State of the Art on Stylized Fabrication

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Abstract

Digital fabrication devices are powerful tools for creating tangible reproductions of 3D digital models. Most available printing technologies aim at producing an accurate copy of a tridimensional shape. However, fabrication technologies can also be used to create a stylistic representation of a digital shape. We refer to this class of methods as stylized fabrication methods. These methods abstract geometric and physical features of a given shape to create an unconventional representation, to produce an optical illusion, or to devise a particular interaction with the fabricated model. In this course, we classify and overview this broad and emerging class of approaches and also propose possible directions for future research.

Course Rationale

A recent generation of tools takes advantage of computational techniques to create non-realistic representations of a given digital shape, with the main goal of enlivening the perception of the spectator. We call these novel directions *stylized fabrication techniques*.

The course will present the state-of-the-art of stylized fabrication techniques and will make a comparison showing the advantage and limitations of each of these lesser-used but appealing fabrication techniques. We will also provide several ideas for future research.

Main Objectives

1. Illustrate the state of the art of Stylized Fabrication techniques.
2. Classify the different methods into macro-categories.
3. Present the advantages of each technique.
4. Discuss computational and Fabrication challenges for each technique.
5. Provide Ideas for future research.

Structure

In this course, we will provide an overview of recent techniques that use digital fabrication devices to create stylistic representations of digital shapes. We subdivide the presented methods into five main categories:

Shapes These methods modify three-dimensional shapes to a simpler, more essential, representation. This strategy enables the usage of highly constrained materials and devices that are popular and inexpensive, such as paper, flat wooden lists, or iron wires. Moreover, this class of methods often does not require sophisticated fabrication devices. Due to the simpler fabrication process, these methods scale relatively well with the overall size of the reproduction.

Materials This class of methods utilizes unconventional fabrication materials (such as cloth or threads) as the means to obtain a particular effect. The mechanical properties of the materials should be taken into account in the design process to anticipate the appearance of the fabricated shape. This kind of approaches usually scales well for large-scale productions.

Light and Shadows These techniques fabricate objects with specific geometries and materials to obtain complex shadows and lighting effects. Lighting can also be exploited to allow the fabrication of simple 2.5D objects that, just by shading, seem to be much more complex representations, like a bas-relief.

Decompositions It is also possible to decompose the shape into a set of disjoint pieces to allow the user to interact and play with it. While other decomposition techniques focus on overcoming additive manufacturing volume limitations, these methods aim to create 3D puzzles in which the assembly process is part of the game. These kinds of representations may require the use of 3D printing devices, as each piece may be unique. However, due to the simplicity of their geometries, the pieces can be mass-produced using mold injection.

Printing the Unprintable The abstract domains of math and art usually requires the production of surfaces that cannot be manufactured in the real world. Hence, such abstract representations can be simplified or redesigned to make their fabrication possible, retaining the aesthetic and visual feeling for illustrative purposes.

