



**Final Report on IAPR TC16  
(January 2021 – August 2022)**

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# 1. TC Background Information

## 1.1. TC Aim and Scope

The TC16 on “Algebraic and Discrete Mathematical Techniques in Pattern Recognition and Image Analysis” has the main aim to identify, discuss and promote emerging research trends in mathematical methods for pattern recognition, including algebraic, geometrical, topological and discrete mathematical methodologies.

The main goals of TC16 are a discussion of actual and prospective lines of research and exchange of the results in Algebraic and Discrete Mathematical Problems and Techniques inspired by Pattern Recognition and Image Analysis.

TC16 achieves its goals organizing several dissemination, communication and clustering actions, including the organization of workshops and conferences, the preparation of publications (survey articles, tutorials, etc.), the design of bibliographical databases and benchmarking datasets, the provision of support for results exchange between members.

We also consider it very important to allow the Algebraic and Discrete Mathematical community involved in Pattern Recognition and Image Analysis to know each other better and to have a forum for discussion.

The main lines of scientific interests of TC 16 are connected with mathematical, methodological and technological advances in image analysis and pattern recognition with a special focus on algebra, discrete mathematics, computational topology and machine learning:

- image algebras, descriptive image algebras, image superalgebras, graded image algebras and lattice algebras;
- new mathematical techniques in image mining;
- discrete mathematics techniques;
- descriptive image analysis;
- ill-structured data representation and processing problems;
- multiple classifiers and fusion of algorithms;
- image models, representations and features of non-statistical nature;
- algebraic models of pattern recognition and image analysis algorithms;
- pattern recognition algorithms based on algebras and discrete mathematics;
- image metrics;
- image equivalence;

- algebraic approach to the knowledge representation and processing in pattern recognition and image analysis problems;
- algebraic and logical techniques application in image databases and knowledge bases;
- algebraic topology in data analysis and learning;
- automation of image and data mining:
  - image and ill-structured data analysis;
  - image mining, computer vision and knowledge-based systems;
  - image databases;
  - image mining technologies.

## 1.2 TC Structure and Organization

### **Chair:**

- Dr. Davide Moroni, Institute of Information Science and Technologies (ISTI), National Research Council, Pisa, Italy

### **Vice-Chairs:**

- Prof. Dietrich Paulus, Institute for Computational Visualistics, University of Koblenz-Landau, Koblenz, Germany
- Dr. Vera Yashina, Federal Research Center “Computer Sciences and Control”, Russian Academy of Sciences, Moscow, Russian Federation

### **Honorary Chair:**

- Dr.-Eng. Igor Gurevich, Federal Research Center “Computer Sciences and Control”, Russian Academy of Sciences, Moscow, Russian Federation

### **Scientific Secretary:**

- Dr. Maria Antonietta Pascali, Institute of Information Science and Technologies (ISTI), National Research Council, Pisa, Italy

### **Bureau members:**

- Prof. Dr. Heinrich Niemann, Friedrich-Alexander-University of Erlangen-Nuremberg Erlangen, Germany

- Prof. Dr. Bernd Radig, Munich Technical University, Munich, Germany
- Prof. Dr. Gerhard Ritter, University of Florida, Gainesville, USA
- Prof. Dr. Ovidio Salvetti, Institute of Information Science and Technologies (ISTI) National Research Council, Pisa, Italy

### **1.3 TC website URL**

<https://iapr.org/tc16>

After IAPR webmaster has provided us this URL, it has become the official URL used in communications.

Notice that it redirects towards <http://iapr-tc16.eu/>, a domain that was registered ad hoc and that has no relationship in the name with the institution of the current chair.

### **1.4 Number of members (people on mailing list)**

The mailing list, based on the previous activity of the TC16, has now 1587 members.

### **1.5. Communication means (e.g. newsletters, social media) and frequency**

TC16 regularly publishes about its work in the IAPR Newsletter. The main communication means are represented by the issue of the IAPR newsletter, by the news section on the website and by contribution to the IAPR newsletter. One issue was released after the success of IMTA 2020 (February 2021) and other two issues were released afterwards.

TC16 regularly holds online meetings of the bureau approximately once a quarter.

