Special Issue
Developments in Language Theory (DLT 2017)
Preface
Guest Editors

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This special issue of the International Journal of Foundations of Computer Science contains eight papers, which are revised and extended versions of the papers selected from the 21st International Conference on Developments in Language Theory (DLT 2017) that was organized by the University of Liège, Belgium, during August 7–11, 2017. The DLT conference series is one of the major international conference series in formal language theory and related areas. The Developments in Language Theory (DLT) conference was established by G. Rozenberg and A. Salomaa in 1993. Since then, the DLT conferences were held in every odd year: Magdeburg, Germany (1995), Thessaloniki, Greece (1997), Aachen, Germany (1999) and Vienna, Austria (2001). Since 2001, a DLT conference takes place in Europe in every odd year and outside Europe in every even year. The locations of DLT conferences since 2002 were: Kyoto, Japan (2002), Szeged, Hungary (2003), Auckland, New Zealand (2004), Palermo, Italy (2005), Santa Barbara, California, USA (2006), Turku, Finland (2007), Kyoto, Japan (2008), Stuttgart, Germany (2009), London, Ontario, Canada (2010), Milano, Italy (2011), Taipei, Taiwan (2012). Marne-la-Valle, France (2013), Ekaterinburg, Russia (2014), Liverpool, UK (2015), Montréal, Canada (2016).

The series of International Conferences Developments in Language Theory provides a forum for presenting current developments in formal languages and automata. Its scope is very general and includes, among others, the following topics and areas: combinatorial and algebraic properties of words and languages; grammars, acceptors and transducers for strings, trees, graphs, arrays; algebraic theories for automata and languages; codes; efficient text algorithms; symbolic dynamics; decision problems; relationships to complexity theory and logic; picture description and analysis; polyominoes and bidimensional patterns; cryptography; concurrency; cellular automata; bio-inspired computing; quantum computing.

This special issue contains a selection of eight contributions selected from 23 papers originally presented at DLT 2017 and 5 invited lectures. We would like to thank all the reviewers of the papers submitted to this special issue for their precious

comments. We also thank Oscar H. Ibarra, Chief Editor of IJFCS, for his help with the preparation of this special issue. We once again thank our main sponsors: University of Liège (Faculty of Sciences and Research Unit in Mathematics) and the national funds for research F.R.S.–FNRS.

Let us present the different contributions by alphabetical order of the first author. The paper "*Operational State Complexity and Decidability of Jumping Finite Automata*" by Simon Beier, Markus Holzer and Martin Kutrib studies the state complexity of standard language-theoretic operations, e.g. intersection, complement and inverse homomorphisms, and decidability results on Jumping Finite Automata (JFA). Such a device is given as a non-deterministic finite automaton, but when reading a word, a JFA can consume a letter at any position in that word. One can thus think of JFA reading words from the commutative monoid over a given alphabet, or, equivalently, Parikh images of words over the free monoid. Such devices were initially studied by Huynh as commutative grammars in the 1980s and received renewed attention over the last ten years.

The paper "*Lower Bounds for Synchronizing Word Lengths in Partial Automata*" by Michiel de Bondt, Henk Don and Hans Zantema presents a number of experimental and theoretical results about synchronization of deterministic automata in both complete (DFA) and partial (PFA) cases. The authors provide a complete check of all synchronizing DFAs and carefully synchronizing PFAs with small numbers of states and arbitrary number of letters with the goal of identifying examples requiring the largest number of steps to synchronize. The search among PFAs leads to extremal examples of carefully synchronizing automata. They also provide examples based on rewriting systems of several infinite series of PFAs over two and three letter alphabets with the exponential growth rate of the shortest carefully synchronizing words.

In the paper "*On a Greedy Algorithm to Construct Universal Cycles for Permutations*" by Alice L.L. Gao, Sergey Kitaev, Wolfgang Steiner and Philip B. Zhang, the authors give a construction of a universal cycle for permutations of length n, i.e. a permutation that contains each permutation of length n exactly once as a factor. They also analyze properties of this universal cycle and compare it to other universal cycles.

