Implementing Digital Crafting: developing It’s a SMALL world

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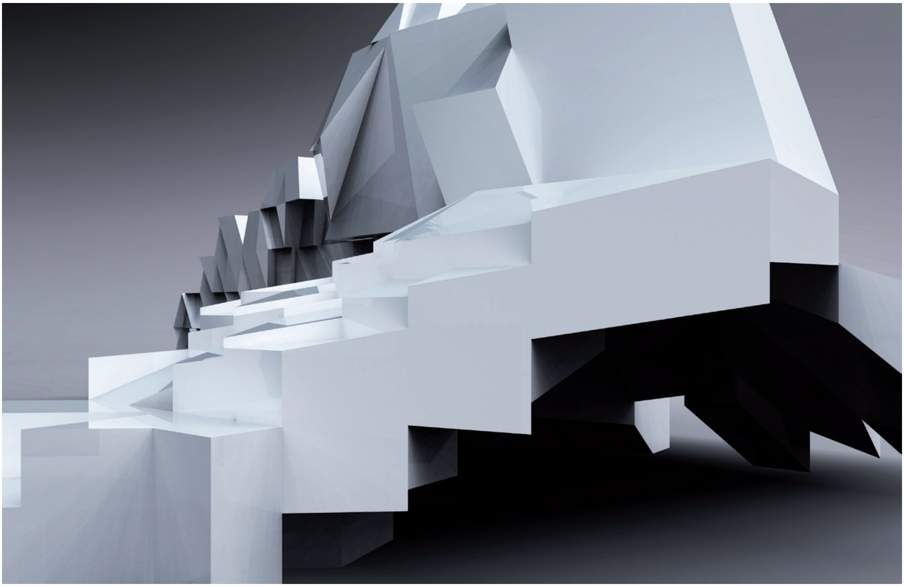


Fig.1 : Rendering of scenario 4

The exhibition design for *It’s a SMALL World* explores how non-standardised design practices can make new use of old materials. Developing bespoke interfaces for digital design and fabrication the exhibition design investigates how these techniques allow us to rethink the traditional boundaries between architect and builder, designer and craftsman (Kolarevic 2008).

Non- Standard-Practice and the new understanding of craftsmanship in design and architecture are the driving questions within the travelling exhibition *It’s a SMALL world* that has its first show from 27. August 2009 to the 1. February 2010 in the Danish Design Centre in Copenhagen. The exhibition presents 18 designers, architects and people from the crafts that have an innovative take on the future questions of sustainability, new materials and technology. Their products challenge traditional Danish Design and are yet interconnected in the countries traits and the way they design. Curated by the Danish Design Centre, The Danish Architectural Centre and the Danish Crafts Organisation groups of three from the different disciplines were identified in 6 scenarios with distinct expression.

