Analysis of experimental data in electrical impedance tomography, and applications towards stable reconstruction algorithms.

The project will take place in the framework of an implementation of electrical impedance tomography (EIT),as developed in the recent paper ``A boundary integral equation method for the complete electrode model in electrical impedance tomography with tests on experimental data" appearing in the SIAM Journal on Imaging Sciences.

Electrical impedance tomography is a proposed imaging technique that seeks to reconstruct the electrical impedance of an object by performing (many) injections of current at the boundary of the object and measuring the corresponding voltage. Potential applications of this technique would be towards medical imaging, where the object to be imaged would be the human body, and the conductivity inside is assumed piece-wise constant, where each organ has a different conductivity coefficient.

The purpose of the project is to develop techniques, to analyse experimental data for errors (in settings where more data has been collected than is needed), and to use this analysis to understand how large errors can be expected in EIT reconstruction, given the expected size of measurement errors. The project will use experimental data that the supervisors have access to.

The FIPS experimental data set considered in the paper has found to contain some errors in the measurements, and moreover the size of the measurements could be estimated. It was found in the paper that making an ansatz on the source of the error allowed us to identify it and then remove it from most of the data. The resulting imaging which relied on the ``corrected'' data yielded much improved imaging. The goal of the project is to expand this to more general data sets, and to incorporate the technique of error estimation into the reconstruction algorithms.

The desired outcome would be to construct cost functions for an EIT optimization that rely less on measurements that are suspected of being faulty. A complementary objective would be to use ``blind'' reconstructions to learn the measurements that are faulty. The underlying theme here is that there exists a function over the space of measurements and the space of internal bodies which assigns the error in a measurement to an error in the reconstruction. A key part of the project is to both model this function from forward solvers, and to ``learn'' it,from experimental data; an approach to this task would use deep learning algorithms.

A further goal would be to use reconstructions that have usually been developed for EIT (especially the monotonicity method)to enhance the reconstruction algorithms we have. in the listed paper. The key challenge is to design algorithms that implement this method. This ties in with the proposed project, since poor reconstructions are known to be tied with local minima of cost functions, which the monotonicity method will seek to avoid. On the other hand measurement errors seem to create local minima. So progress on understanding measurement error yields hope that the monotonicity method can be more successful than it has so far.

The successful applicant will have familiarity with Matlab, a thorough command of multivariable calculus at the level of MAT257, as well as some interest in analysis and geometry.