Decoding Culture Parametrically: Digital Tea House Case Studies

Kaon Ko and Salvator-John Liotta

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Abstract

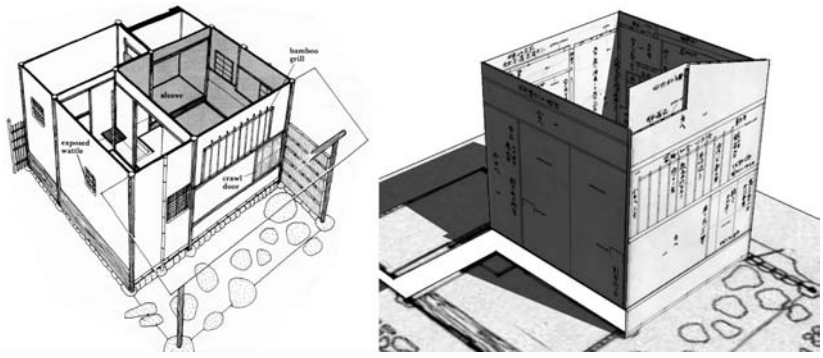
This paper reviews the Digital Tea House, a workshop held at the University of Tokyo with the aim to build three pavilions for hosting tea ceremony. As first attempts on cultivating formal innovations resulting from digital design process applied to construction of tea houses, the works convey that parametric design can be a mechanism through which architects are able to produce new images of a tea house and renew its conceptual meanings, and that it can be a tool to retain architecture convergent with cultural values. The authors analyze issues addressed in the workshop that range from applications of computational design, interpretations of tradition, structural stability, to solutions for quick physical materialization within limited time and budget. This paper clarifies the following: First, that parametric processes are not contradictory to traditional cultural principles; and second, how traditional elements of the tea house were decoded and formally reinterpreted through parametric designs.

1. INTRODUCTION

Digital Tea House is a joint workshop held at the University of Tokyo, together with Columbia University GSAPP, with the aim to design and build three pavilions for hosting tea ceremony. Issues addressed in the three-week workshop ranged from applications of computational design, interpretations of tradition and culture, structural stability, to practical solutions for quick physical materialization within limited time and budget. The workshop was divided into two parts: The first part introduced computational logic and concepts, which led to the second part where explorations related to Japanese tea ceremony culture served as a pretext for further exploring digital design and fabrication. Three teams, each comprised of 6 to 8 members, ultimately produced three full-scale tea houses to test out their concepts, methodologies and materials. Baseline for common software (Rhinoceros and Grasshopper), principal material (50 sheets of 9mm and/or 12mm thick 3x6 plywood), fabrication method (CNC routing), and budget (up to 150,000 JPY, approximately 1,500 USD, per team, excluding plywood and CNC fabrication costs) served to make comparisons and analysis during the process and later in three distinct outcomes.

2. TEA HOUSE AS CULTURAL BACKDROP

The Japanese people in the 16th century created a new culture which consisted of such elements as the 'Tea House' (see Figure 1), 'Sukiya Style Architecture' and the 'Wabi-Sabi' aesthetic of transience. Kengo Kuma [1] comments that the changes thus initiated can be considered "a reorganization of all products where the body is used as the reference. [...] They thought that relying on anything else as the reference would only add to the confusion." The merciless discarding of traditional standards and cultural hierarchy prevalent in Japan to that point constituted a significant break with Japanese tradition. At the time, the 'Tea House' thus represented an exceedingly avant-garde type of architecture (Figure 1).



► Figure 1: Taian teahouse by Sen-no-Rikyu, 1582 (left), *okoshi-ezu*, a 3-dimensional paper model (right).

From the reference to the body, the tea house evolved into a microcosmic situation where host and guest(s) meet and, at the same time, an intellectual device through which one is made aware of the natural phenomena occurring outside. *Okoshi-ezu*, a 3-dimensional paper model which first appeared in the 16th century, was often employed for the planning of tea houses as an effective visualization tool for potential effects resulting from minute alterations in placement of windows, doors and partitions within the extremely small space inside, a preceding method of simulation [2]. Moussavi writes: "architecture needs mechanisms that allow it to become connected to culture. It achieves this by continually capturing the forces that shape society as material to work with it. Architecture's materiality is therefore a composite one, made up of visible as well invisible forces" [3]. The traditional tea house is composed of a variety of elements, including *shoji** screens or bamboo slats that serve as light filter that underscore gradations of light, a small wooden sliding door at *nijiri-guchi*** entryway, *tatami* mats that signify where one may sit, and a recessed alcove *tokonoma**** for hanging scroll and flowers are typically incorporated.

