Large-scale Fabrication with Interior Zometool Structure

Ming-Shiuan Chen
National Taiwan University

I-Chao Shen
National Taiwan University

Chun-Kai Hunag
National Taiwan University

Bing-Yu Chen
National Taiwan University

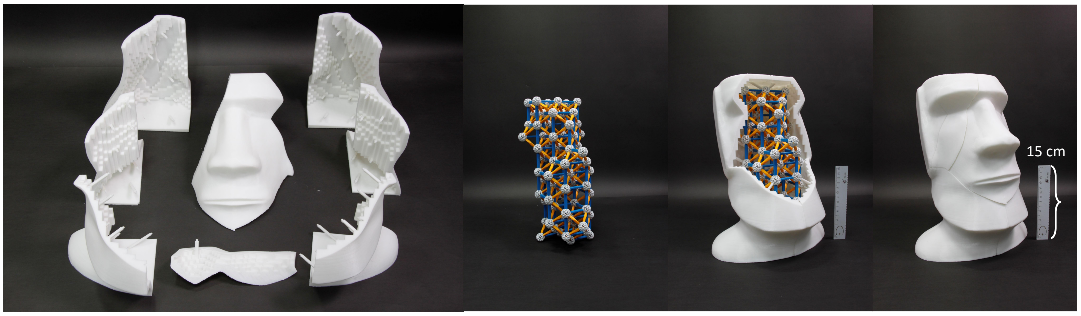

Figure 1: *Given a Moai 3D model with around 30cm height, our method build up the inner Zometool structure and partition the entire model into pieces. Our method greatly reduce the material and time used to print the model.*

CCS CONCEPTS

• **Computing methodologies → Mesh geometry models**; *Volumetric models*;

KEYWORDS

Geometric Algorithms, Fabrication

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1 INTRODUCTION

In recent years, personalized fabrication has attracted many attentions due to the widespread of consumer-level 3D printers. However, consumer 3D printers still suffer from shortcomings such as long production time and limited output size, which are undesirable factors to large-scale rapid-prototyping. We propose a hybrid 3D fabrication method that combines 3D printing and Zometool structure for both time/cost-effective fabrication of large objects. The key of our approach is to utilize compact, sturdy and re-usable internal structure (Zometool) to infill fabrications and replace both time and material-consuming 3D-printed materials. Unlike the laser-cutted shape used in [Song et al. 2016], we are able to reuse the inner structure. As a result, we can significantly reduce the cost and time by printing thin 3D external shells only.

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2 METHOD

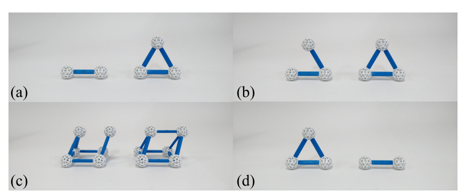
Given a 3D shape our method mainly composed of two parts, i.e. inner zometool structure construction and object partition to generate a hybrid 3D printed object.

2.1 Zometool construction

Zometool [Davis 2007] is widely used as educational toys to replicate complicated scientific structures such as chemical structures. It mainly comprises three kinds of rods, each with three different sizes, and a Zomeball. We measure the quality of the Zometool structure $\mathbf{Z}$ with an energy E which is composed of 4 terms according to different quality measurements:

$$E(\mathbf{Z}) = w_{\text{dist}} \cdot E_{\text{dist}}(\mathbf{Z}) + w_{\text{reg}} \cdot E_{\text{reg}}(\mathbf{Z}) + w_{\text{val}} \cdot E_{\text{val}}(\mathbf{Z}) + w_{\text{sim}} \cdot E_{\text{sim}}(\mathbf{Z}),$$

And we explore the structure of Zometool structure using on Simulated Annealing with Metropolis-Hastings algorithm. During the exploration, we proposed four local perturbation operations, i.e. (a) *split*, (b) *merge*, (c) *bridge* and (d) *kill*, to construct the Zometool structure by minimizing the above energy.



2.2 Object partition

As mentioned in the beginning of this paper, most of the consumer-level 3D printers have limited printing volumes. In order to print our large-scale object, it is necessary to decompose the object into different partitions. Meanwhile, unlike traditional surface partition methods that only take surface features into consideration, we also need to consider the relationship between the outer surface partitions and the inner optimized Zometool structure.

We formulate the problem as a multi-label graph cut minimization. As each triangle t can potentially correspond to different

Zometool nodes, it gets assigned data cost for different corresponding nodes. We consider three costs, i.e.data cost, smoothness cost, and user-guided saliency cost. Data cost measures how well a triangle t covers a zometool node, and smoothness term the spatial consistency of neighboring elements, and saliency cost prevents partition seams to cut through salient region. We employ graph cut algorithm to solve it.

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