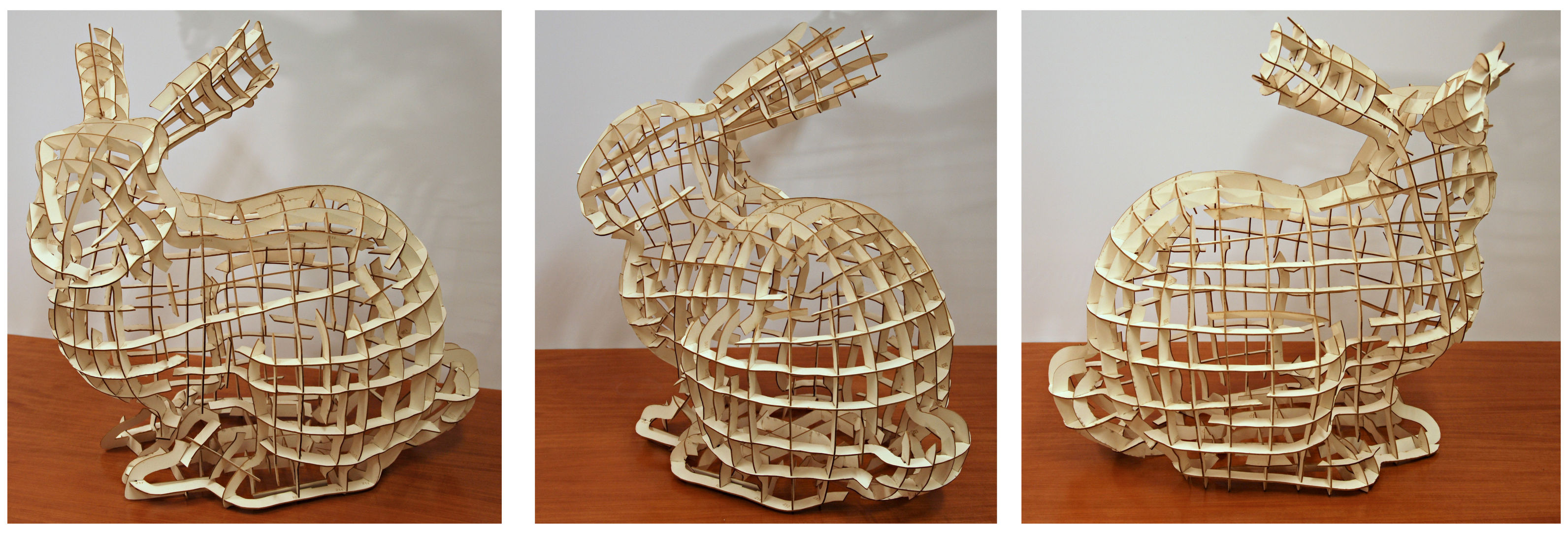

Figure 1: A stylized fabrication of the Stanford Bunny using the method proposed in [2].

Classification

Methods	● Off the Shelf / ○ Custom Tech.	● Artistic / ○ Utilitarian	● Ready-made / ○ Assembly	● Assisted Design / ○ Blind processing
Developable and Foldable Patches				
Paper replicas [MS04b, STL06, MGE07, Tac10] Curved foldings [KFC*08, KMM17] Developable Strips [AKW*16] WeaveMesh [TWZ*17], Principal Strips [TISM16] Origamic architectures [LSH*10, LLLN*14] Multi-style pop-ups [RLYL14]	●	●	○	○
Origamic architectures [MS04a], V-style pop-ups [LJGH11]	●	●	○	●
Interlocking Flat Primitives				
Rigid planar pieces [MSM11, HBA12, CSaLM13, SP13, CPMS14, RA15]	●	○	○	○
FlatFitFab [MUS14], Cardboardizer [ZGPR16]	●	○	○	●
Flexible interlocking [SCGT15]	●	●	○	●
Wires and Rods				
Wire mesh [GSFD*14], WireDraw [YZY*17]	○	●	○	●
Beadwork [IIM12]	●	○	○	●
Wrap jewerly [ILB15]	●	●	○	●
Wireprint [MIG*14]	●	○	●	○
5dof wireprint [WPGM16, HZH*16]	○	○	●	○
On-the-fly print [PWMG16]	○	○	●	●
Rod structures [MLB16]	●	○	○	○
Patterns [DLL*15, MDLW15, CZX*16]	●	●	●	○
Curve networks [ZCT16]	●	●	●	●
Tensegrity structures [GCMT14, Tac13, PTV*17]	●	● (grey)	○	● (grey)
Materials				
Garments [UKIG11], Plushie [MI07]	●	○	○	●
Pillow [MI06]	●	○	○	○
Rubber balloons [STBG12], Soft objects [Hud14]	○	○	●	○
Knitting compiler [MAN*16]	○	○	●	●
Inflatable [STK*14], Printflatables [SUS*17]	○	○	○	●
Kirchhoff-Plateau surfaces [POT17]	● (grey)	●	●	●
CurveUps [GMB17]	●	○	○	○
Low-Dimensional Representations				
Low-relief [CMS97, SRML09], Shadowpix [BBAM12]	●	●	●	○
Bas-relief [WDB*07, SBS07, KTB*09, BH11, ZZZY13, JMS14] High-relief++ [SPSH14, ASH15],Tactile paintings [RMP11, NR13]	●	●	●	● (grey)
Transparency, Caustics, and Shadow				
Light routing [PRM14]	○	○	●	○
Refraction pixel art [YIC*12]	○	●	○	○
Multilayer models [HBLM11]	●	●	○	○
Magic lens [PHN*12] Caustics [WPMR09, PJJ*11, KEN*13, YIC*14, STTP14]	○	●	●	○
Shadow art [MP09]	●	●	●	●
Lampshades [ZLW*16]	●	●	●	○
Decompositions				
Polyomino puzzles [LFL09], Interlocking puzzles [SFCO12] Lego [TSP13, KTM16, WW12, HWS*16, LYH*15] Zometool [ZLAK14, ZK14]	●	○	○	○
Burr puzzles [XLF*11], Pixel2Brick [KLC*15]	●	○	○	●
Printing the Unprintable				
Impossible objects [Elb11]	●	●	●	●
Math models [KS13, Gür15]	●	○	●	●

Figure 2: The classification of different methods

We cataloged each method described in this state-of-the-art report according to a number of orthogonal dimensions/characteristics as specified in [1].

About the authors

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References

[1] Bickel, B., Cignoni, P., Malomo, L., and Pietroni, N. State of the art on stylized fabrication. *Computer Graphics Forum 37*, 6 (2018), 325–342.

[2] Cignoni, P., Pietroni, N., Malomo, L., and Scopigno, R. Field-aligned mesh joinery. *ACM Trans. on Graphics - Presented at Siggraph Asia 2014 33*, 1 (January 2014), art.11.