Unsupervised delineation of landfill geometries based on geophysical imaging results

Matthias Steiner¹, Werner Chwatal¹,², Andreas Freudenthaler², and Adrian Flores Orozco¹
¹Geophysics Research Division, Department of Geodesy and Geoinformation, TU-Wien, Wien, Austria
(matthias.steiner@geo.tuwien.ac.at)
²Pöyry Austria GmbH, Wien, Austria
The motivation ...
Geophysical methods in landfill studies

- Geophysical imaging methods permit
  - the quasi-continuous collection of data
  - in a non-invasive and
  - cost-efficient manner

Seismic Refraction Tomography (SRT)

Electrical Resistivity Tomography (ERT)

Induced Polarization (IP)
However, subjective perception of imaging results might bias the interpretation.

Subsequent delineation of the landfill geometry affected.

Which model to choose?
The approach ...
Landfill geometry from SRT images

- Invert seismic refraction data collected at the landfill with pyGIMLi (Rücker et al., 2017)
- Apply an unsupervised method on seismic velocity models to automatically assess the landfill geometry
(I) Compute velocity gradients

- Compute velocity gradient in x and z direction and plot the magnitude of the gradient vector for each pixel.
(II) Classify the gradient image

- Divide the gradient magnitude values based on the median value into three groups
- Assign distinct marker values to these groups
(III) Segment the subsurface

- Use a random walk algorithm to segment the subsurface based on the defined zones
Based on the gradient magnitude our method identified two subsurface regions presumably corresponding to the landfill body.
(IV) Assess the landfill geometry

- Use the geometry of the segmented polygons to deduce information regarding the geometry of the landfill base

→ Verification?
Flores Orozco et al. (2020) showed
- that the IP is less affected by leachate, and thus
- is more sensitive to the landfill geometry than the ERT

Observed IP anomalies are consistent with the delineated landfill body.
Comparison with the ERT image

- The ERT is widely-used method for waste characterization in landfill investigations; yet, the method is less sensitive to the landfill geometry (e.g. Nguyen et al., 2018).

- Accordingly, the ERT image is of limited use for the verification of the automatically delineated landfill geometry.
Verification based on the official report

- Officially reported landfill base manually delineated based on the seismic velocity model and direct information regarding the landfill geometry
- The automatic interface detection resolved accurately for the known geometry of the landfill
The conclusion ...
What’s done ...

- We used geophysical methods to investigate the geometry of a landfill.
- We developed a method to automatically delineate the base of the landfill.
- We could verify the automatically delineated landfill base with existing information and other geophysical methods.
... and what’s ahead of us

- Incorporate the obtained structural information in the inversion of other geophysical data sets
- Apply our method on data collected at different landfills
- Extend our method to permit the assessment of other relevant parameters, e.g. the waste composition, in frame of joint inversion applications
4TH INTERNATIONAL SYMPOSIUM ON ENHANCED LANDFILL MINING - MANAGING PAST LANDFILLS FOR FUTURE SITE DEVELOPMENT: A REVIEW OF THE CONTRIBUTION OF GEOPHYSICAL METHODS

Frédéric Nguyen\textsuperscript{1}, Ranajit Ghose\textsuperscript{2}, Itzel ISUNZA MANRIQUE\textsuperscript{3}, Tanguy ROBERT\textsuperscript{1}, Gaël DUMONT\textsuperscript{1}

\textsuperscript{1} University of Liege, Urban and Environmental Engineering, 4000 Liege, Belgium
\textsuperscript{2} Delft University of Technology, Department of Geoscience and Engineering