TT Professorship Digital Fabrication
Department of Architecture
Technical University Munich

Participative Digital Fabrication

Design Studio 2020/2021

Technical University of Munich
TUM Department of Architecture

TT Professorship Digital Fabrication
Prof. Dr. sc. ETH Kathrin Dörfler

In collaboration with:

incon.ai

2020/2021

[1]*Augmented Participative Building of a community pavilion*

[1] *Augmented Fabrication Lab*

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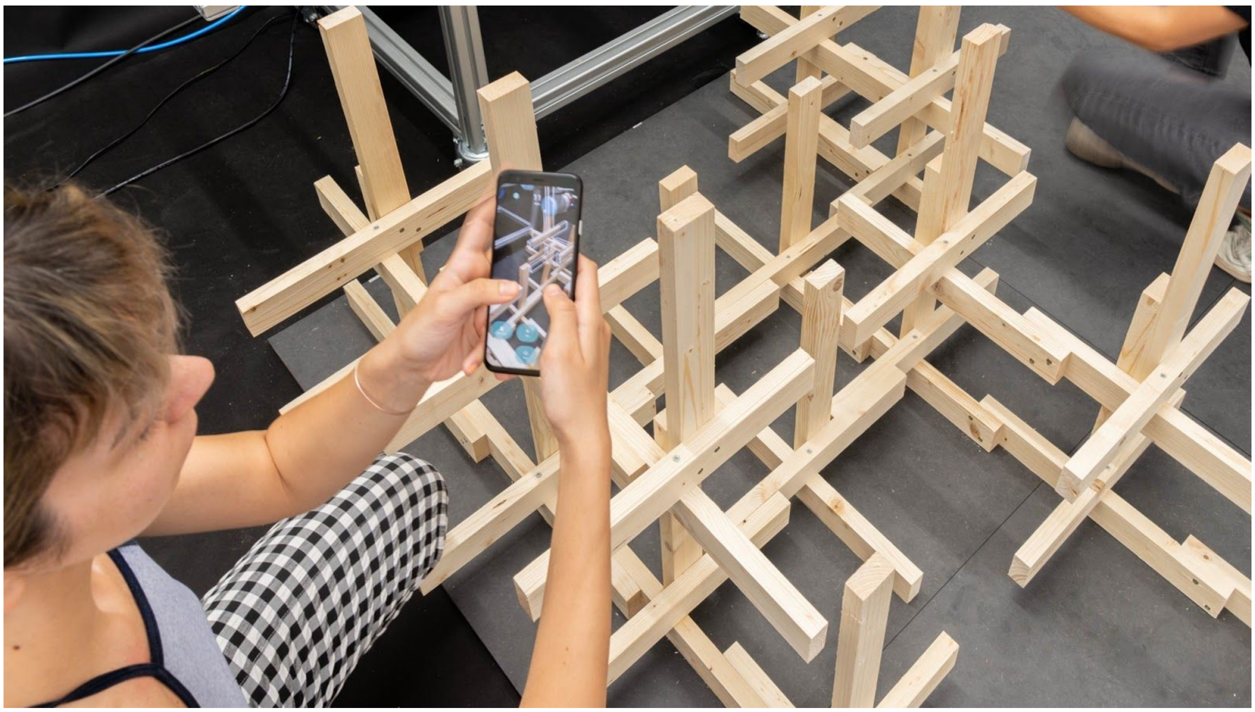
Schedule

Tuesdays 10 a.m. - 1 p.m. and 2 - 5 p.m.

Midterm Presentation 1: 1.12.2020, 2- 5 p.m.
Midterm Presentation 2: 12.1.2020, 2 - 5 p.m.
Final Presentation: 2.2.2021, 2 - 5 p.m.


[2] *Collaborative assembly building guided by an AR device*

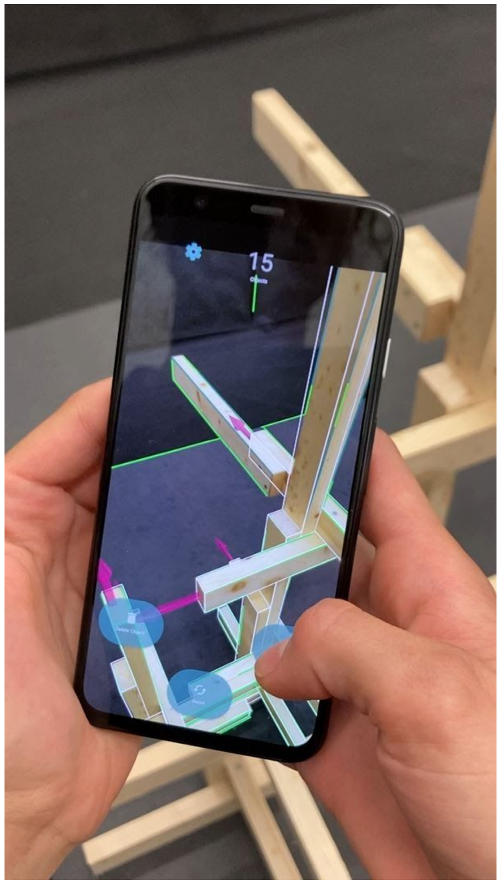
[2] *Augmented Fabrication Lab*

Introduction

"Towns and buildings will not be able to become alive, unless they are made by all the people in society, and unless these people share a common pattern language, within which to make these buildings, and unless this common pattern language is alive itself." [3]