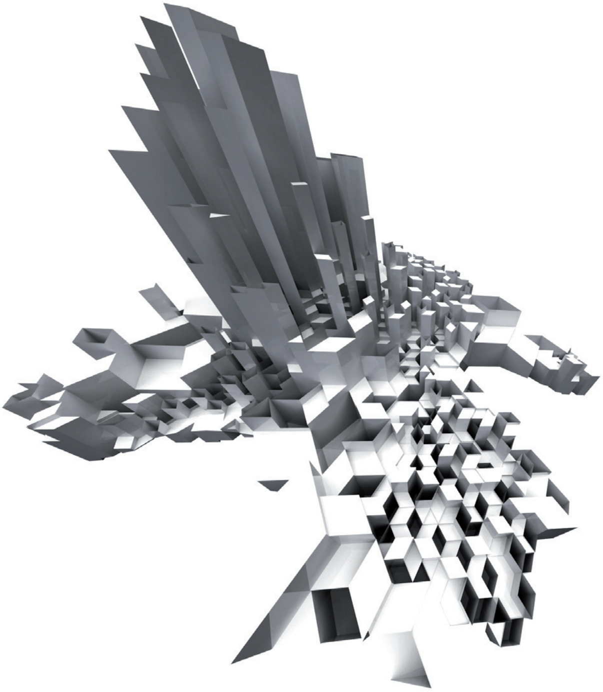


Fig.2 : Testing the different appearances within the generative System

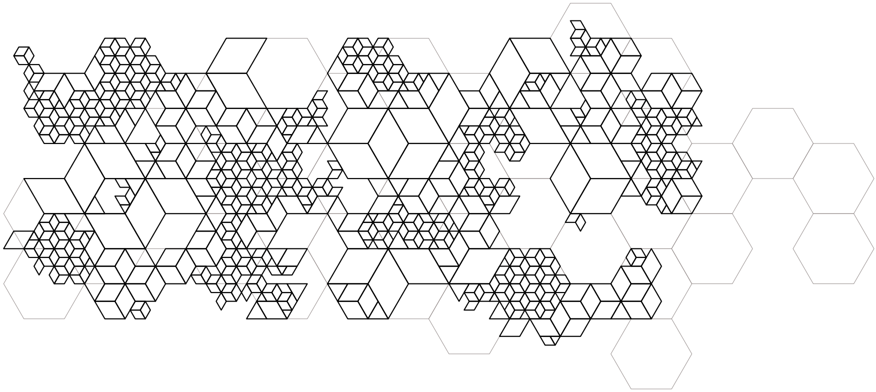


Fig.3: Stage one recursive pattern

Design Concept

The challenge for the design of It's a SMALL world was to responds to the differing scales of the exhibited objects. The exhibition brings together the scales of architecture (landscape, city and building) with the scales of the object (furniture, garment, jewellery). Our scope has been to develop a design that can negotiate these scales while maintaining the audience focus and attention.

Our solution has been to develop a generative design system. The system is parametrically controlled and by defining the variables of the design setups, the structure "grows" in response to the particular needs of each exhibited object. Like a crystal, the exhibition design is defined by a particular underlying logic that frames the structure and sets the core architectural tendency and expression (Fig. 1).

A crystalline logic is of fractal nature. Bearing the same typology elements are self similar, yet the sudden or gradual change in size, direction, offset, angle or length generates a huge variety of appearance. The design draws on this logic, as the changes allow to give the right place, atmosphere and view for each piece in the exhibition, while being able to show different kind of relations to neighbouring objects approaches. In this way very specific scenarios for related pieces can be formulated in a compound context (Fig. 2).

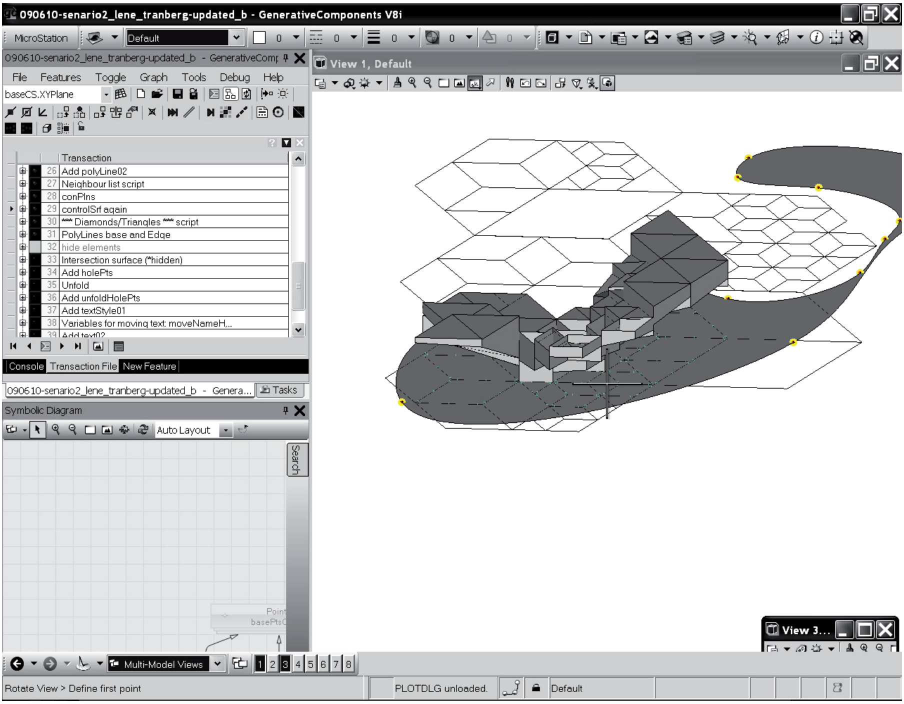
Material and shape

Using the commonplace building material DiBond, a composite of aluminium and plastic usually used in facade and display panels, our aim is to explore how new digital crafting techniques can allow us to redefine the structural properties and uses of the material. The cassettes make use of Dibond's quite singular property of folding. By scoring the material we can place crease lines and fold and plastic weld each cassette accordingly. The folding makes use of the materials inherent strength allowing us to optimise the material use as well as respond to weight concerns for freight and transportation.

Developing the design and fabrication system

The generative system is staged in three different parts. A base pattern defines a substructure of cassettes as a two dimensional layout. This forms the substrate for the second stage of three-dimensional grown cassettes. Those inform the systems third stage being the deviation of fabrication data.

In the *first stage* the underlying hexagonal grid defining the scenarios overall area and orientation are defined (Fig.3). This base layer is locally subdivided in three recursive steps due to local requirements posed by the exhibition objects and design intent.



