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TITLE: Variational approximate inference for inverse problems motivated by medical tomography

ABSTRACT BODY:

Abstract Body: Tomography aims to display cross-sections through human bodies or other solid objects using data collected from around the body or object. Two main branches are positron emission tomography and electrical impedance tomography. Modern positron emission tomography datasets record about 1 billion radioactive events as more than 10,000 highly correlated but separate counts. A common aim is to estimate parameters and represent the spatial distribution of radioactive tracer concentration. This makes such applications challenging inverse problems.
From a statistical perspective, inverse problems are regression models where a response, depending on a number of causal factors or parameters, is measured and the goal is to estimate the parameter values. Since in typical tomography applications inverse problems may be highly multivariate and have predictors which are highly correlated, even simple linear problems cannot be solved by classical regression methods, nor can they be adequately solved using standard dimension reduction or regularised regression techniques. A remedy is to use Bayesian hierarchical models, which can be slow to fit via standard MCMC algorithms.
We propose a mean field variational Bayes (MFVB) approach for accurate approximate fitting and inference on inverse problem models. In parallel, we identify typical factor graph fragments arising in inverse problem Bayesian models and derive the variational message passing version of the MFVB algorithms. The resultant factor graph fragments facilitate streamlined implementation of approximate algorithms for inverse problems motived by tomography and set the basis for software development. As a matter of fact, the factor graph fragment paradigm allows easy incorporation of different penalization structures in the model or changes to the distribution of the outcome variable. Nevertheless, variational message passing on factor graph fragments is such that algorithm updates and streamlining steps only need to be derived once for a particular fragment and can be used for any arbitrarily complex model including such fragment. Hence dramatically reducing set-up overheads as well as providing fast implementation.

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