[3] *Alexander, Christopher, Sara Ishikawa, Murray Silverstein, Max Jacobson, Ingrid Fiksdahl-King, and Angel Shlomo. A Pattern Language: Towns, Buildings, Construction. , 1977.*

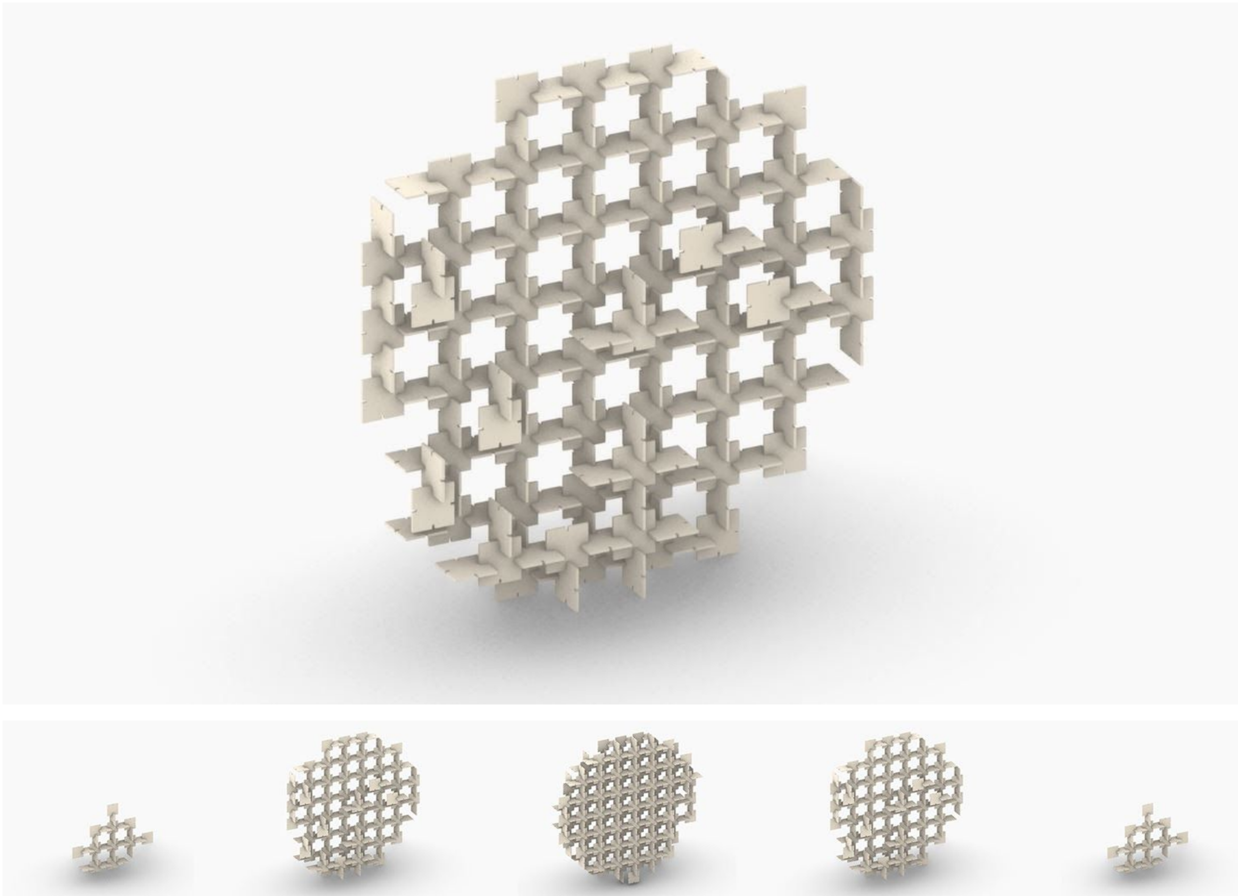
Method



[4] *AR device for tracking objects and visualizing information*

In this semester project we will explore how the use of mobile AR technologies allows users to collaboratively build geometrically complex structures solely from instructions via a mobile interface. We will further look into the design of human-machine interfaces and develop interactive and real-time visual building instructions for users to build a larger structure collaboratively.

