MEG Source Localization using an MLP

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Source localization of electroencephalographic (EEG) and magnetoencephalographic (MEG) signals is important in medical diagnosis of conditions like epilepsy, in surgical planning, and in neuroscience research. There are a number of localization methods in use: optimization using iterative gradient methods like Levenberg-Marquardt (LM), scanning methods like MUSIC and goal function scan (GFS), and linear estimation using least squares or singular value decomposition. Unfortunately the computational burden of these methods can be high for good accuracy, and they can be sensitive to noise.

This computational burden was incompatible with the real-time requirements of a closed loop MEG signal processing system currently under development in our laboratory. In order to reduce the computational burden, and to bound the amount of computation required for each localization, we used a multilayer perceptron (MLP) as an efficient real-time source localizer. The MLP was trained, via backpropagation, on a dataset of 7,500 exemplars: 5,000 for training and 2,500 for testing. Each exemplar consisted of a vector of sensor activations (input) and a dipole location and moment direction (target output). We built an analytical forward model of quasistatic electromagnetic propagation through a spherical head. This model was used to map 7,500 randomly chosen dipoles to corresponding sensor activities, according to the sensor geometry of a 4D Neuroimaging Neuromag-122 MEG system. Gaussian noise was added to the simulated sensor activities.

The trained MLP was faster than any other current method, and robust to noise. Training the MLP took less than an hour on an 800MHz AMD Athlon computer. The MLP was slightly less accurate than iterative methods at high signal-to-noise ratios, but more accurate at low signal-to-noise ratios.

In order to achieve the high accuracy of LM at high signal-to-noise ratios while reducing its computational burden, we combine the MLP with LM. The MLP's estimated dipole parameters are used to initialize the LM method.

We are currently extending the system to multiple dipoles using the EM algorithm applied to a mixture of MLPs.