**Kinetic compressive sensing: improving image reconstruction and parametric maps**

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**Background**

Parametric imaging provides insight into the spatial distribution of physiological parameters, but they result in images of low SNR of tomographic data. Direct estimation from projections (1) allows accurate noise modeling, improving the results of post-reconstruction fitting.

We propose a method, which we name kinetic compressive sensing (KCS), based on a hierarchical Bayesian model and on a novel reconstruction algorithm, that encodes sparsity of kinetic parameters.

**Hierarchical Bayesian Model**

The model has three key components:

1. the model of the acquisition system consists of the ordinary Poisson model as a basis of attenuation, scatter and randoms;
2. the kinetic model encodes the assumption that the voxel intensities are many realizations of a hidden dynamic process, modeled using a multi-compartmental model;
3. a sparsity-inducing prior distribution of the kinetic parameters is introduced as a Markov Random Field (MRF) with Smooth L1 norm cost function (6).

**Algorithm workflow (HCS pg)**

**Simulations**

**Simulation setup**

To assess the effect of the KCS algorithm in comparison with standard kinetic modeling techniques, and to evaluate the performance of the GPU implementation, we realized a Monte Carlo (MC) simulation with 100 noise realizations.

The kinetic behavior of the three main regions has been simulated using a 2-tissues irreversible compartment model, while the square area in the center has been modeled as a blood input region. In this simulation study we generated synthetic dynamic PET data, according to the hierarchical bayesian model presented.

**Results**

We compared the results of three different methods: direct recon, direct recon with kinetic compressive sensing, KCS. In Fig. 1, it is easy to recognize a first reduction in voxel-by-voxel variance when the kinetic model is used to regularize the reconstruction (DIRECT), which increases when the sparsity assumption of the kinetic parameters is enforced (KCS). The bias/variance plot shows how a direct approach improves the quality of the estimate of parametric maps, with respect to the results provided by a standard indirect post-reconstruction fitting, but also how the novel sparsity constraint is able to further reduce the variance of the produced parametric maps, without affecting the bias.

**Human Data**

**PET Dataset**

The conventional indirect and direct, and the novel KCS approaches were applied to [18F]-FDG brain PET data, acquired on a Siemens mMR PET-MR scanner, using a 2-tissue reversible compartment model.

**PET Results**

For row of Fig. 4 shows how the different methods perform in terms of image reconstruction, while the bottom row shows the estimated K, (net uptake rate) parametric maps: the proposed KCS direct method is able to produce spatially coherent images, with low noise and good tissue contrast, also when it comes to parametric maps estimates.

**References**