[4] *Augmented Fabrication Lab*



[5] *Structure consisting of simple building components which could be assembled into any shape and disassembled after*



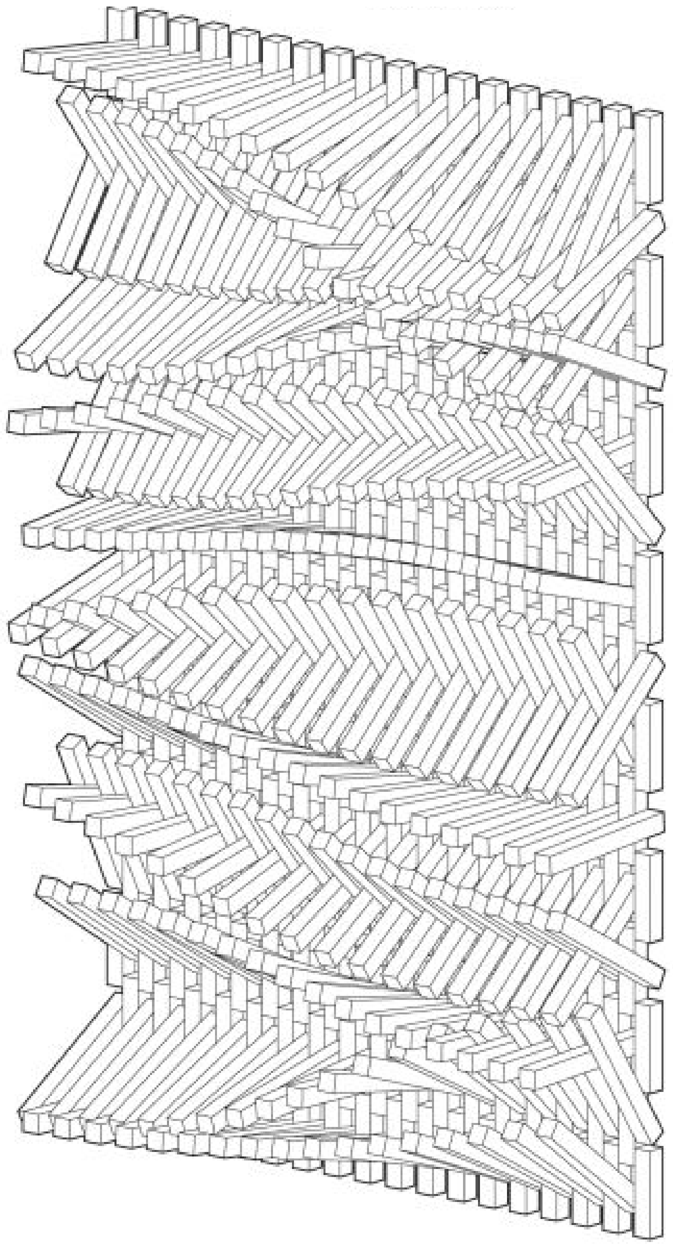

Both on behalf of physical and digital methods, we will look into designing and developing a building kit for the design of a public pavilion for Munich. This building kit should consist of simple building parts, which can be assembled into any type of shape and disassembled after. It should also comprise viable external or in-built joint details for a structural connection between the parts. During the course, we will study and explore possible fabrication workflows by means of physical prototypes at 1:1 scale.

[5] *Augmented Fabrication Lab*

Design brief

Our objective for this semester's studio is to design a public pavilion enabled by the developed concepts. As a part of the design brief students are expected to focus on:

- Design of a building kit
- Validated fabrication workflow
- Design of a pavilion enabled by the developed concepts.



[6] *The Sequential Wall, Gramazio Kohler Research, 2008*

[6] *Gramazio Kohler Research, ETH Zurich, 2008*

Digital Materiality in Architecture
Gramazio & Kohler
Lars Müller Publishers, 2008