Kengo Kuma notes that in recent years, we are starting to witness the diversionary and personal generating new types of creation. He describes that the *digital* is similar in the sense that it is also a reversal of an idea, based on the notion that within the minimal lies a new clue that can turn the world upside down [4].

2.1. Approach and Practicability of Parametric Design

The workshop provides a point of reflection within the academic setting to consider consequences of computational design when applied to physical reality of making, rather than stressing too heavily on the form-finding aspects of computational design. Engagement in a continuous process leads to a constant feedback loop between the software, material characteristics, and contextual considerations as a mode of operation. The parametric tool allows for the input of almost infinite amount of information, producing mathematically logical and countless variations over the entire process, but it obviously cannot determine any hierarchical design decisions. In an essay, Shohei Matsukawa dissects the differences between conventional design process versus the generative model, where diagrammatic process models between environment, architect, building, user, and other basic criteria such as building codes, operate differently, illustrated in examples including linear model or partial feedback loop model [5]. One of the most complicated process diagrams where series of algorithms are employed leaves the architect with the "question" without a definite answer.

In the workshop each of the pavilion's physical presence and their feasibility on multiple levels were evaluated and reconsidered throughout. The process is subject to simultaneous assessment of technology and working with the highly sophisticated parts that can be produced, while for

most participants who were inexperienced in construction, the temporariness of pavilions relieved them of some issues including protection from weather, foundations, and structural stability over an extended period of time. It also encouraged material experimentation, intuitive predictions for structural elements, and trial and error approach in detailing and assembly.

The use of parametric design can, at times, promote a tendency where its users can easily produce forms too complex to control with little regard to issues of economy, society, or culture, in part due to our fascination with the new forms. Constraints including structure, material, budget, time, assembly, site, and function help avoid the risk of designs that are impossible to be realized. For instance, participants coped with possible spans of given plywood structure while considering how long they would have to be temporarily supported during assembly. As a combination of creativity and technical means, architectural design is incoherent without one or the other. When parametric design is integrated into a process within a framework of real-life constraints, its advantages are beyond mere stylistic choices or visual effects. Often, as we are "limited to the constraints of borrowed code, most architects today are forced to squeeze their imagination through the prefabricated structures of existing protocols. To a certain extent this situation has begun to change with the introduction of custom scripting where designers are able to tweak the constraints of their tools." [6] The workshop organizers decided to use software such as Rhinoceros and Grasshopper, because their relative simplicity offers architects a chance to manipulate tools that facilitate their imagination while engaging the challenges of design and construction.

For the duration of the entire process – from design, manipulations, detailing, to fabrication – it became apparent that the use of a graphical algorithm editor tool allows for instantaneous modifications and influences on architectural conditions and context. On the other hand, it is easy to incline towards oversimplification in such models; when a single line, for example, is further manipulated into endless variety of forms and surfaces, it alone can seem to substitute complex architectural elements. How would these simple manipulations translate to construction? What would this diagrammatic and methodical approach produce when combined with a culturally meaningful function as a tea house? As first attempts on cultivating formal innovations resulting from digital design process applied to construction of tea houses, the works resulting from this workshop convey that parametric design can be a mechanism through which architects are able to produce new images of a tea house and renew its conceptual meanings, and that it can be a tool to retain architecture convergent with cultural values.

