools. And these users also stimulate those who are involved in graphics and geometry education to improve these tools as well as the methods and the methodology of their use. Image processing in modern medicine and biology is an example for such an interaction: multidimensional data based on physics and chemistry of the matter via mathematics are turned into images from which one finally can extract multidimensional information again.

Obviously we all have to react to the needs of the not only scientific public, and to adapt our valuable knowledge that has grown over hundreds of years to those needs and stimuli. This, however, requires flexibility and firmness in our own broad knowledge of geometry and that we reflect the methodology in teaching geometry, too.

So one goal of our conference will be, by each of its sections, to contribute to our own further training in the three essential columns of geometry and graphics: "Pure Geometry", "Applied Geometry" and "Geometry and Graphics Education".

The Local Organising Committee have been doing its best to provide a pleasant milieu for a successful meeting and I express me warmest gratitude especially to Professor Dr. Vsevolod Michailenko and Dr. Vitaly Plosky for their efforts in organising this conference. All the participants of this conference will contribute to make the 10<sup>th</sup> International Conference on Geometry and Graphics a successful one. I hope that you will keep this conference in mind as a very fruitful one in promoting scientific exchange but also peaceful co-operation and friendship.

**Address from  
Ukrainian Association for Applied Geometry (UAAG)  
Chairman of the ICGG-2002, President of the UAAG  
Prof. Vsevolod Ye. Mykhailenko**



Dear colleagues!

Speaking on the behalf of Ukrainian National Committee of the 10th International ISGG Conference, I would like to heartily congratulate all the members and to express my hope that here in Kiev you will gain a valuable experience and obtain good memories not only from the Conference itself, but also from the hospitality of Ukrainian people.

Every branch of science, including geometry, has no limits in its evolution. The development of applied geometry in Ukraine already has its history. The foundation of Ukrainian geometry school belongs to a famous scientist, Doctor of Science, Professor Kolotov S.M. (1880-1965), who originated the method of auxiliary projection – right- and oblique-angled. Professor Kolotov S.M. trained 22 candidates of science, which at those times was considered to be a record number of trainees. He was also the first editor of interdepartmental scientific manual "Applied geometry and engineering graphics." In those years the 71<sup>st</sup> issue of this manual was published, containing more than 3000 scientific articles; the 70<sup>th</sup> issue was published in English.

It is a great success that of all 15 former USSR republics namely Ukraine is chosen to be the country where the 10th ISGG Conference will be held. We hope that this choice was not accidental. During the past 40 years more than 400 Candidates and 40 Doctors of Science were trained in Ukraine. In addition to the school of science in Kiev, the schools in Melitopol, Odessa, Kharkov and Donetsk also work successfully and produce good results.

In 1999 a Ukrainian Association of Applied Geometry was founded in Kiev, including a number of regional subdivisions. The Association aims at developing of scientific researches and their popularization, providing production with the necessary information, establishing of international relations, personnel trainings and so on.

At the present time three Councils of Support in Thesis Writing are functioning in Ukraine – one in Kiev and two Ph.D. in Donetsk and Melitopol. Four years ago the Council in Kiev has accepted the second scientific specialization – Technical Aesthetics (Industrial Arts) – which is, namely, the basics of design. Now in Ukraine four interdepartmental scientific manuals are published, including a manual on "Industrial Arts and Design" issued in Kiev. Now many efforts are dedicated to compiling of new textbooks and manuals on descriptive and calculus geometry, engineering and computer graphics; every year scientific and applied conferences are held.

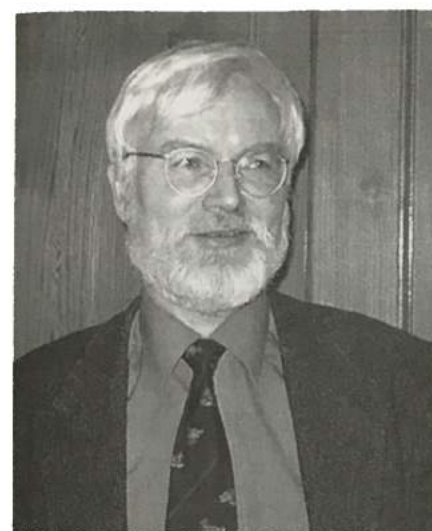
Wishing you all the best and staying with respect.

Welcome to Kyiv!



The 11<sup>th</sup> International Conference on Geometry and Graphics, 1-5 August, 2004, Guangzhou, China

**Message from the President of the  
International Society for Geometry and Graphics (ISGG)  
Prof. Gunter Weiss**



Dear organisers and participants of this 11<sup>th</sup> ICGG 2004,

We are grateful for again having the opportunity to meet in a conference of our society, the ISGG. Again people, who have Geometry and Graphics as their common interest and lifestyle, come together to renew contacts and friendship. Once again we can exchange our teaching experiences and scientific results, are stimulated to new research. Again we will talk about our victories and defeats in keeping up a modernised Geometry and Graphics education for engineers, mathematicians and for informatics as well.

On behalf of the local organisers and the international steering committee of this conference I want to express a warm welcome to you all. But a special welcome should be given to those who join us for the first time. Be sure, in short time you will be totally integrated in our group and you will feel yourself an old member of our society.

Of course we have faced some difficulties and we had to manage them, before we could show up here: We were perhaps scared of SARS, birds pneumonia and influenza; and yes, we did not get enough support from our Universities or no funding at all for this meeting. Yes, bad economy in our home countries forces to reorganise education on all levels and therewith affects university structures. Everybody has to struggle for the survival of his own job and there is little energy and time left for successful research and for writing papers in that situation.

And of course, under all these circumstances it is hard to keep deadlines, to say "yes" to inconveniences following with a conference, but much more difficult is it to say "yes" to such an extra job as organising a conference!

We do recognise these facts and we are grateful. We are very grateful to the local organising team who could summon up so much enthusiasm and idealism for this ICGG 2004. But we are also grateful to each of you, the delegates, who with your contributions and your personality help to make this conference to a successful one.

A little word to "success", a concept usually remaining undefined and up to private imagination. But a simple and even democratic definition would read as follows: "A conference is successful, if and only if the majority of participants, i.e. more than 50%, with good conscious can say, it was worth the money and the stress." I am convinced that for our 11<sup>th</sup> ICGG 2004 the rate of content participants will not be just 50%, our score will be 100%!

The 11<sup>th</sup> International Conference on Geometry and Graphics, 1-5 August, 2004, Guangzhou, China

**Address from the President of  
Guangdong University of Technology (GDUT)  
Prof. Zhang Xiangwei**

On behalf of Guangdong University of Technology, one of the sponsors of the conference, and myself, I'd like to express my warm welcome to the opening of the 2004 International Conference on Geometry and Graphics here in Guangzhou. And I sincerely hope this conference will achieve a great success and experts from all over the world enjoy your stay here in Guangzhou.