	Transaction
26	Add polyLine02
27	Neighbour list script
28	conPlns
29	controlSrf again
30	*** Diamonds/Triangles *** script
31	PolyLines base and Edge
32	hide elements
33	Intersection surface (*hidden)
34	Add holePts
35	Unfold
36	Add unfoldHolePts
37	Add textStyle01
38	Variables for moving text: moveNameH,...
39	Add text02

Rotate View > Define first point

PLOTDLG unloaded.

Fig.4: Screenshot of the design interface at stage two

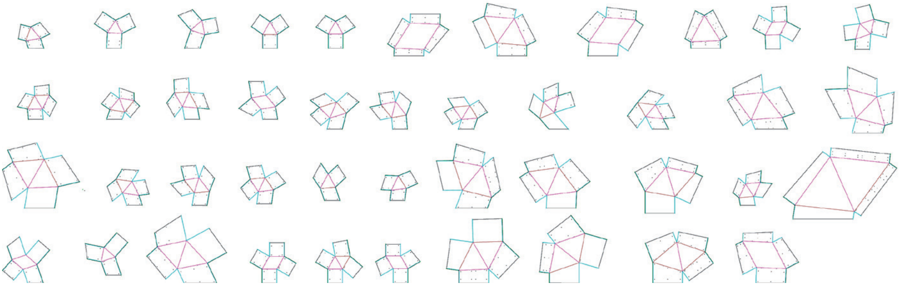


Fig.5: Pattern by custom unfold algorithm in stage three

Wherein common fractal systems draw subsequent recursion levels on top of the prior the need for physical output required substitution algorithms in order to create only one object in place. The object based design environment underlying our system allows a clear identification of every single object the therefore necessary inheritance of properties posed difficulties that had to be overcome in this step.

The *second stage* grows each cassette as a singular object with a particular size, height, off cut and slide. The combination of operations allows for a huge variety of expressions. Through a series of constraints knowledge on material, process and as well aesthetic and programmatic considerations are introduced. (Fig. 4.)

The *third stage* derives the manufacturing data from the three dimensional geometric representation. Key in this process is the design systems ability to address and extract information from each entity. This allows for instance to solve the challenge of identifying the number, type and characters of one elements neighbours in the non matrix based fractal system. A custom set of unfold algorithm creates subsequently cutting patterns that directly inform production. These algorithms inquires each elements properties in order to inform the CNC machineries 7 different steps of tools and cutting depths that are needed to cut one element. All details and numbering are included into this process facilitating the assemblage of the structure (Fig. 5.).

Interface – Controlling the system

The generative system is informed by attractors with specific properties (Minor 1985). These are combined in surfaces allowing the derivation of the different cassette properties at any position. The surface topology can be gradually adjusted allowing for falloff as well as sudden change in the dataset. The amounts of requirements given by the exhibited objects, the curators, space and program lead to a high density of conditions for every scenario. This required special attention to keep up a notion of gradient transition and a distinct expression within each scenario. Furthermore the size and complexity of the structures and its underlying interlaced functions precluded the initial realtime interaction of system and user. Yet the system is flexible enough to allow rapid redesign and control of numbers of cassettes. This was especially helpful when budget limits were reached towards the end of the project. The relevant figures could were always extracted automatically into spreadsheets.

Implementing material and fabrication knowledge

Heading for materialization we have developed our own interfaces in close cooperation with the manufacturer, engineers and through prototypes in 1:10 and 1:1 scale. The knowledge gained in this endeavours was inscribed into the open code of the algorithms within the generative system.