### **1.6. Listing of key event(s) typically organized by the TC**

The brand name of the main event organized by TC16 is “Image Mining: Theory and Applications” (IMTA). During the reporting period, TC16 organized within the framework of ICPR2020, Milan, January 2021 and ICPR2022, Canada, August 2022: IMTA-VII-2021 and IMTA-VIII-2022. IMTA-VII-2021 and IMTA-VIII-2022 continue the successful series of workshops devoted to modern mathematical techniques of image mining and to corresponding applications:

- IMTA-I-2008, Funchal, Madeira, Portugal, in conjunction with the 3rd International Conference on Computer Vision Theory and Applications (VISAPP 2008);

- IMTA-II-2009, Lisboa, Portugal, in conjunction with the 4th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2009);
- IMTA-III-2010, Angers, France, in conjunction with the 5th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2010);
- IMTA-IV-2013, Barcelona, Spain, in conjunction with the 8th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2013);
- IMTA-V-2015, Berlin, Germany, in conjunction with the 10th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2015);
- IMTA-VI-2018, Montreal, Canada, in conjunction with the 1st International Conference on Pattern Recognition and Artificial Intelligence (ICPRAI 2018).

The workshops were organized jointly by the Technical Committee No. 16 “Algebraic and Discrete Mathematical Techniques in Pattern Recognition and Image Analysis” of the International Association for Pattern Recognition and by the National Committee for Pattern Recognition and Image Analysis of the Russian Academy of Sciences until 2015. The 2018 edition was organized in a period during which TC16 was not active and was managed by the National Committee for Pattern Recognition and Image Analysis of the Russian Academy of Sciences.

Proceedings of IMTA-VII-2021, including all accepted papers were published as a separate book A. Del Bimbo et al. (Eds.): ICPR 2020 Workshops, Springer Nature Switzerland AG 2021, LNCS 12665 (Scopus, Web of Science).

Extended texts of IMTA-VII-2021 selected papers were published in the Special Issue of the international journal of the Russian Academy of Sciences “Pattern Recognition and Image Analysis. Advances in Mathematical Theory and Applications”( ISSN PRINT: 1054-6618, ISSN ONLINE: 1555-6212, see PRIA – <http://pleiades.online> and <http://link.springer.com>) (2021, V. 31, No. 3) (Web of Science, Scopus).

Proceedings of IMTA-VIII-2022, including submitted accepted papers, were published in the Special Issue of the international journal of the Russian Academy of Sciences “Pattern Recognition and

Image Analysis. *Advances in Mathematical Theory and Applications*” (2022, V. 32, No. 3) (Web of Science, Scopus).

Extended texts of IMTA-VIII-2022 selected papers will be published in the LNCS volume by Springer after event.

TC16 together with the National Committee of the Russian Academy of Sciences on Pattern Recognition and Image Analysis organized a permanent International Research Seminar "Image Analysis and Understanding (Mathematical, Cognitive and Applied Problems of Image and Signal Analysis)" on the basis of the Federal Research Center "Computer Sciences and Control" of the Russian Academy of Sciences.

### **1.7. Equality, Diversity and Inclusion Plans**

The main principle that TC16 is guided by in its ethical policy is the absolute equality of rights and obligations of all scientists and specialists related to the activities of TC16. The TC16 is guided by general principles for equality, diversity and universal access to resources and services. On our website, a menu item named EDI Policy has been added in which a statement about our principle and policies is published (see <http://iapr-tc16.eu/index.php/edi>). In particular, it is reported that “the IAPR TC16 opposes all forms of unlawful and unfair discrimination. All scientists are equal to us, independently of gender, race, religion or belief, disability, sexual orientation and any other possible status, including pregnancy and civil partnership.” “All the members of the Technical Committee and all external contributors will be treated fairly and with respect.” “Selection for office or any other benefit within the committee will be based on the skills and ability of the candidates.” “The Technical Committee fully embraces and fosters the overarching principles and EDI policy identified by IAPR as reported in <https://iapr.org/constitution/soe.php>.”

Gender balance is also taken into utmost consideration. The main areas are i) gender balance in apical positions; ii) gender balance in general positions and satellite events; iii) balance between private life and academic work; iv) integration of gender dimensions in research; (v) prevention and contrast of mobbing and harassment.

For area i), as it is imperative in the academic context, a gender balance is sought in the available positions within the TC. Namely, in the current configuration with one chair and two vice-chairs, it

required that there should be at least one member with a gender different from the one of the other two.

