2022: DIGITAL VISIONS

RESEARCH GROUP - MACHINE LEARNING IN GEOTECHNICS

General

Recognizing that modern construction sites and scientific databases are increasingly characterized by tremendous amounts of data, the research group Machine Learning in Geotechnics (MLGT) explores possible applications of Machine Learning (ML) for geotechnical and engineering geological problems. MLGT was founded by the Institute of Rock Mechanics and Tunnelling and shortly after joined by the Institute of Soil Mechanics, Foundation Engineering and Computational Geotechnics. While one goal is to increase the utilization of already existing data, another one is to develop workflows that permit efficient handling of the increasing overall amount of data resulting from the ongoing digitalization.

Current fields of research include:

- Reinforcement learning based process optimization and strategy development
- Improving geological predictions in tunnelling
- Synthetic geotechnical data generation
- Data driven analysis of Cone Penetration Tests
- Rock Glacier mapping and inventorying

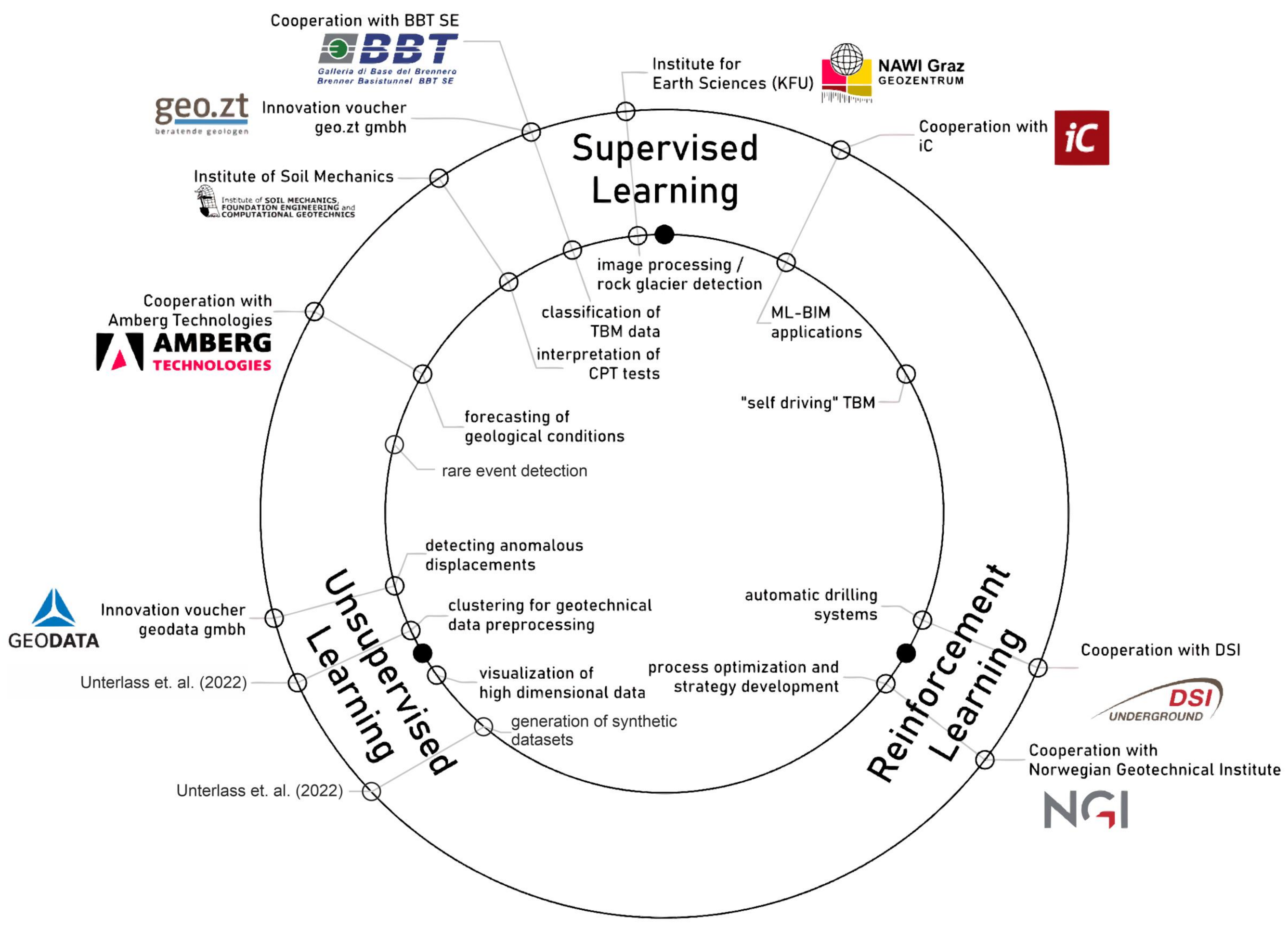


Fig. 1: MLGT Circle showing the current fields of research and cooperations.

