Applied Functional Data Analysis: Methods and Case Studies

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Library of Congress Cataloging-in-Publication Data
Ramsay, J.O. (James O).
Applied functional data analysis : methods and case studies / J.O. Ramsay, B.W. Silverman.
p. cm. — (Springer series in statistics)
Includes bibliographical references and index.
ISBN 0-387-95414-7 (pbk. : alk. paper)
1. Multivariate analysis. I. Silverman, B.W., 1952– II. Title. III. Series.
QA278 .R35 2002
519.5'35—dc21 2002022924

ISBN 0-387-95414-7 Printed on acid-free paper.

Printed in the United States of America.

9 8 7 6 5 4 3 2 SPIN 10944752

Typesetting: Pages created by the authors using a Springer TEX macro package.

www.springer-ny.com

Springer-Verlag New York Berlin Heidelberg
A member of BertelsmannSpringer Science+Business Media GmbH

Preface

Almost as soon as we had completed our previous book *Functional Data Analysis* in 1997, it became clear that potential interest in the field was far wider than the audience for the thematic presentation we had given there. At the same time, both of us rapidly became involved in relevant new research involving many colleagues in fields outside statistics.

This book treats the field in a different way, by considering case studies arising from our own collaborative research to illustrate how functional data analysis ideas work out in practice in a diverse range of subject areas. These include criminology, economics, archaeology, rheumatology, psychology, neurophysiology, auxology (the study of human growth), meteorology, biomechanics, and education—and also a study of a juggling statistician.

Obviously such an approach will not cover the field exhaustively, and in any case functional data analysis is not a hard-edged closed system of thought. Nevertheless we have tried to give a flavor of the range of methodology we ourselves have considered. We hope that our personal experience, including the fun we had working on these projects, will inspire others to extend "functional" thinking to many other statistical contexts. Of course, many of our case studies required development of existing methodology, and readers should gain the ability to adapt methods to their own problems too.

No previous knowledge of functional data analysis is needed to read this book, and although it complements our previous book in some ways, neither is a prerequisite for the other. We hope it will be of interest, and accessible, both to statisticians and to those working in other fields. Similarly, it should appeal both to established researchers and to students coming to the subject for the first time.

Functional data analysis is very much involved with computational statistics, but we have deliberately not written a computer manual or cookbook. Instead, there is an associated Web site accessible from `www.springer-ny.com` giving annotated analyses of many of the data sets, as well as some of the data themselves. The languages of these analyses are MATLAB, R, or S-PLUS, but the aim of the analyses is to explain the computational thinking rather than to provide a package, so they should be useful for those who use other languages too. We have, however, freely used a library of functions that we developed in these languages, and these may be downloaded from the Web site.

In both our books, we have deliberately set out to present a personal account of this rapidly developing field. Some specialists will, no doubt, notice omissions of the kind that are inevitable in this kind of presentation, or may disagree with us about the aspects to which we have given most emphasis. Nevertheless, we hope that they will find our treatment interesting and stimulating. One of our reasons for making the data, and the analyses, available on the Web site is our wish that others may do better. Indeed, may others write better books!

There are many people to whom we are deeply indebted. Particular acknowledgment is due to the distinguished paleopathologist Juliet Rogers, who died just before the completion of this book. Among much other research, Juliet's long-term collaboration with BWS gave rise to the studies in Chapters 4 and 8 on the shapes of the bones of arthritis sufferers of many centuries ago. Michael Newton not only helped intellectually, but also gave us some real data by allowing his juggling to be recorded for analysis in Chapter 12. Others whom we particularly wish to thank include Darrell Bock, Virginia Douglas, Zmira Elbaz-King, Theo Gasser, Vince Gracco, Paul Gribble, Michael Hermanussen, John Kimmel, Craig Leth-Steenson, Xiaochun Li, Nicole Malfait, David Ostry, Tim Ramsay, James Ramsey, Natasha Rossi, Lee Shepstone, Matthew Silverman, and Xiaohui Wang. Each of them made a contribution essential to some aspect of the work we report, and we apologize to others we have neglected to mention by name. We are very grateful to the Stanford Center for Advanced Study in the Behavioral Sciences, the American College Testing Program, and to the McGill students in the Psychology 747A seminar on functional data analysis. We also thank all those who provided comments on our software and pointed out problems.

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January 2002

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