TRIM4Post-Mining: Transition Information Modelling for attractive Post-Mining Landscapes – A Conceptual Framework

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Abstract: TRIM4Post-Mining brings together a consortium of European experts from industry and academia to develop an integrated information modelling system. This is designed to support decision-making and planning during the transition from coal exploitation to a revitalized post-mining landscape enabling infrastructure development for agricultural and industrial utilization and contributing to recover energy and materials from coal mining dumps. The smart system will be founded up on a high-resolution spatiotemporal database utilizing state-of-the-art multi-scale and multi-sensor monitoring technologies that characterize dynamical processes in coal waste dumps related to timely dependent deformation and geochemical processes. It will develop efficient methods for comprehensive spatiotemporal data analytics, feature extraction, and predictive modelling that allow for the identification of potential contamination areas and forecasting the waste dump dynamics. For the interactive exploration of alternative land-use planning scenarios in terms of residual risks, technical feasibility, environmental and social impact, and also affordability, up-to-date data and models will be embedded in an interactive planning system based on Virtual Reality and Augmented Reality technology forming a TRIM – Transition Information Modelling System.

Keywords: Geomonitoring, Data Analytics, VR/AR, Decision Support for Revitalization Planning

1 Introduction

With the currently implemented energy transition, most coal mines in Europe will transfer to the closing phase during the next two decades. The structural transformation of a region from an industrial mining area to an attractive landscape requires a good understanding of risks and opportunities associated with the post-mining landscape, in particular related to...
waste dumps, and ensuring open communication and engaging all stakeholders to explore fruitful options for future land use.

In the light of newly available monitoring-, data management-, modelling-, visualization-(VR/AR) and decision supporting technology, spatially and timely very dense data and information for both, geomechanical and geochemical attributes of coal waste dumps are available and can be effectively used. Examples include active and passive satellite sensors [Jo21], [Ha19], airborne and terrestrial LIDAR – data for areal information [Sc21], [Gun18], geochemical point sensor data including TIR and SWIR [Da17], [Gu19], classical surveying data or self-sufficient deformation sensors for local information. Many operations already continuously scan the dump during construction using laser-scanning technology [Kr21]. Currently, this information is mainly used for operations control. One opportunity but also a challenge is to make these data and information available in the future, especially during the post-mining phase after operations terminate. This leads to the following research questions of TRIM4Post-Mining:

- How can modern monitoring technology be best utilized, to characterize the geomechanical and geochemical behavior inside the heterogeneous waste dump body at an appropriate spatial and timely resolution? (Revitalization Monitoring)
- How can monitoring data be rapidly translated into a better understanding of local developing risks and opportunities? (Data-Driven Predictive Modelling)
- How can newly gained information be translated into a decision support for optimized revitalization planning at different stages? (Revitalization Planning)
- How can relevant data, information, and knowledge be conserved and made available to all stakeholders in the future? (Long-term information access)

2 Methodology

TRIM4Post-Mining is developed around a dense spatiotemporal geodatabase of coal waste dumps, from which the necessary information can be retrieved at any time and newly acquired data can be added (Figure 1). This database forms a grid model, which maps the spatial distribution geochemical and geomechanical properties. One particular feature to be captured is the spectral fingerprint of waste material within. Similar to a spectral library, this allows for the analysis with respect to particular elements also at later stages. The database will further integrate information from different sources, including:

- Operational data originating from the digital geological model and the material tracking system installed,
- Data from terrestrial sensors (face mapping, conveyor belt scanning), including RGB-imaging-, LIBS, Multi-spectral sensors, and terrestrial laser scanning,
- Data from airborne and spaceborne sensor, including radar and multi-spectral remote sensing, airborne laser-scanning and digital photogrammetry,
- In-situ data (drill-hole logging and CPT data).
The investigation of suitable sensor combinations, the development of related data analytics, and monitoring concepts are an intendent outcome from TRIM4PostMining.

The two data analytic “engines” to be developed, “Geotechnical Application” and “Geochemical Application” will make use of the most current data to quickly predict risk- and opportunity related indicators, including slumping, settlement liquefaction potential [Di99],[Fö98],[We20], acidification potential or element concentrations etc. Newly evaluated information of system states will be fed back to the model, so it is “up to date”.

Fig. 1: TRIM4PostMining Approach

The revitalization decision support will apply the model and engines previously described to planning and re-cultivation decisions. Possible reclamation options include recreational areas, agricultural or forestry areas, and lakes or water areas for the remaining residual holes or any constructions related to renewable energy. Each of these options requires some range of geochemical and geotechnical parameters, which are evaluated as part of an objective function aiming for overall societal benefit.

Research activities related to “Stakeholder Visualization” aim to provide interpreted information to different stakeholders. This will include full access to the model to planners and reclamation executers, a web-GIS interface to authorities, and a VR/AR interface to communities and others. The key aspect is that information provided to stakeholders should be pre-interpreted at a level that is appropriate to the technical background of stakeholders and the involvement in the decision process.

3 Outlook

TRIM4Post-Mining aims to develop the framework for a Technology Readiness Level- 5 to 6 (framework tested in an industry-like environment). With this goal, the different research areas contributing and their integration will be developed and demonstrated based on the specific requirement for revitalization planning on two exemplary case sites and involves stakeholder engagement. The case study areas are a waste dump of a lignite
operation south of the city of Leipzig, Germany, and a hard coal waste dump close to the border of the Netherlands and Germany.

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References


