UNIVERSITY OF BIRMINGHAM

Ongoing research within BIM and DT

Geotechnical and tunnel engineering

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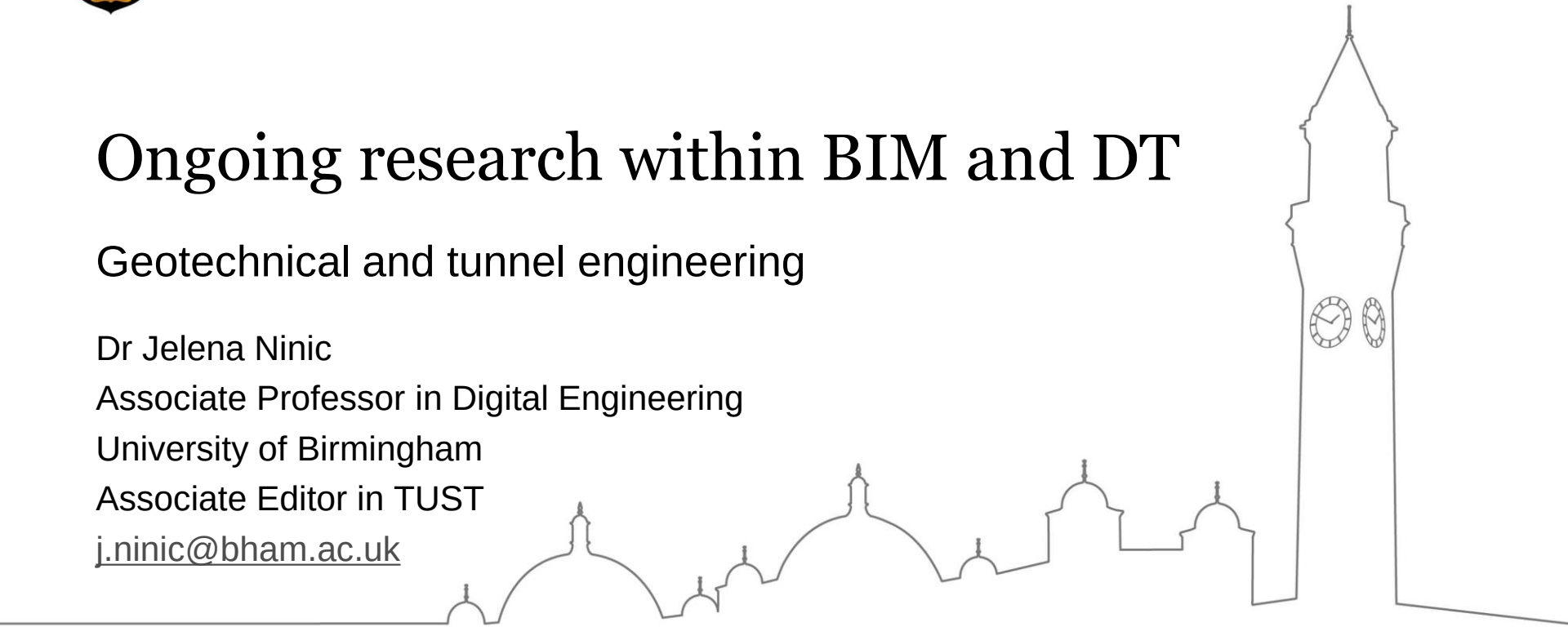
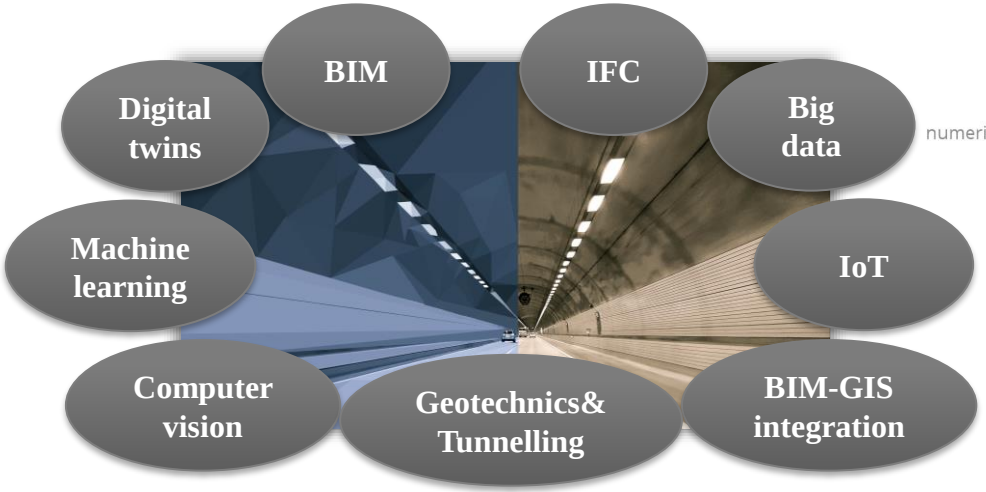
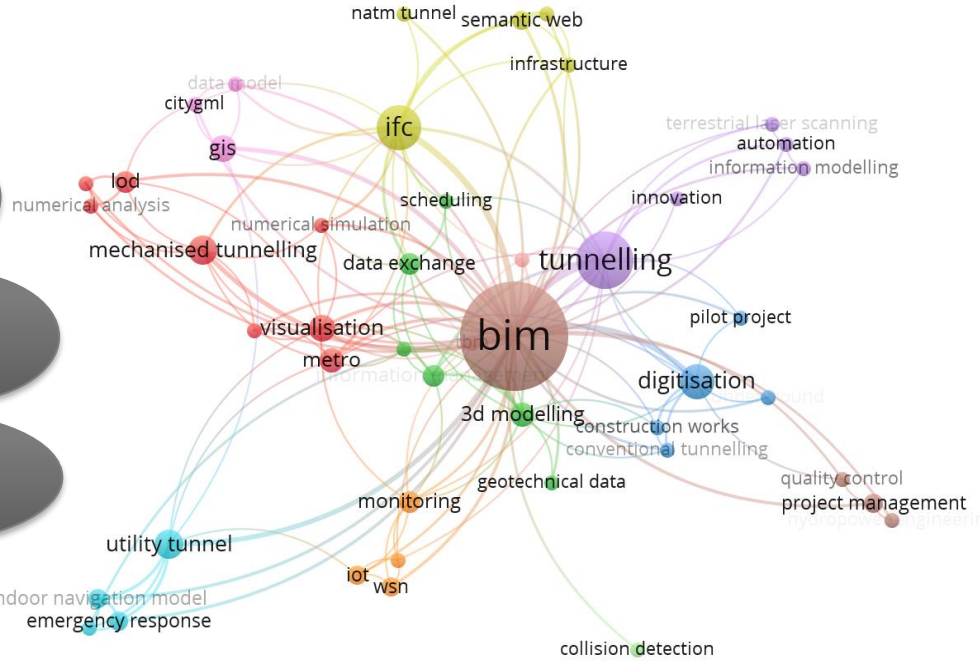