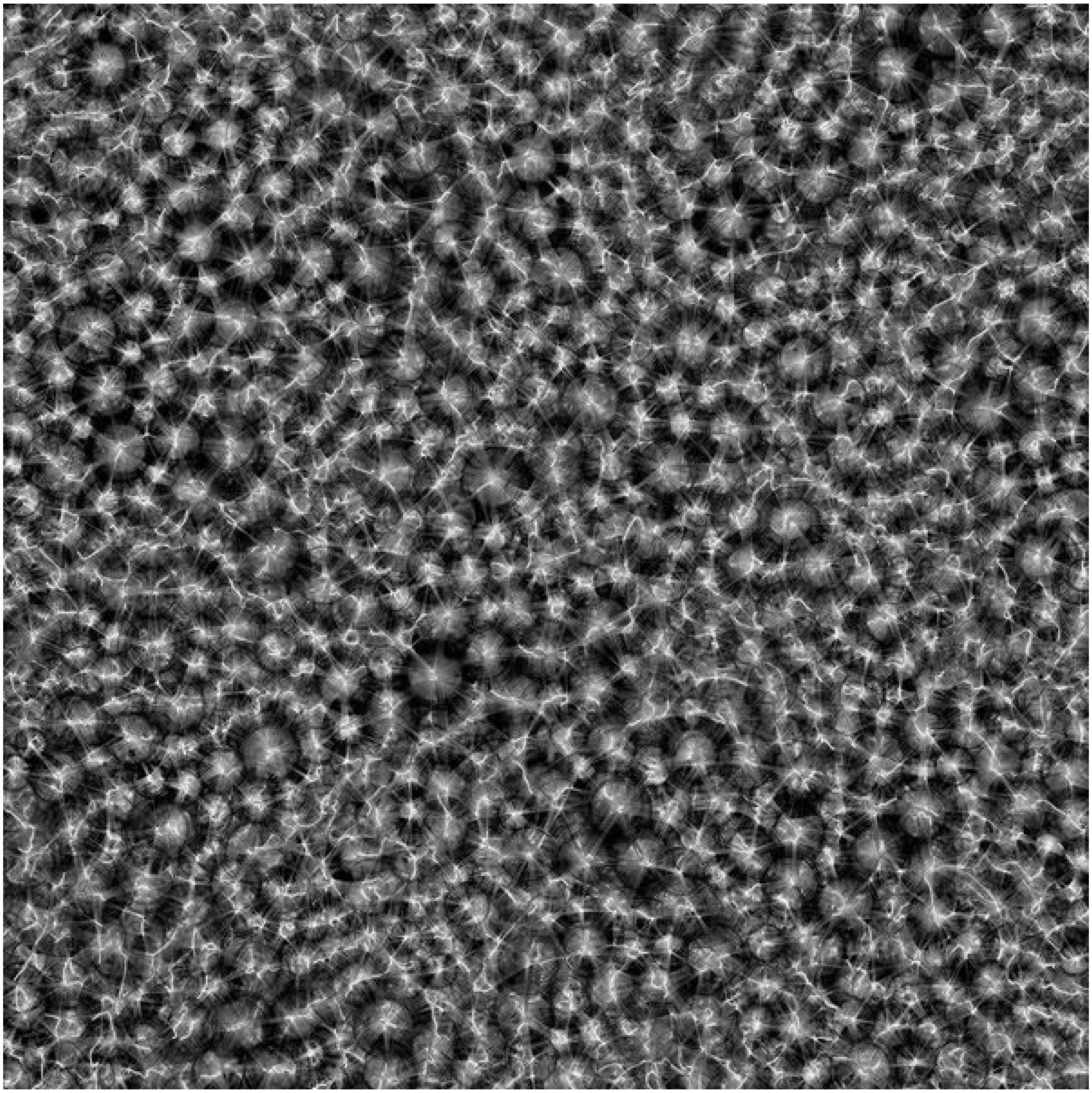
Digital Materiality

We use the term digital materiality to describe an emergent transformation in the expression of architecture. Materiality is increasingly being enriched with digital characteristics, which substantially affect architecture's physis. Digital materiality evolves through the interplay between digital and material processes in design and construction. The synthesis of two seemingly distinct worlds-the digital and the material-generates new, self-evident realities. Data and material, programming and construction are interwoven. This synthesis is enabled by the techniques of digital fabrication, which allows the architect to control the manufacturing process through design data. Material is thus enriched by information; material becomes "informed." In the future, architects' ideas will permeate the fabrication process in its entirety. This new situation transforms the possibilities and thus the professional scope of the architect.

Sensuality of Digital Order

Digital materiality leads to a new expression and-surprisingly enough, given the technical associations of the term "digital"- to a new sensuality in architecture. Digital and material orders enter into a dialogue, in the course of which each is enriched by the other. Digital materiality is thereby able to address different levels of our perception. It is characterized by an unusually large number of precisely arranged elements, a sophisticated level of detail, and the simultaneous presence of different scales of formation. Despite its intrinsic complexity, we experience and understand it intuitively. Digital materiality addresses our ability to recognize naturally grown organizational forms and to interpret their internal order. Its expression is novel, but not alien. Digital materiality is not rooted solely in the material world and its physical laws such as gravity, or in material properties. It is also enriched by the rules of the immaterial world of digital logics, such as its processual nature or calculatory precision. Digital orders intensify the particularities of materials. Materials do not appear primarily as a texture or surface, but are exposed and experienced in their whole depth and plasticity. Even familiar materials-such as bricks, which have been known for over 9000 years-appear in new ways.

