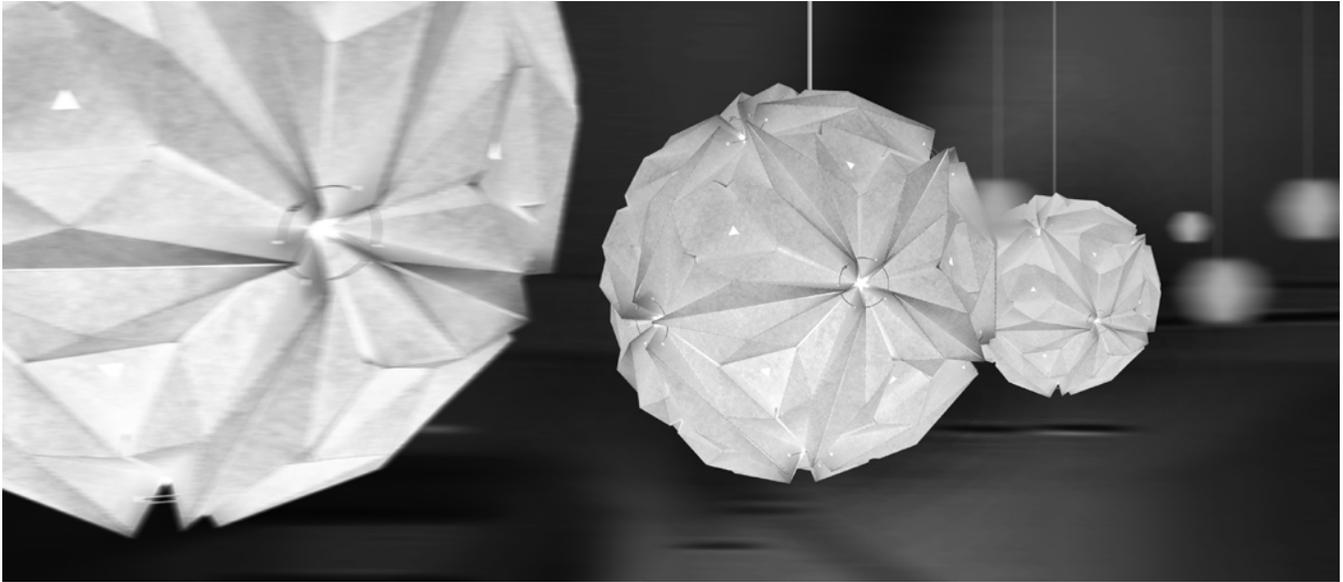


# Zushiki Light Art: Form Finding and Making through Paper Folding

Jiangmei Wu  
Indiana University



**Figure 1:** An example of *Zushiki Light Art*

## Abstract

**Keywords:** origami, digital fabrication, form finding, handmade, laser cutting

**Concepts:** •Computer Aided Design → Materiality; *Design Process*;

## 1 Introduction

There is an increasing interest in “3D Printing” and other digital fabrication technologies that allow design products to be fabricated on-demand instead of being conventionally mass-produced in the past few years. Digital fabrication reduces the gaps between the designers and the consumers by introducing new and innovative ways in which a product can be designed and distributed into the market as more fabrication tools become

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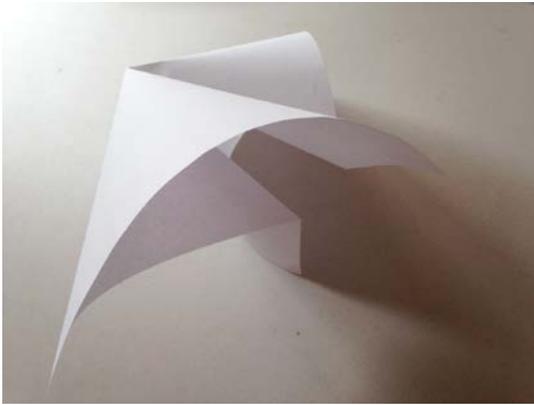
<http://dx.doi.org/10.1145/2929464.2956557>

accessible for non-designers (Atkinson, 2010).

While “3D Printing” has been heralded by some as the “Third Industrial Revolution,” paper folding, or the Japanese art of Origami, is often simply understood as a traditional hand craft. However, in this project, paper folding is understood more than a traditional craft. Here paper folding is investigated as design artifacts: how they are made, what their intrinsic properties are, and how they can contribute to the current design methodology.

