参数化原型

New Computational Paradigms in Architecture

[加] 汤姆·维尔伯斯 + 刘延川 + 徐 丰 编

(Editors) >>> Tom Verebes + Liu Yanchuan + Xu Feng

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内容简介

《参数化原型》以2009年举行的同名国际建筑展为基础，经过增补论文发展而成。本书第1章首先从总体对当今国际建筑界的参数化设计进行了综合论述；第2章选出了国际建筑界最活跃的16个建筑事务所，将他们的实践分为六个主题：生成系统、分析与反馈、合成应用、文档和沟通、管理、原型和制造；从不同方面深入阐述了参数化设计的特点和实践应用；第3章展示了本书编者和策展团队对参数化设计的理解；第4章以对2009年举行的同名国际建筑展的简短回顾结束本书。

本书紧跟时代潮流，讨论了当今建筑界的热点问题，汇集了国际建筑界最活跃的建筑师和理论家的著述和作品，适合建筑学、城市规划、景观设计、室内设计等相关设计专业师生借鉴与学习，也适合相关专业设计师阅读与收藏。

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On behalf of my co-editors of this book, Liu Yanchuan and Xu Feng, I would like thank the administration of Xi' an University of Architecture and Technology (XAUAT), especially Dean Liu Kecheng and Professor Lv Dongjun, for their support and enthusiasm for hosting the exhibition and conference in 2009 which proceeded and led to the publication of this book. We greatly appreciate Zhongxu Planning and Architecture Design Co. Ltd for their efforts to promote the fruition of this project and Mr. Han Yubin for his trust in the possibilities of computational design, as well as their tremendous support and belief in our collective project, without which, this book may not have been published. We recognize the excellent scholarship, design research and professionalism of all our peers, colleagues and friends who attended the conference, and especially the many contributors to this book, whose projects and essays are a testimony to their commitment to the advancement of the discourse, culture and practice of architecture. Lastly, we thank Tsinghua University Press, our book designers Zhou Zishu, Li Huajia and Wang Naiyi, and the many translators, all of whose collaborative effort helped to propel this book towards its eventual design, printing and distribution.

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新运算化设计范式

New Computational Paradigms

2009年西安建筑科技大学（XAUAT）举办了一系列学术活动，作为活动策划委员会的主席，我非常高兴能够代表井敏飞、刘延川、徐丰和庞钦等成员，来为大家介绍本书。这些活动包括：2009年9-10月在贾平凹艺术馆举办大型国际展览，汇集诸多顶级创新的建筑师和工程师；2009年10月17-18日举行国际研讨会，聆听来自亚洲、欧洲和北美洲18位专家的学术演讲；2010年在中国多处进行巡回展览，获得中国媒体的一致好评。本书经过小组成员三年的努力工作，作为展览和研讨会的延续，收录了这一系列活动的精华内容，包括研讨会中的部分论文、特邀撰稿人的深入分析文章，以及会议和展览的照片，以飨读者。

策展团队，从左至右：庞钦，井敏飞，汤姆·维尔伯斯，刘延川，徐丰

Curatorial team, from left to right: Pang Qin, Jing Minfei, Tom Verebes, Liu Yanchuan, Xu Feng

汤姆·维尔伯斯 / Tom Verebes

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翻译: 徐丰,XWG 工作室主持建筑师 / Translation by Xu Feng, Principal of XWG Studio

It gives me great pleasure to introduce this book, on behalf of Jing Minfei, Liu Yanchuan, Xu Feng and and Pang Qin, the curatorial team for a series of events hosted in late 2009 by the Xi'an University of Architecture and Technology, XAUAT. These events included a major international exhibition of leading architects and engineers, all of whom are the forefront of innovation, at the Jia Pingwa Gallery in October-November 2009, along with a two-day international conference on 17-18 October 2009, hosting eighteen speakers from Asia, Europe and North America. The Parametric Prototypes: New Computational Paradigms exhibition has since toured to several venues in China, and has received critical acclaim in the Chinese media. This book encapsulates these events as a document which aims to outlive the ephemerality of an exhibition and conference. In addition to cataloguing the work in the exhibition, this book also includes conference papers, further essays by invited contributors, and a selection of photos from the conference and exhibition.