For the observer, a tension spans the intuitively understandable behavior of a material and the design logic, which may not be immediately obvious. The logic can be sensed, but not necessarily explained. This obscurity seduces our senses, sending them on a voyage of discovery and inviting us to linger and reflect.



[7] *Field conditions diagrams*

[7] *In Points + Lines, 1985 by Stan Allen*

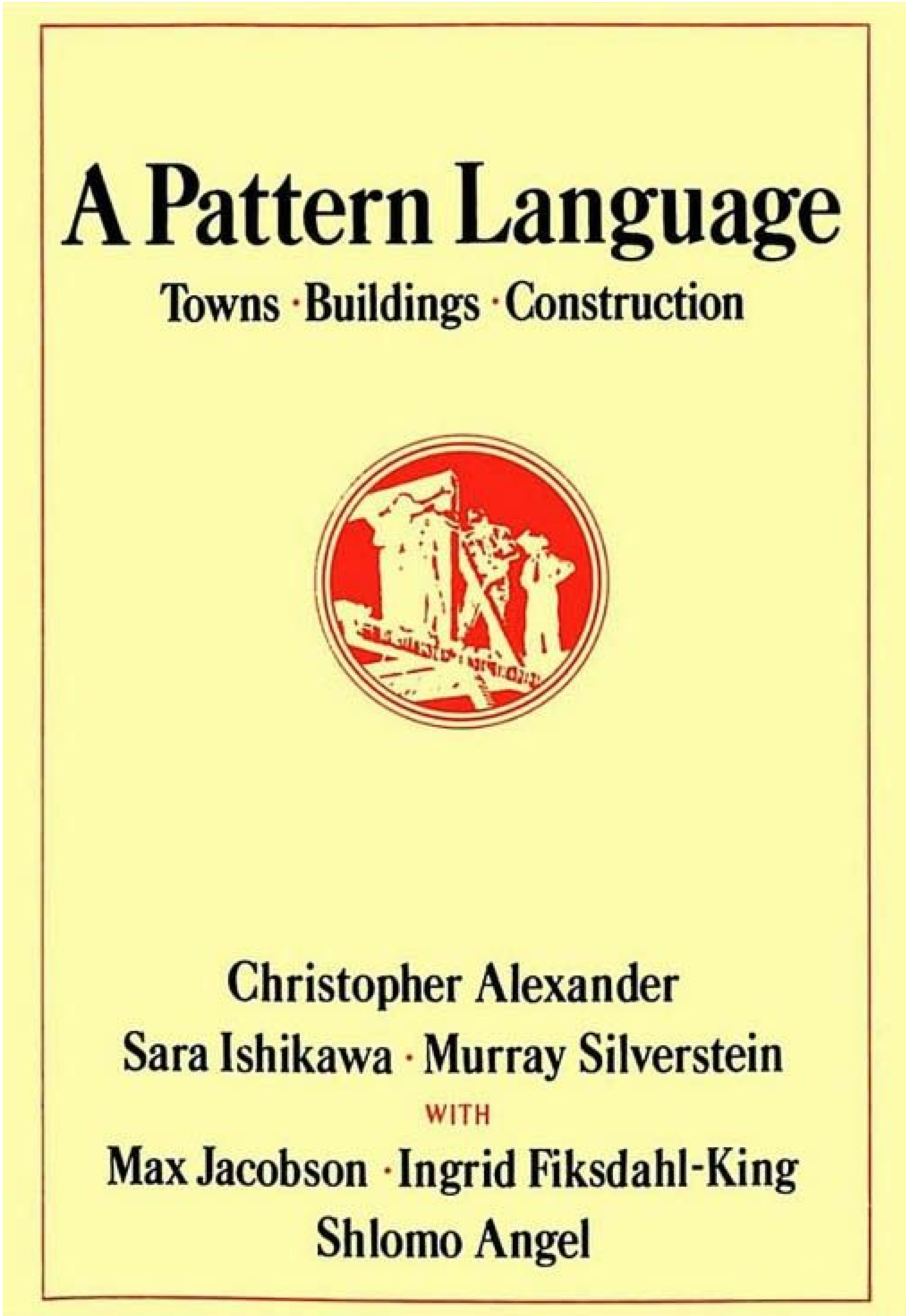
Field Conditions
Stan Allen
Points + Lines, 1985

From Object to Field

The term 'field conditions' is at once a reassertion of architecture's contextual assignment and at the same time a proposal to comply with such obligations. 1 Field conditions moves from the one toward the many: from individuals to collectives, from objects to fields. The term itself plays on a double meaning. Architects work not only in the office or studio (in the laboratory) but in the field: on site, in contact with the fabric of architecture. 'Field survey', 'field office', 'verify in field': 'field conditions' here implies acceptance of the real in all its messiness and unpredictability. It opens architecture to material improvisation on site. Field conditions treat constraints as opportunity and moves away from a Modernist ethic- and aesthetics - of transgression. Working with and not against the site, something new is produced by registering the complexity of the given.

