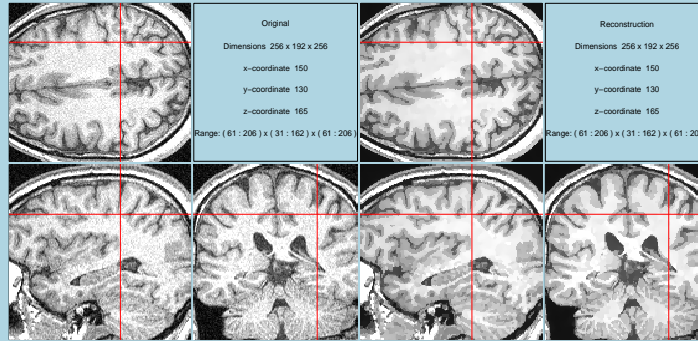


# Structure Adaptive Smoothing Procedures in Medical Imaging

## 3D medical imaging

- ▷ **Data:**  $(X_i, Y_i), X_i \in \mathcal{X}, Y_i \in \mathcal{Y}$
- ▷ **Model:**  $Y_i \sim P_{\theta}(X_i), \theta: \mathcal{X} \rightarrow \Theta.$
- ▷ **Structural assumption:**  $\theta(x)$  piecewise constant



Reconstruction of MR image. Left: original image, Right: result of structure adaptive smoothing

The AWS Procedure:

- ▷ **Initialization:** global MLE  

$$\hat{\theta}_i^{(0)} := \frac{1}{n} \sum_j Y_j, \quad w_{ij}^{(0)} = 1$$
- ▷ **Iteration:** adaptive weights  

$$w_{ij}^{(k)} = K_l(l_{ij}^{(k)}) K_s(s_{ij}^{(k)})$$

where  $K_l, K_s$  are kernel functions and

$$l_{ij}^{(k)} = |X_i - X_j|/h^{(k)}$$

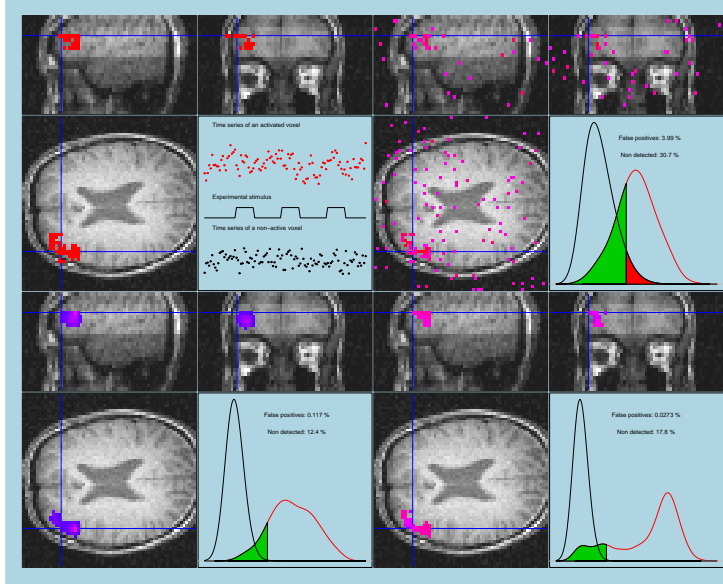
is the location penalty and

$$s_{ij}^{(k)} = \frac{1}{\lambda} \sum_l w_{il} \mathcal{K}(\hat{\theta}_i^{(k-1)}, \hat{\theta}_j^{(k-1)})$$

the statistical penalty. New estimate

$$\hat{\theta}_i^{(k)} := \sum_j w_{ij} Y_j / \sum_j w_{ij}.$$

## fMRI



**fMRI:** Analysis of an artificial functional MRI experiment.

Upper left: Design of the experiment: Voxels with assigned activation. The signals in the time series have been convolved with a hemodynamic response function. Perturbations include autocorrelated noise, heartbeat and magnetic field inhomogeneities.

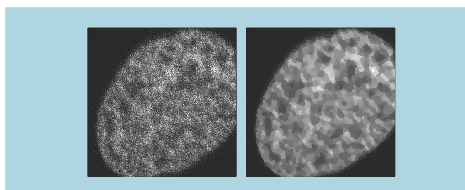
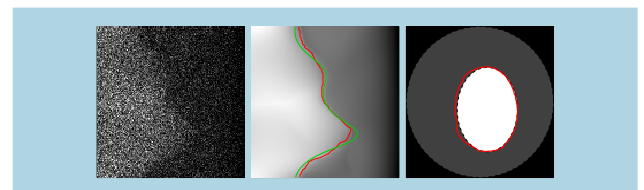
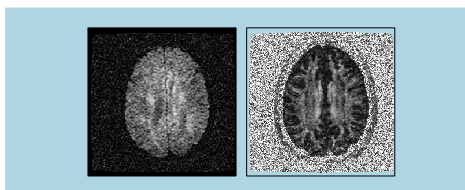
Upper right: Result of a voxelwise analysis.

Lower left: Result of an analysis using non-adaptive smoothing.

Lower right: Result of an analysis using structure adaptive smoothing procedures.

Density plots of empirical test statistics of activated and non-activated voxels are provided. The portion of signals that is not detected is emphasized with green colour, while the portion of false positive is red. The time series in an activated and non-activated voxel are also shown, respectively.

## further applications



**DTI** (upper left): Diffusion Tensor analysis looks for anisotropy information and requires adaptive anisotropic smoothing procedures.

**PET** (upper right): Recovering edges from noisy Poisson data. The discontinuities of the first derivative under Radon transform correspond to tissue borders.

**Microbiological images** (left): studying the structure of the image rather than just denoising: edge detection, segmentation, classification, and pattern recognition

## Publications

1. J. Polzehl and V. Spokoiny (2001). Functional and dynamic magnetic resonance using vector adaptive weights smoothing. *J. Roy. Statist. Soc. Ser. C*, **50**:485-501 (2001).
2. J. Polzehl and V. Spokoiny (2004). Local likelihood modeling by adaptive weights smoothing. WIAS-Preprint No. 787.
3. J. Polzehl and V. Spokoiny (2003). Varying coefficient regression modeling by adaptive weights smoothing. WIAS-Preprint No. 818.
4. A. Goldenshluger and V. Spokoiny. Recovering Edges of an Image from Noisy Tomographic Data. WIAS-Preprint No. 909, 2004.
5. A. Goldenshluger and V. Spokoiny. On the shape-from-moments problem and recovering edges from noisy Radon data. *Probab. Theory Related Fields*, **128** (2004), no. 1, 123–140.