Patch-based super-resolution for arterial spin labeling MRI
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The CBF maps were estimated using the red on the perfusion maps. The ASL series were realigned on the first volume. The M0 image acquired at the same resolution than the pCASL series and Structural image: MPRAGE 3DT1 1x1x1mm, FOV=156x200mm².

In clinical conditions, ASL images are often acquired at low resolutions (LR). This implies partial volume effects (PVE), limiting the validity of cerebral blood flow (CBF) quantifications. In order to validate the ability of the algorithm to retrieve a HR image, we applied it to an original HR CBF map downsampled by a factor of 2 in each direction.

The proposed algorithm therefore consists in:
- a 3rd order spline interpolation to increase the image dimensions
- iterations between the non-local patch-based regularization and an original data fidelity term until convergence

\[
X_t^{t+1} = \frac{1}{Z_i} \sum_{j \in V_i} X_j \exp(-\frac{\|N(S_i) - N(S_j)\|^2}{2\sigma_i^2}) + \frac{\|N(X_j) - N(X_i)\|^2}{2\sigma_j^2})
\]

with \(N(X_i)\) a 3x3x3 neighborhood, \(V_i\) a 7x7x7 search volume around voxel \(i\), \(\sigma_i\) the empirical variance and \(Z_i\) a scaling parameter.

The purpose of the super-resolution algorithm is to retrieve a HR CBF map \(x\) from a LR one \(y\) provided by the scanner, subject to a decimation operator \(D\), a degradation model \(H\) and noise \(\eta\):

\[
y = DHx + \eta
\]

\(X_t\) the estimation of \(x\) obtained by reconstruction from \(y\), is the result of the minimization of the optimization function:

\[
\hat{x} = \arg\min_x \|y - DHx\|^2 + \gamma \Psi_S(x)
\]

with \(\gamma\) a scalar and \(\Psi_S\) a non-local patch-based regularization term, including information from the structural image \(S\).

The quality of the reconstructions was evaluated by calculating the PSNR between this reference and the generated images.