The expressiveness of context-free grammars is not sufficient to handle context-free dependences of programming and natural languages. For that reason several different types of grammars controlling the use of context-free rules have been introduced and studied in formal languages theory. Semi-conditional grammars are such a type of grammars where every context-free rule is assigned two singleton sets where the elements are called the permitting and the forbidding contexts. The rule is then applicable to a sentential form if the sentential form contains the permitting context as a subword and at the same time it does not contain the forbidding context as a subword. In the paper "*A Pumping Lemma for Permitting Semi-conditional Languages*" by Zsolt Gazdag, Krisztián Tichler and Erzsbet Csuhaj-Varj, the authors study the expressive power of a variant of semi-conditional grammars where

the forbidding context of every rule is the empty set. They generalize these grammars so that they do not require that the permitting context is a singleton set. The expressive power of permitting semi-conditional grammars is a longstanding open problem. The authors solved this problem as a consequence of a more general result they proved in the paper.

Next, the paper "*On the Interplay Between Černý and Babai's Conjectures*" by François Gonze, Vladimir V. Gusev, Raphaël M. Jungers, Balázs Gerencsér and Mikhail V. Volkov, is on the reset threshold of automata whose input letters generate the full monoid of transformations of the state set of the automaton. The fundamental problem on synchronizing automata is Černýs conjecture, which states that the reset threshold (length of a shortest reset word) of a synchronizing automaton is at most $n(n1)/2$. This problem has been open for a very long time, so much work has been done to study reset thresholds for certain subclasses of automata. In this paper, the authors restrict themselves to automata whose transformation monoids are the full transformation monoid. In that case, the authors provide a upper bound of $2n^26n + 5$ on the reset threshold. They also provide a $n^2/4 + o(n^2)$ lower bound on the size of the pair digraph for the symmetric group S_n.

In the paper "*Descriptional Complexity of the Forever Operator*" by Michal Hospodár, Galina Jiráková, and Peter Mlynárčik, the authors study the descriptional complexity of a combined operator called the "forever" operator which was initially studied by Birget in 1996. They solve the non-deterministic state complexity of the forever operator which has been an open problem stated by Birget. Given a language L described by complexity of six automata models, they study all possible state complexity for accepting f_L by the six automata models. The six models of automata include complete DFAs, incomplete DFAs, NFAs, BFAs, AFAs, and NFAs with multiple initial states (NNFAs). They establish the precise state complexity for 32 cases out of 36 possible cases.

In the paper "*The Generalized Rank of Trace Languages*" by Michal Kunc and Jan Meitner, the authors generalize the notion of rank to sequences of words. After a study of this notion in a general setting, they focus on the growth of the rank with respect to the length of the sequence (so-called rank sequences). After providing a general asymptotic lower bound (for unbounded such sequences), they study in detail the case where the complement of the relation I is transitive (the quotient of A^* by I then being a finite product of free monoids). In that case, the authors entirely characterize the occurring rank sequences. They also consider the case where the relation I is transitive (the quotient of A^* by I then being a free product of free commutative monoids). In that case, the authors unveil a relationship with min-plus rational series.

Finally, the paper "*Characterization of infinite LSP words and endomorphisms preserving the LSP property*" by Gwenaël Richomme studies in detail LSP words, i.e. words having all their left special factors as prefixes. Finite LSP words were studied previously by G. Fici. The author provides an S-adic characterization of infinite LSP words. He introduces a nice and simple class S of morphisms, called

R-bLSP morphisms, such that an infinite word is LSP if and only if it is recursively desubstitutible by morphisms from this set S and the sequence of morphisms thus obtained is recognized by some automaton. In other words, LSP words are S-adic words whose directive sequences are recognized by the automaton. No matter what set S of morphisms is used some automaton is required to exclude some directive words.