The year 2010 marked a profound anniversary in China's recent history. During the 30 years since China's international emergence, a parallel revolution has taken place across the global landscape of architectural culture – the digital revolution – which has irreversibly transformed nearly every architectural office, institute and school around the world. Alongside this wholesale technological re-tooling of architectural practice and education lies the imminent intellectual challenge for our generation: To discover the theoretical, cultural and social implications of these new computational practices.[1] The organisers of the events related to Parametric Prototypes: New Computational Paradigms in Architecture share the belief that practicing architects, educators, students and lay-people alike must confront these questions concerning the intellectual implications of computational design. In addition, the role of each generation is to scrutinise the theoretical strands, or plateaus, which predate contemporary practices, as well to find architectural precedents as prototypes to today's preoccupations.[2] Beyond the adoption of ubiquitous technologies, the task of the contemporary architect is also to challenge how new methodologies help to re-think the endurance of culturally specific design arenas. Design work by some of the most innovative contemporary international architects, designers, and engineers is compiled in this book, exploring the evolving discourses related to the design and materialization of increasingly complex, computationally driven architecture. Although all architecture is inherently "parametric" – i.e. the result of associations between the forces shaping a design outcome. In this sense all design methods are parametric, and "like so many... software paradigms, 'parametric design' is probably

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对于中国，2010年是现代历史上不平凡的一年：改革开放30年使得中国国际地位日益重要，与此同时，在建筑文化的国际版图上，也进行着一场巨大的变革——数字革命。在全球范围内，数字革命已经不可逆转地使每一所建筑设计院或学校转型。建筑实践和建筑教育这场大规模技术重组给我们的认知带来了巨大的挑战，它迫切要求我们这一代努力去探索这些新兴的运算化实践背后隐藏的内涵，无论在理论方面、还是文化方面和社会方面。与《参数化原型：建筑学中的新运算化设计范式》一书相关的系列活动的组织者有这样一个共识：从业建筑师、建筑业教育者或者业外人士都必须直面涉及计算机参数化之智力内涵的一系列问题。同时，每一代人都应探究先行者的理论依据，以古为今用；细查当代的蛛丝马迹，以预见未来。当今，科技手段无处不在，除了掌握并娴熟应用之外，当代建筑师还应该去挑战运用新的方法论辅助重构文化背景各不相同的设计领域。本书汇集了当代国际上最富创意的建筑师、设计师和工程师的作品，探索日趋复杂化、日趋计算机化的建筑设计。虽然所有建筑设计本质都是参数化的，也就是说，各种受力之间联合的结果，共同形成设计成果。在这个意义上，所有的设计方法都是参数化的，正像很多软件范式一样，“参数化设计”可能有些是用词不当。所有这些活动的初衷就是预测、并明示给下一代建筑师新的设计范式。

数字技术，不仅让当代人改变了对空间的概念，作为一种新型工具，更是对制造方法、产品运输、组装和建设方法的颠覆。数字驱动加工程序产生的巨大反响意味着：可计算性的直接功效就是可建设性。与《参数化原型》一书相关的系列活动，其目标就是直面这一现象，以期探寻当代设计师如何影响、塑造并改变新近采用程序的产品，反之，　这些新的空间类型又如何影响政府官员、使用者和消费者的。《参数化原型》尝试说明基于代码的设计原型制作既是一种方法论，又是一种当代技术和文化的体现和理论化构想。新一代的设计师已经脱离开早期的、偏于手动的设计理念和发展模式。新近发展的计算设计和制造工具在改变当代建筑实践、建筑研究和建筑教育，担当着重要的角色，随着计算机辅助管理（CAM）和计算机辅助教育（CAE）在设计方法上的逐层嵌入，日益复杂的数字设计得以简化。

在此展览之前，原型制作方法论就已经存在于重要的工业设计、产品设计、机器人设计、交互设计，以及汽车，航海，航天等其他工业中。这些新颖设计办法，很快就渗入到当代建筑概念中，渗入到先锋派和主流派建筑实践中。当代原型制作工具早就出现在许多平行的设计学科中，对于这些设计学科，其重要性仍在于具有通过“硬的”物理原型来检验计算系统的能力。对材料的试验作为建筑发展动力的传统，它假设物质能通过“找形”的过程，在材料模型中构建和计算受力结果，来潜在地自我解算自身的状态-空间。在20世纪初叶，高迪（Antoni Gaudi）为巴塞罗那的圣家族教堂项目发展了受拉力的悬索模型，那是一组理性状态下的抛物线，用来反算设定受压的石拱造型。另外在斯图加特轻结构学院，奥托（Frei Otto）的湿棉线网格和其他规则曲面的张拉膜结构试验，可以看作对最后设计结果设定的运算化材料方法。20世纪，举办了很多国际盛会，如世界贸易博览会、世界博览会、奥林匹克运动会等等，其中建设小型场馆等工程项目给建筑设计者提供了越来越多的实验媒介。当然，