Research trends

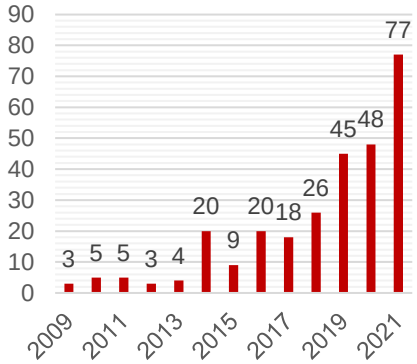


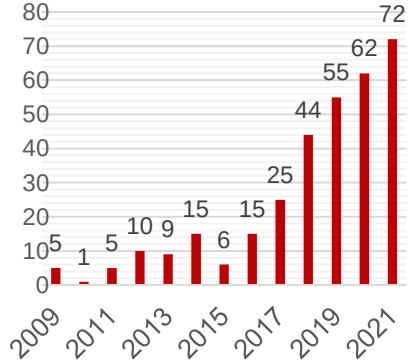


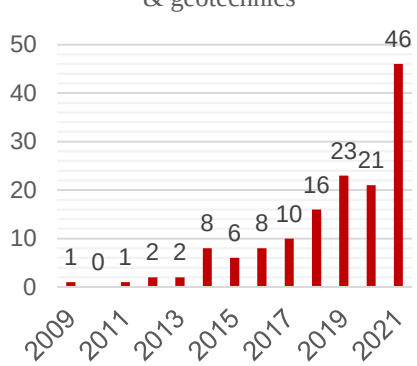
Research Trends

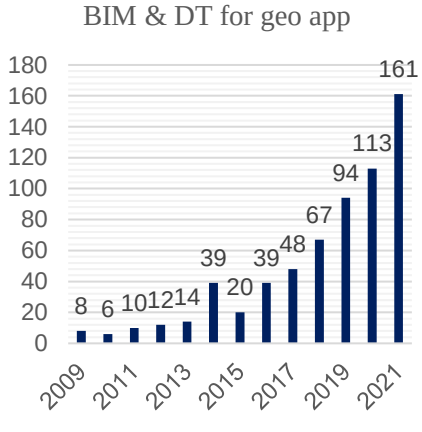
- Publication frequency from 2008 to 2021 (data accessed on Scopus on 10/09/2022)
- Exponential increase in number of publications in related areas of BIM; Digital twins for geotechnics and tunnelling

Scopus









Definitions

Building Information Modelling:

"the **process** of **designing, constructing or operating** a building or infrastructure asset using **electronic** object-oriented **information**" (BS EN ISO 19650-2: 2018)

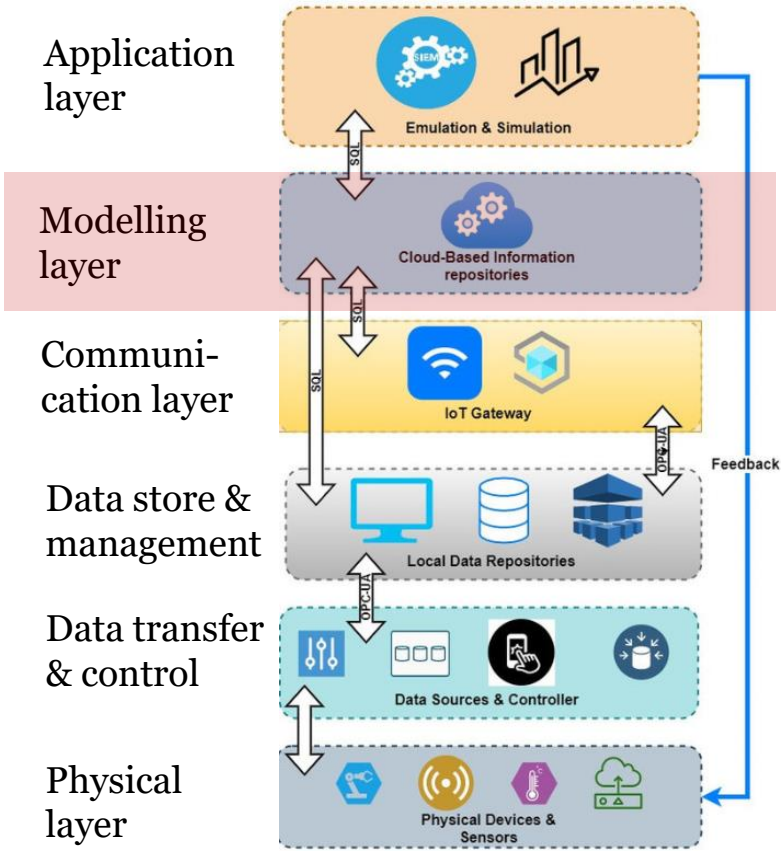
"a **digital** representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for **information** about a facility forming a reliable basis for decisions during its **lifecycle**; defined as existing from earliest conception to demolition." (NBIMS-US™)

