

## **Supervisor's report on the thesis by Anna Derevianko entitled Geometric Algebra in Switched Systems Control**

The thesis provides an application of Geometric Algebra to the problem of controlling the switched systems represented by second order ODEs. Namely, the Geometric Algebra for Conics (GAC), ie., Clifford algebra  $\mathcal{Cl}(5, 3)$  is applied on trajectories of articular  $2 \times 2$  linear systems with constant coefficients and a switching path is found for controllable systems. The algorithm is novel and allows to avoid numerical solutions and thus reduces errors which otherwise increase with increasing number of switches. Complete algorithm with examples and Python code was published in [1].

In order to perform all steps of the proposed algorithm, intersections of specific conics had to be studied. The author used the decomposition of degenerated conics, more precisely the pair of lines, and the decomposition of a point pair in subalgebra 2D CGA, ie.,  $\mathcal{Cl}(3, 1)$ . The whole procedure with examples was published in [2].

Finally, controllability of particular switched systems with  $2 \times 2$  subsystems with constant coefficients is fully classified and, for controllable systems, algorithms for finding a switching path by means of GAC is introduced and demonstrated. Also, periodic solutions are mentioned. This part is yet to be published and is currently available as a preprint. Yet, let me stress that the main contribution is in the application of geometric algebras, not in the field of ODEs, where the mentioned facts are known in classical approach.

As for the personality of the candidate, Anna Derevianko worked hard and showed non-trivial activity, which lead to several conference presentations (AGACSE, ICACGA, ENGAGE, MESAS) and consequent publication in proceedings, see e.g. [3]. She also collaborated on common projects with the University of Defence and currently participates in the common research with ARICOMA, a company focused on AI and its applications. Anna also taught several courses not only on FME but also other faculties - Civil Engineering and Faculty of Chemistry. Summing up, Anna fulfilled all necessary conditions for a Ph.D. candidate at BUT composed of a number of publications, teaching and presentations.

### **Recommendation**

Based on the arguments above, I hereby recommend the thesis for the defense and approve Anna Derevianko as a candidate for Ph.D. title.

In Brno, 22nd April 2024.



doc. Mgr. Petr Vasík, Ph.D.

## References

- [1] A. Derevianko and P. Vašík: *Solver-free optimal control for linear dynamical switched system by means of geometric algebra*, *Mathematical Methods in the Applied Sciences*, vol. 47, no. 3, pp. 1274–1288, 2024.
- [2] R. Byrtus, A. Derevianko, P. Vašík, D. Hildenbrand, and C Steinmetz: *On Specific Conic Intersections in GAC and Symbolic Calculations in GAALOPWeb*, *Advances in Applied Clifford Algebras*, 32(1):2, 2022.
- [3] R. Byrtus, A. Derevianko, and P. Vašík: *Outline of tube elbow detection based on GAC*. In *Advances in Computer Graphics*, number 12221, pages 482–491, Springer Science and Business Media Deutschland GmbH, October 2020. Springer Science and Business Media Deutschland GmbH.