消失的参数化设计——脚本语言在乡土建筑中的应用

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民居聚落的形成需要一个相当长的时间周期；通常规划设计的工作要求在短期内完成。在本土文化浓厚的地区，如何平衡这两点，以较短的设计时间获得蕴涵历史文化沉淀和尊重基地地形脉络的规划设计成果？

运算化设计（包括参数化设计在内的更广泛的和电脑运算处理相关的设计）目前更多地被用来开拓新颖的形式，扩展建筑设计的边界。建筑设计由此可以通过编写脚本，“生成”一个又一个让人头晕目眩的外观，以至于人们开始迷惑似乎任何东西都可以披上建筑的外套，而无论它的身体是什么样的。这让我们想起了上个世纪 20 年代的前卫建筑师们，幻想技术的变革可以兑现一个美丽的世界。然而事与愿违，世界经历了几次大萧条甚至是世界战争。建筑师似乎有一个根深蒂固的毛病，就是自认为自己是救世主，为此建筑也不堪重负，非得解决建筑师一厢情愿的众多问题不可。诚然，这一波数字化技术给建筑领域带来了很多从未经历过的变化，渗透到设计的方式和思考，武装建筑师高深的数字化工具，有些技术甚至是用来设计人造智能生命的！建筑设计的价值越来越扑朔迷离，年轻一代宁愿跟随疯狂的视觉盛宴，而不是冷静的思想便饭。

与其致力于不断推动建筑边界，我们越发发现自己其实更有兴趣如何把运算化设计溶解到整个设计的过程中，追求建筑设计的价值，尤其在社会和经济这两个维度上。这也是为什么我们开始关注一些在三线城市管辖范围内，面临开发的有很强本土建筑文化的区域，希望通过整合数字化工具，让这些已经被规律化的本土建筑风格重现创造的光芒。

有待开发的地区

土地开发，作为当前席卷全中国经济发展浪潮的核心驱动力，迫使欠发达地区（三线城市）面临外来资本与本土风格的直接对话。在城——乡二元对立的模式下，乡村快速城市化的过程带来了很多问题，其中之一就是，如何在利用资本和建设改造当地社区的过程中，继承发展原有的风土人情，建筑的地域特制。通过大量的观察与思考，我们认为在开发过程中，资本逐利和政治功绩对于速度的追求，是导致原有人居环境质量丢失的根本原因之一。而基于本土和文脉的人居环境，通常只能通过自然和长期的聚落发展演变才能够成型和完善。作为为控制土地的群体（如开发商或政府）服务的规划师和建筑师，我们是否能够在保证合同期限的前提下，同样保证设计结果来源于当地，顺应当地百姓的生存环境，具备本土建筑因地制宜的建筑质量？

自律生成的建筑平台

运算化设计（Computational Design）是一个伴随着计算机科学与相关理论以及相应实践技术的发展而逐渐成熟的设计技术。实践表明，不同技术应用到建筑设计（其他设计也适用），除了会对最终成果产生质和量上的影响外，更重要的是会影响设计发展推敲的过程，使其发生微妙而深刻的变化。由此，设计关注的问题、以及思考的方式将随之演化。

本文所述项目，是在贵州省山区某地为政府设计的一个集高档度假酒店、商业街、博物馆、娱乐休闲和住宅等功能在内的综合开发项目。基地位于市郊，地形崎岖，Y 型谷底内有大量耕地（图 1）[ii]。山地一直是建筑项目中极具挑战的基地类型，如何有效利用地形、控制造价、提高使用与出行舒适性、利用自然资源营造独特的景观特质等，都是每个山地开发项目需要认真研究探索的重要课题。尤其是最近，在我国南部发生一系列泥石流和山体滑坡之后，山地居住环境的安全性再一次受到重视，国家也出台了相关的建筑法规，对适宜建造的山地坡度进行了明确规定——大于 30 度的地方不允许建造任何房屋。

首先，由于该项目地形非常复杂，设计团队尝试彻底改变平面规划的设计惯性，利用项目的传统地形测绘数据，探索一个新的“三维”规划方法。具体的做法是，把带有标高点数值的测绘图纸，通过脚本翻译成实际的空间点阵（图 3），得到一个三维的网格面基地模型。由此，所有的设计信息，都可以相对准确而直接地从数字模型上获得，不用再根据原始测绘图的等高线，通过剖面的近似研究来开展设计。另外一个显而易见的好处是，有了准确生成的三维山体与河谷模型后，可以根据设计要求在任意特定的高度，切割生成等高线，进而不再受测绘图中固定的，5 米高差一条等高线的限制。生成的网格面还可直接反映场地各处的实际坡度（图 4）。