Guangdong University of Technology is situated in Guangzhou, a famous and dynamic city in South China. It is a key provincial university with a history of nearly 50 years. The university covers a whole range of disciplines in engineering, science and technology, management, liberal arts and law, offering doctoral, master's and undergraduate programs to students. It is presently made up of 16 colleges with a faculty of over 1000. Among them over 110 are professors and over 350 associate professors. The 2004 total enrollment is over 30,000, including foreign students.

Guangdong University of Technology focuses on teaching and research as its two centers of thrust for further development. It has gained a fine reputation for the quality of its work across the range of teaching, research and development. It has also established academic exchanges and cooperation with over 30 universities in the world. In terms of the comprehensive strength, the university now ranks among China's 100 top universities.

Graphics is the fundamental science to learn about the world, its development exerting great impetus on human civilization. As a university with emphasis on the study of engineering, Guangdong University of Technology attaches great importance to graphics. It not only offers this course to the majority of the students but has also established such specialties as Industrial Design and Digital Media based on graphics. In recent years, the university has made great achievements in graphics both in innovative teaching programs and in scientific research, which exerts considerable influence on the field of graphics in China.

The 2004 International Conference on Geometry and Graphics held in Guangzhou will definitely promote the development of graphic teaching and research in our university. New ideas and accomplishments of all the scholars from all over the world will surely spur our staff's imagination, improve our scientific research and make an impact on our relevant academic institutes.

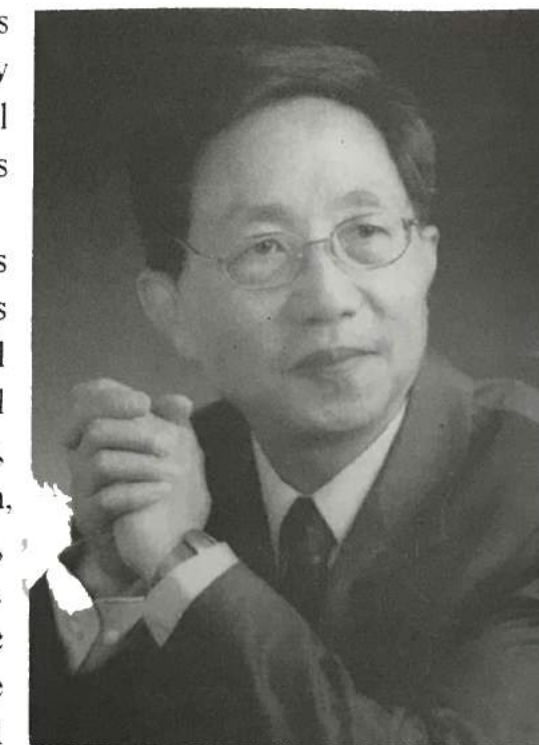
We welcome experts in graphics to visit our university and further strengthen the exchanges and cooperation between us. Once again, I sincerely wish this conference a great success. Be welcome!

The 11<sup>th</sup> International Conference on Geometry and Graphics, 1-5 August, 2004, Guangzhou, China

**Address from the Chairman of the  
China Engineering Graphics Society (CEGS)  
Prof. Sun Jianguang**

On behalf of China Engineering Graphics Society (CEGS), I would express my warmly welcome to all participants of 11<sup>th</sup> International Conference on Geometry and Graphics which is held in China.

Founding in 1980, China Engineering Graphics Society is the home of graphics' scholars and experts in China. The society is composed of several branches and committees, such as theoretical graphics, application graphics, computer graphics, and computer aided design, graphics standardization, graphics education, product information modeling, digital media technology, industry design and so on. The society organizes the national academic activities, holds conferences, and directs the members of the society in their professional development.



We are also interested in international academic activities. The society had hosted the second International Conference on Engineering Computer Graphics and Descriptive Geometry in Beijing. As the initiating members of this series conferences, China Engineering Graphics Society would like pay more effort to the international academic activities, meeting our colleagues, discussing the urgent issues on the discipline of graphics and exchanging the academic thought and viewpoint.

In recent years, we are working in the fields of theory and application of graphics perception, description and processing. A number of academic papers and research results show the development in this field in China.

We will continue to do our contribution to the science of graphics, enhance the development of the discipline of graphics, promote the flourish of science and technology and share the happiness of success of all colleagues all over the world.

Finally I would once again give my best greeting to all delegates of ICGG 2004. I hope you to be very happy in China and wish the conference will be great successful.



12<sup>TH</sup> INTERNATIONAL CONFERENCE ON GEOMETRY AND GRAPHICS (ICGG'2006)  
6-10 AUGUST, 2006, SALVADOR, BRAZIL

**Message from the President of the  
International Society for Geometry and Graphics (ISGG)  
Prof. Emiko Tsutsumi**



Dear Friends!

It is indeed a great honor and pleasure to extend a warm greeting to all of the participants at the 12<sup>th</sup> International Conference on Geometry and Graphics, hosted by the University of São Paulo, Brazil.

Since the First International Conference on Descriptive Geometry that took place in 1978 at the University of British Columbia in Vancouver, Canada, remarkable development in computer aided technology on graphics has attracted a lot of researchers and educators who had been involved in various related fields of geometry and graphics, such as Mechanical Engineering, Architecture, Plastic arts, Information processing, etc. These specialists have got to join us in the subsequent ten Conferences,

which have been held in various regions throughout the world.

Simultaneously, the increasing possibility for better and speedy communication through computer graphics became a trigger for people to take interest in visualization problems itself, not only in the method of computer graphics, but also in the process of everlasting traditional methods like Descriptive Geometry. Such circumstances will enhance further incentive for scientific research and education of graphics based on geometrical thinking. Thus, we, the researchers and educators who are involved in geometry and graphics, should continue to make further progress with firm confidence and faithfulness in their own fields.

Nowadays, communication by the use of Internet technology has developed remarkably, and because of it, we can carry on international cooperation even staying in our own laboratories! Nevertheless, it is worthwhile to gather all together from many countries and get to know one another every two years. Meeting each other, exchanging enlightening comments and experiencing the Conference will contribute greatly to the international understanding that we earnestly wish for.

Finally, I would like to express my sincere gratitude to the Brazilian Organizing Committee and to Professor Eduardo T. Santos, the Conference Chairman, for their great efforts in organizing this conference, and to all the delegates for their hard work in contributing to make this conference a successful one. Let me once again extend my sincere congratulations to all of the participants, and express the wish that your deliberations during the conference become fruitful.

12<sup>TH</sup> INTERNATIONAL CONFERENCE ON GEOMETRY AND GRAPHICS (ICGG'2006)  
6-10 AUGUST, 2006, SALVADOR, BRAZIL

**Message from the  
Honorary Conference Co-Chairman  
Prof. C. Ernesto S. Lindgren**



On behalf of the sponsors of the 12<sup>th</sup> International Conference on Geometry and Graphics, in particular the Brazilian Organizing Committee and the Local Organizing Committee here in the city of Salvador, state of Bahia, Brazil, I invite you to share in the following days the ideas that moved all of you to participate in the event.

