Hybrid Kernelized Expectation Maximization implementation in STIR

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Kernelised OSEM

$$\lambda_j = \sum_{f=1}^{N} \alpha_f k_{fj}^{(n)} \tag{1}$$

Iteratively reconstruct the coefficient α

$$\alpha_f^{(n+1)} = \frac{\alpha_f^{(n)}}{\sum_j k_{fj}^{(n)} \sum_i p_{ij}} \sum_j k_{fj}^{(n)} \sum_i p_{ij} \frac{1}{\sum_l p_{il} \sum_f k_{fl}^{(n)} \alpha_f^{(n)} + a_i} \tag{2}$$

The proposed kernel

$$k_{fj}^{(n)} = k_m(\boldsymbol{v}_f, \boldsymbol{v}_j) \cdot k_p(\boldsymbol{z}_f^{(n)}, \boldsymbol{z}_j^{(n)}) \tag{3}$$

$$k_m(\boldsymbol{v}_f, \boldsymbol{v}_j) = \exp\left(-\frac{\|\boldsymbol{v}_f - \boldsymbol{v}_j\|^2}{2\sigma_m^2}\right) \exp\left(-\frac{\|\boldsymbol{x}_f - \boldsymbol{x}_j\|^2}{2\sigma_{dm}^2}\right) \tag{4}$$

$$k_p(\boldsymbol{z}_f^{(n)}, \boldsymbol{z}_j^{(n)}) = \exp\left(-\frac{\|\boldsymbol{z}_f^{(n)} - \boldsymbol{z}_j^{(n)}\|^2}{2\sigma_p^2}\right) \exp\left(-\frac{\|\boldsymbol{x}_f - \boldsymbol{x}_j\|^2}{2\sigma_{dp}^2}\right) \tag{5}$$

New derived class and executable

- **KOSMAPOSL** derived from **OSMAPOSL**

Parameter file

KOSMAPOSLParameters:=

objective function type:= PoissonLogLikelihoodWithLinearModelForMeanAndList-ModeDataWithProjMatrixByBin
input:=

hybrid:= ;0 for KEM or 1 for HKEM
sigma_m:= ;default 1 controls anatomical edge preservation
sigma_p:= ;default 1 controls PET edge preservation
sigma_dm:= ;default: 1 (usual range 1-5) Spatial Gaussian scaling parameter for the anatomical prior (mm)
sigma_dp:= ;default: 1 (usual range 1-5) Spatial Gaussian scaling parameter for the PET prior (mm)
neighbours_num:= default:3 controls the size of the neighbourhood
num_non_zero_feat_elements:=default:1 controls the size of the feature vector patch
_image_filename:=if hybrid=1 and anatomical image is uniform the algorithm behave similarly to Snyder et al 1985
only_2D:=0
kernelised output filename prefix:=

Compatibility and functionality

- MR image has to be re-sliced to match the PET voxel size or vice versa (z voxel size depends on the scanner)
- The method would work for every scanner in STIR or customized (validated on Siemens mMR and mCT and GE signa).
- It is possible to reconstruct with both sinogram or list-mode, and use all the different objective functions
- If one wants to use any prior available within STIR this is also possible