

HYPERFORM

MARCELO COELHO

SKYLAR TIBBITS

FORMLABS



Foldable Geometry

A single block of material can be 3D printed and unfolded to reveal a large scale object.

CONCEPT DESCRIPTION

We are in the midst of a revolution that promises to forever change how we make things. At one extreme, software tools are empowering individuals to envision, create and share their own designs; while at another, low-cost digital fabrication machines are allowing these one-of-a-kind creations to be built and consumed from the comfort of our homes. However, while 3D printers are becoming increasingly accessible and capable of rivaling the quality of professional equipment, they are still inherently limited by a small print volume, placing severe constraints on the type and scale of objects we can create.

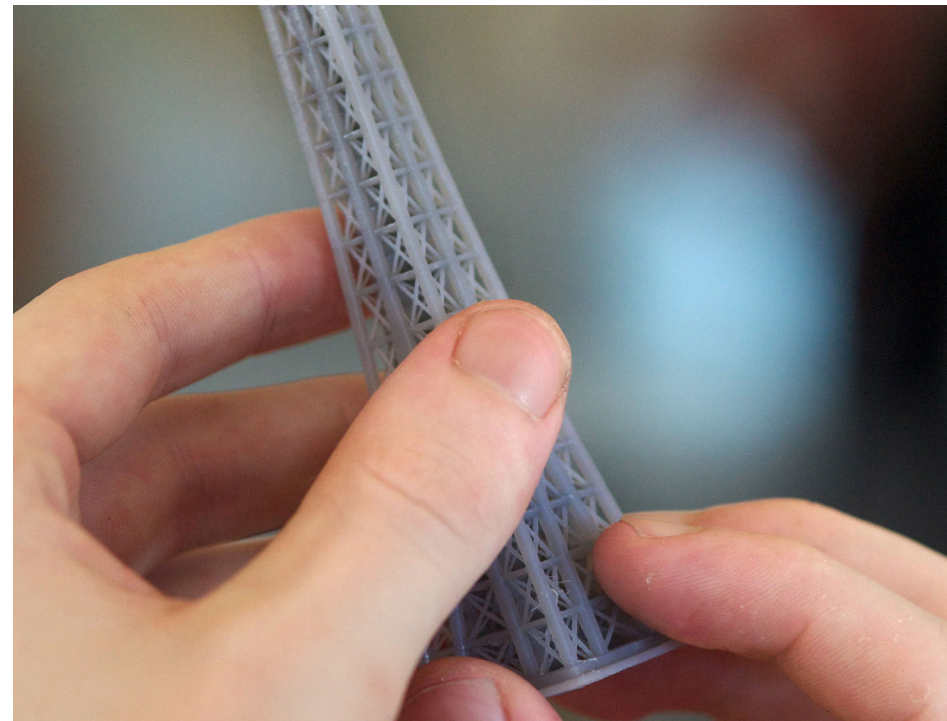
For The Next Idea, we propose to address this problem by identifying computational and material folding strategies that will allow large scale objects to be compressed into a minimal volume to maximize the printing capability of desktop 3D printers. The folding techniques we develop will be exemplified and embodied through a series of representative furniture pieces, and their fundamental principles and designs will be openly published and distributed to encourage others to learn from, use and modify our work.

Our studies and designs will be based on the print volume and material constraints imposed by Form 1, the first low-cost and accessible stereolithography (SL) 3D printer. In comparison to conventional plastic extrusion techniques (FDM), stereolithography is capable of higher resolution parts and supports a wider range of material properties. However, with a print volume of 4.9 x 4.9 x 6.5 inches (125 x 125 x 165mm), Form 1's output is limited to small objects such as jewelry or prototypes at reduced scales.

Folding as a computational design and assembly strategy can be found across natural systems, such as in the structures of proteins and DNA, and in industrial applications, which seek to increase efficiency while supporting high degrees of structural complexity, interoperability and reuse.

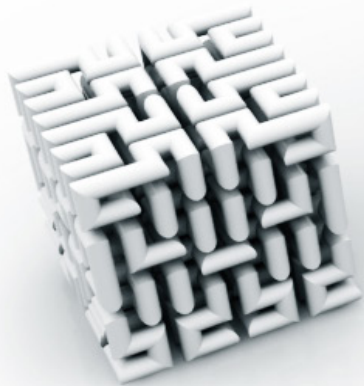
With Ars Electronica support, we plan to: identify and analyze a series of folding strategies; perform material and mechanical tests; design universal and programmable hinges that can be printed as a single piece (and be reversed for disassembly); and make a final archetypal furniture piece that can support, evaluate and communicate our work.

