Mathematical modeling and visualization of functional neuroimages - DTU Orbit
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Mathematical modeling and visualization of functional neuroimages
This dissertation presents research results regarding mathematical modeling in the context of the analysis of functional
neuroimages. Specifically, the research focuses on pattern-based analysis methods that recently have become popular
within the neuroimaging community. Such methods attempt to predict or decode experimentally defined cognitive states
based on brain scans. The topics covered in the dissertation are divided into two broad parts: The first part investigates
the relative importance of model selection on the brain patterns extracted from analysis models. Typical neuroimaging
data sets are characterized by relatively few data observations in a high dimensional space. The process of building
models in such data sets often requires strong regularization. Often, the degree of model regularization is chosen in order
to maximize prediction accuracy. We focus on the relative influence of model regularization parameter choices on the
model generalization, the reliability of the spatial brain patterns extracted from the analysis model, and the ability of the
resulting model to identify relevant brain networks defining the underlying neural encoding of the experiment. We show
that known parts of brain networks can be overlooked in pursuing maximization of prediction accuracy. This supports the
view that the quality of spatial patterns extracted from models cannot be assessed purely by focusing on prediction
accuracy. Our results instead suggest that model regularization parameters must be carefully selected, so that the model
and its visualization enhance our ability to interpret the brain. The second part concerns interpretation of nonlinear models
and procedures for extraction of ‘brain maps’ from nonlinear kernel models. We assess the performance of the sensitivity
map as means for extracting a global summary map from a trained model. Such summary maps provides the investigator
with an overview of brain locations of importance to the model’s predictions. The sensitivity map proves as a versatile
technique for model visualization. Furthermore, we perform a preliminary investigation of the use of pre-image estimation
for localized interpretation of nonlinear models. In the context of image denoising the pre-image analysis proves to
enhance the reliability of brain patterns extracted from multivariate models of the neuroimaging data.

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