MUNI

Annex No. 10 to the MU Directive on Habilitation Procedures and Professor Appointment Procedures

HABILITATION THESIS REVIEWER'S REPORT

Masaryk University	
Applicant	RNDr. Petr Novotný, Ph.D.
Habilitation thesis	Code and Design Safety of Probabilistic Systems
Reviewer	**Assoc. Prof. Dr. Nils Jansen**
Reviewer's home unit, institution	Radboud University, Netherlands

Review of the habilitation thesis

Summary of the thesis

This thesis, entitled "Code and Design Safety of Probabilistic Systems", subsumes a number of articles that have been previously published by the author, and habilitation candidate, Petr Novotný. The thesis centres around the area of formal safety analysis for probabilistic systems. Specifically, the two main concepts of the thesis are "code safety" and "design safety". Here, code safety refers to the correctness of probabilistic programs, and design safety refers to the design of safe probabilistic systems. In the 'commentary on the enclosed publications', the author provides an introduction to notation and necessary formalisms and lies out the central concepts of code and design safety. Importantly, general technical problems like supermartingales or partially observable Markov decision processes are introduced.

The concrete contributions of the thesis are provided in the form of nine previously published journal articles or articles that appeared in conference proceedings. Among those contributions, six are related to the topic of code safety, and three relate to the topic of design safety.

Assessment of the quality of the habilitation candidate

According to the document provided by the habilitation committee, the candidate directly satisfies all necessary criteria to obtain the habilitation degree. Particularly, the number of peer-reviewed results, according to dblp, is 28, while only 15 results are required. The number of citations, excluding self-citations, counts at least 141, while only 40 of such citations are required. Generally, the candidate is an excellent and well-known researcher with a large number of collaborators from all over the world. To substantiate this statement, according to dblp, the candidate has co-authored articles with over 40 different authors. I also see it as a strong asset of the candidate that he has published across various domains, such as programming languages, formal methods, and artificial intelligence.

Assessment of the thesis document

The submitted thesis is, according to the specified thesis type, a 'collection of previously published…works…'. I want to, however, argue that this document has significantly more

value than a mere collection of articles would. In the 'commentary on the enclosed publications', the author provides an introduction and overview of the contributions that goes over 60 pages. I think that this overview is a great document that can readily be provided to starting researchers who would like to, for instance, receive an introduction to the area of probabilistic program verification. Generally, both the motivational and the technical parts are carefully worked out and shine with a high level of consistency.

Assessment of the contributions

The contributions that are listed in this thesis are generally of extremely high quality. As a first substantiation of this excellence, they are all published in highly competitive and important journals or venues from the areas of programming language, formal methods, or artificial intelligence. For example, several articles are published at POPL or PLDI, the premier programming languages venues. Similarly, several works are published at AAAI or IJCAI, the most important venues for artificial intelligence.

In the first identified main concept of the thesis, referred to as code safety, the author focuses on fundamental research regarding the automated verification of probabilistic systems. In particular, the author's work coined the use of martingales towards the verification of important problems in program analysis, such as (here: almost-sure) termination. The contributions range from strong theoretical contributions, such as complexity results, over algorithmic advances, towards the basis for practical algorithms.

In the second main concept, referred to as design safety, the author focuses on the analysis of problems that exhibit uncertainty in the form of probabilities and partial observability. The standard models to capture such problems are partially observable Markov decision processes (POMDPs). For these models, the thesis provides results that are generally concerned with providing hard or probabilistic guarantees on the behavior of (autonomous) agents. Such guarantees have, for a long time, been overlooked by the artificial intelligence community, and the candidate belongs to a circle of pioneers pushing towards guaranteed-to-be-safe behavior in the general field of decision-making under uncertainty.

To summarize, the contributions are strong, have been published at high-profile venues under strong competition, and provide the basis for a plethora of further research.

Reviewer's questions for the habilitation thesis defence (number of questions up to the reviewer)

1. Please elaborate on the notion of safety in general. The term is generally used in an ambiguous way and deserves more explanation. For instance, in AI, safety often refers to the fact that an algorithm 'safely' returns a desired result with high confidence. Contrary, in safety research, it may really refer to disastrous events. In the area of formal methods, it often refers to the satisfaction of some temporal logic formula.
2. In the settings concerning POMDPs, is it assumed that observations are always correct, or may there be a probability that the perceived observation is the wrong one? Is there a way to capture such 'adversarial' observations in the proposed frameworks?
3. How does the work on correctness and safety for POMDPs relate to the general area of Safe Reinforcement Learning?

Conclusion

Both the candidate's profile and the thesis document are excellent, and I strongly recommend the candidate for habilitation.

The habilitation thesis entitled "Code and Design Safety of Probabilistic Systems" by RNDr. Petr Novotný, Ph.D., **fulfils** the requirements expected of a habilitation thesis in the field of Informatics.

Date: April 27, 2023 Signature: