

Habilitation Thesis Reviewer's Report

Masaryk University

Faculty	Faculty of Informatics
Procedure field	Informatics
Applicant	RNDr. Tomáš Masopust, Ph.D., DSc.
Applicant's home unit, institution	Palacky University in Olomouc
Habilitation thesis	Partially Ordered Automata - Expressivity, Complexity, and Applications
Reviewer	Prof. Jiří Srba, PhD
Reviewer's home unit, institution	Department of Computer Science, Aalborg University, Denmark

Thesis overview

The submitted habilitation thesis studies the expressiveness and computational complexity of selected problems from formal languages, in particular related to partially ordered automata where the only allowed loops in the transition diagram are self-loops. The thesis contains a large collection of nontrivial results including the state complexity of the reverse of partially order deterministic finite automata and the characterisation of R-trivial and piecewise testable languages, including the checking of piecewise testability for several different subclasses of nondeterministic finite automata. A particularly studied problem is the separation problem that asks whether two languages can be separated by a language from a given family of languages (e.g. piecewise testable ones) so that one of the languages is included in the separation language while the other one has an empty intersection with the separation language. One of the major contributions of the thesis is the so-called “tower property” that defines a particular infinite sequence of words that alternate between the two languages that we aim to separate. If the tower property holds for two regular languages then they cannot be separated by any piecewise testable language. This property can be decided in polynomial time and the problem is shown to be P-complete. The thesis further refines this result by studying descriptiveness and provides estimates on the number of states of the automaton describing the separation language. The thesis contains also numerous results related to the complexity of

the universality problem for subclasses of partially ordered automata. These results are closely related to the inclusion and equivalence problems. Applications of the theory are explained on deterministic regular expressions, detectability and opacity problems.

This habilitation thesis contains a comprehensive summary on the first 50 pages, introducing the basic notation and background in Sections 2 and 3, followed by the results on separability in Section 4, complexity of the universality problem in Section 5 and the study of piecewise testable languages in Section 6. The thesis summary is finished by connecting the theoretical results to possible application domains in Section 7 and concludes with Section 8. After this summary, the thesis includes selected publications of the author related to the results mentioned in the thesis (pages 54 to 245).

Summary of publications

The thesis is based on a collection of 12 papers published primarily in highly reputable outlets, including leading conferences like ICALP and MFCS (2 publications) and competitive journals such as Information and Computation and Theoretical Computer Science. Tomáš Masopust is the leading author in majority of the publications, working typically in smaller teams with one or two other co-authors and he is the solo author of three publications. This clearly demonstrates his significant contributions to the research contained in this habilitation thesis. The publications are of high quality and match the expected international standards.

Evaluation

The results contained in the thesis are of primarily theoretical nature, focusing on introducing tight complexity bounds and completing the existing results by closing the remaining complexity gaps, with a particular focus on the problems over a fixed-size alphabet. The achieved results are novel, nontrivial and technically well presented. The thesis has a high level of technical precision and the results are of general interest in the formal language community, as documented by a number of publications in renowned venues. I appreciate the last chapter that highlights the possible application domains for the theoretical results and contains also some novel (yet unpublished) results on opacity. In conclusion, the thesis fulfils the international standards both in terms of quality and well as quantity and I recommend this habilitation thesis for a public defence.

Reviewer's questions for the habilitation thesis defence

Can you see some possible benefits of the notion of separability applied to classes of languages described by more expressive formalisms like e.g. pushdown automata or Petri nets, in particular in connection with model checking?

Can the notion of partially ordered automata be extended to other formalisms like visibly pushdown automata, timed automata or to the game setting in order to define practically motivated subclasses with faster verification algorithms?

What are the main unsolved challenges that you would like to work on in the future?

Conclusion

The habilitation thesis entitled “Partially Ordered Automata - Expressivity, Complexity, and Applications” by Tomáš Masopust *fulfils* requirements expected of a habilitation thesis in the field of Informatics.

In Aalborg, Denmark on March 28th, 2021