a misnomer". [3] The shared aim of these events has been to speculate upon, and to articulate, new design paradigms for the next generation of architects.

Digital technologies have not only re-formed contemporary notions of space, but these new tools are also revolutionising methodologies of manufacturing, delivery, assembly and construction. The repercussions of digitally driven production processes imply "constructability...becoming a direct function of computability." [4] The events coordinated for Parametric Prototypes aimed to confront this phenomenon, by interrogating the ways in which contemporary designers influence, shape and change the products of newly adopted procedures, and conversely, how their commissioners, users or consumers are affected by the experience of these new kinds of spaces. The Parametric Prototypes exhibition and conference sought to explicate code-based design prototyping as both a methodology, as well as a theoretical manifestation of contemporary technology and culture. This new generation of designers has departed from earlier, more manual modes of design conception, development and materialisation.[5] The evolution of these new kinds of computational design and production tools transformed contemporary practice, research and education. Increasingly complex digital design work has been made possible by linking architectural design, engineering, fabrication, assembly and construction management.

Prototyping methodologies predate much of the work included in this exhibition, having been adopted as vital processes in industrial and product design, robotics and interaction design, and the automotive, naval, aerospace, and other industries.[6] These new design approaches are quickly becoming embedded in the modalities of contemporary architecture, in the avant-garde as well as in mainstream architectural practice. Contemporary prototyping tools had arrived as imports from these parallel design disciplines, yet their importance to all design disciplines today lies in their ability to test computational systems through a series of 'hard' physical prototypes.[7] The tradition of experimental material practices as an engineering-oriented approach to architecture assumes matter has the potential to self-compute its state-space, through the application of "form-finding" models, constructed to calculate and resolve forces in material models.[8] At the turn of the 20th century, Antoní Gaudí developed his weighted, tension-based, catenary chain models, which developed optiomised parabolic curves for the configuration of load-bearing, compression-based, stone arches of the Sagrada Familia church in Barcelona.[9] In Frei Otto's research into networked minimal path diagrams using wet-grid string models, as well as other ruled surface tension roof structures, a new material methodology was developed for computing the outcome of a final design configuration.[10] Throughout the twentieth century, Worlds fairs, Expos, Olympiads, and other global events have provided designers with an increasingly important vehicle for experimentation, via the succession of small-scale pavilion projects commissioned in these events. Due to the inherent limits of complexity of a small scale architectural constructs, and their more immediate and more cost effective results, the pavilion persists as a vehicle for experimentation. The design work included in this book is not limited in size, and the contemporary research-based methods cross scales and types to be channelled into the design of high rise towers, commercial malls, infrastructural buildings, cultural institutions, bridges, and other building types, often in pursuit of signature, iconicity, and innovation.[11] Emerging in the mainstream of architectural culture is a research-based, integrated approach to architectural and engineering design, production, manufacturing and assembly.

The adoption of computational technologies in twenty-first century architectural practice has created a

囿于其固有复杂度的局限性、以及更看重成本效益的模式，小型场馆建设工程依然只是实验媒介而已。但是，这些当代基于研究的方法，却可以不受规模的掣肘，广泛引入到高层建筑、购物商场、基础设施、文化机构以及其他规划建筑类型中，成为代表形象和创新的地域标志。在建筑文化的主流中，涌现出以研究为基础的、综合的新潮流，引领着工程设计、制造、生产和装配的发展。

21世纪计算技术广泛应用于建筑实践中，在全球范围内创建了一个促进数字化设计和材料运算化方法再融合的公共平台。中国改革开放30多年来，随着互联网的普及以及建筑实践与教育的全球化进程不断加速计算建筑技术的传播，中国的建筑设计师和建筑学专业的学生都不可逆转地受到影响。对中国的建筑行业来说，计算技术和与之相关的文献正处于萌芽阶段，同时也在快速生长阶段。在这种状况下，建筑技术的学习和传播与传统的非数字时代有本质上的差异，这给中国的建筑实践与教育带来巨大挑战的同时，也带来了前所未有的机遇，虽然目前尚无法预言会给这个行业带来多大的发展空间。