CPT Data Interpretation Employing Different Machine Learning Techniques

The classification of soils into categories with a similar range of properties is a fundamental geotechnical engineering procedure. The classifications are usually based on cost- and time-intensive laboratory and/or insitu tests and essential for each individual construction project. Over the past years, the Cone Penetration Test (CPT) has established itself as a quick and inexpensive method for soil investigations. Based on a dataset of 1339 CPTs performed in Austria and southern Germany, the ability of ML for the interpretation of subsoil conditions got evaluated. Three different algorithms were used to predict soil classes based on soil behaviour type (SBT, SBTn, ModSBTn) charts and grain size distribution (Oberhollenzer_classes) and eventually compared in terms of their performance. Models based on random forest classifier yielded the most accurate classifications for both, the soil behaviour types and the grain-size based soil classes.

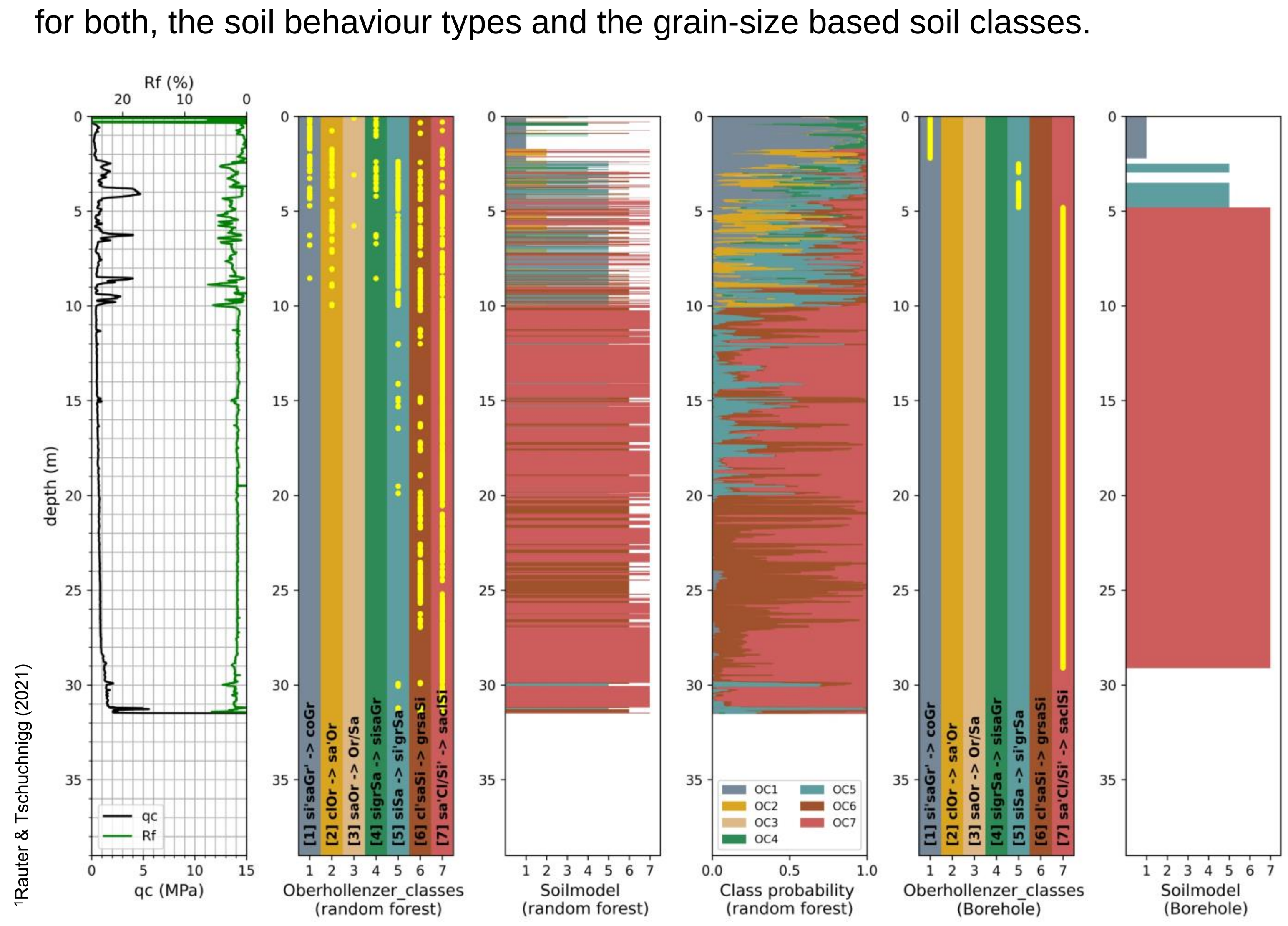
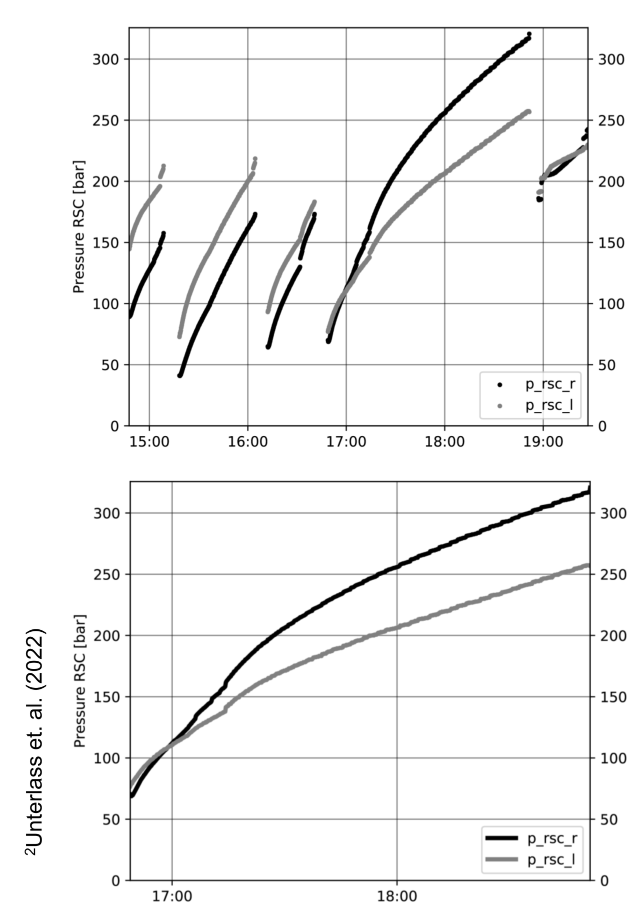