A distinct but related set of meanings begins with an intuition of a shift from object to field in recent theoretical and visual practices (Figs 1 and 2). In its most complex manifestation, this concept refers to mathematical field theory, to nonlinear dynamics and computer simulations of evolutionary change. It parallels a shift in recent technologies from analogue object to digital field (Fig 3). It pays close attention to precedents in visual art, from the abstract painting of Piet Mondrian in the 1920s to Minimalist and Post-Minimalist sculpture of the '60s. Post-war composers, as they moved away from the strictures of Serialism, employed concepts such as the 'clouds' of sound, or in the case of lannis Xenakis, 'statistical' music where complex acoustical events cannot be broken down into their constituent elements.2 The infrastructural elements of the modern city, by their nature linked together in open-ended networks, offer another example of field conditions in the urban context. Finally, a complete examination of the implications of field conditions in architecture would necessarily reflect the complex and dynamic behaviours of architecture's users and speculate on new methodologies to model programme and space.
To generalise from these examples, we might suggest that a field condition would be any formal or spatial matrix capable of unifying diverse elements while respecting the identity of each. Field configurations are loosely bounded aggregates characterised by porosity and local interconnectivity. The internal regulations of the parts are decisive; overall shape and extent are highly fluid. Field conditions are bottom-up phenomena: defined not by overarching geometrical schemas but by intricate local connections. Form matters, but not so much the forms of things as the forms between things.

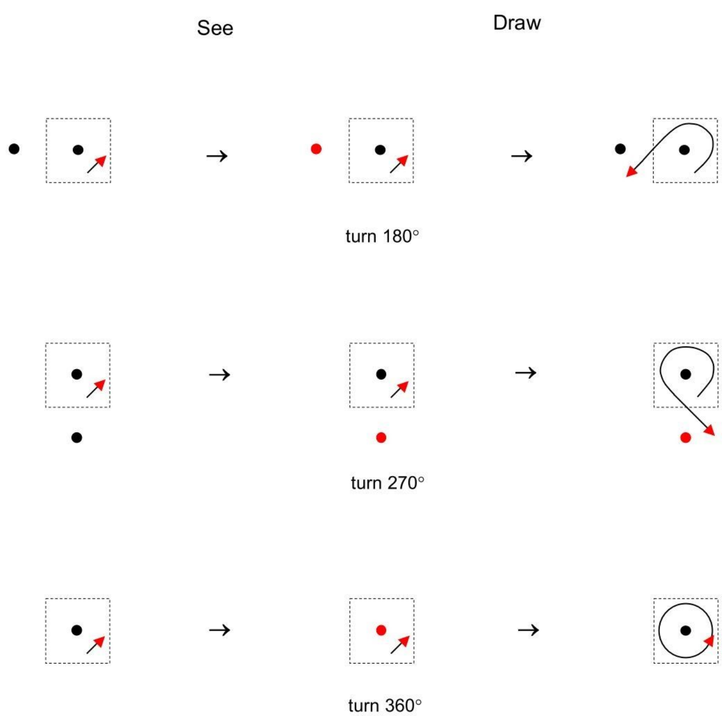
Field conditions cannot claim (nor does it intend to claim) to produce a systematic theory of architectural form or composition. The theoretical model proposed here anticipates its own irrelevance in the face of the realities of practice. These are working concepts, derived from experimentation in contact with the real. Field conditions intentionally mixes high theory with low practices. The assumption here is that architectural theory does not arise in a vacuum, but always in a complex dialogue with practical work.


A Pattern Language
Towns · Buildings · Construction
Christopher Alexander
Sara Ishikawa · Murray Silverstein
WITH
Max Jacobson · Ingrid Fiksdahl-King
Shlomo Angel

