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Integrating Differential Evolution with Deep Learning for EIT Inverse Problem

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Electrical impedance tomography (EIT) is a noninvasive imaging technique that reconstructs the internal conductivity distribution of an object by measuring electric potentials on its surface. Mathematically, EIT is twofold: the forward problem solves a generalized Laplace equation with conductivity coefficients to determine the electric potential, while the inverse problem requires estimating conductivity from noisy and incomplete boundary measurements—an ill-posed task highly sensitive to noise. In this paper [1], we proposed a hybrid deep learning–evolutionary framework for EIT image reconstruction. The fully-connected feedforward neural networks (FNNs) and convolutional neural networks (CNNs) were trained to approximate the forward map from conductivity to electric potential, eliminating the need for repeated finite element simulations during inversion. For the inverse problem, we formulate the recovery of conductivity distributions as a global optimization task using differential evolution and its variants. Among them, success-history based adaptive differential evolution (SHADE) achieved the most accurate and robust results. While the proposed CNN-SHADE algorithm demonstrated competitive reconstruction performance, the FNN-SHADE approach provided a favorable trade-off between accuracy and computational efficiency. Furthermore, the FNN-SHADE framework outperformed the traditional finite element-based method in computational speed, while maintaining accuracy. By embedding a neural forward operator into the differential evolution loop, the framework offered a scalable, data-driven alternative to traditional EIT reconstruction methods.

This is a joint work with Margaret Esther C. Cruz and Renier G. Mendoza.

References

- [1] M. Cruz, R. Mendoza, and R. Mohammad. Image reconstruction in electrical impedance tomography using deep neural networks with differential evolution. *AIMS Electronic Research Archive*, 33(12):7637–7675, 2025.