Fig. 2: Comparison of the predicted and actual soil model (based on grain-size distribution). CPT data q_c and R_f predicted classes, predicted soil model, class probabilities, actual soil classes and actual soil model (f.l.t.r.).

Identifying Rock Loads on Tunnel Boring Machine Shields During Standstills (Non-Advance-Periods)

Tunnel boring machine (TBM) operational data is mostly analysed with respect to data that was recorded during the advance of the TBM. Focusing on data that was recorded during standstills of a gripper TBM, we analyse rock loads that were passively recorded in the cylinders of a small roof support shield. These roof support cylinders are situated beneath the TBM's shield – extending it against the rock mass during non-advance periods. Equipped with pressure sensors, they enable the unique opportunity of logging rock load variations throughout the tunnel. Hence due to the big amount of resulting data, techniques of unsupervised ML (i.e. cluster analysis) are used to automatically pre-process the TBM data. Furthermore, regression analysis is used to determine sections of the tunnel where rock loads are mainly occurring on the left or right side respectively. The data driven analysis shows that the main rock loads are occurring on the right side of the TBM which is in good accordance with observation from the construction site, as well as numerical models from literature. This work contributes towards the understanding of rock load conditions in anisotropic rock masses recorded during the drive of a deep hard rock tunnel.



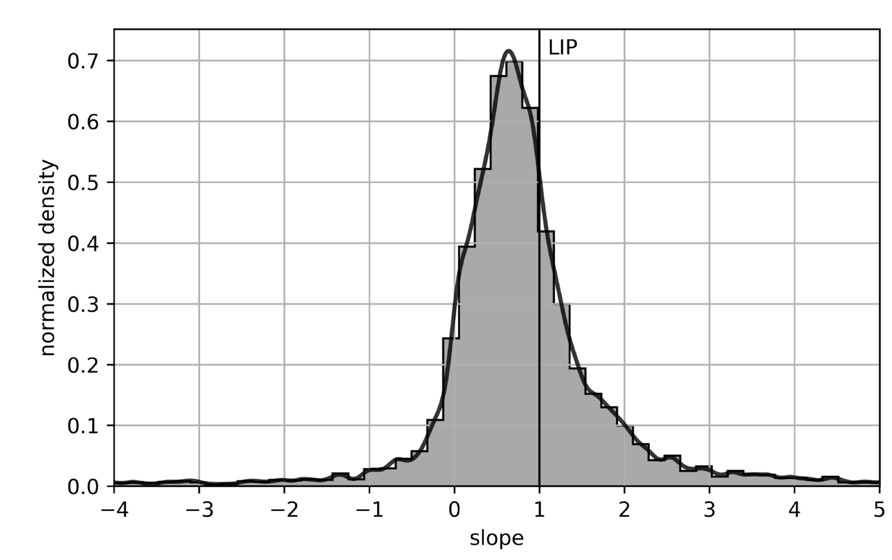


Fig. 3: Left: Upper plot showing the pressures increase in the left and right roof support shield for the time of one stroke. Lower plot shows one singled out pressure increase after clustering. Right: Histogram of all analysed strokes with the highest density between 0 and 1 signifying that the main loads are occurring on the right side of the TBM.

