

# ITAT 2023 Proceedings

23rd Conference on  
Information Technologies – Applications and Theory  
Hotel Hutník I, Tatranské Matliare, Vysoké Tatry, Slovakia

September 22 – 26, 2023

ITAT (Information Technologies – Applications and Theory) is an annual Czech-Slovak conference gathering scientists and experts working within a broad scope of computer science. The conference serves as a platform for workshops focused on results produced by senior scientists and young researchers fostering an exchange of ideas and informal discussions among participants.

ITAT 2023 took place in Hotel Hutník I, Tatranské Matliare, Vysoké Tatry, Slovakia. ITAT 2023 hosted *Workshop on Computational Intelligence and Data Mining*, *Workshop on Natural Computing*, *Workshop on Automata, Formal and Natural Languages*, *Workshop on Bioinformatics and Computational Biology* and *Computational Aspects of Large-Scale Problems in Discrete Mathematics*. In summary, five international workshops provided an extensive overview of many interesting fields of computer science.

The first ITAT was organized in Zuberec in 2001. Accompanying workshops were introduced for the first time in 2013 in Donovaly. The popularity of such workshops has grown over time, attracting more international submissions. Based on this development, the ITAT steering committee in 2019 has decided to discontinue the main track of the conference and transform ITAT into a platform for hosting international workshops. By focusing on a smaller number of areas of interest, we are able to secure internationally recognized expert reviewers in workshop areas, which improve the papers under review and help to increase the quality of future papers by ITAT authors, whether submitting again to ITAT workshops or other international events. Despite its Czech-Slovak origin, workshop organizers open their workshops to participants from other countries.

The members of the steering committee of the ITAT series of conferences:

- Peter Gurský, Pavol Jozef Šafárik University in Košice, Slovakia
- Martin Holeňa, Czech Academy of Sciences, Czech Republic
- Tomáš Horváth, ELTE University, Budapest, Hungary, and Pavol Jozef Šafárik University in Košice, Slovakia
- Markéta Lopatková, Charles University in Prague, Czech Republic
- Tomáš Vinař, Comenius University in Bratislava, Slovakia

The organizing committee of ITAT 2023 worked in the following format:

- Peter Gurský, Pavol Jozef Šafárik University in Košice, Slovakia
- Šimon Horvát, Pavol Jozef Šafárik University in Košice, Slovakia
- Dávid Varga, Pavol Jozef Šafárik University in Košice, Slovakia
- Zoltán Szoplák, Pavol Jozef Šafárik University in Košice, Slovakia

We would like to thank members of the steering committee, the members of the program committees, the organizers of workshops and conference, the authors, the reviewers, and all the other people who significantly contributed to the successful ITAT 2023 conference.

The editors

# 11th International Workshop on Computational Intelligence and Data Mining – IWCIDM 2023 (Preface)

The 11th International Workshop on Computational Intelligence and Data Mining (IWCIDM 2023) has been organized as a part of the ITAT 2023 conference. The workshop is aimed at participants with research interests in any of these areas, but especially at PhD students and postdocs. Interested participants were invited to submit a paper in English, prepared according to the instructions at the ITAT 2023 web page.

At the start of this workshop series, ten years ago, we had only seven regular submissions from two countries. However, the interest in the computational intelligence and data mining workshops has grown over time. This year, we received 11 papers from 6 countries, among which 10 have been accepted for oral presentation and inclusion into the CEUR proceedings.

A key factor influencing the overall quality of the workshop and of the final versions of the submitted papers is the workshop's program committee. We are grateful to 31 reviewers from 15 countries who read the submitted papers and have provided competent, and in most cases very detailed, feedback to their authors. Each paper was reviewed by at least two anonymous reviewers. Most of reviewers have a great international reputation witnessed by hundreds of citations in the Web of Science.

## The Program Committee:

- Petr Berka, University of Economics, Prague
- Daniela Chudá, KiNIT, Bratislava
- Carola Doerr, Sorbonne University, Paris
- Hans Engler, University of Georgetown
- Jan Faigl, Czech Technical University, Prague
- Johannes Fürnkranz, Johannes Kepler University, Linz
- Pitoyo Hartono, University of Chukyo
- Martin Holeňa, Czech Academy of Sciences, Prague
- Andreas Holzinger, Vienna
- Tamás Horváth, Eötvös Loránd University, Budapest
- Ján Hric, Charles University, Prague
- Karel Hron, Palacký University, Olomouc
- Arne Johannssen, University of Hamburg
- Jan Kalina, Czech Academy of Sciences, Prague
- Jiří Kléma, Czech Technical University, Prague
- Georg Kreml, University of Utrecht
- Tomas Krilavičius, Vytautas Magnus University, Kaunas
- Věra Kůrková, Czech Academy of Sciences, Prague
- Philippe Lenca, IMT Atlantique, Brest
- Antoni Łigeza, AGH University of Science and Technology, Krakow