On the personal side I wish to transmit similar wish expressed to me by Steve Slaby who would, if he could, be present. I recall that back in 1982 when the conference

took place in Beijing we discussed the possibility of having it take place in Brazil where traditionally geometry and graphics attract a great number of scholars. I am very happy that finally, through the efforts and interest of Professor Eduardo Toledo Santos and his associates, it became a reality.

Of all that was said or can be said about geometry and graphics, in my view their significance was best summarized by a geometer whose name I unfortunately do not recall: "With geometry we sail looking at the coast". I am certain that once more, as in past conferences, this will be demonstrated in the papers that will be presented.

Welcome to Brazil and let us all enjoy this opportunity of "sailing looking at the coast".

12<sup>TH</sup> INTERNATIONAL CONFERENCE ON GEOMETRY AND GRAPHICS (ICGG'2006)  
6-10 AUGUST, 2006, SALVADOR, BRAZIL

**Message from the Executive Chairman of the  
12<sup>th</sup> International Conference on Geometry and Graphics  
Prof. Eduardo Toledo Santos**



Dear Friends,

It is with great pleasure that we are organizing in Brazil the 12<sup>th</sup> International Conference on Geometry and Graphics, for the first time in Latin America.

Following the tradition from Iberian countries, Descriptive Geometry is a well developed discipline in many Latin American nations and it is taught in most of our Engineering and Architecture courses. As the colleagues from other continents, we are also fighting for placing Geometry and Graphics back into its deserved position as a fundamental field for developing human reasoning and enabling engineering achievements. Therefore, it was about time a ICGG was held here.

I hope we have honored the trust conceded to us by the ISGG Board Committee in Guangzhou, 2004, when they accepted our proposal for organizing the next Conference in Brazil and I thank the support provided by ISGG as well as by JS GS since then.

I want to welcome all of you in Salvador, a piece of Brazil which I love for special reasons, to taste not only the delicious local food, but also the hospitality of the people which surprises even Brazilians from other parts of the country and to enjoy its historic architecture and the natural beauties of its beaches.

Finally, I wish to express here my deepest thanks to all my colleagues in the Organizing Committees, specially to Prof. Arivaldo Amorim, who accepted this challenge without hesitation, despite the difficulties and endless duties, to turn the vision of this event into a reality.





## WELCOME ADDRESS OF THE PRESIDENT OF THE INTERNATIONAL SOCIETY FOR GEOMETRY AND GRAPHICS ISGG

**Prof. Dr. Emiko TSUTSUMI, (Tokyo, Japan)**

On behalf of the International Society for Geometry and Graphics, I would like to extend a warm greeting to all of the participants attending at the 13th International Conference on Geometry and Graphics, hosted by the Dresden University of Technology, Germany.

Since the First International Conference on Descriptive Geometry that took place in 1978 at the University of British Columbia in Vancouver, Canada, many colleagues have been supporting the conference in our three decades history. A lot of researchers and educators who had been involved in various related fields of geometry and graphics have joined in the successive conferences and have exchanged views and shared common perceptions on Geometry and Graphics. Such circumstances have enhanced further incentive for the scientific research and education of graphics based on geometrical thinking. I feel blessed to have gotten to know all of you.

We will get to know in the near future that the year 2008 is a special year for us not only because of our three-decade anniversary but also a significant shift in relation between our society and other academic societies of all nationalities. Recently, some colleagues gave us a nascent sign of further progress. They are making proposals to our society that they want us to act as adviser for their international curricula or an exam for CAD skill grading.

Now, we are trying to make the next leap forward. By promoting such an international cooperation, we will be able to acquire a more fruitful future by joining together. It is in large part due to the successive international conferences which have been hosted by many motivated colleagues. Finally, I would like to express my sincere gratitude to the German Society for Geometry and Graphics, DGfGG Organizing Board, Local Organizing Committee at TU Dresden, International Scientific Committee and to Professor Gunter Weiss, the Local Conference Administration Chair, for their great efforts in organizing this conference, and to all the delegates for their hard work in contributing to make this conference a successful one. Let me once again extend my sincere congratulations to all of the participants, and express the wish that your deliberations during the conference become enjoyable and fruitful!

Emiko Tsutsumi



## The DGfGG-PRESIDENT'S GREETING ADDRESS for the 13<sup>th</sup> INTERNATIONAL CONFERENCE ON GEOMETRY AND GRAPHICS

**Prof. Dr. Albert SCHMID-KIRSCH (Hannover, Germany)**  
President of the German Society for Geometry and Graphics

Dear president Emiko Tsutsumi of the organization board and dear vice president Gunter Weiss of the local organizing committee as representatives for all the participants of this conference please receive our greetings!

You have noticed the German Society for Geometrie and Graphics (DGfGG) as co-organizer of the the 13th ICGG 2008. This year's conference of the German Society for Geometry and Graphics will be part of the 13<sup>th</sup> ICGG 2008 conference.

The DGfGG is still a young organisation. Founded in February 2003 here in Dresden with Gunter Weiss as our founding father as a national branch of the International Society for Geometry and Graphics we have reached the tender age of five years now.

Our 58 members are working in Geometry and Visualisation in Research, Teaching and Practise.

The conferences of the DGfGG range from classical Descriptive Geometry to Computational Geometry. Our hitherto conferences took place in Hannover 2005, Bremen 2006 and Stuttgart 2007. The excellent proceedings of the Bremen conference is still available in booktrade. The others you can find on display here in the conference. This year we have the opportunity to join the 13<sup>th</sup> ICGG 2008. We would be glad to recruit some new members here in Dresden.

We are also glad to have reached a cooperation treaty with ADG, the Austrian Assosiation for Geometry in June 2007. In this context I would call the ADG our elder and friendly brother who shares his experiences with us. We shell meet a lot of members of the ADG as well as members of the ICGG during the conference.

Our assistance to the 13<sup>th</sup> ICGG 2008 is small and great at once. Small because of our limited resources and means. Great because of the contributions of some of our common members like Gunter Weiß, Gert Bär and Daniel Lordick.

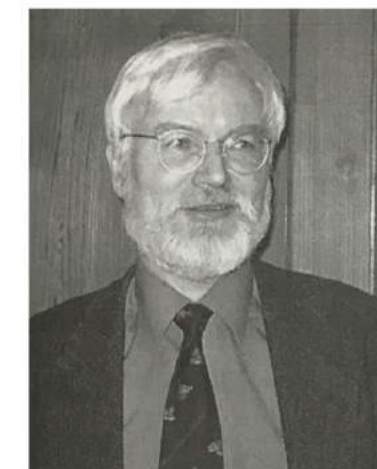
The latter is together with Verena Hupasch one of the curators of the exhibition "Good vibrations" on Geometry and Art.

