A nonlinear inverse problem in polyenergetic tomosynthesis image reconstruction

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Tomosynthesis imaging is a limited angle tomography approach that uses conventional x-ray systems to obtain 3-dimensional image reconstructions. Most breast tomosynthesis image reconstruction algorithms use a simplified, but incorrect assumption that the source x-ray beam is comprised of photons with a constant energy; that is, the x-ray beam is assumed to be monoenergetic. We consider mathematical models that use the physically correct, and hence more accurate, assumption that the x-ray beam is polyenergetic. The image reconstruction problem requires solving the nonlinear inverse problem

$$\boldsymbol{b} = \exp(\boldsymbol{R}\boldsymbol{\mathcal{M}})\boldsymbol{\rho} + \boldsymbol{\eta}\,,$$

where $\boldsymbol{b}$ is known measured projection data, $\boldsymbol{R}$ is a known *ray trace* matrix, $\boldsymbol{\rho}$ is a known vector that contains information about the source x-ray energy, $\boldsymbol{\eta}$ is a vector that represents unknown additive noise, and $\boldsymbol{\mathcal{M}}$ is an unknown matrix, where each entry $\mu_{i,j}$ is the attenuation coefficient for voxel i and x-ray energy level j. The exponentiation is done element wise on the entries of the matrix $\boldsymbol{R}\boldsymbol{\mathcal{M}}$.

The image reconstruction problem requires computing an approximation of $\boldsymbol{\mathcal{M}}$. In this talk we describe how this model arises from the physics of the x-ray tomosynthesis system, discuss computational approaches to compute approximations of $\boldsymbol{\mathcal{M}}$, and consider applications for breast imaging.

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