Preface

This book is dedicated to bridging the classical beam theories and modern numerical simulation using the NURBS concept. If we observe carefully the state of the art and well-recognized finite element analysis (FEA) and computer-aided design (CAD), they are two different disciplines in engineering and science that do not go along with each other, until T.J.R. Hughes and co-workers in 2005 introduced the isogeometric analysis to bridge the gap between the CAD and the FEA approaches in which it gained significant thrusts to all research studies on this topic.

This book is intended for students in engineering and science who are beginning a series of courses in structures and mechanics, practitioners in companies who are starting to learn how to analyze the NURBS curves that they usually draw in their daily work, and researchers who are going to pursue or extend their research in a beam element using NURBS curves.

This book is written as a textbook or workbook with tutorials in how to get the problems solved. All the beam theories and NURBS concepts are accompanied by MATLAB® program lists which are intended for easy understanding and learning how the formulas work. Just like in computer science, we know the modern editor software now has been adopting the *WYSIWYG* system in which the displayed text can be edited in a form exactly resembling its appearance when printed on a piece of paper.

As for the organization of the book: In Chap. 1, the representation of curves on a plane is presented, starting from the parametric modeling of polynomial curves through several standard curves which are the foundation of the NURBS. All the methods described are accompanied by the MATLAB program and function lists. Some important concepts such as the control point, knot vector, weight, and rationalization are discussed. In Chap. 2, the numerical integration technique Gauss-Legendre quadrature is introduced. The Jacobian operator and curvature of a curve are explained by using examples with accompanying program lists. Chapter 3 reviews the classical theory of beams, how to get the governing

equations, and how to formulate the beam in the finite element context. The applications of NURBS in the theory of beams and how to formulate the governing equation of various types of beams are described in Chap. 4. The core of this book is in Chap. 5, where a new proposed "Sandwich" condensation is introduced. The Sandwich condensation will condensate the increasing degree of freedom in the midspan of the beam due to adopting the NURBS, to a two-node six-degree-of-freedom standard beam element. Verification and validation are given. The program and function lists are provided. By condensing the NURBS-based beam element to a standard beam element, several merits will be gained. First, when we deal with nonlinear beam analyses where iterative calculations are needed, computing cost can be reduced significantly. Second, program and function lists can be *plugged in* seamlessly to the existing finite element codes either the in-house or commercial customizable software. In Chaps. 6, 7, and 8, the straight beam examples, circular curved beam examples, and free curved beam examples are given to demonstrate the advantage of the NURBS. Appendix A provides the element stiffness and mass matrices of the traditional straight beam element for verification purpose.

The writing of this book was my pleasant experience. I received benefits from my professional works, encouragements and supports from many colleagues as well as my students who have taught me how to explain to them complicated concepts in simple terms. While it is not possible to name all of them, without their helps and supports, it would not have been possible for me to finish the writing of this book.

My sincere thanks are due to my respected former Emeritus Professor Fumio Nishino in University of Tokyo, for his philosophies in teaching and research which have been useful in my professional life. Great appreciations are to Professor Mitsuharu Kurata in Nihon University, for constantly motivating me to find the "truth" in science. I wish to thank Dr. Nguyen Dinh Kien, my research colleague in VAST, for his fruitful ideas, encouragements, and support in my research works. I am indebted to Prof. Han Ay Lie in Universitas Diponegoro, for her continuous encouragements and inspiring ideas in doing my research works. I am also grateful to Prof. Lee Jaehong, Prof. Lee Seunghye, and Prof. Kim Nam Il in Sejong University for their hospitalities, collaborations, and many stimulating discussions concerning several research topics during my sabbatical leave. I would like to thank my former master's students, Mr. Shuichi Sekine and Mr. Yuto Konai, who have been working hard to modify and improve the program and work out some examples. I appreciate much the helps and supports from the Senior Publishing Editor Mr. Michael Luby, Project Coordinator Mr. Murugesan Tamilsevan and Project Manager Ms. Kirouchenadassou Sharmila during the preparation and publication of this book.

The readers are welcomed to use the MATLAB program and function lists freely. However, the author does not guarantee that the program and function lists are without any error. Also, the author is not responsible for any damage or loss by using the program or function lists. The reader is fully responsible for verifying before using the programs or function lists given in this book.

Most books are not free from errors, especially those with many mathematical equations and numbers. I wish to thank in advance those readers who are willing to draw attention to any typos and errors, using the e-mail address: [buntara@arch.ce.nihon-u.ac.jp].

Koriyama, Fukushima, Japan Buntara S. Gan

MATLAB® is a registered trademark of The MathWorks, Inc.

http://www.springer.com/978-3-319-56492-0

An Isogeometric Approach to Beam Structures
Bridging the Classical to Modern Technique
Gan, B.S.
2018, XIV, 233 p. 65 illus., 44 illus. in color., Hardcover
ISBN: 978-3-319-56492-0