As an architect I recommend you to have a look at the marvellous city of Dresden on the banks of the Elbe river. The old buildings are great, but don't forget to have a look at some new ones like the new Saxonian University Library and the new Synagogue.

So we wish this conference and the participants from all over the world every success! Looking at the scientific programm there is no doubt about that.

Thank you for beeing a part of this great event!

Albert Schmid-Kirsch



## PREFACE

### LOCAL ORGANIZERS' WELCOME ADDRESS AND GUIDELINES

Dear Participants,

a warm welcome to you all at the 13th ICGG 2008 in Dresden! We are really glad that you joined the conference and that you contribute to the further development of Geometry and Graphics. We, the Local Organizing Team, try our best to make you feel at home here among new colleagues and old friends.

By this booklet you have received together with the Conference Materials you are provided with lots of information, which are meant to help you to orient yourself in space and time at our University Campus.

The first block of pages concerns maps and timetables as well as greeting addresses, the main block contains the (extended) abstracts to scheduled presentations. This block is followed by listings of delegates together with additional information, e.g. when they give their presentations or chair a section. Of course some of these data might have changed in the meantime. So please read the daily announcements carefully.

But the most important and lasting part is hidden in an envelop sticking to the last page: the Proceedings of the 13th International Conference for Geometry and Graphic, an e-book CD containing the reviewed articles to your presentations. This ISBN-registered e-book replaces the traditionally printed proceedings of former ICGG.

As we are all human beings we might have made typos or even bigger errors. Please pardon us for that. In case you feel that more detailed information is needed or you have a very personal question or problem, please just ask us, we will try to help you. Maybe you have an idea to improve something, please tell it to us! The organizers of future conferences will be very grateful for such hints.

Have a nice stay in Dresden!

Cordially

Yours

Gunter Weiss

Chair of the Local Organizing Team





Welcome Address of the President of the International Society for Geometry and Graphics – ISGG  
Prof. Ted Branoff (North Carolina State University, USA)

As president of the International Society for Geometry and Graphics, it is my honor and pleasure to welcome you to Kyoto for the 14th International Conference on Geometry and Graphics. We are grateful that you have been able to make it to Japan to share your knowledge related to geometry and graphics. I especially want to welcome those of you who are attending an international conference for the first time. My hope for you is that you will meet several people from around the world with which to share time intellectually and socially. I attend many conferences around the United States related to engineering education and graphics, but I have found that the International Conference is quite a different venue for sharing ideas. Although we may struggle to communicate verbally with one another, graphics is truly an international language. There is nothing like discussing graphics with someone from a different country.

It is important for me to take this opportunity to promote the International Society for Geometry and Graphics. This conference is one of the ISGG sponsored forums for discussing and presenting research, applications, and education in geometry and graphics. As you will see during this conference, we are a truly international society covering a broad spectrum of graphics areas. These include theoretical research, applications in industry and design, and graphics education. The ISGG also sponsors the Journal for Geometry and Graphics. This is a refereed scientific journal for the purpose of stimulating “scientific research and teaching methodology in the field of graphics and graphics-related geometry.” If you are not a member of ISGG, please make it a point to talk to an ISGG member at this conference and consider joining the society.

I would like to close by thanking the individuals and organizations who have made this conference possible. First I would like to thank all of the societies, companies, organizations, and institutions that have helped to fund this conference. We know an event like this could not happen without your support. Special appreciation must go to Michio Kato, Hirotaka Suzuki, and the Local Organizing Committee for all of their hard work preparing this conference. It is difficult enough to prepare a conference in one’s own country, but I know that the International Conference presents unique challenges that are not easy to solve.

Again, let me extend my sincere welcome to all of the conference participants. I hope you have a productive and enjoyable time in Kyoto!

Ted Branoff



Welcome Address from the Local Organizing Committee  
Michio KATO (The University of Tokyo, Japan)  
Chair of ICGG 2010 Local Organizing Committee

First I thank to all delegates and accompanying persons for coming to the Far East end of the world. And I would like to be thankful to you who had approved of our proposal that the 14th ICGG is held in Japan.

I have been telling that the study on figures is in an increasingly developmental process. However, the development has spread in all the fields where figures are used as a tool. Such a situation is glad in another discipline of study, for example, mathematics and physics. However, in our field, it threatens our identity. Why?

I think that the cause is deeply concerned with the purification which is one of modern characteristics. After Kant our recognition has been purified with replacing our directly received senses or experiences into words. According to Saussure, *signifiant* (word) has no direct relations with a physical object or its visual image. Only differences between *signifiants* (words) compose a linguistic system called *lang*. There is the division of words and images. I think it lies in the center of modern European and American culture.

But Japan has had another tradition. We, Japanese and Chinese, have recognized the world with Chinese character *KANJI* which had originated from visual images. So our division of image and character is not so clear. Japanese culture such as *Syodo* (calligraphy) or *Ukiyoe* demonstrates it. They are plays of a different type of signes from those of Europeans or Americans.

So I think it is important our conference is held in Japan which Bartes calls the *L'Empire des signes*. I hope the fusion of traditions of European, American and Japanese will create a new hybrid frame that has the potentiality overcoming modern crisis and developing a new future in the world-wide range.

Michio KATO



Welcome Address from the Local Executive Committee  
Hirotaka SUZUKI (Osaka City University, Japan)  
Chair of ICGG 2010 Local Executive Committee

Dear colleagues who love Geometry and Graphics!

On behalf of the ICGG2010 local executive committee, I would like to welcome all of you to Kyoto. For long, Kyoto was Japanese’s capital; moreover, the city serves as Japan’s cultural and spiritual center. I am sincerely proud to be able to host the conference on the 14th in Kyoto. Following its establishment in the spring of 2009, the ICGG2010 local executive committee has been paying attention to natural disasters, epidemics and economic crises that may affect the operation of ICGG2010, and we are sincerely glad to be able to hold the ICGG2010 safely independent from such factors.

After the establishment of the ICGG2010 program committee in September 2009, the ‘call for papers’ for the ICGG2010 technical session was announced on November 10, and saw more than 200 abstracts being submitted before the January 5, 2010 deadline. For the poster session, the ‘call for papers’ was announced on February 25, and saw about 30 abstracts being submitted before the March 31, 2010 deadline. In all, abstracts from about 30 countries were submitted. The submitted abstracts were reviewed by the reviewers as per the allocations made by the program committee. Moreover, the full papers submitted for the technical session were reviewed again. The papers that pass through such a strict review process will be presented at the conference and published in the proceedings.

In addition to the academic sessions, the program itinerary includes an excursion to Kyoto city and a banquet. In the excursion, we are planning to learn about the old theater arts of Japan and to see the grand temple. In the spatial environs of historical Kyoto, you will be able to find various design applications of geometry and graphics. The excursion will be preceded by a wonderful dinner banquet that will be organized in a beautiful garden. I would really appreciate if these programs serve to foster social interaction among the conference participants.

