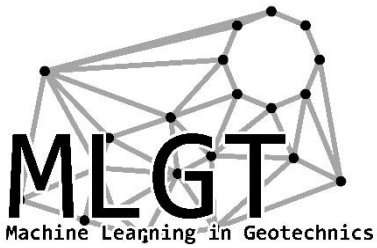
FACT SHEET to the research project MLGT



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SHORT TITLE / ACRONYM

MLGT

LONG TITLE

Machine Learning in Geotechnics

DESCRIPTION

Today's construction sites and scientific research projects usually involve the collection of tremendous amounts of data. Whether this data is collected for documentation purposes or generated as a biproduct of the construction process, it hardly ever is utilized to its full extent.

Machine learning (ML) involves algorithms that identify patterns and extract knowledge from complex datasets (Raschka & Mirjalili, 2022). Advances in deep learning, generative models, and large-scale data processing now enable predictive modeling, simulation, and decision support in engineering. To leverage these developments, the Institute of Rock Mechanics and Tunnelling founded the Machine Learning in Geotechnics (MLGT) group. Its goals are to maximize the value of existing geotechnical datasets through advanced analytics, to design scalable workflows for (near) real-time processing, and to ensure robust data pre-processing.

Current field of research include:

- Data pre-processing
- Generation of synthetic geotechnical datasets
- Anomaly detection in TBM operational data
- Process optimization and strategy development in tunnelling based on reinforcement learning
- Rare events detection
- Information Extraction
- Application of AI to geotechnical data (incl. LLM)
- Application of KANs
- Application of PINNs in rock mech. and tunnelling
- Optimisation with ML/AI

CONTRIBUTORS

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RELATED MASTER'S THESES

YEAR	AUTHOR	WORKING TITLE
2019	Geisler	Tunnel Boring Machine data analysis with respect to the geotechnical conditions
2019	Heikal	Finding Structure in Data - Analysis of TBM advance data
2020	Unterlass	Identifying rock loads on TBM shields during standstills (non-advance-periods)
2021	Theußl	The influence of pre-processing of TBM data evaluated by torque ratio based classification
2022	Saßmann	Field Stability Assessment of Martian Lava Tubes
2023	Leiner	Machine Learning Assisted Analysis of Tunnel Seismic Prediction Data
2023	Soliman	Information extraction from excavation logs data
2023	Visnar	Data Analysis of TBM Data at the GKI Site
2024	Wölflingseder	Anomaly detection with a Variational Autoencoder in TBM data
2025	Klein	Intelligent Analysis of MWD Data: A deep learning approach using Transformers and LSTM

RELATED PUBLICATIONS

YEAR	AUTHOR(S)	PUBLICATION TITLE
2019	Erharter, Marcher & Reinhold	Application of artificial neural networks for Underground construction – Chances and challenges – Insights from the BBT exploratory tunnel Ahrental Pfons
2019	Erharter, Marcher, Reinhold	Artificial Neural Network Based Online Rockmass Behavior Classification of TBM Data
2019	Erharter, Marcher, Reinhold	Comparison of artificial neural networks for TBM data classification
2020	Marcher, Erharter, Winkler	Machine Learning in tunnelling – capabilities and challenges
2020	Erharter, Marcher	MSAC: Towards data driven system behaviour classification for TBM tunnelling
2021	Erharter, Marcher	On the pointlessness of machine learning based time delayed prediction of TBM operational data
2021	Oberhollenzer, Premstaller, Marte, Tschuchnigg, Erharter, Marcher	Cone penetration test dataset Premstaller Geotechnik
2021	Erharter, Oberhollenzer, Frankhauser, Marte, Marcher	Learning decision boundaries for cone penetration test classification
2021	Erharter, Frode Hansen, Liu, Marcher	Reinforcement learning based process optimization and strategy development in conventional tunnelling
2021	Erharter, Tschuchnigg, Poscher	Stochastic 3D modelling of discrete sediment bodies for geotechnical applications