关于行业惯例和行业标准的数字革命，“参数化原型”展览的策展小组提出了一些的问题，指出了一些关注点。尝试阐明这些问题正是本次展览、国际会议以及本书的目的。

如果运算化设计开创了设计实践的新领域，那么，这些新型设计实践的目标是什么？
如果数字技术只是用作当代建筑的工具，我们可以期待这些新技术制造出何种新型的建筑？
鉴于建筑革命趋向于追随其他相关学科的先进之处，这些学科目前给建筑学提供了哪些机遇？
多种学科间的计算技术的迁徙可能如何继续影响建筑学学科和专业？

汤姆·维尔伯斯，在“参数化原型：新型运算化范式”会议中进行主题演讲，2009 年 10 月
Tom Verebes, Introducing *Parametric Prototypes: New Computational Paradigms* Conference, October, 2009

common platform within a global context for the re-integration between digital design and computational modes of materialisation.[12] In the three decades since China introduced policies of Economic Reform and Opening-up, Chinese architects and students have been irreversibly transformed by the effects of the increasing ubiquity of the internet and the globalization of architectural practice and education, both of which have enabled the accelerated dissemination of computational architecture in China. For architecture in China, the adoption of computational technologies and their associated discourses are still in an embryonic yet quickly progressing state. This contemporary condition differs fundamentally from pre-digital processes of learning and dissemination, and while this poses a huge challenge to architectural practice and education in China, with it will come great new opportunities, however unpredictable and still unknown these possibilities may be.

The curatorial team of the Parametric Prototypes exhibition raised several questions and concerns, with regards to the impact of the digital revolution upon the conventions and standards of production. The exhibition and its associated conference sought to explicate a variety of issues, and this book aims to consolidate the theoretical and practical ramifications of computation in architecture.

Given computational design creates a new field of operation, what are the goals of these new practices?

If digital technologies are merely the tools by which contemporary architecture is produced, what new kinds of architecture can be anticipated in the future as outcomes of these new technologies?

As architectural revolutions tend to follow advances in other related disciplines, what opportunities do other disciplines currently provide for architecture, and how might the migration of computation across a multiplicity of disciplines continue to effect the discipline and profession of architecture?

These complex questions arise from the diverse positions surrounding these issues. Although the events to be held as part of Parametric Prototypes – New Computational Paradigms will not claim to answer the proceeding questions, and it is precisely the existence of these questions, as well as their complex nature, which has driven the organisers of these events to hold them in the first place. The theme, participants and content is the result of a series of discussions among the curatorial team in Spring 2009.

The emphasis of the broad body of work included in the exhibition, conference and this book, is on the decision-making and thought processes inherent to contemporary computational design and production. The objectives of the curatorial team has been to host a series of events which will be valued by professional architects, through the engagement of some of the most cutting edge proponents of contemporary architectural practice and education in discussion and debate about the rich, and relatively undiscovered, conceptual arena inherent to computational technologies. Through the interrogation of avant-garde projects lies an opportunity to situate their associated world-views, to an audience who is not bound by habits, conventions and doctrines. The Parametric Prototypes exhibition and conference crossed conventional disciplinary boundaries by bringing together a wide range of architects, urbanists, engineers, mathematicians, programmers, software developers, manufacturers, theorists, and other specialists. The projects included in the exhibition and this book range from experimental pavilions, furniture and interiors, large scale architectural icons, infrastructural spaces and urbanism – many built projects, un-built proposals, competition entries, as well as more speculative,

这些复杂的问题来源于围绕这些问题的多种多样的立场。虽然与本书相关的系列活动并未声称回答上述所有问题，但毫无疑问，正是这些问题的存在，以及它们的复杂本质，才真正促使组办方举办以上活动。本书的所有参与者、本书的主题和内容也正是2009年春策展小组深入讨论的结果。

