

## **Multi-approach based digital twin development methodology**

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In the development of complex systems, it is necessary to use more than one modelling approach, and the development of a single, simplified conceptual model is not enough to fully reflect the nature of the system. The proposed MultiDigiIII methodology includes developing conceptual models at different levels of abstraction to represent complex systems in the conceptual model more fully.

The goal of the thesis is to develop a methodology for the development and validation of a multi-approach-based digital twin for cyber-socio-technical ecosystems.

Novelty - An innovative methodology has been developed, which gives the modelling architect a transparent combination of methods for the development and validation of the multi-approach-based digital twin. The methodology helps to develop not only a digital twin but also a simulation model of any combination of modelling approaches.

### **Research projects**

- 2 APR 2024 – CURRENT National research program project “Climate Neutrality Decision Models in Action”. Duties to be performed - work on data collection, processing and analyses.
- 3 DEC 2019 – 30 SEP 2023. Horizon 2020 program project - reSilienT fARminG by Adaptive microclimaTe managEmEnt (STARGATE). Duties to be performed - to participate in the implementation of project activities, in the achievement of scientific results and auditable values - in the development and approval of the imitation multi-approach model for agricultural needs.
- 1 JUN 2021 – 31 DEC 2023 Advancing Human Performance in Cybersecurity, ADVANCES, Project No: S-BMT-21-6 (LT08-2-LMT-K-01-051). Duties to be performed - project administration.
- 17 SEP 2020 – 23 DEC 2020 Life with COVID-19: Assessment of overcoming the crisis caused by the coronavirus in Latvia and proposals for the future resilience of society (COLife) (No. VPP-COVID-2020/1- 0013) WP5. Duties to be performed – work on the development of a prototype of the strategic communication and management imitation model.
- 2 OCT 2017 – 30 NOV 2017 National Research Program project No.5.2.2 "Innovation and Entrepreneurship Development in Latvia in Accordance with the Smart Specialization Strategy". Duties to be performed - statistical analysis of survey results, development of simulation models, preparation of scientific publications, data processing.
- 1 NOV 2016 – 15 DEC 2016 Valmiera City Municipality funded scientific grant project "Development of a simulation model and platform compatible software prototype for long-term analysis and monitoring of energy consumption of municipal objects" Duties to be performed - work on the development of the basic principles of the simulation model, clarification of requirements for the software prototype, work on the development of the simulation model, development of the concept of the software prototype, participation in the preparation of the final deliverables of the grant project.
- 1 APR 2014 – 30 NOV 2014 Valmiera City Municipality funded scientific grant project "Development of a simulation model and software prototype for the assessment of the use and sustainability of natural resources in households in the protected area" Duties to be performed - work on the development of the basic principles of the simulation model, clarification of requirements, work on the development of the simulation model, development of the software prototype concept, participation in the preparation of the final deliverables of the grant project.

### **Research papers**

1. Zake, M., & Majore, G. (2022, October). Application of Multi-perspective Modelling Approach for Building Digital Twin in Smart Agriculture. In 2022 63rd International Scientific Conference on Information Technology and Management Science of Riga Technical University (ITMS) (pp. 1-7). IEEE.
2. M. Zake, G. Majore, G. Krūmiņš and Z. Zakis, "Methodology for Construction of Multi-approach Based Digital Twin in Strategic Communication," 2020 IEEE 8th Workshop on Advances in Information, Electronic and Electrical Engineering (AIEEE), 2021, pp. 1-6, doi: 10.1109/AIEEE51419.2021.9435626.
3. Lescevicā, M., Zamuele, A., Zake, M., & Jirgenšons, J. (2019). Minimizing migration: Modeling of Latvian diaspora’s involvement in cooperation with education and science, and governmental institutions, businesses and society. *Procedia Computer Science*, 149, 483–490.
4. Majore, G., Fjodorovs, A., Zake, M., Majors, I., Kepka, M., Integration of Web Map Application and Simulation Modeling Tools for Sustainability Analysis in Regional Development, *Procedia Computer Science, ICTE 2016, Latvia, 2017, Volume 104*, pp. 213-221.

5. Majore G., Zakis V., Zake M., Ginters E., Zakis K., Fjodorovs A. Holistic Benchmarking of the Bioeconomy in Protected Landscape Areas. *Procedia Computer Science* . ICTE in Regional Development, December 2014, pp. 118-126.
6. Mairita Zake, Egils Ginters. Migration among simulation paradigms and tools. //In: Proceedings of 26th European Modelling & Simulation Symposium (EMSS 2014), ISBN 978-88- 97999-38- 6 / EMSS 2014 (paperback) ISBN 978-88- 97999-32- 4, 10-12 September, 2014, Bordeaux, France, pp.364-371