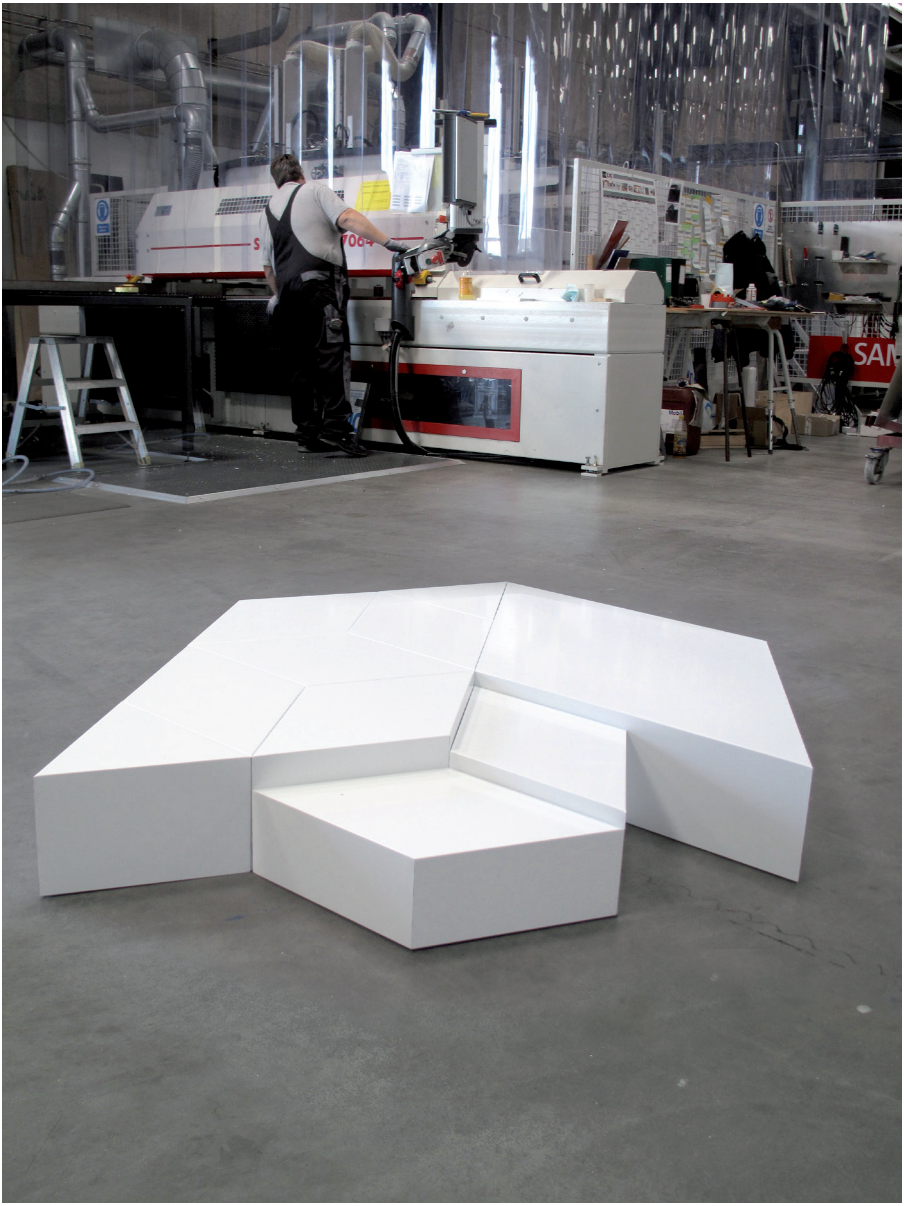


Fig.6: A test piece in the production site

As seen in other projects (Thomsen 2009) the prototypes were essential for the development, as they allowed observing the design and possible inconsistencies in the algorithms logics. Being cut on a lasercutter in cardboard already the 1:10 models used techniques close to the later building process. This allowed concluding on material and processing knowledge. As every scenario was build at least once in 1:10 scale an efficient quality management system was set in place. This allowed us to eradicate all flows in the systems underlying set of rules.

The 1:1 prototypes were produced in Dibond under real production preconditions. These allowed insights into all aspects of production, including time need and material requisites. Furthermore structural data could be deduced that helped to set up material properties for the finite element calculations done by the projects engineers. These allowed a rough estimate on the structure overall behaviours and the identification of areas that needed change in structural strength. The prototypes gave finally a sufficient indications whether the chosen assembly strategy and the output of the intense research on a joining was working well. (Fig. 6)

Manufacturing

Through the intense communication with the manufactures and the series of test runs a quality standard could be defined and handing over the fabrication data was of little problem. Yet the knowledge on assembly resided solely within the development team, as external constraints didn't allow the manufacturer to test the assembly beforehand themselves. Information of the assembly was given by a rich set of data, being a extensive numbering on every element displaying its own ID as well the accompanying neighbours ones, 2d diagrams, renderings and cardboard models- After two coached assembly sessions the production team was enabled to compose almost 400 different modules flawlessly into 12 objects. (Fig.7)

Conclusions

The project shows how a project specific design and fabrication environment can be developed. Time and effort needed are suitable for projects with a high number of elements or various application areas. Key moments within the development were the production of scaled models and full-scale prototypes fabricated under near and real production preconditions.

The project demonstrates how digital chains allow for the emergence of new collaborative practices between architectural design, engineering and fabrication. The project finds new applications for a common building material exploring detailing and structural logic as well as design expression and feel. Production and process knowledge can be encoded in the digital chain. . This allows design to test boundaries and unleash a systems design potential by activating and combining each member's specifics within the system. These might be a materials ability to flex or fold or the manifold of computational logics in design, as a generative structure.

Fig.7: It's a small world under construction

These are all around us. They appear in nature as systems that structure order and growth and emerge in the structure that govern our cities. As a design strategy generative systems are a means of managing complexity. If industrialisation brought forth a culture of mass production and systemisation, the new digital platforms allows for more complex understanding of serialisation and repeats. These are useful tools in a building practice which is becoming increasingly complex and multilayered. Developing creative strategies for design solutions that engage the specific challenges of a given site programme and environment, generative design allows real opportunities for more adaptive building practices.

Acknowledgments

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