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Tracer moment tracking and forecasting in time-lapse electrical resistivity tomography

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Quantitative analysis of ERT investigation and monitoring images can assist in the interpretation of shallow subsurface physical properties and processes. Regions of contrasting electrical properties can be automatically identified using machine vision and computational imaging techniques. Feature extraction allows for the identification of distinct resistive regions representing the underlying structures. In time-lapse monitoring, using 2-D and 3-D ERT imaging, these approaches can be used to identify ongoing changes to the imaged volumes.
In experiments where a saline tracer is monitored over a time-series of ERT images, the tracer plume can typically be distinguished as a region of low resistivity against the background. This study looks at combining quantitative properties of the tracer plume, automatically extracted from inverted resistivity images, with motion models to track and forecast fluid flow. Due to issues of resolution and smoothness resulting from the inversion process, a level of uncertainty is present in the ERT images. This is also true of the mathematical models used to describe the dynamic systems, and so in combining them with the ERT, the detected results can be used to correct the model, while the model allows accommodation for error in the detections.
It has been possible to use the spatial distributions of detected tracer regions to create a semi-axial representation of centralised second-order tracer moments. A Kalman filter-based approach is used to match the detected regions between time-steps using motion models and tracking information, which allows forecasting of the proceeding tracer movement. This also enables a robust handling of the artefacts present in ERT, as well as other regions-of-interest, in the automated detection scheme. Independent tracks are maintained for each distinct contrasting feature and where these deviate from the expected motion models, they are discarded as part of the ongoing tracking system. The results show the effectiveness of this approach in tracking and predicting tracer motion through a system, as guided by mutual validation of model and observation.