Preface

The rapid development of computational design technologies has significantly impacted on design and design education beyond the replacement of drawing boards with computers or pens and papers with Computer-aided Design (CAD), Computer-aided Manufacturing (CAM), and Computer-aided Engineering (CAE) applications. The emergence and adoption of these technologies has greatly challenged and is still changing the ways of design and educating designers. *Computational Design Methods and Technologies: Applications in CAD, CAM and CAE Education* presents the state-of-the-art developments in computational design methods and technologies and explores their applications in and interactions with contemporary design and education.

**BOOK OVERVIEW**

*Computational Design Methods and Technologies: Applications in CAD, CAM and CAE Education* is a significant body of work including the following 23 chapters of original contributions from a cohort of international experts in the following areas: (1) research and development of computational design methods and technologies; (2) theory and practice of computational design; and (3) design education. This book reflects on the current trends and inspires future extensions in the advancement of computational design methods and technologies as well as the evolvement of design and education under such influences, by exploring and challenging the interactive relationships between the two. With such foci, the book provides unique references for design research, education and practice, to the following primary reader groups:

- Researchers in the broad domain of computational design.
- Academics who are interested in applying computing design methods and technologies in teaching and learning.
- Pedagogic scholars who study the role and impact of computational design on education.
- Developers of computational design technologies.
- General design communities who follow the latest developments and applications of new media and technologies in the field.

The book presents and demonstrates design education as an important test field for applying new computational design methods and technologies, providing significant research evidence to validate the effectiveness of these methods and technologies in design. It was observed that firstly, design researchers
often explore, validate, and refine research through self-reflection. Because most academic researchers are also educators, educational case studies become ideal revenues for such reflective purposes. Secondly, the introduction of leading-edge computational technologies and computational thinking brings tremendous benefits to design students, exposing them to new ideas and practices, and better preparing them for the future. Students with exposure to such knowledge and challenges are most likely to support and sustain the innovation, leading the design and the industry.

The emphases of the following 23 chapters can fall into three categories, with many across multiple categories.

- **Category I**: Introduction and current development of computational design methods and technologies.
- **Category II**: Educational case studies of utilizing these methods and technologies.
- **Category III**: New theories and future trends in the field.

Category I aims to showcase and critically evaluate the state-of-the-art development of computational methods and technologies in design, and discuss their impacts on design and design education. Examples of the work in this category include research into the development and application of fundamental theories and techniques for design, through computation or computational thinking, for example, the concepts of design generation and optimization through grammatical, parametric, diagrammatic, and other knowledge-based approaches. Works also include the research into the development and application of computer-mediated tools for design, collaboration and management, for example, the development and application of digital fabrication tools, BIM systems, collaborative virtual environments, computer game engines, virtual and augmented reality systems, sensory and interactive devices, and so on.

Category II focuses on the presentation and reflection of a variety of successful educational case studies that adopt different computational design methods and technologies, which aim to explore and better understand their roles in design and design education, supported with cognitive evidences or critical reflections of the design experience and/or outcome.

Category III emphasizes the impact and implication of the evidences and results presented in Category II. Based on these understandings, some re-assess educational design theories and formulate new principles or guidelines. Some discuss how these understandings can assist design educators in developing, refining, and implementing curricula that best utilize the technologies and suit the current design culture. Others suggest and highlight future theoretical and technological trends in computational design.

**INTRODUCTION TO CHAPTERS**

*Computational Design Methods and Technologies: Applications in CAD, CAM and CAE Education* will take readers on a journey to the domain of computational design. The journey starts with two introductory chapters, which provide two conceptual frameworks in order to develop an overall understanding about the field. These two frameworks are developed from two different perspectives that compliment each other. In *Systems and Enablers: Modeling the Impact of Contemporary Computational Methods and Technologies on the Design Process*, Michael Ostwald introduces the System-Enabler Model. The model provides a formal approach to develop an elevated understanding between the evolution of the design process and the roles of different computational design technologies, while Rivka Oxman’s DDNET
semantic system, as introduced in Novel Concepts in Digital Design, provides a methodological and pedagogical basis for contemporary computational design.

Following this introduction, readers will then experience each of the main topic areas in contemporary computational design, through scholarly writings of a combination of technological developments, pedagogical cases, and up-to-date critiques of theories and practices. These main topic areas are generative and parametric design systems, digital fabrication, BIM, collaborative virtual environments, virtual and augmented reality systems, and interactive and intelligent environments. Many of these areas share common concepts and purposes. Therefore these groupings can be useful for thinking about a complex field, but they are not necessarily definitive.

- **Generative and parametric design systems:**
  - *Slow Computing: Teaching Generative Design with Shape Grammars* by Terry Knight, and

- **Digital fabrication:**
  - *Direct Building Manufacturing of Homes with Digital Fabrication* by Lawrence Sass.

- **BIM:**
  - *Building Information Modeling and Professional Practice* by Dennis Shelden,
  - *Advancing BIM in Academia: Explorations in Curricular Integration* by Karen Kensek, and
  - *Applying BIM in Design Curriculum* by Clark Cory and Shanna Schmelter-Morret.

- **Collaborative virtual environments:**
  - *Constructivist Learning Theory in Virtual Design Studios* by Leman Figen Gul, Anthony Williams, and Ning Gu,
  - *Understanding Collaborative Digital Media Design in the 3DCVE: A Vygotskian Approach* by Theodor Wyeld and Ekaterina Prasolova-Förlund, and
  - *Will Different Scales Impact on Design Collaboration in 3D Virtual Environments?* by Jerry Jen-Hung Tsai, Jeff Kan, Xiangyu Wang, and Yingsiu Huang.

- **Virtual and augmented reality systems:**
  - *Augmented Reality Research for Architecture and Design* by Mi Jeong Kim, Xiangyu Wang, Xingquan Zhu, and Shih-Chung Kang, and

The journey continues by examining two specific approaches to computational design and education: A diagram-based approach by Christiane Herr (in *Supporting Design Thinking with Evocative Digital Diagrams*), and an Architecturological approach by Caroline Lecourtois and François Guéna (in *Architectural Design Education and Parametric Modeling: An Architecturological Approach*).

Applying the above computational design technologies and methods in design curricula creates both opportunities and challenges to all parties involved. These complex issues are discussed in the final section of the book from the relatively higher level of institutional transformation by Dean Bruton (in *Design Education and Institutional Transformation*), to the development of specific skill set by Halil Erhan, Belgacem Ben Youssef, and Barbara Berry (in *Teaching Spatial Thinking in Design Computation*).
The book concludes with Computational Methods and Technologies: Reflections on Their Impact on Design and Education, provided by Ning Gu and Michael Ostwald, aiming to contextualize the knowledge presented in this book, to create a foundation for further work, and to act as a point of reference for the development and critique of new design knowledge.

SUMMARY

In the remaining of the book, readers will find the latest technological and theoretical developments, empirical research findings, educational case studies, pedagogical theories, design reflections, future trends and many more. Each chapter has been double blind reviewed by the Editorial Advisory Board to maintain the highest possible standard. Readers will be critically informed how applying research and pedagogical outcomes and reflections in the field of computational design have influenced and will continue to transform design and education into the future.

Ning Gu
University of Newcastle, Australia

Xiangyu Wang
Curtin University, Australia