Digital Twin:

"a digital twin is an exact digital replica of a construction project or asset"

BIM and DTs

- In general DTs consist of:
  - Physical layer
  - Data transfer, store, management and communicating layer
  - Modelling layer
  - Application layer
- BIM is hence a subset of DT
- BIM and DT are not:
  - Models that contain only 3D data
  - Models with no support of behavior
  - Models that are not used for collaboration
  - Models that are not updated throughout the lifecycle



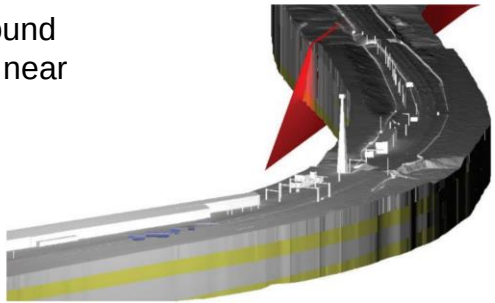
Challenges and trends for Geo applications

- Ground modelling
- Modelling of underground structures
- BIM-GIS integration
- Sensing and monitoring
- Interoperability
- Applications
  - Integration with numerical modelling
  - Machine learning for prediction
  - Computer vison for inspection & maintenance

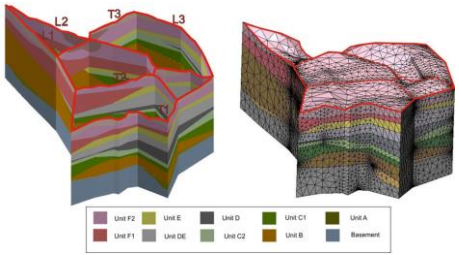
Ground modelling

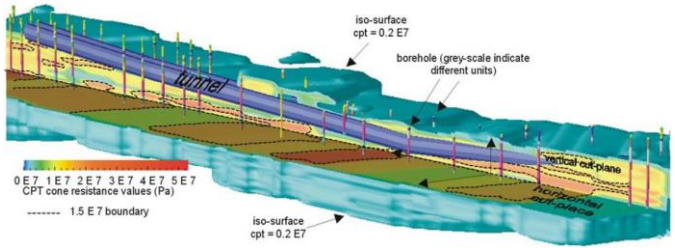
- How to manage geodata i.e. borehole and testing data?
- How to model uncertainties in ground?
- How to create 3D geological models?
- How to integrate models in GIS?
- Creating interactive visualisation tools and management systems

Conceptual ground model of a site near Leeds (UK)

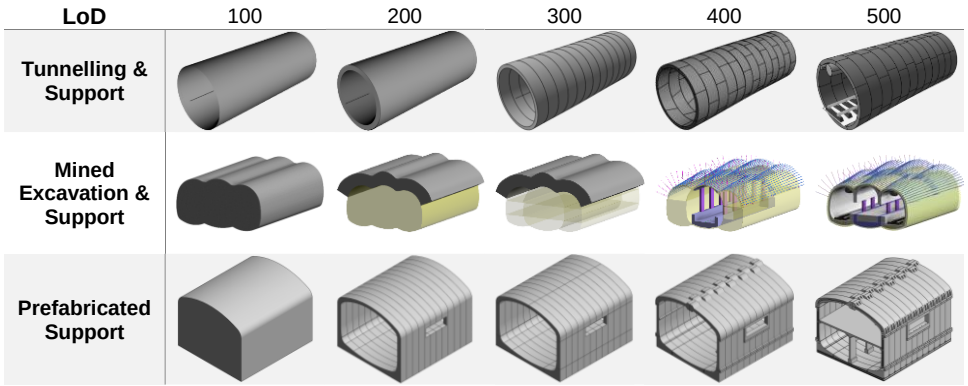


Geological model for an area of Barcelona, NE Spain (Velasco et al., 2013)





