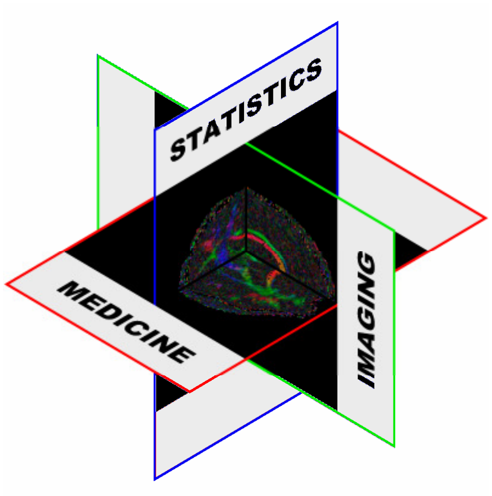
Our structure adaptive smoothing techniques

- preserve discontinuities
- efficiently reduce high-level noise



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More information and literature:

www.wias-berlin.de/projects/matheon_a3/

More core competences:

www.matheon.de

Core competence

Structure Adaptive Smoothing in Medical Imaging

with applications to fMRI, DTI, and more

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The Research Center **MATHEON** „Mathematics for key technologies“ of the German research foundation DFG is run by the three Berlin universities - the Technical University, the Free University and the Humboldt University - as well as by the Zuse Institute (ZIB) and the Weierstrass Institute (WIAS). Under the guidance of internationally leading experts about 200 highly motivated researchers carry out application-driven research in close cooperation with partners from industry, with life sciences as one major focus.

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Challenges in modern medical imaging

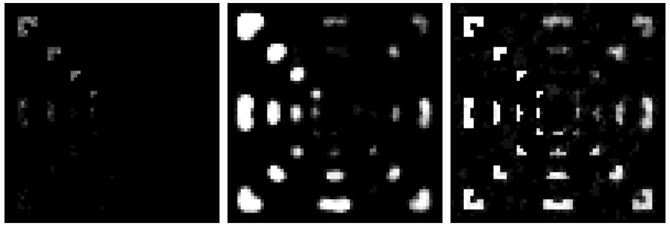
Imaging has become omnipresent in medicine and bioscience in the last decade, since it enables physicians and researchers to examine the human body in-vivo. However, imaging modalities like Computer Tomography (CT), Magnetic Resonance Imaging (MRI) and others suffer from significant noise. Interesting structures and signals are weak and can hardly be detected. 3D or 4D data renders an analysis via visual inspection almost impossible.

There is clearly a need for automatic methods for signal detection, structure enhancement, dimension and noise reduction. Classical smoothing techniques often fail as they tend to blur important details and boundaries of interesting structures.

Structure adaptive smoothing

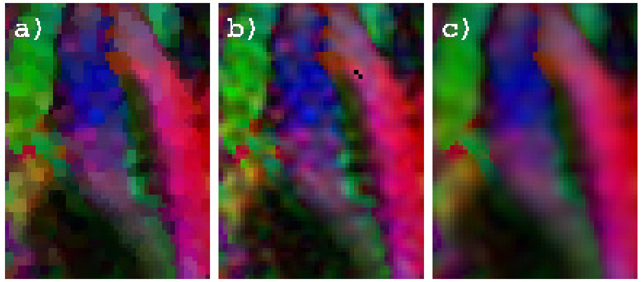
… is a way to meet these challenges. Our adaptive image processing techniques provide powerful tools for improving the quality of medical imaging data dramatically.

Example 1: Signal detection in fMRI



In this artificial example of functional magnetic resonance imaging (fMRI) data we show the probability of signal detection. We simulate data with different signal strengths and shapes of simulated activation areas. **Without smoothing (left)**: The activation appears weak due to low signal intensities. Noise reduction is inevitable. **With non-adaptive smoothing (middle):** Activation areas can be detected but corresponding boundaries are blurred. **With structure adaptive smoothing (right):** Activation areas show sharp contours.

Example 2: Smoothing diffusion weighted data



Color-coded images of the fractional anisotropy of diffusion-weighted data of the human brain. Structure adaptive smoothing (left) the original data (center) helps to define tissue contours instead of blurring them by non-adaptive smoothing (right).

Technical background

The basic idea behind our structure adaptive smoothing techniques is to use information on the structures of interest in the smoothing algorithm for local modeling. A qualitative structural assumption is used to improve estimates of the parameters of the local model while these estimates are used to infer on spatial regions defined by the structures of interest. This is incorporated in an iterative procedure that operates from very local scales to a user defined limit. The resulting algorithm achieves a maximum of variance reduction in homogeneous regions and preserves discontinuities.

Main properties of the algorithm

- Propagation: Efficient reduction of noise
- Separation: Preservation of discontinuities
- Data independent tuning parameters
- Fast processing due to early dimension reduction

Software packages

Many of our methods are available as software packages for the **R** Language for Statistical Computing or are adapted to environments like AMIRA™ and Matlab.

For instance, the R-package *fmri* provides numerous functions for analyzing functional magnetic resonance data with structure adaptive smoothing procedures.

Our core team and competence network

Prof. Dr. V. Spokoiny heads the research group „Stochastic Algorithms and Nonparametric Statistics“ at the Weierstrass Institute. Together with his colleagues Dr. J. Polzehl and Dr. K. Tabelow he is working for many years in the field of medical imaging in close cooperation with scientists from e.g. Weill Medical College of Cornell University, Berlin NeuroImaging Center, Universität Münster, and University of Haifa.

Are you interested?

The principles behind our adaptive smoothing methods are applicable to a wide range of imaging data. We are constantly looking for new challenges.

If you are interested in our methods, we are happy to discuss with you in detail, what we may contribute to the solution of your R&D problems.