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# Accelerating the Landweber method for the eikonal equation by a CNN

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The nonlinear eikonal equation results as a high frequency approximation of the Helmholtz equation, more generally, of the wave equation. We investigate the eikonal equation with respect to the theory of inverse problems in the context of terahertz tomography. We integrate neural networks in the Landweber iteration for the reconstruction of the refractive index $n(x)$, $x \in \Omega$, of an object. To reduce the computing time in the reconstruction process, we substitute the forward operator $F$ by a Convolutional Neural Network $\varphi_\Theta$, so that we obtain the Landweber step $n_{i+1}^\delta = n_i^\delta - \omega F'(n_i^\delta)^*(\varphi_\Theta(n_i^\delta) - y^\delta)$. In a second step, we save energy in the learning process of our network by generating a sparse forward operator. We add to the cost functional of the CNN a $l1$-regularization term $\alpha R(\Theta) = \alpha \sum_{i=1}^L ||\Theta^{(i)}||_1$, where $\alpha$ denotes a regularization parameter, $L$ the amount of layers and $\Theta^{(i)}$ the matrix of weights for the associated layer. We compare the normal Landweber method with the learned and sparse one. Numerical results will be presented.

**Primary authors:** MEISER, Clemens (Saarlands University); Prof. SCHUSTER, Thomas

**Presenter:** MEISER, Clemens (Saarlands University)