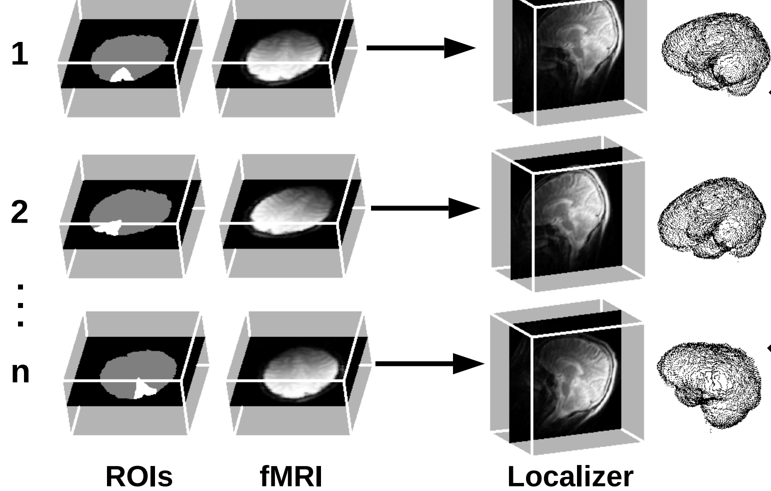

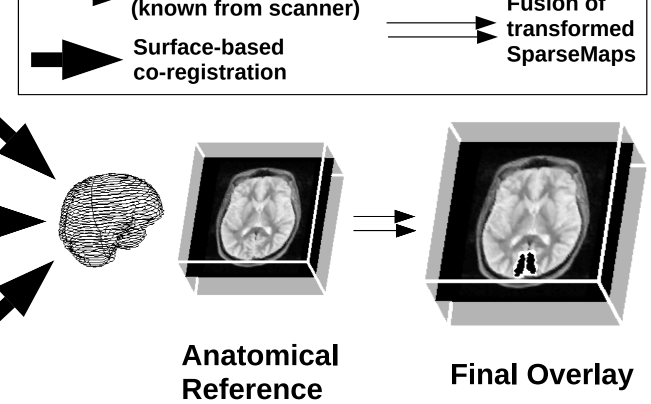

__Methods__: **Image registration:** A high-resolution anatomical reference scan $\mathcal{R}$ is acquired for final overlaid display of the fused activation. Subjects are immobilized with a bite-bar during each functional imaging session, such that little or no motion occurs between the acquisition of anatomical localizer $\mathcal{L}^n$ and functional $\mathcal{F}^n$ scans in session n. Because functional time-series may suffer from low resolution, partial brain coverage, and poor image quality especially with surface coils **(Figure)**, direct co-registration of $\mathcal{F}^n$ to $\mathcal{R}$ (using surface-based [1,2], intensity-based [3] or other methods) should be avoided. Instead, it is possible (assuming no intrascan motion) to compute the affine transformation $A^n_{\mathcal{F}\to\mathcal{L}}$ between $\mathcal{F}^n$ and $\mathcal{L}^n$ using information from the scanner (e.g. from file headers).

Three-dimensional (3D) image registration then allows recovery of the affine transformation $A^n_{\mathcal{L}\to\mathcal{R}}$ between $\mathcal{L}^n$ and $\mathcal{R}$. Accuracy better than 1mm of translation and 1° of rotation was demonstrated for this step using our automatic brain surface segmentation and anisotropic chamfer-based surface matching method [1,2]. A final affine transformation is then computed, linking $\mathcal{F}^n$ to $\mathcal{R}$: $A^n_{\mathcal{F}\to\mathcal{R}} = A^n_{\mathcal{L}\to\mathcal{R}} A^n_{\mathcal{F}\to\mathcal{L}}$. No image reslicing is performed.

Creation of Sparse Maps: A set of 3D ROIs is defined in each functional scan $\mathcal{F}^n$, either manually (e.g. early visual cortex in the **Figure**), or automatically by applying an fMRI activation detection test [4]. In the latter case (used in our laboratories), the ROIs should include even weakly activated volume elements (voxels), since we want to detect weak but consistent activity patterns.

Sparse maps are derived for each functional scan, containing for each voxel i inside the ROIs: 1) the 3D coordinates of its center C_i, in the referential of the functional scan; 2) three 3D vectors x_i, y_i, z_i defining the size and orientation of voxel i: $x_i = (sx, 0, 0)^T$, $y_i = (0, sy, 0)^T$, $z_i = (0, 0, sz)^T$, where a final composite sparse map $\mathcal{S}$. $\mathcal{S}$ contains time-series and associated localization information in the coordinate system of $\mathcal{R}$, from all the ROIs of all functional scans.

fMRI activation can then be reconstructed from $\mathcal{S}$, at the resolution of $\mathcal{R}$. Each voxel in $\mathcal{S}$ is modeled as the 3D shape of the voxel convolved with the 3D impulse response of the scanner, and convolved with a 1mm-width 3D Gaussian to account for registration inaccuracies. The model is approximated in our implementation by the box (x_i, y_i, z_i) convolved with the Gaussian. Each voxel j in $\mathcal{R}$ is successively examined; a time-series is computed for j as a weighted average of all the time-series from the voxels in $\mathcal{S}$, with weights computed from the overlap between j and the functional voxel models. An fMRI detection test [4] is then applied, which transforms the time-series of j into a functional score. The scores for all voxels in $\mathcal{R}$ are finally displayed as a color overlay on $\mathcal{R}$.

__Discussion and Conclusion__: Our implementation could be further optimized by using a more precise model for functional voxels, and by reducing the redundancy in the sparse maps (only 9 degrees of freedom are required to fully specify each voxel's geometry, while we use 12). This method requires contiguous fMRI slices and good overlap between the ROIs in order to avoid patchy-looking results. Using this method, we have been able to fuse large numbers of fMRI scans (up to 22). The final activation score computed for each voxel in $\mathcal{R}$ reflects not only how strongly this anatomical location is activated in each fMRI scan, but also how reliably this activation is seen across scans.

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__REFERENCES__:

1. L Itti *et al.*, Proc. 4th ISMRM, p. 35, 1996
2. L Itti *et al.*, Human Brain Mapping 1997;5:1-17
3. RP Woods *et al.*, J Comput Assist Tomogr 1992;16:620-33
4. P Bandettini *et al.*, Magn Res Med 1993;30:161-73