Preface

Form follows function. This old adage from art and architecture, credited to American architect Louis H. Sullivan, holds true. The shape of an object is intimately connected to its purpose. Nature provides many examples of this: the shape of a tree and its leaves to harvest light, the wings of a bird to fly, the body of a snake to slither, and the structure of the human heart to keep us alive. So good is this rubric that it finds application in modern design principles, e.g., the shapes of tools, the profile of an automobile, and the design of a bridge.

In an 1896 essay, Sullivan wrote

. . . form ever follows function and this is the law.

Sullivan means that form depends completely on function. But what about the reverse? If an object's shape changes, how is its function affected? Is the object's function improved? Is the object better? In other words, does it make sense to consider function as dependent on shape? In a certain context, yes. The main purpose of this book is to explain how to differentiate a function (in the calculus sense) with respect to a "shape variable."

This book is written to be as self-contained as possible. It can be read by undergraduates who have completed the usual introductory calculus-based math courses. It can be read by experts from other fields who wish to learn the fundamentals of differential geometry and shape differential calculus and apply them in their own disciplines. It also makes a useful reference text for a variety of shape differentiation formulas. Chapter 1 gives more details on the prerequisites, framework, and overall philosophy of the book.

This book started as a set of notes I had created for my own use. Over time, I continued to refine them and used them in a special topics course I taught at Louisiana State University (LSU) in Fall 2011. Eventually, after sharing the notes I realized their potential value to others and sought to create this book to make shape derivatives accessible to a broader audience.

Acknowledgments I would like to thank the following people for reading earlier versions of the text and making useful comments: Harbir Antil, Christopher B. Davis, and Antoine Laurain. I especially want to thank Mari Walker for proofreading the entire book. I thank the anonymous reviewers; their compliments and criticisms certainly improved the manuscript. I gratefully acknowledge prior support by NSF grants DMS-1115636 and DMS-1418994.