由此发展，设计概念逐渐清晰明朗。根据地势坡度，遍历寻找适宜进行建设的建筑基座范围，并相应进行建筑体量推敲；对于交通流线道路的设计，则是在特定的高度上切割等高线。不同高度之间的道路连接，由另一个脚本语言根据数学几何逼近的原理模拟生成，得到自然合理的道路形式与走向。通过脚本语言的应用，设计者可以在任意等高线决定的平台上，探测生成所有符合设计要求的建筑基座平台形式。然后，通过控制符合建筑坡度要求的平台进深范围（比如：3 米的高差按照 30 度计算，最小的进深要在 5.1 米以上），结合功能和空间组合的设计主观要求，针对不同的进深范围，设计出符合要求的建筑策略。设计过程中，我们按照土方添挖需要与建筑密度的设定，选取合适的等高线高差，并通过对初始等高线巧妙地调整设置，上下各错动该高差数据的一半，也就是从理论上，把上面挖下来的土，填到下面，在方案阶段，就实现场地内整体的土方平衡。即使有可能根据设计条件与设计控制的变化调整场地设计，土方平衡仍可以通过设计的参数化控制保持。

自然生长的建筑形态

由于该区域是当地少数民族的主要聚居地（图 2），所以地方政府对于传统民俗文化格外重视，除了要求充分利用地形与自然融合，还必须在体现这些建筑传统形式的基础上，有效地进行创新。

在之前工作的基础上，我们通过设定一系列的主观设计考量，如景观规划和空间组织，策略性地增减或调整个别平台体块，并参考当地传统民居类型的特点，在结合场地生成曲折的双坡屋顶同时，确保所有的屋面都是平面形状。这一策略也有利于降低建造难度、控制造价。同时，只要把握了基地和屋顶的形式关系，整体的效果就不会缺失当地传统建筑聚落的灵魂。（图 7）

在这个项目的酒店和商业街部分，通过运算化设计，控制建筑顺应地形的聚集形态，而不是专注于控制单体几何形式。编写脚本的时候，考虑了可能的多种变化参数，用来区分不同功能组团的整体形态，比如建筑的进深范围、屋顶的坡度控制、屋脊线的不同三维转折等。（图 8）

对于基地北坡的博物馆，我们选用了不同的形态生成策略。考虑到展览空间的采光要求和空间的流线原则，设计采取沿等高线延续的流线体形，屋面高差的地方自然地形成北向高窗。几条蜿蜒的流线空间体量，在西侧入口广场处抬升，形成比较大的悬挑；在东南侧尽端的地方，逐渐潜入地下，宛如几条虬龙，盘伏在山谷的北侧坡地上(图 9)，又仿佛是层层叠叠的梯田，和山地景观相映成趣。

对于整个场地的视觉中心——新风雨桥和重檐塔的形态设计，在仔细充分研究传统形式的基础上，挖掘其中一些可以突破的、利用现代材料和施工技术不合理的地方，通过恰当的变化，延续了传统形式的“神”，而非表面的“形”（fig 10,11）。

综合考量的建筑价值

可以说，我们在这个项目中秉承了自己一贯的将运算化设计技术融合到项目全过程的方法与设计理念。这一基本出发点也是与同济大学规划设计研究院全面协作展开工作的重要基础。目前，运算化设计（Computational Design）连同参数化设计（Parametric Design）常常会被定位于附着在项目设计核心之外的锦上添花的“招数”,要不就是全部。而在这个项目中，它已经和设计团队的设计方法、创作思维、方案描述产生了“化学效应”，从“招数”上升到了设计意识的精神层面。从最初的概念、规划的推进、到单体建筑的设计生成，都渗透着运算化设计技术的运用。

结语

光有技术远远不够。我们希望技术的应用不是突兀存在，而是幻化无形融入到设计过程之中。显然，项目的最终设计价值，很大程度上仍源自人的智慧和创作灵感的现实体现。这也应该是避免使用无所不在的数字化技术造成设计结果趋同的有效策略。设计方案的独特之处，绝对不会取决于使用什么样的工具和技法，归根结底还是在于把握方案的人。工具、技法从来就不是目的，而是实现设计概念、执行设计过程、评估设计成果、选择设计决定的媒介。但是不能否认的是，忽视设计技术和方法的设计策略，往往流于表面形式的模仿，而不能达到和建筑项目本身相关的逻辑、建造、管理、造价、可持续性、信息交互等更根本的层次上的协调统一。

过去的 10 年，我们已经经历了测试数字化工具在建筑设计领域的极限；我们已经开始习惯那些打着推动建筑设计边界为由的花拳绣腿；我们已经对眼花缭乱的形式有些麻木，无论它如何歇息地理地叫喊。在面临这些日新月异的数字化手段时，更重要的是如何集成整合这些技术、技法到设计概念、方案发展、项目实现、知识传承、价值评估、运营管理、可持续性发展、信息交流，等等。一句话，就是让我们能做出更好的设计决定。

电脑的能力不应该也不会超越人脑。人类社会发展的复杂程度远远不是靠几个高级程序能够解决的了的。是的，建筑有时候需要革命性的主张和观点，但是它最终会融汇到进化的长河中。我们的未来不可能简单的由电脑脚本书写出来，但它不可避免地要从人脑和处理器的协作中借力。

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Scripted Vernacular Architecture – Invisible Computation

By GAO, Yan[ii]

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Within a given short period of time, how to achieve the equal quality of collective customization as vernacular architecture does through a long time? How to systematize vernacular styles without losing its semiotic meaning to the local community in the context of computational design?

