

REVIEW

on the habilitation theses of Patrik Rusnák

The habilitation theses submitted by Patrik Rusnák represent a substantial and methodologically rigorous work dedicated to an exceptionally relevant field—the reliability analysis of complex technical systems using structural functions, logic differential calculus (LDC), direct partial logic derivatives (DPLD), and survival signature. The work combines theoretical investigation, the development of novel computational approaches, and their application to real engineering problems. Such scope and structure clearly demonstrate the author’s high level of scientific maturity and competence.

The thesis provides a comprehensive systematization of existing reliability analysis methods and introduces new approaches aimed at improving computational efficiency and enhancing analytical capabilities. Among the most significant scientific results is the development of a new algorithm for computing system state frequency (SSF) based on binary decision diagrams. This algorithm outperforms existing methods by avoiding numerical overflow and reducing computational costs, which is especially important for systems with high structural complexity. Another major contribution concerns the development of new types of direct partial logic derivatives adapted for survival signature representation—a novel and promising direction that enables the study of systems with groups of heterogeneous components.

The applied value of the work deserves special emphasis. The proposed methods are successfully applied to the reliability assessment of drone fleets, RAID-type data storage systems, and energy-related infrastructure. These case studies convincingly demonstrate the universality of the author’s approaches and the ability to adapt mathematically rigorous methods to practical engineering tasks. The research shows that DPLDs and newly defined structural importance measures (SI) allow for identifying critical system components, assessing system sensitivity to failures, and justifying optimal choices of architecture or component configuration.

The scientific novelty of the thesis is evident in the following contributions:

- introduction of three new DPLD types formulated specifically for survival signature;
- development of efficient algorithms for their computation, including an optimized workflow that reduces overall computational effort;
- extension of structural importance theory for systems with multiple component types;
- demonstration of the practical superiority of the proposed methods over existing classical approaches.

The contribution of Patrik Rusnák to the further advancement of reliability engineering is notable not only in conceptual innovations but also in the implementation readiness of the proposed algorithms. Several published works confirm that the author’s methods can be effectively applied to models of real industrial systems, which significantly increases the practical importance and scientific impact of the results.

Comments and suggestions

Despite the high quality of the thesis, a few aspects may further strengthen the work:

- It would be beneficial to include a broader comparison with alternative analytical frameworks, such as Bayesian Networks or Markov Reward Models.
- A discussion of the effect of dependent component failures on DPLD-based assessments would improve the generality of the conclusions.
- Additional attention to the sensitivity of results to inaccuracies in component lifetime parameters would further enhance the applicability of the methods.

These remarks are intended as constructive suggestions and do not diminish the scientific significance of the thesis.

Questions to the author

1. How scalable are the proposed algorithms when the number of components reaches tens of thousands?
2. Is it feasible to generalize the new DPLDs to multi-state system models without binary reduction?
3. Are there plans to implement the proposed methods such as an open-source or commercial software toolkit?

Overall evaluation and conclusion

The habilitation theses presented by Patrik Rusnák are a well-structured, innovative, and practically meaningful contribution to the field of reliability analysis. The author demonstrates a deep understanding of mathematical modeling, algorithm development, and engineering applications. The results meet international scientific standards and clearly indicate that the author possesses the qualifications required for a university-level academic title.

Conclusion: I fully support and recommend awarding Patrik Rusnák the academic title of Associate Professor (Docent) based on the successful defense of these habilitation theses.

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