Implementation of dynamic optimization with machine learning, applied to electrical impedance tomography.

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 a smarter optimization algorithm, to yield better-quality imaging results for EIT; the test will be on experimental data that the supervisors have access to.

As opposed to the more rudimentary optimization software used in the paper, the optimizer here will be dynamic, in the sense that it will re-start after a small number of steps have been taken. The re-start will seek to decrease a new objective function, and perhaps will alter parameters such as the subspace in the parameter space on which we perform optimization, or numerical parameters within the optimization software, such as the maximum step size, or altering the configuration of bodies found.

Ultimately, the project could involve some implementation of machine learning, aimed at ``learning'' which class of objective function or which particular subspace in parameter space tends to yield better reconstruction, for a given(apriori known)object that is being imaged. Further extensions of the project could be towards extending the core of the EIT solver to handle 3-dimensional objects (the current solver allows only 2-dimensional ones), by extending the approach in the paper to three dimensions.

Further extensions might involve incorporating previously developed EIT solvers that can be fast, but less precise than ours, such as the publicly available EIDORS.

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.