2.2. From Context-Neutral to Context-Aware Design

How can we bridge the digital environment to the physical environment in which we live? First, we addressed the consequences of the designs, in how every part should to be considered for strength, weight, its assembly sequence, and surface treatment. There are also questions regarding appropriateness and scale of design, which often cannot be resolved in the isolated modeling phase. How to reconcile the disparities is one of the biggest challenges in the design process; this workshop uses a cultural function of the Japanese tea house as a starting point to address the gap. The often scale-less nature of design through scripting is applied via traditional set of rules, such as the prototypical 4.5 *tatami*-mat scale of a tea house, to be physically implemented. Iwamoto writes:

> "[…] the route from virtual to actual is one of constant calibration. […] Taking such exigencies into account, one may observe a host of exciting digital-fabrication projects that have cropped up, using material and constructive constraints to alter end results. Because of the nature of designing in such a manner is improvisational […] relationships among the design, material, fabrication, and assembly are intentionally kept flexible through the final building stage. The design-build process fosters experimentation, where fortuitous "accidents" may lead to new insights and unintended design consequences." [7]

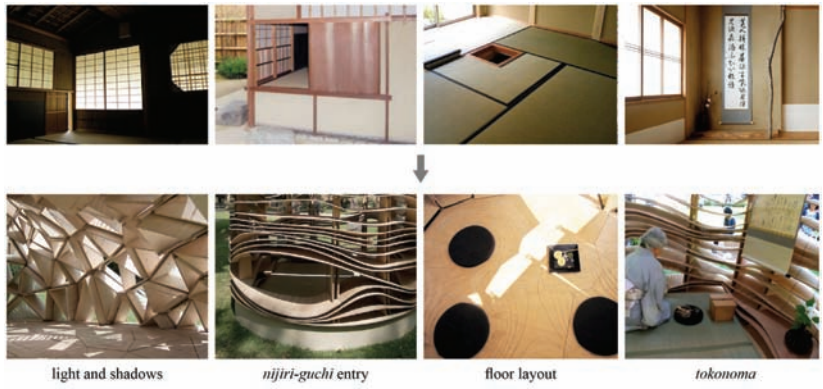
Concurrently a kind of geometrical rationale embedded in parametric processes can be contradictory to traditional cultural principles. The type of optimization that are clearly present in the relatively simplified model in the parametric process can have a very contradictory set of values compared to the traditional sense of esteem for subtle and intricate deformities and variances in nature. Perhaps with practice such subtleties can be emulated, but are extremely difficult with the level of computational skills that the participants possessed. Layers of complexity can be incorporated to the model, however, and each of the pavilions constitutes such an attempt. All three groups have done so in visually pronounced manner, at macro rather than micro scale for maximized effect. Anywhere between trying to apply rationalistic principles to the chosen rational set of traditional rules and to exact the perfect middle-ground, or between the effort to tame the material to finding the least confrontational approach to material, the struggle is visible in their outcomes. The process of computational design and fabrication can amplify complexity as desired, but perhaps more intriguing are considerations on what new values can be extracted from the combinations of culture, tools, and materials, and what sets of cultural values are left behind in the process of translation, or decoding. The development process from context-neutral idea to context-aware architecture calls for multidimensional views, and the deviations apparent in

the outcomes each show different approaches and emphasis to the problem of rationalization of the traditional aesthetic sensibilities.

3. DIGITAL TEA HOUSE CASE STUDIES

Three case studies are described in the following sections. In each of the outcomes, basic elements and characteristics of the traditional tea house have been boldly interpreted via parametric processes, effectuating aesthetic choices otherwise unachievable. Moussavi [8] writes: "These affects may start with found imagery or iconography as raw cultural material. However they do not remain as pure acts of consumption, but rather are disassembled and reassembled to produce new sensations that remain open to new forms of experience. It is in this way that they are contemporary and committed to progress."

► Figure 2: Traditional elements, above, were used as inspiration to create innovative interpretations below.



Pavilion 'Nami-no-ma' translated the textures and shape of a tea bowl to linear layering of the plywood, while pavilion '1300082520l0' focused on light patterns and transparency. In pavilion 'Poetry and Parametrics' reinterpretations of traditional rules were applied more literally (Figure 2).

