Blind deconvolution for human speech signals

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Abstract: The structure of vowel sounds in human speech can be divided into two independent components. One of them is the "excitation signal," which is a kind of buzzing sound created by the vocal folds flapping against each other. The other is the "filtering effect" caused by resonances in the vocal tract, or the confined space formed by the mouth and throat. The Glottal Inverse Filtering (GIF) problem is to (algorithmically) divide a microphone recording of a vowel sound into its two components. This "blind deconvolution" task is an ill-posed inverse problem. Good-quality GIF filtering is essential for computer-generated speech needed for example by disabled people (think Stephen Hawking). Also, GIF affects the quality of synthetic speech in automatic information announcements and car navigation systems. Accurate estimation of the voice source from recorded speech is known to be difficult with current glottal inverse filtering (GIF) techniques, especially in the case of high-pitch speech of female or child subjects. In order to tackle this problem, the present study uses two different solution methods for GIF: Bayesian inversion and alternating minimization. The first method takes advantage of the Markov chain Monte Carlo (MCMC) modeling in defining the parameters of the vocal tract inverse filter. The filtering results are found to be superior to those achieved by the standard iterative adaptive inverse filtering (IAIF), but the computation is much slower than IAIF. Alternating minimization cuts down the computation time while retaining most of the quality improvement.

Nonlinear mathematics of electrical impedance imaging

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Abstract: The aim of electrical impedance tomography (EIT) is to reconstruct the inner structure of an unknown body from voltage-to-current measurements performed at the boundary of the body. EIT has applications in medical imaging, nondestructive testing, underground prospecting and process monitoring. The imaging task of EIT is nonlinear and an ill-posed inverse problem. A non-iterative EIT imaging algorithm is presented, based on the use of a nonlinear Fourier transform. Regularization of the method is provided by nonlinear low-pass filtering, where the cutoff frequency is explicitly determined from the noise amplitude in the measured data. Numerical examples are presented, suggesting that the method can be used for imaging the heart and lungs of a living patient. Furthermore, the complex geometrical optics (CGO) solutions needed in the nonlinear Fourier transform are discussed in the context of detecting and recovering singularities in conductivity.