2021	Heikal, Erharter, Marcher	A new parameter for TBM data analysis on the experience of the Brenner Base Tunnel excavation
2021	Dickmann, Hecht-Méndez, Krüger, Sapronova, Unterlass, Marcher	Towards the integration of smart techniques for tunnel seismic applications
2022	Erharter, Wagner, Winkler, Marcher	Machine learning - An approach for consistent rock glacier mapping and inventorying - Example of Austria
2022	Sapronova, Unterlass, Marcher, Hecht-Méndez, Dickmann	Improving the subjective labelling of interpretation of geological conditions ahead of the tunnel face
2022	Morgenroth, Unterlass, Sapronova, Khan, Perras, Erharter, Marcher	Practical recommendations for machine learning in underground rock engineering – On algorithm development, data balancing, and input variable selection
2022	Hansen, Erharter, Marcher, Liu, Tørresen	Improving face decisions in tunnelling by machine learning-based MWD analysis
2022	Erharter, Weil, Tschuchnigg, Marcher	Potential applications of machine learning for BIM in tunnelling
2022	Unterlass, Erharter, Marcher	Identifying Rock Loads on TBM Shields During Standstills (Non-Advance-Periods)
2023	Sapronova, Unterlass, Dickmann, Hecht-Méndez, Marcher	Prediction of Geological Conditions Ahead of the Tunnel Face: Comparing the Accuracy of Machine Learning Models Trained on Real and Synthetic Data
2023	Unterlass, Erharter, Sapronova, Marcher	A WGAN Approach to Synthetic TBM Data Generation
2023	Erharter, Goliasch, Marcher	On the Effect of Shield Friction in Hard Rock TBM Excavation
2023	Sapronova, Unterlass, Shringi, Marcher	Towards the development of a harmonized inventory database for decision support: automatized information extraction
2023	Sapronova, Unterlass, Sakai, Miyanaga, Soliman, Marcher	MWD data analysis for optimization of tunnel excavation
2024	Sapronova, Klein, Marcher	MWD data Analysis for Risk Assessment and Process Optimization in Tunneling
2024	Unterlass, Erharter, Marcher	Transfer Learning Based Tunnel Boring Machine Advance Classification
2024	Hansen, Erharter, Marcher	Towards reinforcement learning - driven TBM cutter changing policies
2024	Sapronova, Marcher, Soliman, Klein	Enhancing Rock Mass Characterization with Advanced Pre-Processing of MWD Data
2025	Sapronova, Marcher	Improving Data Quality with Advanced Pre-Processing of MWD Data
2025	Erharter, Unterlass, Radoncic, Marcher, Rostami	Challenges and Opportunities of Data-Driven Advance Classification for Hard Rock TBM excavations
2025	Wölflingseder, Unterlass, Marcher	Rock Mass Anomaly Detection with a Variational Autoencoder in Tunnel Boring Machine Data

RELATED THIRD-PARTY FUNDED PROJECTS

YEAR	PROJECT DESCRIPTION	INFORMATION TO FUNDER(S), FUNDING PROGRAM(S) AND CO-OPERATION PARTNER(S)
2019	MaLMoCT.1: Applicability of Machine Learning methods to geotechnical monitoring data in conventional tunnelling projects	• Funder: FFG - The Austrian Research Promotion Agency • Funding program: Innovation Voucher (De-minimis-grant) • Co-operation partner: Geodata Informationstechnologie GmbH
2019	Big Tunnels - Big Data: AI based rock mass classification in tunnelling	• Funder: FFG - The Austrian Research Promotion Agency • Funding program: Innovation Voucher (De-minimis-grant) • Co-operation partner: geo.zt GmbH - Poscher beratende Geologen
2021	Analysis of seismic data (Integration of smart techniques for tunnel seismic applications)	• Funded by Amberg Technologies
2022-2023	TADA (Tunnel Advance Decision Assistance). Optimisation of safety, time and cost in construction processes by extracting knowledge from past excavations.	• Funded by Geodata
2022-2026	Analysis of measurement while drilling (MWD) data to enable quantitative rock mass classification and drilling plan optimization.	• Taisei Inc, Japan
2022	DAVINCI (Data Advance Via Intelligent Content Integration) Award.	• https://ircai.org/top100/entry/davinci/ • Listed as IRCAI GLOBAL TOP 100 in 2022
2024-2025	Joint online course with NTNU – Application of AI in Geotechnical Engineering. A guide through the data-driven project life-cycle and an introduction to generative AI.	• Graz University of Technology