- Rafael Gomes Mantovani, Federal University of Technology, Paraná
- Lauro Cassio Martins de Paula, Brasil Federal University, Bahia
- Mirko Navara, Czech Technical University, Prague
- Ostap Okhrin, Technical University of Dresden
- Irina Perfilieva, University of Ostrava
- Tomáš Pevný, Czech Technical University, Prague
- Petr Pošík, Czech Technical University, Prague
- Jan Rauch, University of Economics, Prague
- Matthias Verbeke, KU Leuven
- Tingting Zhang, Mid-Sweden University, Sundsvall
- Filip Železný, Czech Technical University, Prague

## 4th Workshop on Automata, Formal and Natural Languages – WAFNL 2023 (Preface)

The Workshop on Automata, Formal and Natural Languages was focused on automata, formal languages, natural language processing, as well as on computational linguistics. It was held for the third time as a part of the Information Technologies – Applications and Theory (ITAT 2023) conference on September 25, 2023. The workshop’s main aim was to encourage cooperation among researchers in formal languages and natural language processing in Middle Europe. In order to attract young researchers, master and doctoral students of formal languages and computational linguistics were invited to participate.

The workshop consisted of an invited lecture, a regular papers track, and an open session.

We thank Karel Oliva (Prague, Czech Republic) for accepting our invitation and presenting recent results in his invited talk “Roots of the Tension Between Standard And Vernacular Czech: A Short (and Possibly Surprising) History of Czech Diglossia”.

The regular papers track comprised research papers as well as overview and work-in-progress papers. All such contributions presented new scientific results not published elsewhere. Each submitted paper was reviewed by at least two reviewers. Six papers accepted for the presentation at WAFNL 2023 are included in the proceedings of ITAT 2023.

The poster and open session was organized in order to encourage further cooperation and sharing of information among investigators in automata and natural language processing. This offered an opportunity for anyone to present her/his work without writing a paper. Nevertheless, the text or at least the abstract of all open session contributions are published in separate proceedings available online on the web page of ITAT 2023.

We thank the members of the program committee of WAFNL 2023 for reviewing the submitted papers:

- Gabriela Andrejková, Pavol Jozef Šafárik University, Košice
- Ondřej Dušek, Charles University, Prague
- Jaroslava Hlaváčová, Charles University, Prague
- Markéta Lopatková, Charles University, Prague
- David Mareček, Charles University, Prague
- Peter Mlynářčík, University of Prešov
- František Mráz, Charles University, Prague (co-chair)
- Karel Oliva, Prague
- Friedrich Otto, University of Kassel
- Dana Pardubská, Comenius University, Bratislava (co-chair)
- Martin Plátek, Charles University, Prague (co-chair)
- Martin Procházka, Prague
- Daniel Průša, Czech Technical University, Prague
- Rudolf Rosa, Charles University, Prague
- Alexandr Rosen, Charles University, Prague
- Jana Straková, Charles University, Prague
- Peter Vojtáš, Charles University, Prague

# Workshop on Natural Computing – WNC 2023

## (Preface)

The Workshop on Natural Computing was hosted as part of the ITAT conference on September 23 – 27, 2023, and encouraged especially young researchers and PhD students to present their work and exchange ideas in a collaborative environment of four workshops with inspiring thematic overlaps. During the workshop, contributions were presented in the field of natural computation, i.e. computational processes observed in nature, and human-designed computation inspired by nature. Topics included, e.g.:

- Molecular computing (e.g., DNA computing),
- Cell-inspired computing (membrane computing, amorphous computing),
- Cellular automata, swarm intelligence, nature-inspired algorithms,
- Artificial immune systems, artificial life,
- Synthetic biology, biological networks (genetic networks, protein-protein networks, transport networks),
- Deep learning systems and applications.

All published papers were refereed by at least two anonymous reviewers. Three regular papers were complemented by an invited talk by David Orellana-Martín (University of Seville, Spain) entitled “Parallel virus machines”.

### The WNC 2023 Workshop Program Committee:

- Artiom Alhazov, State University of Moldova
- Luděk Cienciala, Silesian University in Opava
- Lucie Ciencialová, Silesian University in Opava (co-chair)
- Erzsébet Csuha-j-Varjú, Eötvös Loránd University
- Marian Gheorghe, University of Bradford
- Alberto Leporati, Università degli Studi di Milano-Bicocca
- Radka Poláková, Silesian Univerzity in Opava
- Agustín Riscos Núñez, University of Seville
- Petr Sosík, Silesian University in Opava
- György Vaszil, University of Debrecen
- Claudio Zandron, Università degli Studi di Milano-Bicocca
- Gexiang Zhang, Chengdu University of Technology

The editors express their gratitude to the conference organizers, the program committee, the invited speaker, the authors of the papers, the reviewers, and all the participants for their contributions to the success of WNC and ITAT 2023.