A Pattern Language
Christopher Alexander
Oxford University Press, 1977

In this book, we present one possible pattern language, of the kind called for in *The Timeless Way*. This language is extremely practical. It is a language that we have distilled from our own building and planning efforts over the last eight years. You can use it to work with your neighbors, to improve your town and neighborhood. You can use it to design a house for yourself, with your family; or to work with other people to design an office or a workshop or a public building like a school. And you can use it to guide you in the actual process of construction.
The elements of this language are entities called patterns. Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.
[...]
In short, no pattern is an isolated entity. Each pattern can exist in the world, only to the extent that is supported by other patterns: the larger patterns in which it is embedded, the patterns of the same size that surround it, and the smaller patterns which are embedded in it. This is a fundamental view of the world. It says that when you build a thing you cannot merely build that thing in isolation, but must also repair the world around it, and within it, so that the larger world at that one place becomes more coherent, and more whole; and the thing which you make takes its place in the web of na-ture, as you make it.
Now we explain the nature of the relation between problems and solutions, within the individual patterns.
Each solution is stated in such a way that it gives the essential field of relationships needed to solve the problem, but in a very general and abstract way so that you can solve the problem for yourself, in your own way, by adapting it to your preferences, and the local conditions at the place where you are making it.
For this reason, we have tried to write each solution in a way which imposes nothing on you. It contains only those essentials which cannot be avoided if you really want to solve the problem. In this sense, we have tried, in each solution, to capture the invariant property common to all places which succeed in solving the problem.
But of course, we have not always succeeded. The solutions we have given to these problems vary in significance. Some are more true, more profound, more certain, than others.
[...]
The fact is, that we have written this book as a first step in the society-wide process by which people will gradually become conscious of their own pattern languages, and work to improve them. We believe, and have explained in *The Timeless Way of Building*, that the languages which people have today are so brutal, and so fragmented, that most people no longer have any language to speak of at all - and what they do have is not based on human, or natural considerations.
[...]
In this sense, we have also tried to penetrate, as deep as we are able, into the nature of things in the environ-ment: and hope that a great part of this language, which we print here, will be a core of any sensible human pattern language, which any person constructs for himself, in his own mind. In this sense, at least a part of the language we have presented here, is the archetypal core of all possible pattern languages, which can make people feel alive and human.

[8] *Woman drawing a kolam pattern from rice powder*



[9] *The rules of making grammar*

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[8] *Source: http://www.anthropologieenligne.com/images/Kolam_3.jpg*
[9] *Terry Knight, 2017*

Craft, Performance, and Grammars
Terry Knight, 2017

From Shape Grammars to Making Grammars

Shape grammars provide a unique, computational theory of design, one aligned especially well with creative design practice. They are distinctive for their visual approach. The rules of a shape grammar generate designs by computing directly with shapes made of basic spatial elements (points, lines, planes, and solids), rather than with symbols, words, numbers, or other abstract structures that represent visual shapes indirectly. Computations with shape rules involve seeing and doing. In each step of a computation, the user can choose what shape to see and then what action, or rule, to apply next. Designing with shape grammars is thus a kind of performative, making activity. Shape grammar theory offers a natural basis for a computational theory of making.

Making Time and Making Grammars

A key feature of making is time. Craft practices, and making activities in general, are continuous, temporal events. Making sense of and participating in a craft practice not only involve structuring in some way the spatial aspects of the things being made, they also involve structuring the temporal actions involved in the making of those things. Such structuring might be retrospective and deliberative – as in analysis – or it might be impromptu and on-the-fly – as in real time making. Shape grammars focus on the spatial qualities of designs and the ways that rules structure designs by segmenting them spatially through visual perception. Making grammars offer opportunities to explore the temporal qualities of making things, and the ways that rules structure and segment things and their making both spatially and temporally.

[...]The idea behind making grammars intersects with some of the ideas above, in particular the roles of spatial and temporal segmentations in understanding and generating events and actions. Making grammars, though, make no claims for generalized knowledge about the way people segment the world. The rules for different making activities, and the ways rules segment making activities, can vary as widely as the things studied and the people who make them. Also, making grammars are directed toward creative human activities – not cutting an apple. Further, making grammars are limited to representations of things and how they are sensed. Other context, such as the maker or performer, the physical setting, and so on, which are sometimes included in computer science work, are not included in making grammars.

A making grammar can describe and structure both the spatial and temporal aspects of things and their making through its rules. Making rules describe spatial aspects of things by segmenting things spatially in the same way that shape rules describe spatial aspects of shapes by segmenting shapes spatially.

[10] *Interactive spaces*

[10] *Montessori School, Delft, Netherlands, 1960, Herman Hertzberger*

Space and the Architect: Lessons in Architecture 2
Herman Hertzberger
010 Publishers, 1999

The Idea of Space

Space is more an idea than a delineated concept. Try to put it Into words and you lose it. The idea of space stands for everything that widens or removes existing limitations and for everything that opens up more possibilities, and is thus the opposite of hermetic, oppressing, awkward, shut up and divided up into drawers and partitions, sorted, established, predetermined and immutable, shut In, made certain. Space and certainty are strangers. Space is the potential for the new.
Space is what you have in front of you and above you (and to a lesser degree below you), that gives you a freedom of view and a view of freedom. Where there is room for the unexpected and for the undefined. Space is place that has not been appropriated and is more than you can fill.
Space also comes from an openness to multiple meanings and interpretations; ambiguity, transparency and layeredness instead of certainty. Depth Instead of flatness, a greater dimensionality in general and not exclusively and literally the third dimension.
Space, like freedom, is difficult to get hold of; Indeed, when a thing can be grasped and so comprehended it has forfeited its space; you cannot define space, you can describe it at most.