I wish to express my gratitude to all the people who are cooperating to make this conference successful including the sponsors, the cooperating organizations, the reviewers, the delegates, the cooperating students, the members of ISGG executive board, members of ICGG2010 program committee and the members of the ICGG2010 organizing committee and the ICGG2010 executive committee.

Hirotaka SUZUKI



## Organization

### Under the auspices of

The International Society for Geometry and Graphics (ISGG)



### Patronage

Department of Mechanical Engineering, Faculty of Engineering, McGill University  
School of Architecture, Faculty of Engineering, McGill University  
Canadian Society for Mechanical Engineering (CSME)

### Co-Chairs

Prof. **Paul Zsombor-Murray**

Associate Professor, Department of Mechanical Engineering, McGill University (retired)

Prof. **Aaron Sprecher**

Assistant Professor, McGill University School of Architecture  
Director, LIPHE Research Lab, McGill University

### Local Organizing Team

Bruno Angeles  
Marco Hamann  
Berit Edlich  
Hans-Peter Schröcker  
Irène Cartier

## Preface

### Welcome address

Dear Friends and Colleagues:

You will note no civic dignitaries or senior university officials have graced us with their presence. Though invitations were extended none were accepted. One of the reasons we meet like this every two years, I believe, is to check on the health of our diverse community of graphics teachers, geometers, artists and architects. Who has passed on? Who has arrived for the first time? In this regard a special welcome is extended to Chinese delegates and Italian architects; many who have come. The unique representation of Estonia and Kosovo is pleasantly surprising.

In his opening remarks at ICGG2010 in Kyoto Ted Branoff urged all to attend presentations in sessions other than those pertaining to their peculiarity. This necessary message is repeated now in order promote the survival and, it is hoped, prosperity of geometry and graphics.

Before Professor Sprecher, from an architect's perspective, delves into the conflicting dichotomy between analytical and synthetic aspects of modern science, consider the old biblical tale about the Tower of Babel.

This is oft regarded as a parable of pride and fall. An ancient advanced civilization presumes to attempt a task of heroic, even divine proportion. God's punishment of hubris ensues. Waking one day they find themselves unable to communicate, hence proceed, because each language of various groups is no longer comprehensible to the others. It is commonly assumed that this is a childish explanation for prevailing linguistic diversity. Another interpretation is that this situation is merely the result of selfish overspecialization and attempt to protect indispensability of acquired talent. Knowledge is masked with jargon which none, save those initiated into the mysteries of the guild, can understand let alone apply. Alas, those who create the problem make themselves irrelevant. By seeking to preserve power, which diminishes when distributed, instead of transmitting knowledge, which grows when shared, a "dark-age" is precipitated.

For those who are irritated by this modern, amateurish attempt to philosophically connect Babel with apocalypse and B-spline the words of Peter Schreiber, a geometer-philosopher-historian commenting on modern philosophical thought, might provide grim satisfaction. "Philosophy was meant to be the bridge between the social and natural sciences. The bridge is in ruins and modern philosophical thought grows like weeds among the wreckage."

A couple of quotes to end with: "If we don't hang together we shall all hang separately." "Pray, work hard, don't complain."

Good luck. Let us enjoy the conference.

Paul Zsombor-Murray  
McGill University Department of Mechanical Engineering  
Co-chair, ICGG 2012

### Welcome address

Dear Participants,

It is an immense pleasure to welcome you to the 15<sup>th</sup> International Conference on Geometry and Graphics at McGill University. About two years ago, my colleague Professor Paul Zsombor-Murray invited me to co-chair this famous bi-annual event celebrating the unity of geometry, architecture and engineering. I consider our partnership in the organization of this conference to be inspiring and crucial as regards recent technological advancements that inherently transform our perception of the world. With this year's conference venue in the McGill School of Architecture, our objective is to create an environment in which researchers in diverse fields share and exchange ideas about the present and future of experimental research in the fields of visualization, simulation and fabrication of new models that reveal the complexity of our natural, social, cultural and even political environments. This question regarding the visualization of parametric, associative and generative geometries has been at the core of a fierce debate in the scientific community during the past century. The distinction between image and logic, number and diagrams, syntax and semantics represents one of the classical notions that had to be purged from science in order to unleash its full potential to sustain the intensive movement of convergence among disciplines that were otherwise considered autonomous. This dichotomy has been a controversial subject since the advent of modern science.

As Peter Galison describes in his fundamental essay Einstein's Clocks, the instability of the image in the scientific representation of nature appears repeatedly since Gaspard Monge's mathematical models until Eric J. Heller's calculation-intensive diagrams<sup>1</sup>. This debate is best exemplified by the iconoclast position of the mathematician Werner Heisenberg and the contrasting opinion of his colleague Erwin Schrodinger. Werner Heisenberg seized on Niels Bohr's theory of atomic movement and developed a systematizing method of calculation to solve complex problems. Heisenberg ultimately created a system that would be able to model all possible trajectories of electrons in motion. The result of his concepts was an array of numbers along with a set of formal rules for the manipulation of these arrays. Heisenberg's method was highly successful as it solved a wide range of problems in the physics of the very small. On the other side of the scientific scene, Erwin Schrodinger was repelled by this rather obscure list of numbers. He called for a visualization of the phenomena. His principle regarding wave mechanics aimed to create an understanding of the detailed processes that underlie what we could perceive with our eyes or our instruments.

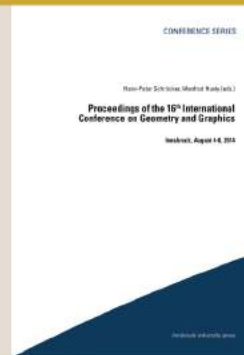
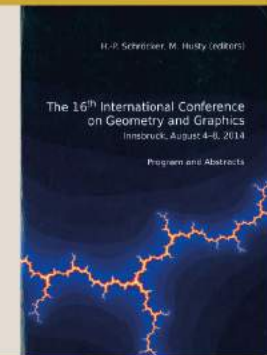
Following this flickering conflict, back and forth between images and data, it becomes clear that the impulsion toward image and the preoccupation with the manipulation of data can no longer stabilize science and its methods<sup>2</sup>. Quite the contrary, neither the pictorial-representative nor the analytic-logical adjective can exist as a fixed condition. Instead, across a wide span of design disciplines including engineering and architecture, we see that the image itself is constantly in the process of fragmenting and re-configuring. It is this synergy between the image and the non-image that exemplifies the transdisciplinary nature of our research practices today. It is precisely this synergetic condition that we hope you will enjoy at ICGG 2012. With keynote lectures delivered by world-renowned Professors John Conway and Mark Burry, and peer-reviewed paper and poster presentations from an international panel of researchers, I wish you an inspiring, provocative and above all creative conference.