The full potential for 3D printing to democratize and make accessible the means of production is yet to be realized and folding geometries can play a critical role in this process. By expanding the boundaries of what can be made today, these new techniques will also unleash entirely new opportunities. Of particular importance is reversibility, which can allow for the shipping of flat materials that expand to maximum volume on-site, and self-transformation which can allow objects to kinetically respond to their environment and accommodate changing use conditions.



Eiffel Tower segment

Even for small scale models, designs need to be split into separate segments to accommodate the volumetric constraints of 3D printers.



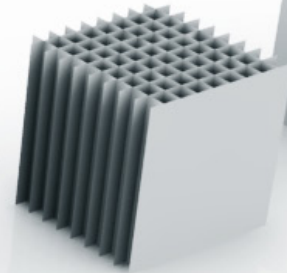
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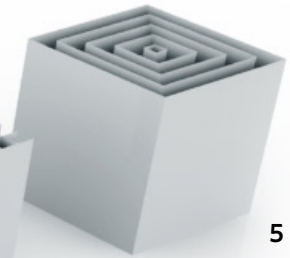
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FOLDING STRATEGIES

- 1 Hilbert cube
- 2 Yoshimoto-inspired dissections
- 3 Cross-sectioning
- 4 Press-fit
- 5 Spiral folding

PRODUCTION PLAN

We have divided our research and production plan into six phases as detailed below:

Phase 1. In this first phase, we plan to study, prototype and test a series of folding and packing strategies we have already identified, such as a Hilbert curve, cross sectioning, Yoshimoto-inspired 2D and 3D dissections, press-fitting geometries and spiral packing. These initial studies will be evaluated against the development of archetypal furniture forms, such as lamps, chairs, tables, etc.

Phase 2. During this phase, we will isolate and focus our efforts on one particular folding strategy, developing the computational tools for designing distinct forms and their transformation path so they can transition from a solid 3D printed block into a desired shape.

Phase 3. Our initial designs will be 3D printed and tested for material and mechanical integrity.

Phase 4. We will develop a universal hinge mechanism that can be: printed as a single piece, lock at computationally determined angles, be rigid enough to support the mass of the unfolded object, and be reversible for unfolding.

Phase 5. We will integrate the knowledge from previous phases into the design of a functional, foldable furniture piece.

Phase 6. This final phase is reserved for design iteration and form optimization, seeking to create a series of objects that can be showcased at Ars Electronica.

SOFTWARE

Software development and FEA analysis for our designs will take place primarily through Rhino and Solidworks. In addition, STL models will be sliced and prepared for printing through Formlabs *Form Software*.

HARDWARE

We will use Form 1 for our design studies and final furniture fabrication. We will attempt to create any necessary jigs or fixtures using the same printing techniques to avoid the requirement of any external hardware.

While the goal is to initially use the standard off-the-shelf resins developed by Form 1, we are not excluding the possibility of re-engineering a resin to match the requirements of our particular application. We don't foresee at this point the need to modify the 3D printer hardware, but this is also a possibility.

BIOGRAPHIES

Hyperform will be developed as a collaboration between Marcelo Coelho and Skylar Tibbits, with support from Natan Linder and Yoav Reches from Formlabs, and the Ars Electronica team.

MARCELO COELHO

Marcelo Coelho is a designer and Research Affiliate at the MIT Media Lab, and his work explores how materials that embody computational properties can reshape the ways in which we design, interact and communicate. During his doctoral work, Marcelo studied how shape-changing materials can be used in the design of transformable surfaces in order to computationally reconfigure their topology, texture and permeability.

SKYLAR TIBBITS

Skylar Tibbits is a trained architect and computer scientist whose research focuses on developing self-assembly and programmable material technologies for the built environment. Skylar is the director of the Self-Assembly Lab at MIT and is faculty in the Department of Architecture, teaching design studios and co-teaching How to Make (Almost) Anything, a seminar at MIT's Media Lab. The Self-Assembly Lab and Stratasys Inc. have recently developed a new technology called 4D Printing that consists of multi-material shape-changing structures that transform over time, completely on their own.

NATAN LINDER

Natan Linder is a Co-founder of Formlabs and a PhD student in the Fluid Interfaces group at the MIT Media Lab. His work fuses design and engineering to create novel human experiences. Natan's background is in Computer Science, Product Design and Entrepreneurship and before joining the MIT Media Lab, he was the Lead UI Designer at Heartland Robotics.

YOAV RECHES

Yoav Reches is a London based Industrial Designer and the designer behind Form 1. His multidisciplinary work explores the practical and conceptual applications of product design. In his previous work "Cells", Yoav explored the constraints of size and volume of the PolyJet 3-D printing technology by printing a collapsible telescopic structure that could be extended to a 9.5 meter body.