Space and Freedom

Though space has a liberating effect, it is not freedom. Freedom is unbridled, unlimited release. Space is ordered, targeted, even if that order is emotional by nature and impossible to define. Freedom is virtual, existing only as something in the distance that is not part of you, such as a horizon that shifts when you think you have got closer to it. Or behind bars, In the minds of prisoners. Freedom is something you feel when it is not yours, you feel space when you feel free. Freedom presupposes independence, and that is a dead-end street. Space complies, seeks embedding; freedom devours, like fire, indiscriminately. Freedom takes no account of things, has no respect, is anti-social, antl-authoritarian; freedom cannot choose for with every act of choosing it reduces itself; it is a menu without end. Where everything is possible and permitted there is no need of anything. Space is a supply, that creates a demand. Space has shape, it is freedom made comprehensible.

'Freedom is amorphous.' Salvador Dali

Space arouses a sense of freedom. Comparatively speaking, the more space, the more freedom , and that which frees brings space.
Footballers or chessmen that manage to achieve freedom of movement do so within the limitations of the rules of play: that way they create space. When we talk about freedom we usually mean space. Feeling free means having the space you need.

[11] *Chair P, Assembly components, scale 1:5, 2002.*

[11] *Corraini Edizioni, Mantua Archivio E. Mari, Comune di Milano, CASVA*

Autoprogettazione? (Proposal for a Self-Design)
Enzo Mari
Edizioni Corraini, 2002

[...] Almost everyone has a hammer at home, and almost everyone has driven a nail at least once. As for materials, a wooden table is still the easiest to acquire. As for technical culture, things are a bit more difficult. There is an example of technical culture theoretically in the public domain even though it is adopted just by one working category— the carpenters, not the joiners. Such technique is reduced to the minimum terms and in practice is never taught. It's about making scaffoldings, workshop tables, or else, based on very simple principles that can be considered as the fundamental principles of engineering and architecture: the beam and the pillar. The junction between the beam and the pillar takes place through the driving, and since this process is a kind of joint and doesn't guarantee a complete blockage, it is necessary to support the joint with a nailed diagonal element. The result is a construction largely based on a triangle that, once more, is one of the basic principles of engineering. A triangle is non-deformable. Since the carpenters' economy of work implies the total recovery of the materials employed for a certain construction, they are used to keep elements of diagonal stiffening at their minimum. As I said, it's an easily accessible technique. Once a beam is nailed between two pillars, all that is left to do is adding transversal elements to give solidity to the structure. Using these two options as a starting point— tool and technique— I tried with the assistance of my young collaborators to realize a series of objects (tables, benches, chairs, beds) with this technique, in the sense that the objects weren't designed in advance but through a series of pothooks, we gave shape to the objects by attaching the minimum number of pothooks necessary. We also decided not to be concerned about the quality of the solution in the sense that the realized model would have as its only parameter of judgment its solidity and not the economy of the employed materials or lucubration of formal relationships. These models were collected in a small book* and the book was distributed in different forms. The definitive form was to send it for free to anyone who requested it. My proposal was that people would have been solicited from the suggested examples to realize what they needed, including further typologies originally not contemplated, and to realize them in a free form by assuming the suggested example simply as a source of motivation and not as a model to repeat. The proposal was successful and I received thousands of requests, to the point that the book had to be reprinted. But once more the hypothesis of the work failed because in 99% of the cases the proposal wasn't understood or perceived in the right way. Obviously, the objects should be produced according to the most advanced technologies.
This is the only possible way to have low-cost objects of good quality. Obviously, the models proposed here were absolutely non-economical from this point of view. Any table correctly produced with a machine, for example, needs no more than 30% of the material employed for the proposed models with far superior results of consistency and resistance. Obviously, the wood has to be employed only when is more economical than other materials. The assumption of wood is not the proposition in response to more modern materials such as plastic, which is more suitable to real standards of production. Actually, from this point of view all the proposals of using natural materials such as wood tend to be reactionary. I was aware of these things and I tried to tell them. It was simply about using this material and this technique as the only possible way to realize this designing exercise. Another objection was that I was somehow supporting the DIY phenomenon, but obviously a hobby is always reductive— it's always a small-bourgeois metaphor for the acquisition of technical cultures. As a matter of fact most of the people required the book for the following reasons: To satisfy the need of a taste that was about to start at the same time and to which I somehow contributed— the "poor," wooden, pseudo-handcrafted, naive, back-to-nature object. To solve real decorating problems of young students that simply wanted to do what they needed at the lowest possible cost. To decorate a country house or a second house in rustic style. I think only a small portion, about 1 or 2% of them, understood the meaning of this experiment.

Collaborators

Instructive Construction
incon.ai

Imprint

TT Professorship Digital Fabrication

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