Aaron Sprecher  
McGill University School of Architecture  
Co-chair, ICGG 2012

<sup>1</sup> Galison P., "Einstein's Clocks, Poincare's Maps. Empire of Time", New York: W.W. Norton & Company, 2003

<sup>2</sup> Latour B. and Weibel P. (eds.), Iconodasm: beyond the Image Wars in Science, Religion and Art, Cambridge: MIT Press, 2002



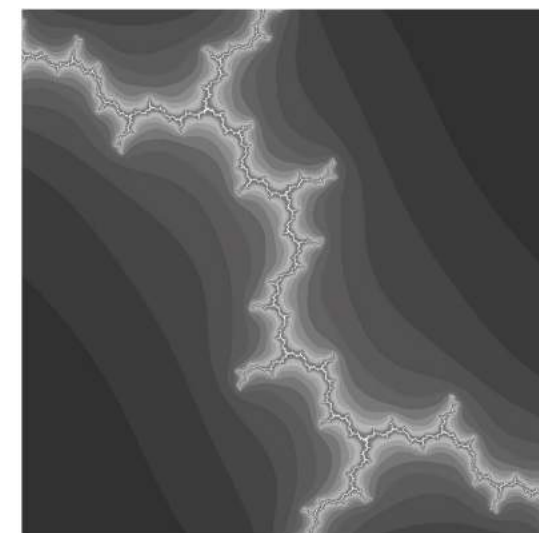


## Conference Logo and Background Image

The logo of ICGG 2014 is a variation on Poncelet's Porism: If it is possible to find an  $n$ -gon inscribed into one conic and circumscribing another conic, then it is possible to find infinitely many  $n$ -gons with that property. The logo contains two triangles inscribed and circumscribing two ellipses.



The background image displays a Julia fractal. It was created using the Asymptote graphics programming language, see <http://sourceforge.net/asymptote/>.



```
import graph;
import palette;
int w = 1024;
size(w, 0);
pair c = (0, 1);
pen[] col = Gradient(10, darkblue, deepblue,
                    blue, orange, white);
real m = 2 + length(c);
int n = 20;
pair J(pair z) { return z^2 + c; }
real julia(pair z, int imax = n, real M = m) {
    int i = 0;
    while (i < imax) {
        z = J(z);
        if (length(z) > M) { return i; }
        ++i;
    }
    return imax;
}
real fractal(real x, real y) { return julia((x, y)); }
bounds range = image(fractal, (-1.0, -1.0), (1.0, 1.0), w, col);
```

Conference logo and background image design by Hans-Peter Schröcker.

## 1 Welcome Addresses

### Welcome Address by Otto Röschel, President of ISGG

It has become a family tradition within the International Society for Geometry and Graphics to hold a biannual International Conference. It has also become a tradition that this conference is hosted in term by partners from "our" three great regions: Asia/Australia/Oceania, North America/South America and Europe/Near East-/Africa. The last two conferences in this series were organized in Kyoto (Japan 2010) and Montreal (Canada 2012). For the upcoming conference in 2014 we got three applications, each of them with a clear conception and good ideas.



It took some careful discussion to make a decision. Finally, the board of ISGG went for Innsbruck to be the host for this 16<sup>th</sup> International Conference on Geometry and Graphics.

Let us recall the recent history of our community. Years ago this series of conferences started with a few members and grew from conference to conference. It is amazing to watch our flourishing community (the International Society for Geometry and Graphics) with an encreasing number of members coming from all over the world and covering scientific and teaching expertise in the broad field of geometry, especially in the three categories

- Theoretical research
- Applications in industry and design
- Education.

The different sections of this year's conference will be devoted to these topics. Admittedly, modern media and technology would allow to exchange information directly via the internet. The oral presentation, though, can give a deeper impression of the authors' ideas, considerations, experience and argumentation. Discussions follow the presentations and certainly inspire further research and encourage new teaching approaches. This is what we expect to be scientific exchange and exchange of teaching experience on a high level.

On this conference you can embrace the opportunity to cross borders by also listening to lectures from sections that are beyond your personal focus of interest. Take this chance at ICGG2014 and let geometry enjoy your mind!

Organizing such a big conference like ours is a tough job. It is being done by the highly qualified and motivated geometry group of the University of Innsbruck. I deeply appreciate what they have already achieved and what they will be organizing throughout the conference.

### 1 Welcome Addresses

Many, many thanks to all of them! I also want to express my gratitude to the University of Innsbruck for supporting us.

The venue of this year's ICGG conference is Innsbruck, a marvellous city in the western part of Austria, enclosed by impressive mountains. I am confident that you will not only enjoy the landscape but also make new friends, get to know the people behind fascinating geometric ideas and reinforce the impression that geometry is a prolific, highly vivid and active field of research.

I wish you a pleasant stay and a succesful participation in the International Conference on Geometry and Graphics at Innsbruck!

### Welcome Address by Manfred Husty, Local Organizing Committee

At the ISGG board meeting during the ICGG 2012 in Montreal, Innsbruck has been chosen to host the ICGG 2014. The University of Innsbruck and the members of the unit Geometry and CAD were very happy about this decision and now, two years later, we are delighted to welcome all the participants and accompanying persons here in Innsbruck. The University of Innsbruck and the local organizing committee wish that we have done everything to make your participation at ICGG 2014 an unforgettable and scientifically profitable event. We dearly hope that aside of the scientific work you can also enjoy our beautiful city, the marvellous landscape in the surroundings and maybe even a bit more of our country Austria.

The organizing committee is proud that this conference has attracted more than 200 scientists and teachers of geometry coming from all five continents. 213 papers have been submitted and after review by at minimum of two independent reviewers 160 have been selected for presentation at the conference. We thank all the participants for the effort to submit papers and hope that this event will contribute to further development of geometry, the teaching of geometry and most of all to create a bond between people who teach and love geometry. Welcome in Innsbruck to ICGG 2014!





## Welcome Address from the International Society for Geometry and Graphics

**Prof. Otto Röschel**

President of the International Society for  
Geometry and Graphics

It has become a family tradition within the International Society for Geometry and Graphics to hold a biennial International Conference. Traditionally, this conference is hosted, in turn, by partners from “our” three great regions: Asia/Australia/Oceania, North America/South America and Europe/Middle East/Africa. The latest two conferences in this series were organized in Montreal (Canada 2012) and Innsbruck (Austria 2014). For the upcoming conference in 2016 we got an application from our colleagues from Beijing Institute of Technology. Their offer was based on a clear conception and convincing ideas.



Let us recall the recent history of our community. Years ago this series of conferences started with only a few members and grew from conference to conference. It is amazing to watch our flourishing community (the International Society for Geometry and Graphics) with an increasing number of members coming from all over the world and covering scientific and teaching expertise in the broad field of geometry, especially in the three categories:

Theoretical research

Applications in industry and design

Education.

The different sections of this year’s conference will be devoted to these topics. Admittedly, modern media and technology would allow the exchange of information directly via the Internet. The oral presentation, though, can give a deeper impression of the authors’ ideas, considerations, experience and argumentation. Discussions

following the presentations may inspire further research and encourage new teaching approaches. We are convinced that this immediate kind of scientific exchange can spark lots of new ideas.