Machine Learning – an approach for consistent rock glacier mapping and inventorying – Example of Austria

Rock glaciers (RG) are landforms that occur in high latitudes or elevations and — in their active state — consist of a mixture of rock debris and ice. Despite serving as a form of groundwater storage, they are an indicator for the occurrence of (former) permafrost and therefore carry significance in the research for the ongoing climate change. Creating RG inventories, however, usually involves manual, laborious, and subjective mapping of the landforms. This work proposes an approach for RG mapping based on supervised ML which can help to increase the mapping efficiency and permits rapid RG mapping in vast and not yet covered areas. We found deep convolutional artificial neural networks (ANN) that are specifically designed for image segmentation to be well suited for this classification problem. The general workflow consists of training the ANNs with orthophotos and slope maps of digital elevation models as input. The output (RG label-maps) is derived from a recently published RG inventory of the Austrian Alps that features 5769 individual RGs. Based on this inventory, the ANNs have learned the average expert opinion and the RG map generated by the ANN can be used to increase the consistency and completeness of already existing RG inventories.

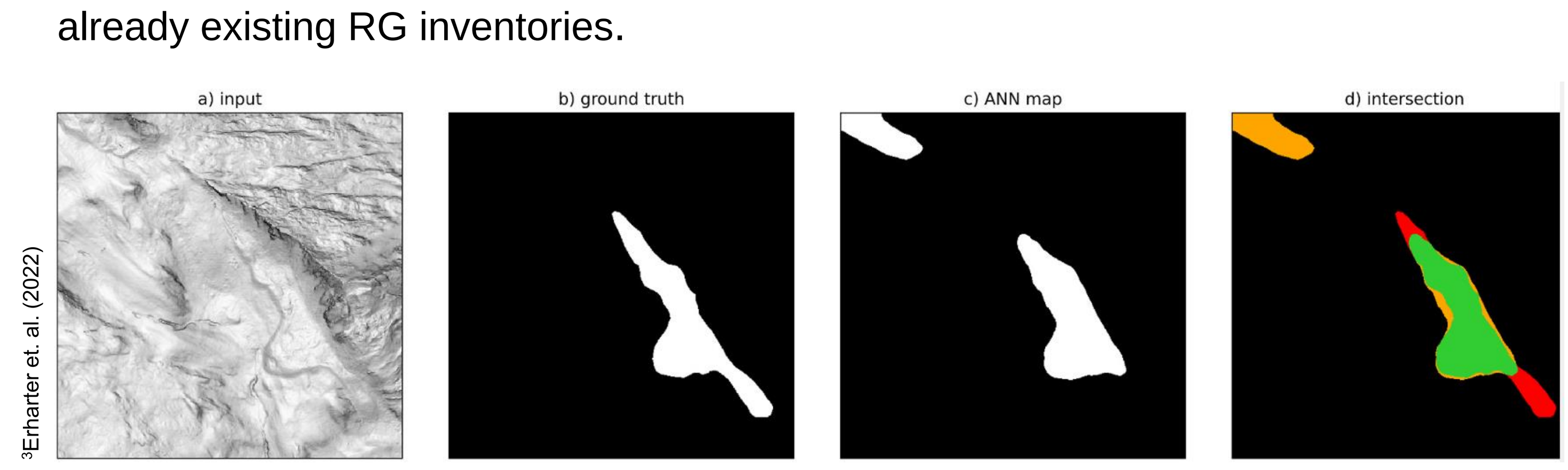


Fig. 4: Discretized sample from the test dataset. F.l.t.r. the figure shows: a) The first channel of the respective input sample; b) the ground truth label-map; c) label-map based on a weighted average classification of 10 ANN models; d) intersection of the ground truth with the ANN label-map showing true negatives in black, true positives in green, false positives in orange and false negatives in red.

Literatur / Zitat

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