Computational design has been mostly used to explore new forms for pushing the boundary of architectural discipline. More and more surprising "architecture" is generated by scripting to make people so dizzy that it seems anything can dress up as "architecture", no matter what the "body" may be. It reminds me the Avant-garde architects in 1920s who naively believed new technology can bring human being a beautiful world, whereas the world evolves into many depressions and even the two world wars. Architects tend to be heroistic with the belief that they can save the world. Consequently, architecture has to bear obligations to resolve all the problems which would never follow the same way as the architects wish. It is true that this digital wave has changed architectural design for the first time in many aspects, such as influencing design thinking, changing design processes and, equipping architects with tools as advanced as those for creating artificial intelligent life. All the values of architecture have become so intangible that young architects often follow the visual madness rather than the thoughtful calmness.

Rather than keeping pushing the boundary of architecture, we are more interested in how to immerse the digital means into the synthesis of architectural design including social and economic values. This is why we look into new possibilities for vernacular architecture which has been formulated and is ready for a new creative presence.

Undeveloped regions in China

Economic development has become the irresistible force sweeping all over China where internationalism clashes into Regionalism. The tension between cities and villages intensifies at suburbs. How to sustain the culture merits which are deeply rooted in the local majority, meanwhile favoring the political and commercial interests of the minorities, is one of our main agendas for applying computational approaches. For new real estate developments in those areas, the lack of sustainability compared to the vernacular living environment is essentially because of the rapid speed of development for both political and economic reasons. Consequently, in order to meet the deadline, it has to erase architectural diversities and adaptability, which can be only achieved through the evolution for a long time. Can we design out one-off developments with the same qualities as vernacular architecture has? Intelligent computation together with empirical design sensation makes it possible.

Find architectural platforms

This essay is based on a project near Gui Yang, the capital of Guizhou Province[ii]. The gross land surface area is 95 ha. It comprises a high end resort, commercial streets, a museum, leisure & sport facilities and, residential buildings. The site location is between the old city center and the new city district triggered by the national high speed railway. （fig 1）

Our first challenge is the rugged site topography. For mountain architecture, how to make the best of lands in terms of controlling costs, improving land using efficiencies and, stimulating coherent sceneries in site contexts, are among the issues haunting around many architects. Recently the central government has been stringent about the codes for mountain architecture after several fetal landslides and mud-rock flow occurred in southern China, e.g. to forbid any structure on slops with a gradient of more than 30 degree. In correspondence to this, we started this planning project directly in 3D by reading point coordinates (fig 3) on a survey map and translated them into a 3D mesh surface, so that many design decisions can be based on this relatively accurate 3d surface model with color-coded

slope gradients (fig 4). Another obvious advantage was that we liberated from the survey map which always surveys contour lines based on 5m height difference. Now could we find the contour line wherever we introduce cutting levels. As for the road design, we had two approaches. One was cutting horizontally at particular level in relation to the adjacent roads. Secondly, for roads connecting different levels, we developed another script to find the shortest splines between two given points at different levels on a given surface.

Thanks to this set of scripting tools, we can freely find all the appropriate building platforms at any level and controlled them parametrically (fig 5). For instance, if the height difference between two contour lines is 3m and the gradient is constrained to 30 degree, then the depth of that building platform has to be minimal 5.1m, which further varies according to the functions of that building. The adjustment of different combination of parameters also indicates the control of architectural density in relation to the landscape and public realms. The determination of the height difference between contour lines is the result of balancing land excavation and refill, as well as the visual and daylight impact to buildings at different levels. Even though the design may probably change later for many foreseeable and unforeseeable reasons, this design approach allows us to easily adapt the design content to new conditions without losing the overall quality.

Grow architectural forms

The site is within a minority tribe region called Miao (fig 2). The local government is stringent about any new buildings against the architectural tradition of the minority culture. Design outcomes have to be valid creation based upon existing vernacular styles in addition to coherence to the complex topography.

Based on the exercises for finding appropriate architectural platforms with various evaluation criteria, we studied the syntactic rules of the vernacular architecture of Miao, which is essentially a timber frame structure with double pitched roof and living volumes suspended off grounds. Rather than the singular building style, it is the collective effect by thousands of houses on their best locations and with appropriate orientations that gives a recognizable vernacular style. Understanding this we need to advance the generation process to grow architectural forms out of the architectural platforms.