It has to be pointed out that there has been a remarkable Conference Fee Sponsoring Program which was financially supported by the organizers of ICGG 2014 in Innsbruck and the Japan Society of Graphic Science. This sponsoring program allowed the support of up to ten young delegates of this year’s conference in Beijing. Let me speak in the name of the sponsored people: I want to express my deep gratitude to the sponsors for their generosity and the award committee for their work. For a discipline one of the best ways of promotion is the support of young scientists, enabling them to take part in fascinating international conferences. I am sure that the grant will encourage brilliant minds and stimulate scientific research in our fields of expertise.

On this conference you can embrace the opportunity to cross borders by also listening to lectures from sections that are beyond your personal focus of interest. Take this chance at ICGG 2016 and let geometry enjoy your mind!

Organizing such a big conference is a tough job. It is being done by the highly qualified and motivated geometry group of Beijing Institute of Technology. I deeply appreciate what they have already achieved and what they will be organizing throughout the conference. Many, many thanks to all of them! I also want to express my gratitude to Beijing Institute of Technology for supporting us.

The venue of this year’s ICGG conference is Beijing, the impressive capital of China. I am confident that you will not only enjoy the city but also make new friends, get to know the people behind fascinating geometric ideas and reinforce the impression that geometry is a prolific, highly vivid and active field of research.

I wish you a pleasant stay and a successful participation in the International Conference on Geometry and Graphics in Beijing!

## Chairman Jianguang Sun’s Address at the 17th International Conference on Geometry and Graphics

**Jianguang Sun**

Chairman of China Graphics Society, Chinese Academy of  
Engineering, and Professor of Tsinghua University

Distinguished experts, ladies and gentlemen:

Welcome to Beijing and experience our heartily  
“hot” hospitality!

On the occasion of the 17th International Conference on Geometry and Graphics (ICGG) held in Beijing, on behalf of China Graphics Society (CGS) and myself, please allow me to offer our warm congratulations on the successful convening of ICGG, to express our heartfelt welcome to all experts, scholars and friends present at this conference, and extend our sincere gratitude to the President of ICGG, leaders from the Association for Science and Technology of China, and leaders and colleagues from Beijing Institute of Technology. We are deeply grateful for all of your ardent support of this conference.

As an academic event for researchers and educators on graphics worldwide, the International Conference on Geometry and Graphics serves as a platform facilitating communication among scientific workers on graphics. Nearly 200 Chinese and foreign representatives from over 20 countries come together to exchange views and conduct discussions on their shared concern, namely, the technological advancement and applications of graphics, and thus promote the development of the discipline of graphics.





Politecnico di Milano, 3 – 7 August 2018

**WELCOME ADDRESS BY THE PRESIDENT OF ISGG, THE INTERNATIONAL SOCIETY FOR GEOMETRY AND GRAPHICS, CONFERENCE CHAIRMAN OF THE ICGG 2018**



**YASUSHI YAMAGUCHI**  
*President of ISGG*  
The University of Tokyo  
Tokyo, Japan

Dear participants and organizers of the 18th ICGG 2018.

On behalf of the International Society for Geometry and Graphics (ISGG), it is my honor and pleasure to welcome you to Milan for the 18th International Conference on Geometry and Graphics (ICGG). ICGG has a series of international conferences held in every even-numbered year. The first conference took place in Vancouver, Canada, in 1978, and was hosted by the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE). Therefore, this is the fortieth anniversary of the conference series. During the first four conferences, the core members confirmed the importance of having an international academic forum concerning geometry and graphics. ISGG was established at the 5th conference in Melbourne in 1992. Since then, it is our tradition to hold ICGG hosted by our members from the three regions all over the world, namely, Asia/Oceania, Europe/Africa, and North/ South America. We are grateful to have the opportunity to meet in Milan, Italy, for a memorable conference. Milan is one of the most suitable cities for its historical/cultural background in terms of geometry and graphics. Also, Italy is one of the countries which provides the most active members of our society. At the last conferences, Italy was the first or second country for the number of participants excepting the host country. I hope to maintain the great relationship with Italian colleagues and the national body of Italy, Unione Italiana Disegno (UID), for the future.

As a president of ISGG, it is important to take this opportunity to promote ISGG. This series of conference is one of our main events for the presentation and discussion of research related to geometry and graphics. ISGG covers a broad spectrum of geometry and graphics as does the conference, which includes theoretical graphics and geometry, applied geometry and graphics, engineering computer graphics, graphics education, and geometry and graphics in history. The ISGG also sponsors the Journal for Geometry and Graphics (JGG). It is a peer-reviewed scientific journal. The excellent papers presented in the conference will be selected for the further reviewing process for publication in JGG. The journal appears in one volume per year, consisting of two issues. All members of ISGG receive JGG free of charge. Please, ask our members about the society and consider joining ISGG, if you are not a member as yet. Finally, I would like to extend my sincere gratitude to the individuals and groups who have been organizing the conference. I would like to thank all of the societies, companies, organizations, and institutions that have helped to fund the conference. I am grateful to the local organizing committee and the host, Politecnico di Milano. It would be impossible for us to have the conference without their support. Last but certainly not least, I wish to express my true appreciation to Luigi Cocchiarella because of his dedicated work as the executive chair. Again, allow me to extend my welcome to all the conference participants. I wish you a pleasant stay in Milan and a productive and successful participation in the conference.

**WELCOME ADDRESS BY THE EXECUTIVE CHAIRMAN OF THE ICGG2018**



**LUIGI COCCHIARELLA**  
*ICGG2018 Executive Chairman*  
Department of Architecture and Urban Studies (DASTU)  
School of Architecture Urban Planning Construction  
Engineering (AUIC)  
Politecnico di Milano  
Milan, Italy

With profound sentiments of honor and happiness, as Executive Chairman of the ICGG2018, I address my warmest welcome to all the participants of The 18th International Conference on Geometry and Graphics, on the special occasion of the celebrations of its 40th anniversary in Milano!

This edition is held in Italy at the Politecnico di Milano and here granted and organized at the Department of Architecture and Urban Studies (DASTU) under the auspices of the International Society for Geometry and Graphics (ISGG), financially supported by the aforementioned institutions, together with the Japanese Society for Graphics Science (JSGS), the School of Architecture Urbans Planning Construction Engineering (AUIC), the Department of Mathematics of the Politecnico di Milano (DIMAT), the Postgraduate Program BIM Courses (DASTU), and other generous sponsors listed on the ICGG2018 webpage <http://www.icgg2018.polimi.it>. The conference has also obtained the patronage of the Unione Italiana per il Disegno (UID) and the following Italian patrons: Istituto Lombardo Accademia di Scienze e Lettere; Istituto di Studi Superiori dell'Insubria Gerolamo Cardano; Fondazione Fratelli Confalonieri; Associazione Guido Ucelli Amici del Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci. As a significant symbolic link to its origins, and as a good wish for the 40th anniversary, the University of British Columbia (UBC) and the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE), which respectively organized and sponsored the first edition in 1978, have also honored us with their patronage. Patrons and Sponsors are listed by active links to the corresponding websites on a dedicated section of the ICGG2018 webpage [www.icgg2018.polimi.it](http://www.icgg2018.polimi.it).