# Computational Aspects of Large-Scale Problems in Discrete Mathematics – CADM 2023 (Preface)

CADM 2023 workshop was part of the ITAT conference, which took place in Hotel Hutník I, Tatranské Matliare, Vysoké Tatry, Slovakia, from September 22nd to September 26th, 2023. The aim of the workshop was to bring together young researchers in Discrete Mathematics whose work has a significant computational component or includes problems of significant computational complexity. Participants were generally expected to prepare a short article about the specific computational aspects of problems they consider in their research and to present a 20 minute talk based on this article. However, it was also possible to participate by presenting a 20 minute talk accompanied by a short abstract in place of the article, or simply to attend without presenting a talk. On-site collaboration and exchange of ideas, techniques, tricks or hints was particularly encouraged. Doctoral students presenting preliminary reports on their work, wishing to learn more about problems of computational character, or simply looking for inspiration, were specifically encouraged to apply.

All topics involving computational aspects or actual use of computers in Discrete Mathematics were considered. Each submitted contribution was reviewed by two members of the Programme Committee and evaluated with regard to the relevance of the topic, the originality of the use of the computing techniques, and the contribution's potential in becoming a topic of shared interest among the participants of the workshop. All published papers were refereed by at least two anonymous reviewers.

We thank Kolja Knauer (Universitat de Barcelona, Spain) for accepting our invitation and presenting recent results in his invited talk “Some problems in Cayley graphs and computational approaches”. In addition, we thank Primož Šparl (University of Ljubljana and University of Primorska, Slovenia) for accepting our invitation and presenting recent results in his invited talk “When theoretical results and computer power join forces”.

## The Program Committee:

- Marien Abreu, Universita degli Studi della Basilicata, Italy
- Grahame Erskine, Open University, UK
- Geoffrey Exoo, Indiana State University, USA
- Jan Goedgebeur, KU Leuven, Belgium
- Štefan Gyurki, Slovak Technical University, Slovakia
- Tatiana Jajcayová Comenius University, Slovakia co-chair
- Robert Jajcay, Comenius University, Slovakia co-chair
- Jan Karabáš, Matej Bell University, Slovakia
- František Kardoš, Comenius University, Slovakia; Université de Bordeaux and LaBRI
- György Kiss, Eötvös Lóránd University, Budapest
- Petr Kovář, Technical University of Ostrava, Czech Republic
- Tereza Kovářová, Technical University of Ostrava, Czech Republic
- Rastislav Kráľovič, Comenius University, Slovakia
- Edita Máčajová, Comenius University, Slovakia
- Primož Šparl, University of Ljubljana, Slovenia
- James Tuite, Open University, UK

# Workshop on Bioinformatics and Computational Biology – WCBC 2023 (Preface)

The Workshop on Bioinformatics and Computational Biology was held at Hotel Hutník in Tatranské Matliare, Vysoké Tatry, Slovakia on September 22 – 23rd, 2023 as part of the ITAT conference. While the conference is a traditional forum for Slovak and Czech computer scientists, the workshop follows a more recent tradition of a relatively irregular extension of topics into the realm of bioinformatics and computational biology. Similarly to the main conference (ITAT), it serves as a platform for the exchange of ideas in a friendly but stimulating environment. The workshop allows younger researchers to meet their more seasoned colleagues in an informal setting, sparking discussions that would be hard to initiate elsewhere. For example, the settings often allow for a short hiking trip in the Slovak mountains. This year the organizers secured a keynote speaker from North America and also reached out with invitations to colleagues from neighboring countries, giving the workshop a more international tone.

The workshop program included 14 talks covering 5 papers and 9 abstracts on topics mostly related to:

- Algorithmic approaches to sequencing data analysis
- Algorithmic approaches and data structures in genome representation
- Molecular modeling
- Bioinformatics of repetitive sequences, and
- Medical bioinformatics

All published papers were reviewed by at least three anonymous reviewers and complemented by an invited talk by Travis Gagie (Dalhousie University, Halifax, Nova Scotia, Canada), entitled “Flexible grammar-based indexes”.

## The Program Committee:

- Broňa Brejová, Comenius University in Bratislava, co-chair
- Matej Lexa, Masaryk University in Brno, co-chair
- Vladimír Boža, Comenius University in Bratislava
- Jaroslav Budiš, Geneton, Bratislava
- Krisztian Buza, Eötvös Loránd University
- Vojtěch Bystrý, Central European Institute of Technology, Brno
- Luca Denti, University of Milano-Bicocca
- Norbert Dojer, University of Warsaw
- Askar Gafurov, Comenius University in Bratislava
- Mária Lucká, Comenius University in Bratislava
- Szabolcs Makai, Semmelweis University
- Jan Oppelt, University of Pennsylvania
- Karol Pál, Pennsylvania State University
- Agnieszka Rybarczyk, Poznan University of Technology



- Tomáš Vinař, Comenius University in Bratislava
- Martina Višňovská, Oslo University Hospital
- Filip Železný, Czech Technical University in Prague