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Review of the PhD thesis of Vojtech Havlena (Brno University of Technology).

- 1. Is the topic appropriate to the particular area of dissertation and is it up-to-date from the viewpoint of the present level of knowledge?*

Broadly speaking, this dissertation explores new methods to improve the performance of algorithms for computationally hard problems in automata theory (and related logic problems like WS2S). Since the complexity of these problems is known and worst-case optimal algorithms already existed, the focus is on improving the performance in practice and on building efficient software tools. The methods include approximations, heuristics, subsumption and problem transformations, in order to reduce the computational overhead in many practical cases.

This is an important area of research and the results make several central problems in automata theory and formal verification more tractable in practice.

The description of (and the comparison to) related work is extensive, very clear and well written and up-to-date. The new contributions are state of the art, in the sense that they provide new insights and improve upon the best performance of previously existing tools in at least some classes of problem instances (though not necessarily in all instances).

- 2. Is the work original and does it mean a contribution to the area - specify where the original contribution lies?*

The thesis contains a large body of work on several different problem areas: Approximate NFA minimization and its application in network traffic monitoring (part 1), new algorithms for deciding WSkS and string constraint systems (part 2) and Buchi automata complementation (part 3).

In some cases (particularly parts 1 and 3) it clearly improves upon the performance of existing tools. For part 2, it

improves upon the performance (of the well established reference tool MONA) in some particular cases, though not in general. This is partly due to the fact that MONA has been developed and optimized over many years. Still, part 2 contains many interesting new ideas that may find application in future tools.

Generally speaking, this work has an engineering flavor with a clear focus on tools, i.e., finding new ways to improve the performance in practice. It does not establish many deep theoretical results. However, even so, the correctness proofs of the described new techniques are interesting in their own right and not trivial.

3. *Has the core of the doctoral thesis been published at an appropriate level? (The doctoral thesis is required to include reprints or copies with complete bibliographies. A receipt as a proof of admission for publishing at a prestigious forum could also be acceptable.)*

The results in this thesis have been published in several papers in good international conferences and journals (8 conference papers and 3 journal papers), and it clearly made a substantial contribution to the knowledge in this field.

4. *Does the list of the candidate's publications imply that he is a person with an outstanding research erudition?*

The candidate's publication record is impressive, with 11 papers published. However, it should be noted that these papers have 3-6 authors, so they are the joint work of several people. In particular, besides the supervisors T. Vojnar and O. Lengal, also L. Holik was a co-author in many of the candidate's papers. This is not very surprising, since this engineering-style line of research and tool building requires the collaboration of a larger number of researchers.

The candidate describes his level of contribution to each of these papers in Section 13.2 of the thesis, and I have no reason to doubt that his contribution to the presented work is very substantial.

5. More characteristics of the candidate.

Besides his theoretical work, the candidate has made large contribution to the implementation of the six software tools described in the thesis.

He has presented some papers at conferences, refereed papers for conferences, collaborated internationally with colleagues (e.g., in Taiwan and Sweden) and done some teaching at Brno University of Technology.

This shows that the candidate is an active and competent researcher.

To conclude, this doctoral thesis clearly meets the requirements of the proceedings leading to PhD title conferment.

Sincerely,

Dr. Richard Mayr
(Edinburgh, 22. Oct. 2021)

Some small technical comments on the thesis:

Page 19, line 11: Confusion of the terms “coarse” and “fine”. A binary relation is coarser if it is larger (by set inclusion) than another relation. It is finer if it is smaller. Thus coarser/larger equivalence relations have fewer equivalence classes and thus a smaller quotient. Simulation is coarser than bisimulation, and bisimulation is finer than simulation.

Throughout Part I: Rather cite [206] than [205].

Page 66, The automata-based decision procedure, item (i): You need to transpose the vector to obtain a scalar after the product (since b is a scalar).

Page 67: “Presburger” should be capitalized.

Pages 91-107: It is nice to explore the antiprenexing on its own. However, your experiments are not very extensive.

Part III: The experiments are extensive, but the results do not show a very clear trend. It might be interesting to explore why certain algorithms perform better than other on certain classes of instances.

In several places in the thesis: You wrongly use the word “haunt” when you probably mean “hunt”. However, “search” would be a more meaningful term in this context.