No strict requirements are set on the bureau members and the honorary chairs, but, since these positions derive from people who have a prominent role in past TC16 activities, it is expected that it will grow in a balanced way in the years to come. In case of inclusions of new members in the bureau, they will be added at least in pairs, including each time people of a different gender.

For point ii), it is expected to have a general balance in all the activities that require the definition of boards and/or particular members. In the main event associated with the TC 16, a minimum ratio of 1/3 of members with a gender different from the other 2/3 will be compulsory. At the same time, a perfectly balanced situation is encouraged. The same will apply in the selection of invited and keynote speeches as well as in the definition of editors of proceedings and special issues stemming from the activities of the TC.

For point iii), we will seek the balance between work and private life in order not to discriminate against people who might be involved more intensively in care. Meetings should be scheduled well in advance (at least five days) through a mechanism for finding a general consensus schedule and giving the possibility of rearranging, in case, other commitments, both work and private ones.

Point iv) is perhaps the most subtly to be planned and implemented, especially in TC which is oriented towards fundamental research. In any case, characteristic research activities in pattern recognition which can have an impact on a gender-specific domain will be favoured.

Finally, as for v), the TC takes positions against any kind of discrimination and will not tolerate any behaviour that may be considered related to mobbing or harassment, including but not limited to written text in email both public and among TC members and in the occasion of events organized by the TC.

## **2. Activities in the last two years (since ICPR 2020)**

TC16's activities starting in 2020 (18 months of service) and the implementation of plans drawn up at the beginning of 2021 were significantly complicated and limited due to the persistence of COVID19 outbreak and the current international political conjuncture.

### **2.1. Website Updates**

The main activity of TC16 and the organization of TC16 events, including IMTA, is implemented through intensive use of the TC16 website and the placement of call-for-papers, registration of speakers and the like.

In addition, a new name has been registered: the previous url [iapr-tc16.isti.cnr.it](http://iapr-tc16.isti.cnr.it) (which has an explicit reference to the institution of the current chair) is now complemented by [iapr-tc16.eu](http://iapr-tc16.eu).

A page containing the EDI policy has been added.

### **2.2. Conferences/Workshops organized**

The flagship workshop of the TC16 has been proposed for presentation at ICPR 2022 and was accepted. IMTA-VIII workshop will take place as a satellite virtual event of ICPR 2022 (Montreal, Canada) on August 21st.

The main purpose of the IMTA is to provide the fusion of modern mathematical approaches and techniques for image analysis/pattern recognition with the requests of applications using an image as initial data representation.

Participants will enjoy the opportunity to discuss methodological aspects and mathematical and computational techniques for automation of image mining on the base of mathematical theory for pattern recognition and image analysis. The workshop aims at discussing artificial intelligence techniques, in particular, linguistic and knowledge engineering tools for image mining and to estimate the prospects of the algebraic approaches in the representation of image analysis knowledge. The interpretation of mathematical and linguistic techniques will be illustrated by application problems, mainly from biology and medicine, from automation of scientific research, industrial applications and of many other domains generating breakthrough and difficult application tasks.

The program is enriched by a number of invited lectures:

- V.V. Evdokimova, S.A. Bibikov, A.V. Nikonorov “Meta-Learning Approach in Diffractive



Lens Computational Imaging”;

- I.B. Gurevich, V.V. Yashina ” On Modelling of Descriptive Image Analysis Procedures at Specialized Turing Machine”;
- N.Yu. Ilyasova, N.S. Demin “Application of Artificial Intelligence in Ophthalmology for the Diagnosis and Treatment of Eye Diseases”;
- A.V. Khvostikov, A.S. Krylov, I.A. Mikhailov, P.G. Malkov “Visualization of Whole Slide Histological Images with Automatic Tissue Type Recognition”.
- Eduardo Bayro-Corrochano "Algebraic Methods in Color Image Processing"
- P. Frosini "A new approach to topological data analysis and geometric deep learning through group equivariant non-expansive operators"
- G. X. Ritter, G. Urcid “Biomimetic Neural Networks”.

This year we received more than 40 submissions from 11 countries.