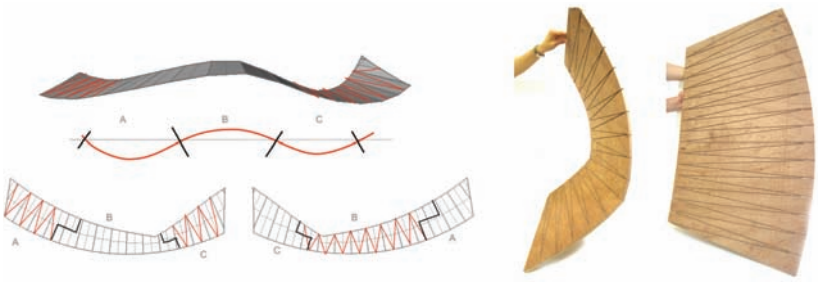
3.1. Pavilion "Nami-no-Ma (Space of Waves)"

Guided by strong aesthetic characteristics from the tea ceremony, the expression of the beauty and imperfection of nature inspired by the tea bowl is translated to plywood, which surrounds the basic 2-tatami traditional layout of the interior space. The initial concept was drawn from the slightly irregular traces left from the process of throwing the tea bowl on the potter's wheel. The bowl used in Japanese tea ceremony favored controlled imperfection in the aesthetic of *yuragi* and *yugami*. *Yuragi* is the slightest warping often from the uneven pressure of the kiln, which later developed into a more as deliberate and artistically restrained distortion of *yugami*.

Pavilion Nami-no-Ma boldly translates the phenomenon of *yugami* in the same calculated manner as the ceramicists of the past, with every layer of plywood by taking advantage of the CNC router. Efforts to create a natural and flowing form from the 3-axis CNC routing, which is a flat surface fabrication, pushed for experimentations with half-depth grooves in specifically calculated patterns on the 9mm plywood. The key challenge was in achieving the desired bend in a continuous curve following a circular geometry of the plan. Enabled by close communications with CNC router operators, tests initially began with grooves of different depths and stitch patterns of varying lengths. The triangulated grooves eventually proved to be the ideal solution for 3-directional curves to be fixated on site, whereas perpendicular grooves only enabled 2-directional bending per panel. The resulting pavilion is a soft envelop for the interior activity, accentuated by modest connections to the surrounding environment (Figure 3).

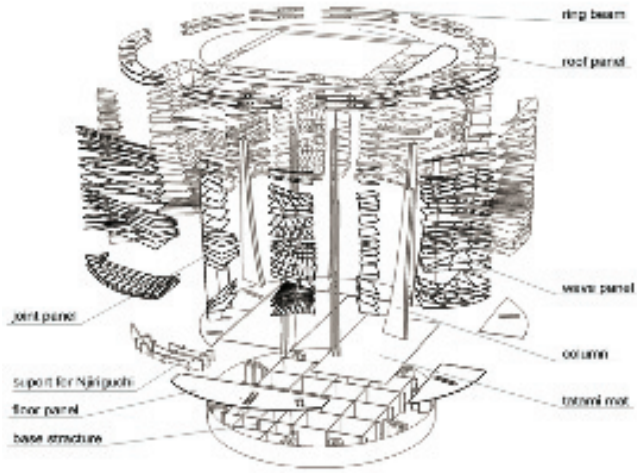
◀ Figure 3: Pavilion "Nami-no-Ma" (left), interior view (right).

Tea house typically offers limited level of openness to the outside; in this interpretation, the varying thickness of the wall becomes the boundary between the tea ceremony taking place inside and the surrounding nature, while the views are controlled by the density and bending angle of each layer. The undulating waves (Figures 4 and 5) also facilitate functions of *tokonoma* and *nijiri-guchi*, where the largest opening in the pavilion is structurally reinforced beneath the lower curvature to support body weight.



◀ Figure 4: Groove patterns and densities determined according to the desired bending (left), tests of the groove patterns and bending characteristics with plywood (right).

► Figure 5: Exploded axonometric drawing shows composition of parts to be assembled.



3.2. Pavilion "130008252010"

Designed for the precise moment of 13:00 on Aug. 25, 2010, when the tea ceremony took place, the interior space is planned for specific lighting condition where fragmented shadows align with the cut-out straw mat floor pattern, serving as ever-changing ornament but also indicating where host and guests may sit. Angles and depths of 192 triangular patterned sun-shading units over a semi-conical arch structure, leaning forward at 35.5 degrees that is the latitude of Tokyo, have been designed with considerations for the passage of time and changes in sunlight. (Figure 6) In the tea house, "window placement is calculated not only for ventilation and visual effect on the walls, but also to create just the right play of light and shade when the tea ceremony is performed." [9]

► Figure 6: Pavilion 130008252010 (left), interior view (right).

