Preface

The overwhelming amount of applications and information produced by modern technology is supported on subtle mathematical methods. Variational method is one of them. More than a technique, it has developed to become a very general point of view that solve a class of problems, too wide to be summarized in just one book.

One of the first applications of variational ideas in data modelling was the creation of variational splines theory, introduced in the mathematical literature by I. J. Schoenberg in 1946. Since then, splines have been applied in many branches of mathematics, such as approximation theory, numerical treatment of differential and integral equations, and statistics. In addition, they have become useful tools in many field of applications, especially CAGD, manufacturing, animation and tomography. Currently there exists a great amount of research in these fields, thus there is a great demand for a text of this kind that offers an introduction to the theme from the very beginning of variational calculus and that can be used to understand more advanced material.

In the area of surface reconstruction the goal is to obtain a digital representation of a real, physical object or phenomenon described by a set of points, which is sampled on or near the object's surface. This representation is a continuous model obtained from a discrete number of samples by interpolation or approximation. Recently there has been a growing interest in this field motivated by the increased availability of point-cloud data obtained from medical scanners, laser scanners, vision techniques (e.g. range images), and other modalities.

This book is an introduction to variational methods for data modelling and its application in computer vision. We see interpolation as an inverse problem that can be solved by Tikhonov regularization. The solutions are generalizations of one-dimensional splines, applicable to n-dimensional data. The central idea is that these splines can be obtained by regularization theory, using a trade-off between fidelity to data and smoothness properties; as a consequence, they are applicable both in interpolation and approximation of exact or noisy data.

In order to obtain a self-contained text, we provide the necessary fundamentals of functional analysis and variational calculus as well as splines. The implementation and numerical experiments are illustrated using Matlab. The discussion includes the necessary theoretical background for approximation methods and some details of the computer implementation of the algorithms. A working knowledge of multivariable calculus and basic vector and matrix methods should serve as an adequate prerequisite.

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