The subject of the workshop includes theoretical and applied aspects of a wide class of problems in the following fields:

- (a) extraction, processing, analysis, comparison, clustering, and detection of objects, recognition and assessing image quality;
- (b) signal recognition, including spectral analysis;
- (c) statistical problems, including development of special metrics;
- (d) studies of the mathematical, including algebraic, properties of multimodel image representations;
- (e) methods for constructing, combining, and learning fast multialgorithmic and fuzzy classifiers;
- (f) in-depth study and optimization of convolutional neural networks;
- (g) applied problems of machine vision, artificial intelligence, and machine learning.

The main applied directions of the research reported in the workshop are medical problems - histology, machine tomography, ophthalmology, electroencephalogram analysis, laser coagulation, neoplasm detection, diagnostics of neurodegenerative diseases, diagnostics of cardiac diseases, and other automation problems of medical diagnostics; as well as recognition of audiovisual emotions,

classification of living natural objects, remote sensing, studies of variability of climate change factors, recognition of texts and symbols, document processing, automation of scientific research, and development of intelligent systems.

Analysis of the scientific contribution of IMTA-VIII-2022 allows us to make the following conclusions:

- (1) the construction of a unified mathematical theory of image analysis is still underway;
- (2) the number of contributions devoted to the theoretical aspects of image analysis decreases, which is explained by the commercialization of this direction to the detriment of scientific development; in the future, the organizers of the seminar plan to reduce the number of purely applied presentations and invite authors with theoretical results.
- (3) problems of artificial intelligence are based on the fundamental results of mathematical theories of pattern recognition, machine learning, and image analysis;
- (4) when developing new methods of image analysis and recognition, there is a tendency to expand the mathematical apparatus by involving the areas of mathematics that were not previously used in image analysis (in particular, lattice algebra, Turing machine, and topology);
- (5) the gap between the capabilities of new mathematical methods of image analysis and recognition and their actual use in solving applied problems remains significant;
- (6) there is still an excessive use of neural networks in solving applied problems of image analysis and image recognition, and quite often without proper justification of the solution method and interpretation of the results;
- (7) technological achievements and extended storage capabilities support the growth of large and detailed, albeit possibly noised and damaged, sets of data represented as images;
- (8) methods of intelligent data analysis allow one to extract valuable knowledge from complex, disaggregated, and ill-structured data, which makes it possible to successfully apply them in quite diverse applied fields: medical diagnostics, robotics, technical diagnostics and non-destructive control, precise agriculture, new computer and information systems for support of industrial and information technologies, remote sensing, anthropogenic and environmental forecasting and monitoring, automation of scientific research, and many others.

### **2.3. Promotion of research, publicity and dissemination activities**

The purposes of the TC16 were disseminated at several conferences, including ICCCI 2021 held in Rodes and in public newsletters of the community, including CVML, CVPL (Italian branch of IAPR) and AIXIA. Promotion will also be executed at ICCCI2022, SITIS 2022 and in other forums.

TC16 together with the National Committee of the Russian Academy of Sciences on Pattern Recognition and Image Analysis participates in the publication of the international journal of the Russian Academy of Sciences “Pattern Recognition and Image Analysis. Advances in Mathematical Theory and Applications”( ISSN PRINT: 1054-6618, ISSN ONLINE: 1555-6212, see PRIA – <http://pleiades.online> and <http://link.springer.com>) (Web of Science, Scopus).

All members of the TC16 Bureau and a number of TC16 members are members of the international editorial board of the journal, the honorary chairman of TC16 is the deputy editor-in-chief of the journal. TC16 members participate in reviewing journal articles and recommend authors and articles for publication in the journal, including in open access mode.

The journal is published in English and distributed worldwide by Springer Nature.

The journal regularly publishes special issues dedicated to papers at events organized by TC16.

TC16 regularly publishes about its work in the IAPR Newsletter.

The main activity of TC16 and the organization of TC16 events, including IMTA, is implemented through intensive use of the TC16 website and the placement of call-for-papers, registration of speakers and the like.

#### **2.4. Collaborations with other organizations and TCs**

Thanks to previous contacts of the leader team, connection were established with the MUSCLE WG of the European Consortium of Mathematics and Informatics.

TC16 helps to organize and provides scientific and methodological support for scientific cooperation and joint research projects of TC16 members from various countries, in particular Germany, Italy, the Russian Federation, the USA.

#### **2.5. Other (Dataset Curation, etc.)**

In preparation, expected in 2023.