First of all, we designed a set of parameters sufficient for generating overall building frames which are essentially governed by pitched roofs. Based upon the outlines of the architectural platforms, we can compute the projection of roof ridge lines and lift them according to the building heights as per FAR. Then several rotating plans are introduced along roof ridges to define the plans where pitched roofs are to be located. The final shape of each pitched roof is the intersection between the inclined roof plans and extrusions of building footprints. Further down the line, the building façade frame can be developed according to the rafter spacing of the roofs (fig 6). All the faces have to be planner shape for not only referring to the traditional styles but also concerning of costs. It appears that the soul of the local vernacular architecture can be inherited as long as the collective roof effect against topography is achieved (fig 7).

In order to differentiate various clusters, e.g. hotels, retail shops, villas and so on, automatically and parametrically, we constructed the syntax of aggregation as per the topography beyond the shape of individual buildings with the parameters including building depth, roof pitching angles, degrees of folding ridge configurations in 3d and so on (fig 8).

With regards to the museum on the northern slope of the mountains, due to its functions and location, we used different generative strategies inspired by the terrace farmland of Miao. A series of contour lines were smoothened as the spines for the main museum volumes. The gaps between terrace roofs automatically formed high level windows facing north as if fins. The main entrance is under the cantilevered strands stretching out over the west plaza. In contrast, the other end of the building series was buried into the land gradually. With strategic combination of green roofs and metallic cladding systems, the museum was unfolded well into the landscape. (fig 9)

Other meaningful elements on site are Wind & Rain Bridge, an inhabitable bridge with vernacular styles, and Iterative Eave Pagoda, a high structure used for communal gathering and orientations in old days. We examined the traditional syntactic and semantic implications and removed the irrational components on the basis of contemporary materials and building technologies, then extracted the intrinsic merits of these two elements and developed them into parametric systems through scripting and parametric tools like Grasshopper, recreating new outlooks without losing the spirit of those vernacular signs.

Summarize architectural value

Instead of taking for granted the conventional ways of doing master plan, this project transcends the inertia of 2D planning with a new way of 3d planning, i.e. computing gradients of the site topography for the most appropriate architectural platforms which then generate individual building forms referring to the vernacular styles. We explored a set of techniques for intelligent massing in real time. As a result, no single house is identical and all match the topography perfectly. A series of evolutionary design strategies were also made to further teeth out both buildings in different shapes and in-between public spaces in various scales. The automated and valid customization processes for collective architecture deliver similar quality of being genuine and diversified as the local vernacular architecture, sustainable in both cultural and economic dimensions.

End

No exceptionally, this project exhibits our design philosophy to immerse computational techniques (no objection to any tools and not being constrained by any tools) into design processes comprehensively and thoroughly so that concepts, ideas, intentions are celebrated and achieved extensively instead of showing off how advanced we can use those tools. Our goal is neither to focus on the computation itself, but address deeper issues associated with design values in reality for architectural design, urban planning, landscape design and, interior design. The results don't have to be visually complex, but it must respect the complex context. Computational design, or more popularly known as parametric design in China, is neither the whole asset of design, nor the add-on to design. It should intermingle with team collaboration, creative ideas, thinking processes and, effective presentations. It should be promoted from the technic level to the mental level and become invisible eventually. After all, no clients will interest on how you do it more than what you can deliver.

Technology cannot simply bring us a beautiful world on its own. We embrace new digital means but not obsessed with them. We are more interested in extending values of design in the increasingly complex realities when everything is connected with everything else. Our aim is to not talking about computational design as it is part of our instinct. In the end, it is the people who drive design decisions instead of ubiquitous computational tools that make a design project different from others. Whatever digital means you choose to use, e.g. scripting, macro or parametric software, they are only one of many ways to do it, but not the purposes of design activities. The significance of implementing digital means, e.g. scripting, is to enhance designers' abilities of extending design ideas, generating more design possibilities, improving design executions and, the last but not the least, ensuring design qualities. We have passed the decade of testing the limits of these tools. We get used to hearing claiming of pushing design boundaries. We stay calm however the forms scream. What we are envisaging, as these advanced digital means enable us, is the synthesis of innovative ideas, development processes, material & building technologies, project deliveries, intellectual properties, evaluation criteria, sustainable performances, information communication and many others. All in all, we want to make better design decisions.

The power of computation shouldn't and cannot over run the power of human brain. Human society is far more complex than the digital empire itself. Yes, architecture sometimes needs revolution to leap forward. But, it will eventually become a drop of the evolutional stream. Hence, our future cannot be simply scripted out of computer, but rather benefit from the synergy of processors and human brains.

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