在广义上，本次展览和国际会议以及本书的工作重点放在当代运算化设计和制造固有的操作模式、决策和思考过程。策展小组的工作目标是，吸引当代最前沿的建筑设计与建筑教育的倡导者积极参与，对于丰富的、却相对隐藏的、概念性的领域进行讨论和辩论，成功组织一系列专业建筑师关注的活动。对这些先锋与前卫工程进行详查审视，可以将设计者的世界观置于一群不受习惯、传统和教条束缚的观众面前。"参数化原型"展览集结了相当大范围内的多个领域的专家，如建筑设计师、城市规划专家、工程师、数学家、电脑程序师、软件开发者、生产商、理论家等等，打破了传统的学科界限。本次展览中包括了多种类型的工程项目：实验性的场馆、家具和室内布景装潢、大型标志性建筑，基础设施和城市规化项目，其中有已建项目、未建项目、参赛作品、设计方法（包括自发的、学术性的、以研究为导向的设计方法）等。计算工具在城市设计者、基础设施、建筑和小型家具、室内布景装潢以及各种设计规模、各种类型的实验性的基于研究的原型建模之间自由游走，更进一步颠覆了设计工具、设计策略和设计结果应该依附于任何一种设计理念的陈旧观念。本次系列活动中的主要工程和实践，按照某些学科标准的不确定性、不同的规划分类、工程的规模、在当代作为原型的示范地位等进行分类。

参数设计和原型建模系统跨越多个设计产业，不可避免地涉及多个话题，如具体的工作流程序、操作模式、决策、和思考过程等，以下六大策展主题将针对这些话题进行论述。16位重点投稿人和其他几位参与展览的将努力阐释这六大主题。各主题之间互不排斥，亦不能脱离开其他方法和结果单独生效 。本书所选择的设计单位用实例诠释当代运算化设计和制造的趋势，每个实例除了例示其所在

"参数化原型：新型运算化范式"展览开幕，2009 年 10 月
Parametric Prototypes: New Computational Paradigms Exhibition Opening, October, 2009

academic and research-oriented approaches to designing through prototypes.

In today's collaborative and increasingly connected design world, digital media and material fabrication processes migrate across disciplines, freely between designers of cities, infrastructure and architecture, interiors, furniture, and products. The projects and practices featured in these events are defined by the contingencies of their specific disciplinary criteria, their programmatic typologies, the scale and size of the projects, and their exemplary status as prototypes of, and for, their generation.

The following six curatorial themes address the sequence of workflow procedures inherent to computational design and production systems, from conception to construction. Over twenty project contributors are punctuated by fourteen essays, explicating the following six themes. Each of these themes are not mutually exclusive, and nor is any one practice exclusively working within this single method or outcome. The offices serve to exemplify contemporary tendencies related to each theme, and the cluster of practices within each theme is not limited to each specific classification, but rather, the multiplicity of practices confirms the increasing prevalence and importance of these technological attributes in contemporary architectural culture.

Generative Systems
Analysis & Feedback
Synthesis & Application
Documents & Communication
Management
Prototyping & Production

01 Generative Systems

This theme surveys generative design research work, which investigates the mathematical basis of contemporary code-based design methods and media. Included in this category are parametric modelling, and other algorithmic, scripting and programming procedures, applied as experimental media in the initial stages of design. Recursive design methods aim for the association of components within 3d modelling environments, and the potential for multiple, rather than singular, design outcomes. These new tools enable increasing control over complex information, in which algorithmic input-output methods generate the formation of complex spatial articulations.

It may not be a coincidence how the practices selected to explicate the theme of generative systems are led by some of the youngest designers in the exhibition, as the design tools they have mastered are the domain of an emerging, highly advanced digerati. These designers borrow software from other disciplines, misappropriate their intended application and target new design arenas pursuing new organisational paradigms. EZCT researches the "deep changes occurring in contemporary sciences" while focusing on design tools such as C++ programming, Mathematica programming, genetic algorithms, and Xd3d Software for visualization & finite element analysis.[13] Kokkugia's application of algorithmic design and computational geometry to collaborations with ARUP Advanced Geometry Unit generates architectural spaces with inherently structural attributes. THEVERYMANY approaches the act of producing proto-architectures through "explicit and encoded protocols", focusing on computation and the generation and automaton of components through Rhinoscript coding. [14]

02 Analysis & Feedback

Performance-based methods aim to test and provide feedback mechanisms of design schemes. Simulation-based software enables an analytical approach to design, where the optimisation of a proposal can be

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