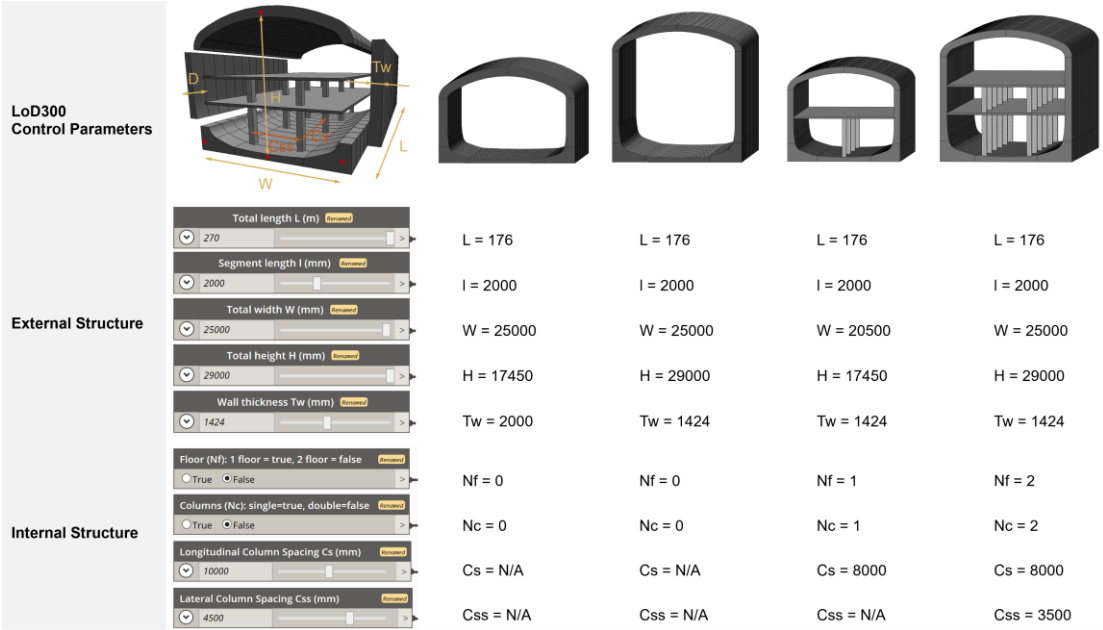
Modelling of underground structures



- A virtual version of Crossrail is proving as important to the London rail project's smooth running as its physical counterpart
- For geo applications, BIM software generally includes foundations, drainage systems etc. For underground structures such as tunnels, underground stations, utility tunnels, we need a new definition

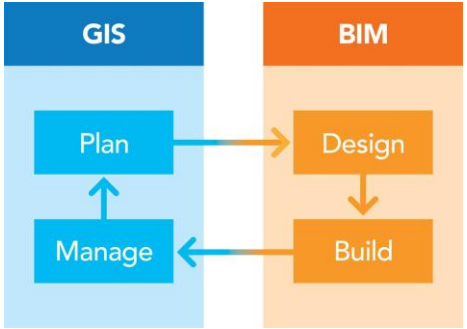
Modelling of underground structures

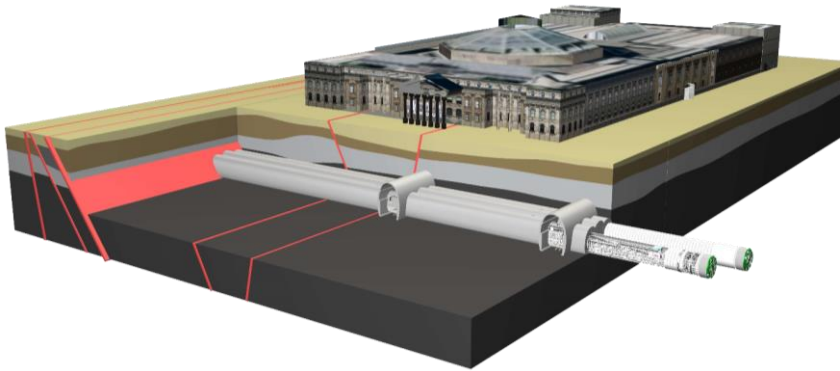
Dynamic BIM utilizing a parametric object modeling concept



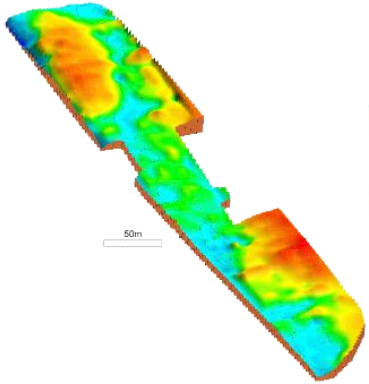
BIM-GIS integration

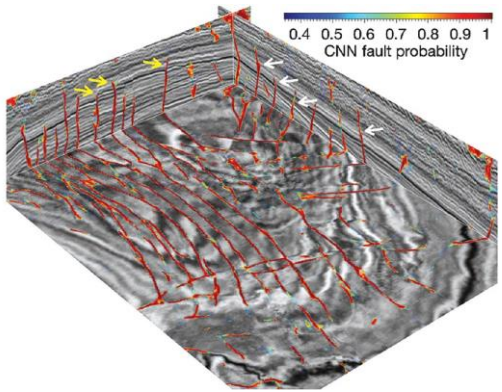
- GIS is a framework for gathering, managing, analysing and visualising georeferenced data
- BIM and GIS are both associated with information repository and data management
  - BIM encompasses detail-oriented information
  - GIS for manipulative management of geospatial data
- GIS extends the value of digital BIM design data through visualization and analysis of assets in the context of the natural and built environment.
- GIS benefits from detailed information and analysis from BIM

