VISIBILITY ALGORITHMS IN THE PLANE

A human observer can effortlessly identify visible portions of geometric objects present in the environment. However, computations of visible portions of objects from a viewpoint involving thousands of objects is a time-consuming task even for high-speed computers. To solve such visibility problems, efficient algorithms have been designed. This book presents some of these visibility algorithms in two dimensions. Specifically, basic algorithms for point visibility, weak visibility, shortest paths, visibility graphs, link paths, and visibility queries are all discussed. Several geometric properties are also established through lemmas and theorems.

With over 300 figures and hundreds of exercises, this book is ideal for graduate students and researchers in the field of computational geometry. It will also be useful as a reference for researchers working in algorithms, robotics, computer graphics, and geometric graph theory, and some algorithms from the book can be used in a first course in computational geometry.

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Dedicated to my loving parents

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Preface

Education is the manifestation of the perfection already in man.

Swami Vivekananda (1863–1902)

This book is entirely devoted to the area of visibility algorithms in computational geometry and covers basic algorithms for visibility problems in two dimensions. It is intended primarily for graduate students and researchers in the field of computational geometry. It will also be useful as a reference/text for researchers working in algorithms, robotics, graphics and geometric graph theory.

The area of visibility algorithms started as a sub-area of computational geometry in the late 1970s. Many researchers have contributed significantly to this area in the last three decades and helped this area to mature considerably. The time has come to document the important algorithms in this area in a text book. Although some of the existing books in computational geometry have covered a few visibility algorithms, this book provides detailed algorithms for several important visibility problems. Hence, this book should not be viewed as another book on computational geometry but complementary to the existing books.

In some published papers, visibility algorithms are presented first and then the correctness arguments are given, based on geometric properties. While presenting an algorithm in this book, the geometric properties are first established through lemmas and theorems, and then the algorithm is derived from them. My experience indicates that this style of presentation generally helps a reader in getting a better grasp of the fundamentals of the algorithms. Moreover, this style has also helped in refining several visibility algorithms, which is a significant contribution of this book. In keeping with the distinctive approach of this book, all the algorithms herein have been explained using this approach.

Structure of the book

The book consists of eight chapters. The first chapter provides the background material for visibility, polygons and algorithms. Each chapter from 2 to 8 deals with a specific theme of visibility. In the first section (i.e., Problems and Results) of these chapters, results on visibility problems under the theme of the chapter are reviewed. In each intermediate section of a chapter, one or two algorithms are presented in detail or some properties of visibility are proved. Sometimes, two algorithms for the same problem are presented to show the improvement in time complexity or that the different approaches lead to the same time complexity. Two algorithms for two different types of polygons are also presented for the same problem. In the last section (i.e., Notes and Comments) of every chapter from 2 to 8, results on parallel or on-line algorithms for the problems considered in the chapter are mentioned. In the same section, some visibility issues connected to the theme of the chapter are discussed.

Exercises in the book are placed at suitable positions within a section to allow a reader to solve them while reading that section. This process of solving exercises will help in gaining a better understanding of the current topic of discussion.

Prerequisites

Some time back, I offered a graduate course in the Tata Institute of Fundamental Research entitled 'Algorithmic Visibility in the Plane' using a preliminary version of this manuscript. After every lecture, an appropriate section was given to each student for reading. In the next lecture, I asked them to explain the algorithms contained in that section. It was very satisfying to see that these students, who did not have any background in computational geometry prior to my course, had comprehensively followed the algorithms. However, the students had prior knowledge of algorithms and data structures. Courses on algorithms and data structures are essential prerequisites for understanding this book.

As stated earlier, this book is not meant as a first course in computational geometry. However, some algorithms herein can certainly be included in such a course in computational geometry. Moreover, this book can be used for assigning research projects to students. In addition, this book can be a natural choice for graduate-level seminar courses.

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