### **3. Future plans (timeline until ICPR 2024 and beyond):**

#### **3.1. Planned activities**

TC16 Leadership meeting. Due to the current international political situation the possibility of TC16 meeting live is not obvious. TC16 plans to hold at least 4 online meetings per year and a live meeting in Munich. A TC16 core meeting will be scheduled as soon as the general situation will make it possible to travel again. The selected venue will be in Munich, Germany. The meeting will serve to better shape the objectives and emerging research lines relevant to TC16 and will include an in-depth thematic workshop.

Exchange, visits and students. We are looking for opportunities of exchange and visit among the TC16 core members. Funding for this initiative will depend on the specific funding program of the institutions to which the members are affiliated. In Pisa, a PhD program on the themes of TC16 has been started and a grant was offered to a student. It is expected that student mobility will be fostered to activate collaboration and joint publications among the TC16 community.

Summer school. We plan to organize a summer school with a 1-week intense program in mathematical methods for pattern recognition. Possible venues include facilities near to the city of Pisa, which is well linked to several worldwide destinations.

IMTA-IX and large scale events. It is expected to organize the next edition of IMTA in 2023. Specific plans will be made after the evaluation of the impact of the forthcoming edition scheduled for August 21<sup>st</sup>, 2022.

After the abortion of X-OGRW organization, it is planned to re-considered the opportunity of such a meeting as a catalyst of new cooperation among TC16 member and the Italian, German and Russian communities working on mathematical aspects of pattern recognition, however the international political situation make it impossible to make plans at this time.

Clustering with other committees and working groups. It is expected to activate links (in the form of joint events) with the organizers of the Open German Russian Workshop (OGRW) on Pattern Recognition and Image Understanding.

Community building, social identity and white paper. Promotion of the TC16 will be sought using social media and, in particular, creating a LinkedIn group, which seems to be the better choice given the nature of the group. Slack's use will also considered for a more lively sharing of news, recent research and datasets, open positions, and other events.

### **3.2. Recommendation to ExCo for TC leadership team for 2022-2024 term**

During this anomalous term, the current board has made efforts to restart the TC16 successfully. The success of the event IMTA-VII-2020 at ICPR 2020 and then the excellent participation in IMTA-VIII at ICPR 2022 suggests that the performed actions have had a relevant impact in resuming the activities and creating a community interested in the topics of the TC16. Nevertheless, not all the steps already planned reached final results, and they are still work in progress with new difficulties related to the geopolitical crisis that makes the physical organization of events very hard.

For this reason, we suggest confirming the current board for another term so that it can complete what has begun. Notice that the group has served for a period inferior to two terms: indeed the TC leadership team was appointed on March 15th, 2019 and started its activities from scratch in late spring-summer 2019.

The main activity of the TC16 management was devoted to the restoration of the committee's activities after an almost 7-year break caused by reasons beyond the control of the TC16 management. Since the beginning of 2020, the covid19 pandemic has had a significant negative impact on the work of TC16, which, coupled with subsequent international political events, made it impossible to implement a number of plans outlined by the TC16 leadership for these two periods and did not allow them to fully implement their ideas on improving the work of TC16 and uniting the international community interested in development on this basis scientific and technical topics TC16.

In order for the implementation of these ideas and plans of the current leadership of TC16 to be possible, we strongly ask that Dr. Moroni be given a chance and extend his term of office as chairman of TC16 for another term 2022-2024. TC16 Board members give their consent to continue performing their duties for the specified period in the same composition. A formal and motivated request will be sent to the ExCo.

### **3.3. Other Comments (please suggest members of TC for leadership roles such as standing committee memberships, if possible)**

The Honorary chair of TC16 Dr.-Eng. Igor Gurevich is interested in the activities of the committee “The Hall of Fame” and “Publications and Publicity Committee”. The vice-chair Dr. Vera Yashina has already involved in the activities of standing committees, now she is a member of the “Education Committee” and “Membership Committee”. She would be glad to continue these deals, or/and to be

involved in the activities of the “Publications and Publicity Committee” and “Conferences and Meetings Committee”. The Scientific Secretary Maria Antonietta Pascali might be interested in joining a standing committee such as the “Conferences and Meetings Committee” and “Equality, Diversity and Inclusion Committee”.