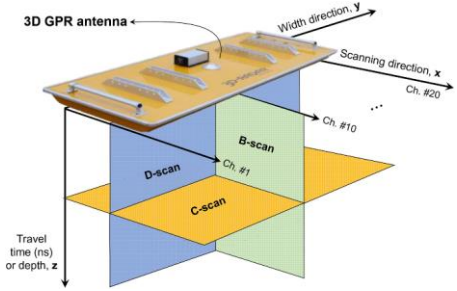




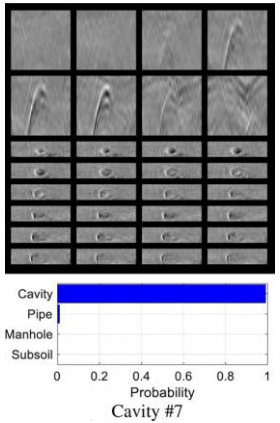
Sensing and monitoring



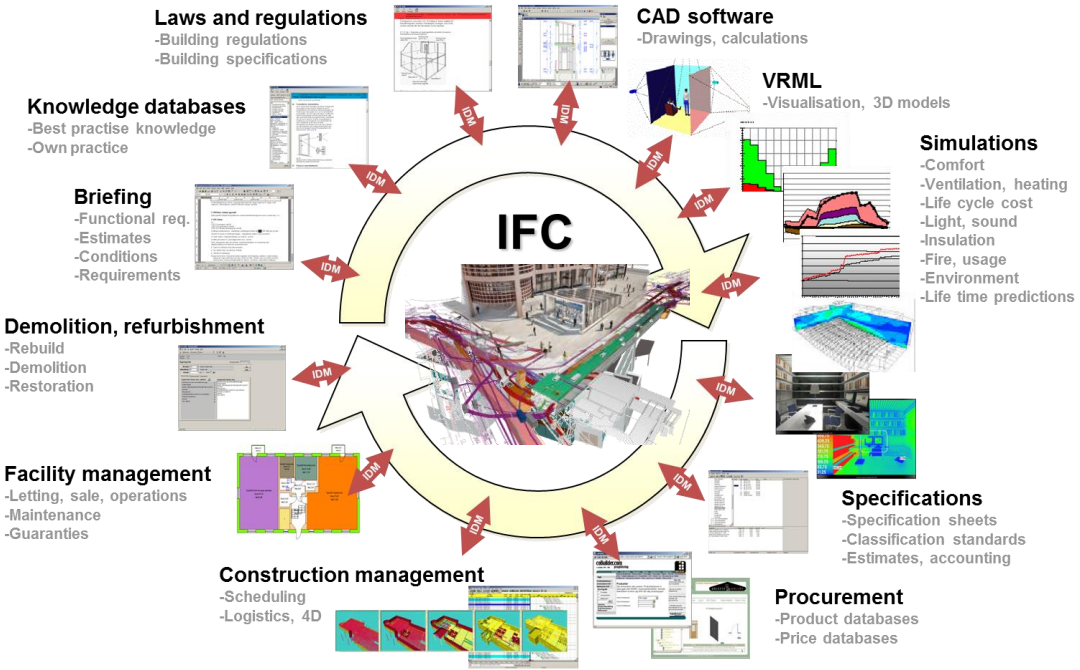




- Traditional geotechnical sensing and monitoring (strain gauges, load cells, piezometers, extensometers, inclinometers, etc)
- Advanced sensing technologies: TBM's built-in sensors, InSAR, Ground-Penetrating Radar (GPR), imaging, and laser scanning, fiber optic deformation sensors, quantum technology sensing, etc.



Interoperability



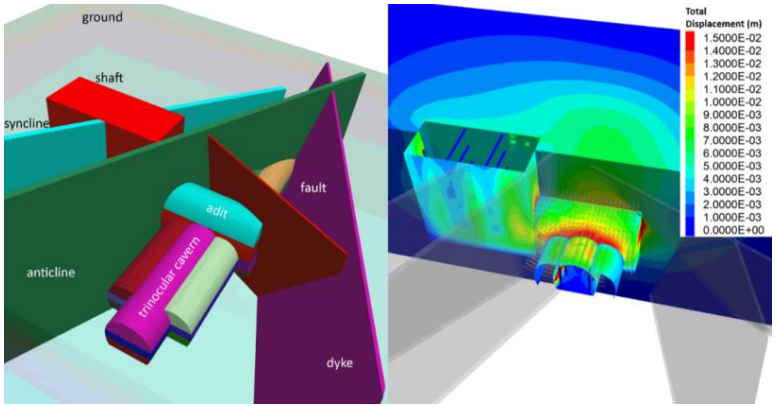
IFC Tunnel (based on v4.4)

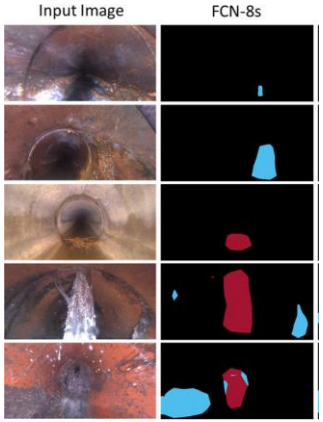
Use cases:

- Initial state modelling
- Geologic factual data
- Geologic and geotechnical modelling for planning
- Geotechnical modelling for design
- Geotechnical modelling for construction and maintenance
- Design coordination
- Structural & geomechanical analysis (low priority)

Applications

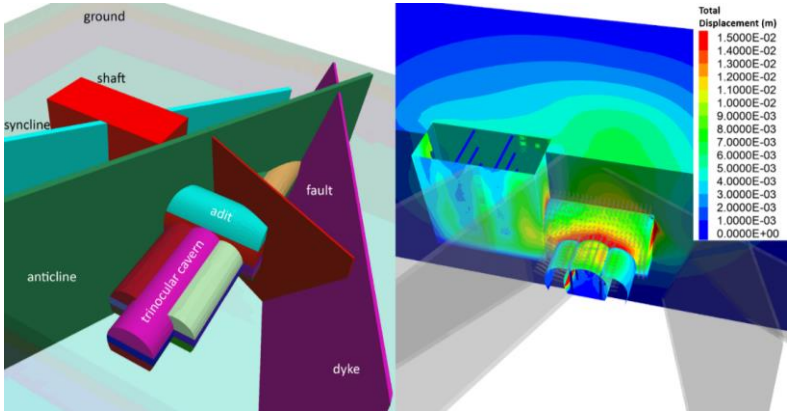
- Integration with numerical modelling
- Machine learning for prediction
- Computer vision for inspection & maintenance