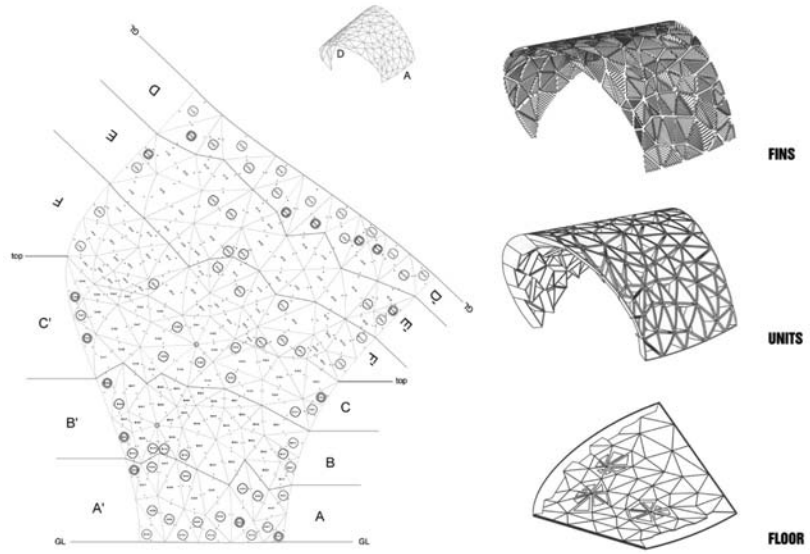
The design of '130008252010' was partially influenced by the traditional concept of *sabi,* which refers to that art of imperfection celebrated in *The Book of Tea* by Kazuko Okakura. Traditionally, according to Okakura, there is a compulsion to divide space into equal parts in Western art forms, to

attain a sort of mathematical and geometrical balance and perfection, and leaving nothing for the viewer to add [10]. Conversely, according to De Mente one of the traditional Japanese ways is "to utilize asymmetry and austerity to achieve surprise and delight elicited by the unbalanced, by the apparent randomness of things that allows the viewer to complete the image" [11].

Pavilion '1300082520l0' is almost entirely based on this concept of letting the viewer complete the image: As the inclination of sunlight coincides with the pattern designed on the floor only few minutes per year, the tea house becomes a continuous recreation of the image. This work is imbued with the spirit of a Zen teaching called *yugen*, which refers to a type of beauty, in a harmony so delicate and so right that only attentive observer can see and perceive it.

The external surface of the pavilion is a smooth continuous curvature while the internal surface is irregular, with varying depths of the triangular units. These units posed a challenge in terms of connections due to their wide range of angles; finger joints resolved the issue by increasing the contact surface area, but these joints would have been considered differently with a 5-axis router or a different tool to enable smoother edge conditions where as many as seven angles congregate. Corresponding angled fins made of laser-cut white translucent paper-plastic laminate inserted into each unit further regulated desired lighting conditions (Figure 7). However half of the fins were lacking in the end because of miscalculation of time; while parametric manipulations are almost instantaneous, to physical realization through labor takes much longer. Pavilion '1300082520l0' is essentially a shading device, materializing the natural phenomenon of daylight through their tea house. It is a way of visualizing something as ephemeral as light via incorporation of the 4th dimension, time, by utilizing parametric software (Figure 8). Although traditional sequential and spatial considerations were somewhat sacrificed by its singular focus, it was also very poignant within the ever-changing interior conditions.

◀ Figure 7: Plywood panels ready for assembly (left), assembly process (right).



► Figure 8: Surface map of all triangular units, divided into alphabetical zones for organization (left), exploded isometric (right).

