

A general digital twin driving mining innovation through statistical and logical modelling

Magnus Lövstrand

Mechanical Engineering, Örebro University

Partners

Örebro University-Mechanical Engineering, Umeå University, Computing Science, Epiroc Rock Drills AB, Kaunis Iron AB, MinProc Analys AB

Project duration

2022 - 2025



Goals of the project

The goal with the DT-MINN project is to improve ecological and economical sustainability in terms of extraction of raw materials, through development of decision support to operate a mine as efficiently as possible.

- Digital twin platform for production process availability prediction and maintenance optimisation
- Interfaces between the above systems and between these systems and primarily Epiroc machinery in the Kaunis IT infrastructure and production process
- Information models for the above



Results so far

- Statistically based simulation approaches developed for predicting event outcomes developed
- Process and information models being developed, relating Epiroc machinery to mining production processes
- Data structuring is standards based
- General methods for improving system uptime under development

New contacts for future research applications developed at SMI Luleå events.

KK Foundation Avans project awarded for developing a *two-year mechanical engineering master program* data driven product and production development at Örebro University



Results so far

- Satyam, P., Turnbull, R., Khodadad, D. & Löfstrand, M. (2022). A Vibration Based Automatic Fault Detection Scheme for Drilling Process Using Type-2 Fuzzy Logic. *Algorithms*, 15 (8).
- P. Eklund, U. Höhle, *Finite quantales and applications*, LINZ2022, 39th Linz Seminar on Fuzzy Set Theory, Linz, Austria, February 7-10, 2022.
- A. Shamsgovara, *A catalogue of every quantale of order up to 9*, 39th Linz Seminar on Fuzzy Set Theory, Linz, Austria, February 7-10, 2022.
- Reed, Sean, Löfstrand, Magnus; *Discrete Event Simulation Using Distributional Random Forests to Model Event Outcomes*, Winter Simulation Conference, Singapore, December 11-14, 2022.
- P. Eklund, *Assessment computations involve numeric and symbolic values*, IGI Global, chapter
- S. Reed, M. Lofstrand, J. Andrews, *Modelling stochastic behaviour in simulation digital twins through neural nets*, *Journal of Simulation* 16 (5), 512-525, 2022
- Shamsgovara, A. (2023). *Enumerating, Cataloguing and Classifying All Quantales on up to Nine Elements*. *Relational and Algebraic Methods in Computer Science*. RAMiCS 2023. Lecture Notes in Computer Science, vol 13896. Springer, Cham.
- S. Reed, M. Löfstrand, *Efficient Estimation of Survival Signatures through Simulation with Depth-First Search of Indices*, European Safety and Reliability Conference ESREL 2024, June 23-27 2024, Jagiellonian University, Cracow, Poland.

Upcoming activities and next step

- Project meeting and review with Epiroc in Örebro November 8, 2024
- 4 - 5 publications in development
- Recruitment of three new staff at Örebro University under way
- Planning for new funding applications to continue development is under way
- Project meeting with the offshoot KKS Avans project in November



Mining innovation for a sustainable future