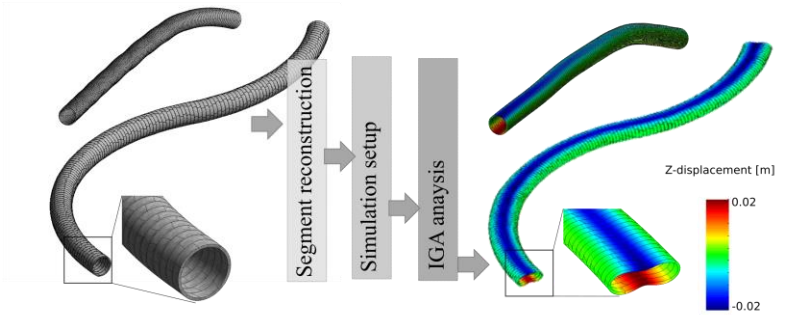




Integration with numerical modelling

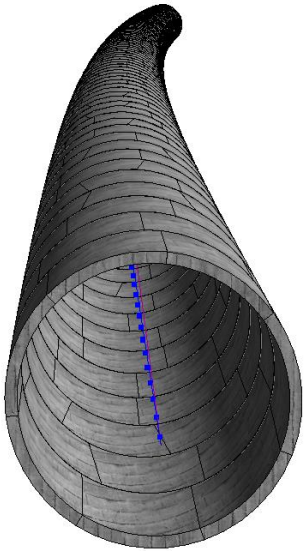
- Design-to-design use case
- Challenges:
  - Numerical software doesn't have standardised formats for geometry
  - Boundary conditions must be applied
  - Mesh generation
  - Postprocessing of the results
- Opportunities
  - To adopt interoperability principles
  - To go for open-source platforms with advanced methods: IGA, CutFEM

