ITAT 2020 Proceedings

20th Conference on
Information Technologies – Applications and Theory
Hotel Tyrapol, Oravská Lesná, Slovakia.

September 18–22, 2020

1 Preface

ITAT (Information Technologies – Applications and Theory) is a traditional Czech-Slovak conference gathering scientists and experts working within a broad scope of computer science. ITAT conference offers not only a platform for workshops focused on scientific results of scientists, young researchers and PhD. students, but includes also a possibility to exchange the important ideas, fruitful information, informal communication and discussions among participants.

The first ITAT was organized in Zuberec in 2001. After 12 years of annual conference, in 2013 in Donovaly, several small accompanying workshops were introduced as a part of the conference for the first time. The popularity of such workshops has grown in the following years and they also started to attract more international submissions. Based on this development, the ITAT steering committee has decided to discontinue the main track of the conference and transform ITAT to the collection of specialized international workshops. This change was symbolically taking place 2019 in Donovaly, where the workshops were introduced for the first time in 2013. We strongly believe that by focusing on smaller number of areas of interest we are able to secure internationally recognized expert reviewers in workshop areas which, in turn, not only improve the papers under review but also contribute to a higher quality of future papers by ITAT authors, whether submitting again to ITAT workshops or to other international events. Despite its Czech-Slovak origin, due to increased interest, workshop organizers have got the opportunity to open their workshops for participants from other countries as well.

This year, the conference ITAT 2020 takes place in Hotel Tyrapol, Oravská Lesná, Slovakia. Due to the actual epidemiological situation, several researchers participate at the conference also online. However, it does not decrease the interest and enthusiasm of researchers, and the quality of submitted and presented contribution. As the main result, we are very delighted that the traditional

Workshop on Computational Intelligence and Data Mining have been complemented by *Workshop on Natural Computing, Workshop on Automata, Formal and Natural Languages*, and *Workshop on Numeration and Substitution Systems*. In summary, four international workshops provide an extensive overview of many interesting fields of computer science.

The members of 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, Commenius University in Bratislava, Slovakia

This year, the organizing committee of ITAT 2020 works in the following format:

- Peter Gurský, Pavol Jozef Šafárik University in Košice, Slovakia

- Alexander Szabari, Pavol Jozef Šafárik University in Košice, Slovakia

- Richard Staňa, Pavol Jozef Šafárik University in Košice, Slovakia

- Lubomir Antoni, Pavol Jozef Šafárik University in Košice, Slovakia

We would like to thank the members of steering committee, the members of program committee, the organizers of workshops and conference, the authors, the reviewers, and all the other people who significantly contributed to the successful ITAT 2020 conference.

The editors

2 8th International Workshop on Computational Intelligence and Data Mining – WCIDM 2020 (preface)

As a part of the workshop bundle ITAT 2020, the 8th international workshop "Computational Intelligence and Data Mining" has been organized. It is aimed at participants with research interests in any of these related areas, especially at PhD students and postdocs. Interested participants were invited to submit a paper in English of up to 8 double-column pages, prepared according to the instructions at the ITAT 2020 web page.

As this workshop started, 7 years ago, it had only 7 regular submissions from 2 countries. However, the interest in the computational intelligence and data mining workshops has been gradually increasing since that time till 2019. This year, due to the difficult pandemic situation, we received one paper less than a year ago – altogether 14 papers from 3 countries.

A key factor influencing the overall quality of a workshop and of the final versions of the submitted papers is the workshop's program committee. The 8th international workshop "Computational Intelligence and Data Mining" is grateful to the 30 reviewers from 11 countries who read the submitted papers and have provided competent, and in most cases very detailed, feedback to their authors. Most of them have a great international reputation witnessed by hundreds of WOS citations.

- Dirk Arnold, University of Dalhousie

- Petr Berka, University of Economics, Prague

- Ricardo Cerri, Federal University of Sao Carlos

- Carola Doerr, Sorbonne University, Paris

- Hans Engler, University of Georgetown

- Jan Faigl, Czech Technical University, Prague

- Rafael Gomes Mantovani, Federal Techonology Universitz, Paraná

- Pitoyo Hartono, University of Chukyo

- Martin Holeňa, Czech Academy of Sciences, Prague

- Tomáš Horváth, Eötvös Loránd University, Budapest

- Ján Hric, Charles University, Prague

- Arne Johanssen, University of Hamburg

- Jan Kalina, Czech Academy of Sciences, Prague

- Jiří Kléma, Czech Technical University, Prague

- Georg Krempl, University of Utrecht

- Tomas Krilavičius, Vytautas Magnus University, Kaunas

- Chandresh Kumar Maurya, Indian Institute of Technology, Roorkee

- Věra Kůrková, Czech Academy of Sciences, Prague

- Philippe Lenca, IMT Atlantique, Brest

- Johannes Lengler, ETH Zürich

- Antoni Ligęza, AGH University of Science and Technology, Krakow

- Engelbert Memphu Nguifo, Blaise Pascal University, Clermont-Ferrand

- Mirko Navara, Czech Technical University, Prague

- Ostap Okhrin, Technical University of Dresden

- Tomáš Pevný, Czech Technical University, Prague

- Petr Pošík, Czech Technical University, Prague

- Jan Rauch, University of Economics, Prague

- Heike Trautmann, University of Münster

- Thomas Weise, University of Hefei

- Tingting Zhang, Mid-Sweden University, Sundsvall

- Filip Železný, Czech Technical University, Prague

3 Workshop on Natural Computing – WNC 2020 (preface)

The Workshop on Natural Computing was organized as a part of the Conference ITAT on September 20–22, 2020, encouraging especially young researchers and PhD students to present their work and exchange ideas in the joint environment of four workshop with inspiring thematic overlaps. Submissions were obtained in the area of natural computing, i.e., computational processes observed in nature, and human-designed computing inspired by nature. Topics included:

- Cell-inspired computing (membrane computing, P colonies)

- Swarm intelligence, nature-inspired algorithms

- Bio-inspired grammatical models of complex systems (e.g., grammar systems, Lindenmayer systems)

- Deep learning systems and applications

Eight regular talks were completed with two invited talks by Alica Kelemenová (Variants of grammar systems - motivations and problems) and Erzsébet Csuhaj-Varjú (P Systems: Bio-inspired Computational Models for Complex Systems)

The program committee of WNC 2020:

- Luděk Cienciala, Silesian Univerzity in Opava

- Lucie Ciencialová, Silesian University in Opava

- Erzsébet Csuhaj-Varjú, Eötvös Loránd University

- Marian Gheorghe, University of Bradford

- Ladislav Huraj, University of SS. Cyril and Methodius in Trnava

- Alica Kelemenova, Silesian University in Opava (co-chair)

- Alberto Leporati, Università degli Studi di Milano - Bicocca

- Andrei Paun, University of Bucharest

- Mario J. Pérez Jiménez, University of Seville

- Agustín Riscos-Núñez, University of Seville

- Jose M. Sempere, Universitat Politècnica de València

- Petr Sosík, Silesian University in Opava (co-chair)

- Martin Stepnicka, University of Ostrava

- György Vaszil, University of Debrecen

- Gexiang Zhang, Chengdu University of Technology

4 Workshop on Automata, Formal and Natural Languages – WAFNL 2020 (Preface)

Workshop on Automata, Formal and Natural Languages is an international workshop focused on Automata, Formal Languages, Natural Language Processing and Computational Linguistics. Its main aim is to encourage cooperation among formal language researches and Natural Language Processing researchers in Middle Europe; we therefore also invite Master and Doctoral students of formal languages and computational linguistics to participate. The workshop is part of the ITAT conference. The date of the workshop itself is from September 18th to September 20th, 2020.

The workshop consists of regular papers track, overview and work-in-progress papers track and an open session. A regular paper presents new scientific results not published elsewhere. Each paper is reviewed by 2 reviewers. Overview papers summarize the research of the author(s) from a higher level of perspective and work-in-progress papers with preliminary results, even negative results papers are welcome here. To further encourage cooperation and sharing of information among automata and Natural Language Processing researchers, we offer an opportunity for anyone to present her/his work, without writing a paper.

We have the invited talk by Friedrich Otto, University of Kassel (25 Years of Restarting Automata: Lots of Results and Open Problems).

The program committee of WAFNL 2020:

- Martin Plátek (KTIML MFF UK, Praha), main organizer

- Dana Pardubská (KI UK, Praha), main organizer

- Frantisek Mráz (KSVI MFF UK, Praha), main organizer

- Daniel Průša (KK FEL ČVUT, Praha)

- Markéta Lopatková (ÚFAL MFF UK, Praha)

- Rudolf Rosa (ÚFAL MFF UK, Praha),

- Ondřej Dušek (ÚFAL MFF UK, Praha),

- Karel Oliva (Praha)

- David Mareček (ÚFAL MFF UK, Praha)

- Alexandr Rosen (ÚTKL FF UK, Praha)

- Alexander Szabari (UINF PF UJPŠ, Košice)

- Jaroslava Hlaváčová (ÚFAL MFF UK, Praha)

- Friedrich Otto (Kassel, Germany)

- Tatiana Jajcayová (FMFI UK, Bratislava)

5 Workshop on Numeration and Substitution Systems – NSS 2020 (Preface)

The Workshop on Numeration and Substitution Systems aims to bring together researchers interested in interactions between numeration systems, ergodic theory, number theory and combinatorics. The topics include

- General numeration systems, abstract number systems

- Arithmetic algorithms in non-standard numeration systems

- Transcendence (algebraicity) results related to numeration

- Analytic and probabilistic study of arithmetic functions

- Automata related to numeration, sums of digits, automatic sequences

- Continued fractions and their generalization Substitutive dynamical systems, self-affine tilings

The workshop is held on September 18–19, 2020. The researchers from abroad participate also online. Since the workshop had no paper submission procedure, only the titles and the speakers of the presentations discussed during the workshop are included in the proceedings. In total 9 contributions are discussed. Moreover, we have also the invited talk by Francesco Dolce (Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague) called Interval Exchange Transformations: from Symbolic Dynamics to Combinatorics.

The program committee of NSS 2020:

- Petr Ambrož (FNSPE, Czech Technical University in Prague)

- Jaroslav Hančl (FS, University of Ostrava)

- Tatiana Jajcayová (FMFI, Comenius University in Bratislava)

- Jan Legerský (FIT, Czech Technical University in Prague)

- Zuzana Masáková (FNSPE, Czech Technical University in Prague)