Automatic differentiation as an effective tool in Electrical Impedance Tomography

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Electrical Impedance Tomography (EIT) is a non-invasive imaging method that produces images by determining the electrical conductivity inside a subject using only electrical measurements obtained at its surface. More specifically, sinusoidal currents are applied to the subject through electrodes placed in certain locations at the surface of the object. The resulting voltages are then measured, making it possible to infer internal properties of the objects. EIT is a low-cost method and harmless for human beings, since it only applies low amplitude currents. A particularly relevant application of EIT is in the early determination of breast cancer, specifically for young women where the risk of the ionizing X-rays of mammographies outweigh the benefits of regular check-ups. The goal is to locate a potential region affected by cancer from measurements on the breast surface.

We start by formulating the EIT problem for the screening of breast cancer in an optimization framework. To solve this problem we used derivative-based methods, like gradient descent. For this we need a method to simulate the propagation of electrical current given an electrical conductivity, which we designate by differentiable simulator, and a way to compute its derivatives. Currently, the latter computations are done manually and can be fairly cumbersome and expensive to program efficiently. In this work, we explore automatic differentiation methods for the computation of the derivatives of the differentiable simulators. We validate that the latter method solves the optimization problem as efficiently as the manual methods. Moreover, we verified that automatic differentiation is as computationally and time efficient as programmatically computing the manual formulation of the derivatives. Hence, this methodology permits a faster implementation of novel algorithms for the solution of the EIT problem and lets us focus on the important aspect of implementing efficient differentiable simulators.

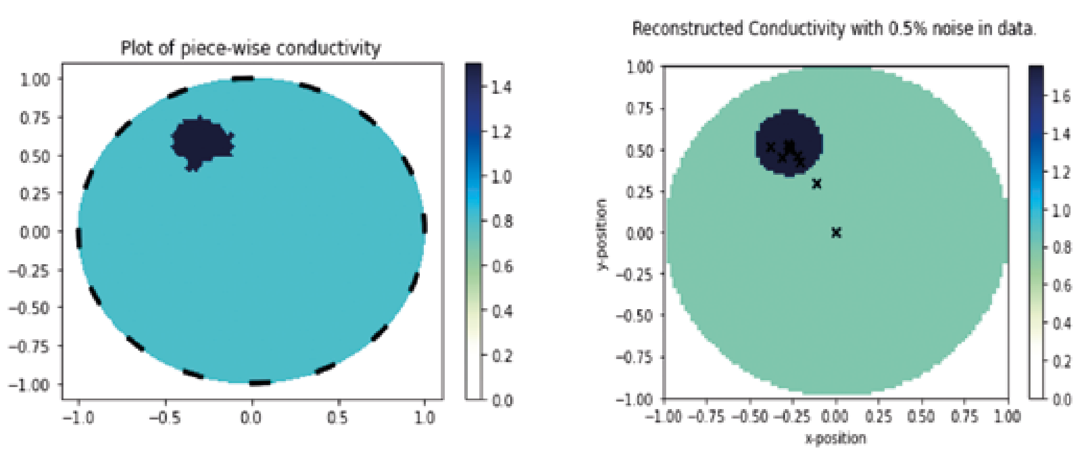

FIGURE 1
Slice of conductivity profile representing breast cancer on the left and the reconstruction obtained with automatic differentiation on the right. The color represents the conductivities in each region.