Personally speaking, the responsibility of undertaking the organization of such an important event will be part of the unforgettable records of my academic career, as well as a private memory. I wish that something of this feeling could also pervade our welcome participants, delegates and accompanying persons.

When at the 17thICGG in Beijing, at the beginning of August 2016, quite unexpectedly the events started moving in the direction of a Conference in Europe again in 2018, and namely in Italy at the Politecnico di Milano. it was clear that the time to organize the event was much shorter than usual, and in addition the upcoming 40th anniversary would increase our concern. On the other hand some occurrences of numbers and coincidences –a kind of kabbalah as we liked to say- seemed to encourage us: indeed, eighteenth edition would have been in two thousand and eighteen, the 40th anniversary would be in the 20th from my first attendance in 1998 at the Austin Conference, the last with the old name ICECGDG and in turn celebrating then the 20th anniversary from the Vancouver's edition in 1978, which again coincided with an anniversary, namely the 50th of the American Society for Engineering Education. The proposal was immediately supported by the Head of the Department DASTU, with the agreement of the Rector of the Politecnico di Milano. Finally, although it was not possible to announce the Venue of the 2018 meeting at the closing ceremony in Beijing: thanks to the support of the Politecnico di Milano and the guidance of ISGG, the generous engagement of Chairs and Co-Chairs, Members of Steering and Program Committees, as well as to the special dedication of some members of our Local Organizing Board and Staff, and students, the Conference was scheduled and organized, and it ended up being one of the greatest participation in the series. My heartfelt thanks go to all the individuals and institutions contributing to make this result possible.

Some names need to be mentioned. From the ISGG, Hans-Peter Schröcker, member of the Board of Regents organizing with Manfred Husty the 16thICGG in Innsbruck, especially for the initial detailed recommendations and advice, and Hirotaka Suzuki, ISGG treasurer and organizer of the 14thICGG in Kyoto, for visiting in advance our Conference Venue. Here in Milano, in my University, I cite Pierfranco Galliani, to whom no words would suffice for diverse appropriate advice on every aspect of the Conference; Dario Angelo Maria Coronelli, Luisa Rossi Costa, and Damiano Cosimo Iacobone, for the help on the program; Federico Alberto Brunetti for movies and photographs; Susanna Sancassani and Bruno Aliprandi for the support on the online services; Mascia Sgarlata and Cristina Giannetto for the relations with institutions and services; Gloria Paoluzzi, Giuseppe Piamplano and Gianluca Ferrante for the administrative issues. And many others, including colleagues, students, and friends could be mentioned for their kind encouragement and help. On the private side my grateful thoughts go to my wife Francesca Scherillo, for her lovely patience, her constant wise presence, and help.

At the Austin's Conference in 1998, just after my PhD, I was the only Italian delegate. I met there, for the first time, Hellmuth Stachel, Kenjiro Suzuki, and Guner Weiss, who have since then been key reference persons in the process of fostering the international relationships between the Italian scientific community and the ISGG. Over time, the number of the Italian participants has gradually increased, until becoming the highest one after those of the organizing countries in the last two editions, and the highest in this edition. The engagement of the Unione Italiana per il Disegno (UID) and the personal commitment of the president in office Vito Cardone in front of the Italian academic community have been crucial in this process, during which also the affiliation of the UID as an institutional member of the ISGG, between 2013 and 2014, could be finally possible. In this period I had the great privilege –and I still have it today– to be member, at the same time, of the Board of Regents of the ISGG and of the Commission for the International Relationships of the UID. The present Conference is held at the Politecnico di Milano, at the Leonardo Campus, the main historical district of our University, where participants attend the technical sessions and most of the plenaries, and can also relax in the gardens and public spaces of the Campus, which is in the urban area of Città Studi and Lambrate. The Opening Ceremony at the Triennale di Milano and the Closing Ceremony at the Museo Nazionale della Scienza e della Tecnologia "Leonardo da Vinci", involve two relevant cultural institutions of our City, both located in the city center, where participants can enjoy masterpieces of Modern Art and History of Science and Technique. According to the Conference focus, 7 Invited Speaker of high scientific profile coming from various disciplinary fields related to Geometry and Graphics will open and close the scheduled working sessions. Several plenary sessions are also scheduled, including poster sessions, round tables with the session–chairs, a panel session, and of course opening and closing ceremony, aiming at further stimulating the scientific cross fertilization in our international community during the Conference days. The annual meeting of the ICGG Board of Regents is also part of the official program. More than 280 scientific contributions have been submitted to the review, by about 450 authors from 43 Countries of the Five Continents, concerning Geometry and Graphics in several disciplinary fields, about 80% of them are published on the Proceedings, grouped according to the following ICGG2018 topics: Theoretical Graphics, Applied Geometry and Graphics, Engineering Computer Graphics, Graphics Education, and Geometry and Graphics in History, a new topic added for this edition. As in our Conference tradition, a welcoming party, a conference dinner, a conference tour and accompanying persons' tours are also organized, including a leave taking snack at the end of the closing ceremony.

As also the Conference Logo tries to synthesize, we liked to dedicate this conference to Leonardo Da Vinci, after whom our Campus is named and to whom we would pay homage as a genius among the greatest showing the widest power of Geometry and Graphics in investigation and creativity between Science and Art, and to Giulio Natta, professor at the Politecnico di Milano and Nobel prizewinner for Chemistry in 1963, together with Karl Ziegler, as a mentor on the profound function – and beauty! – of Geometry and Graphics in Science and Technology, even at the invisible scale of the molecular world: from these thoughts the choice to include Geometry and Graphics in History in the list of the 2018 conference topics. On the Conference website, the 3D configuration originating the graphic logo appears, suspended and oscillating in the virtual graphic space of the webpage, as a clear sign of the present statute of Geometry and Graphics, digital and still human centered.

My sincere thanks go to Otto Röschel, the ISGG President in office in 2016, when it has been proposed to organize the ICGG2018 in Milano, and to the members of the ISGG Board of Regents, for their trust in us, as well as in me personally, and to Yasushi Yamaguchi, the esteemed present President in office of the ISGG, for his secure leadership and reliable support.

My deepest gratitude is addressed to all the participants to the ICGG2018, authors, delegates, students, and accompanying persons, adults and often kids, since without their interest, engagement, and participation, this Conference, one of the most attended up to now, would have simply not been possible.

I sincerely hope that you all could have rich and profitable academic benefits from the 18th International Conference on Geometry and Graphics, a memorable experience at our University, and an enjoyable time in Milano.

Once more, also on behalf of the ICGG2018 Organizing Board, WELCOME!