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INTEGRATING GIS INTO GEOSPATIAL DIGITAL TWINS FOR MINING OPERATIONS: A REVIEW OF TECHNOLOGIES AND CASE STUDIES FROM ROMANIA

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Abstract

Mining operations need interoperable geospatial data (INSPIRE / INIS), and the European direction is towards geospatial digital twins (Destination Earth). This review groups the technologies into three pillars — satellite remote sensing, UAV photogrammetry and laser scanning/SLAM — and, through Romanian case studies, shows how GIS acts as the integration layer linking them into a mining digital twin, useful for deformation monitoring and hazard assessment.

• Introduction

- Mining needs accurate, up-to-date geospatial data for safety, deformation monitoring and planning. The INSPIRE Directive and, in Romania, Government Ordinance 4/2010 (INIS) mandate interoperable spatial data — the foundation for a geospatial digital twin, a direction endorsed by the EU’s Destination Earth initiative.

• Material and Methods

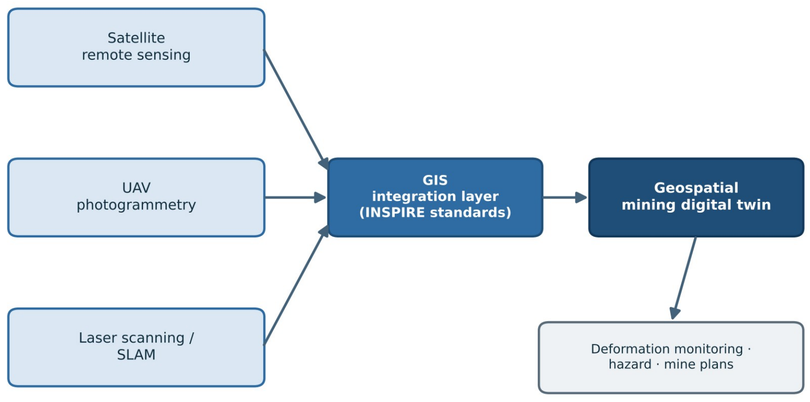
- A synthesis review of published case studies, mostly Romanian, searched in Web of Science, Scopus, Google Scholar and field journals (RJAS, Mining Revue, Remote Sensing, ISPRS). Studies were organized into three pillars and analysed for strengths, limits and the role of GIS as the integration layer.

• Results and Discussions

- Satellite remote sensing tracks land-cover change in mining basins (Vorovencii, 2024: built-up +110.7%, dumps −53%). UAV photogrammetry yields cm-level DTM and orthophotos (Simon et al., 2021). Laser scanning/SLAM gives detailed 3D, including underground, with ~7 mm local accuracy but drift over distance (Křemen et al., 2024). GIS, on INSPIRE standards, links these into one georeferenced twin; deformation data (Herbei et al., 2022: tilt −4.8…+4.9 mm/m) add the hazard dimension.

• Conclusions

- No single pillar covers mining needs; the value comes from integration, with GIS as the engine of a geospatial digital twin. Such a model supports deformation monitoring and hazard assessment. The way forward is building an integrated twin for a real mining perimeter, combining surface and underground data.



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