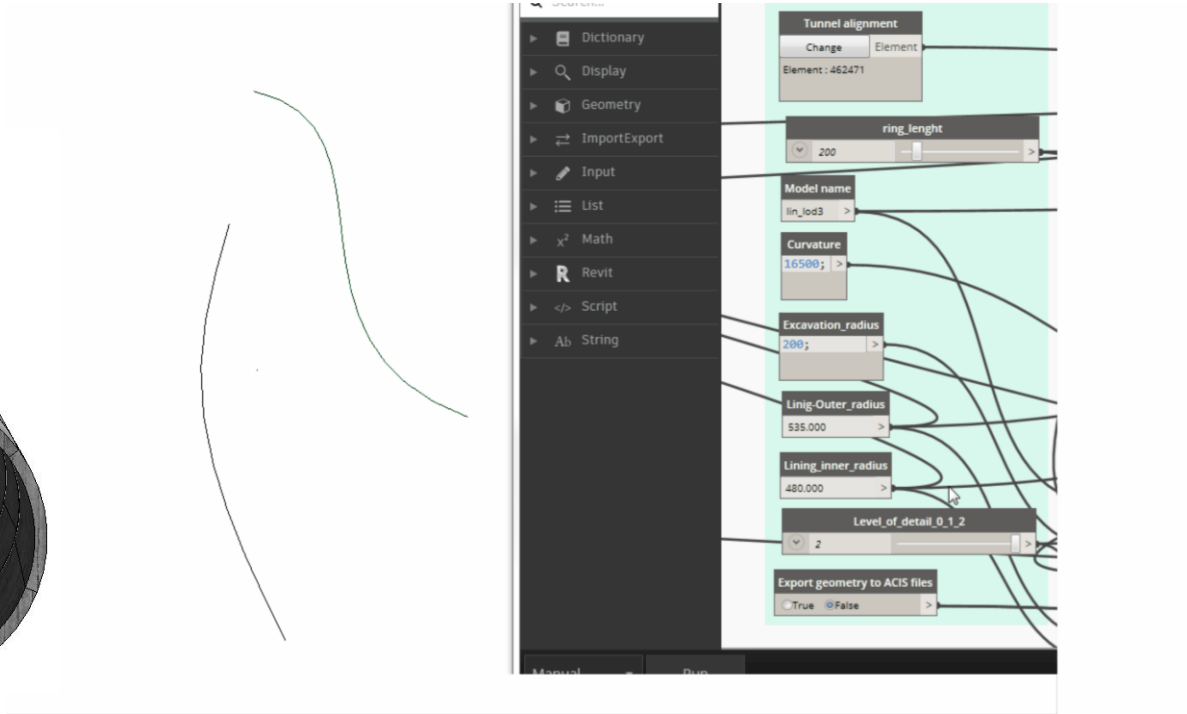




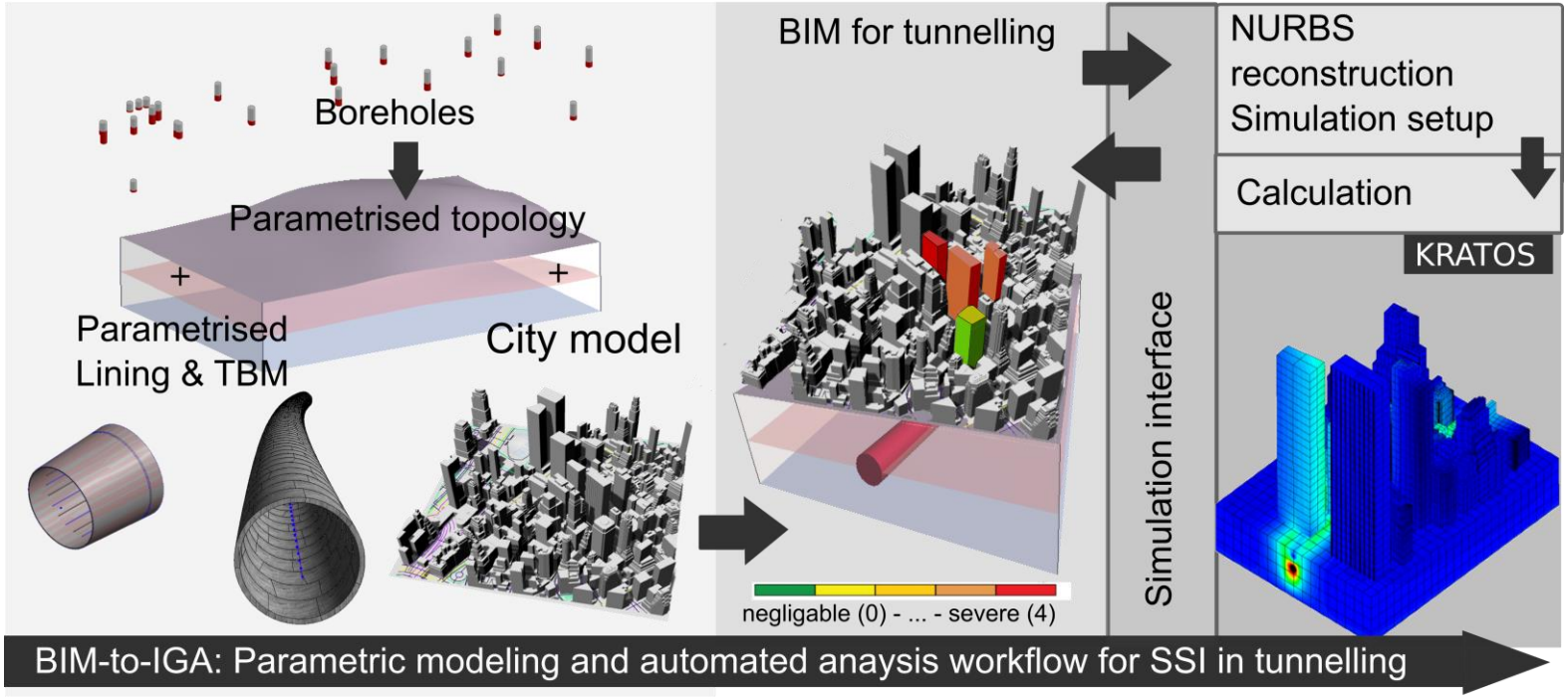
Integration with numerical modelling

Segmental tunnel lining

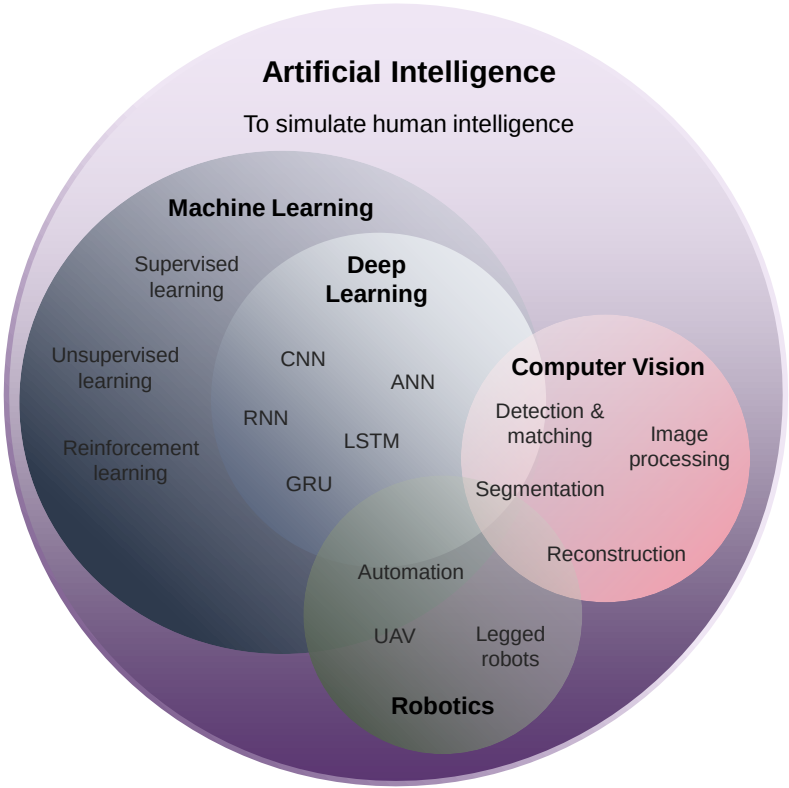




Integration with numerical modelling



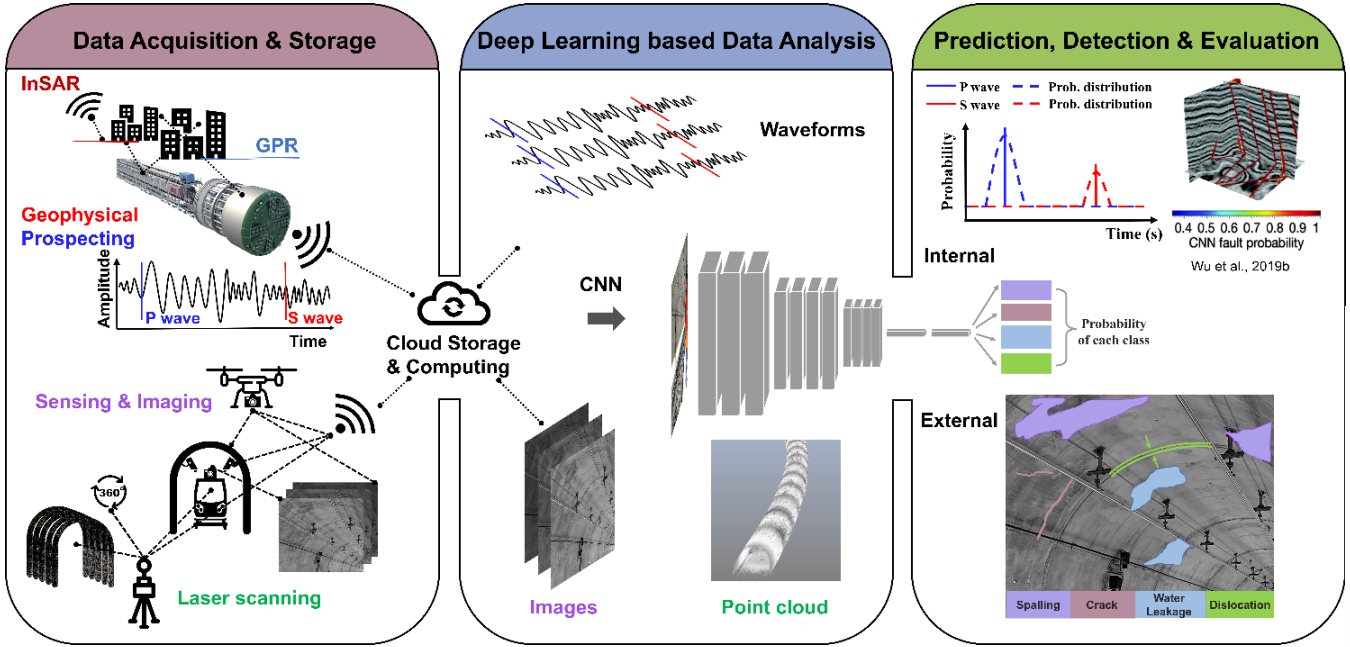
AI for prediction in geotechnical engineering

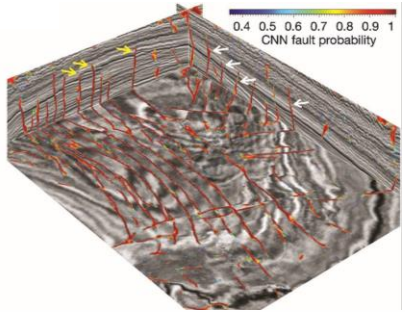


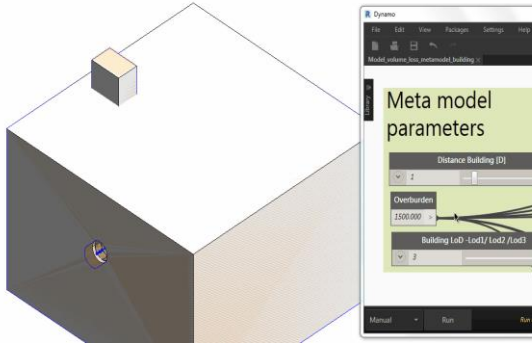
AI in geotechnical engineering is applied to:

- Soil properties identification
- Settlement/deformation prediction
- Process steering
- Back-analysis
- Condition diagnostics
- Prediction of durability
- Sensitivity analysis

