COMPUTING BRAIN ACTIVITY MAPS FROM fMRI TIME-SERIES IMAGES

fMRI is a very popular method in which researchers and clinicians can image human brain activity in response to given mental tasks. This book presents a comprehensive review of the methods for computing activity maps, while providing an intuitive and mathematical outline of how each method works. The approaches include statistical parametric maps (SPM), hemodynamic response modeling and deconvolution, Bayesian, Fourier and nonparametric methods. The newest activity maps provide information on regional connectivity and include principal and independent component analysis, crisp and fuzzy clustering, structural equation modeling, and dynamic causal modeling. Preprocessing and experimental design issues are discussed with references made to the software available for implementing the various methods. Aimed at graduate students and researchers, it will appeal to anyone with an interest in fMRI and who is looking to expand their perspectives of this technique.

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To Kerry

Contents

Preface

You will find here a comprehensive review of all fMRI data processing methods proposed in the literature to 2005. I have endeavored, however, to produce a review that is useful to more than those already in the know. With the introduction of each major method I have additionally given an overview of how the method works in wide and hopefully intuitive terms. The overviews taken together should give the newcomer a broad idea of all the choices that can be made for transforming raw fMRI data into a brain activity map.

The term activity map is used here to include the specific forms of maps labeled as activation maps and connectivity maps. Activation maps show regions of the brain that are active in response to a task given to the person in the MRI, while connectivity maps are intended to provide information on the neural connectivity between the active regions.

All methods are described in a precise manner from a mathematical perspective. So a certain amount of mathematical and/or statistical background is assumed of the reader. However, the math is presented at a high level. You will not find here details of how to implement any of the methods reviewed. For the details you will need to consult the original literature listed in the references.

In short, this book can help the newcomer to the field of fMRI (or a seasoned researcher wanting to know about methods used by others) to become oriented via a three-step process. The first step is to more or less skim through the book, reading the descriptive overviews to get a perspective on the big picture. Then, after some methods of interest are identified, a more careful reading of the high level mathematical descriptions can be done to become more familiar with the underlying ideas. Finally, if the reader is convinced of the utility of a particular method, the original literature can be consulted, the methods mastered and contributions of one's own to the field envisaged. This is the path that all graduate students using fMRI are interested in taking so I imagine that it will be those graduate students who will find this book most useful.

This book (in a slightly shorter form) was originally written as a review article for *Current Medical Imaging Reviews* (*CMIR*) and submitted for peer review. The finished manuscript proved to be longer than I originally envisaged. I was under

the impression when I first began to write that there were only a "few" basic ways to process fMRI data. That impression was proved to be very wrong as I dug into the literature to find literally hundreds of ways of turning raw fMRI data into something interpretable. So, while the reviews of the original manuscript came back from *CMIR* generally positive, it was far too long to be published in the journal. At that point the editor for *CMIR*, Sohail Ahmed, agreed to support the publication of the review in book form by Cambridge University Press. With thanks to Martin Griffiths at Cambridge University Press this book has subsequently become a reality. Thanks are due also to Clare Georgy for her help in the details of producing the final manuscript and Betty Fulford for looking after the legal aspects. Thanks to my technical assistant, Jennifer Hadley, here at the University of Saskatchewan, for preparing some of the figures and for organizing copies of all the references into an ordered stack of paper that stood at a height just slightly less than my own. Thanks, finally and mostly, to my family: Kerry, Dominic and Darien, for their patience and understanding with the long night hours I devoted to writing this review.