3.3. Pavilion "Poetry and Parametrics"

Participants from GSAPP focused on the choreography of the tea ceremony sequence by pushing the aspect of parametric design to translate the traditional tea ceremony sequence of separate host and guest entries. Attractor points organized the interior space, each designating a field of influence: Positions of host, two guests, and the *tokonoma.* The spiraling boundary contains the activity within the two *tatami*-mat space. The idea for the design began with one simple module, which can be used to create the entire structural system and facade for the tea house.

Disjunction between limited amount of materials and the preferred geometry were reconciled in the use of parametric adjustments in the Grasshopper script. The method left room for play, which appears in a suspended radial roof enclosure inspired by origami folding and floor patterns created by grooves in the plywood resembling the stepping-stones surrounded by ripples. The wall panels also add to the diversity of surface treatments; the density of groove lines scored on the surface of the panels, either facing outside or inside dependent on the angle, visually indicates the positional deviations. The investigations relating to how the geometry and proportions are brought together in the assembly system (Figure 9).

To design the radial roof, participants were advised to use a design system in which they could intuitively vary any origami pattern in 3D. Tomohiro Tachi, an origami specialist who has written many softwares for the use of traditional Japanese folding in designs and architecture, provided critical technical assistance. [12] *Origamizer* and *Rigid Origami Simulator* software were used; the first is 3D origami design software that generates a crease pattern that fold into a given polyhedron, and the second one

simulates kinematics of rigid origami from existent crease patterns, respectively.

◀ Figure 9: Pavilion "Poetry and Parametrics" (left), interior view (right).

◀ Figure 10: Origami roof model (left), making process (right).

4. CONCLUSION

Conceived and finished in a very condensed period of less than one month, both computational design and digital fabrication enabled the speed and the challenges undertaken in each of the tea houses. Every decision inevitably affected other aspects of the design and making at once, especially since each pavilion was designed to be movable and reassemble-able multiple times in other locations. Applying materials suitable for both design and fabrication processes was crucial, since factors such as joints and weight of preassembled parts inhibited students from directly realizing what was envisioned initially. Each constraining factor pushed for creative and feasible solutions. This paper clarifies the following: First, that parametric processes are not contradictory to traditional cultural principles; and second, how traditional elements of the tea house were decoded and formally reinterpreted through parametric design.

From a cultural point of view, aspects of the tea house were interpreted in a contemporary digital manner and can be seen as reviving the tradition

of avant-garde. This points to the benefit of implementing present technologies of parametric design and digital fabrication, but also with certain specificity. When the specificity is drawn from a cultural reference, one seems to be more sensible of the complexities and rationales that require interpretation. Through the workshop it was made clear that such traditional values combined with new digital technologies is not contradictory, as exemplified in the tea houses and enforced by the final tea ceremony held inside in the forecourt at the University of Tokyo. On the contrary, the projects of *Digital Tea House* proved that it is possible to innovate and offer new interpretation of the long established tradition and aesthetic.

The shift in focus from satisfying public at large to increasingly personal scale has also driven these digital tools to become an ideal opportunity. Smallness of the tea house and its avocational function, both of which are deeply rooted in culture and its sensibilities, may not yield monumental visions single-handedly. The potential for individual insights to be optimized by use of parametric tools and processes points to a direction where framework of culture, for one, can serve as a starting point of the selective optimization.

Design has evolved alongside technology, with mutually beneficial relationship. The workshop has been a framework for assessment of design and available technology, both of which were then experienced and evaluated by the participants as well as the tea masters and guests. As a result of one of the most significant innovations initiated by parametric modeling software, participants were ultimately able to extract, edit, and abstract the traditional aspects pertinent to their works and transform into their contemporary possibilities of what a tea house might be.

Notes

- *Shoji* is a vertical screen, typically composed of Japanese washi paper stretched over delicate wooden frame.
- •• *Nijiri-guchi* refers to a small entryway specific to the tea house, approximately 60cm in both height and width. The tightness of the opening makes the guest crawl through with his or her head down.
- ••• *Tokonoma*, a small recessed alcove within a room where guests are received, is where flower arrangement and hanging scroll are commonly displayed.

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Kaon Ko and Salvator-John Liotta

University of Tokyo
Department of Architecture
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656 Japan

ko@komystudio.com, sja.liotta@gmail.com