Machine learning for predictions

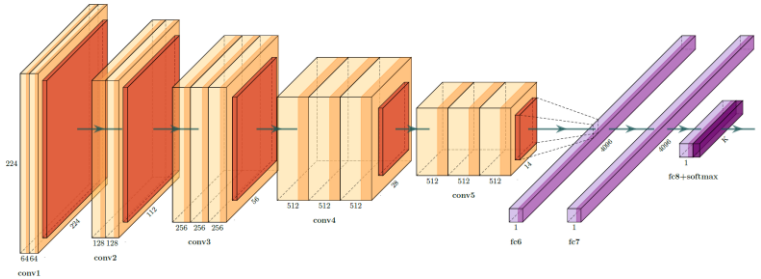




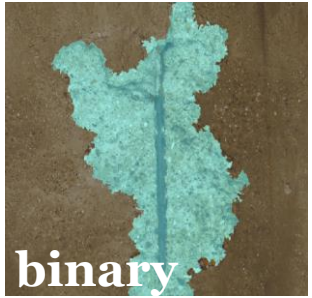


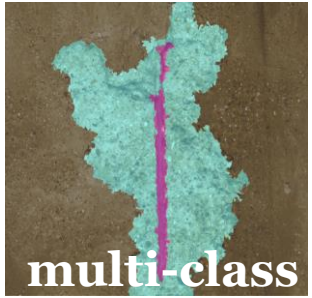
Machine learning for inspection

Deep neural networks for assessment



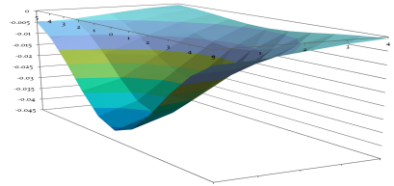
Semantic segmentation

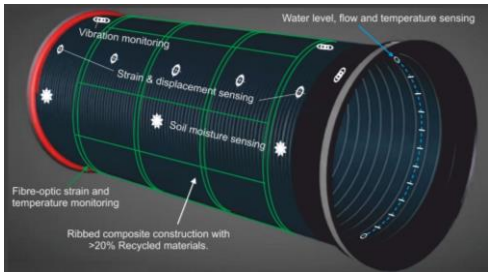




- background
- spalling
- exposed reinforcement

Digital twin for underground infrastructure





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Thank you for your attention!

Looking forward to the discussion later!

Or you could contact me at:
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