## 2 Paper Folding as Form Finding and Making

Paper folding allows for complex and innovative structures formed with simple and low cost tools at the point of assembly. From simple pieces of paper, folded designs can be easily deployed into a three-dimensional volume and can be flattened to a two-dimensional shape for ease of shipping and storage. This workshop is to demonstrate practical means of using paper folding, the art of origami, in light art design in order to seek innovative ways of form finding and making. The goal is to explore alternative ways in product fabrication by navigating seamless between the tactile physical space and digital space and by blurring the lines between the designers and consumers.



**Figure 2:** Paul Jackson's *one single crease fold* (folded by the author)

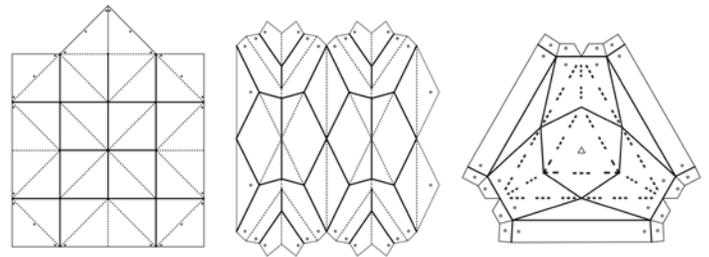
Paper may be easily cut, scored, torn, rolled, or folded. Artist Paul Jackson has experimented folding paper using only one single crease to transform a flat and passive sheet of paper into something that is structural, spatial and dynamic (Jackson, 2011). One of the early design explorations through paper folding was found in Josef Albers' preliminary design class in the Bauhaus (Wingler & Stein, 1969). When a flat piece of paper is folded, the stiffness of the paper is significantly increased. When paper is folded in certain tessellation patterns, the mechanical behavior of the paper is altered as it becomes deployable and kinetic. While paper folding is easy to make, it is very difficult to model. Paper folding is a real physics. To model the paper folding in the computer, one needs to work in a simulated physical environment. Describing paper folding scientifically to a level of generalization and representing the morphology happened when a flat sheet of paper is folded, would essentially require complex mathematical modeling.

To experiment with form generation through paper folding, the easiest method is to work with the material tactilely following a step by step procedure or algorithm: start with a flat sheet of paper, transform the paper by folding, turning, rotating, pulling, pushing, wrapping, etc, and end with a three-dimensional paper structure that can be aggregated and tested for the intended functionality. In this process, the paper's capability of morphogenesis and creating the form on its own is emphasized. The resulting three-dimensional paper structure can then be unfolded to a flat shape to reveal the geometric crease patterns consists of a set of mountain folded lines and valley folded lines. These crease patterns, or blue prints, are carefully studied according to the geometric constraints. They are then drawn in CAD programs and sent to commercially available digital cutter or laser cutter to cut and score. A new model is then folded from the digitally cut and scored blue prints for the further advancement in the rapid prototyping process. Since the final digitally fabricated product is a direct descendant of the initial handmade product using the same or similar paper material, the problems typically resulting from the changes of materiality from digital to physical spaces, are significantly mitigated.

While designers are often at the center of a conventional design process, the users and consumers can participate and produce the paper-folded products at various stages. For example, the crease patterns, or the blue prints, can be purchased directly by the consumers to cut and score directly at their own digital cutters or laser cutters at home to allow the on-demand production.

Furthermore, the consumers can even modify or design the crease pattern on their own design programs, such as Adobe Illustrator, to create their own paper folding designs in the spirit of "Do-It-Yourself."

### 3 Zushiki Light Art



**Figure 3:** Examples of crease patterns of Zushiki Light Art

Zushiki is a Japanese word for plan, scheme, pattern and design. Zushiki Light Art is inspired by modular origami in which multiple sheets of paper are used to create a larger and more complex design. These designs are not possible using single-piece origami techniques. Three unique Zushiki design, Gokakukei, Sakuru, and Sankakei, will be available for participant to make at Studio in SIGGRAPH. Predesign crease patterns will be sent to a laser cutter to be perforated and cut. These laser-cut pieces will be then hand folded connected by small plastic snap buttons and small metal rings. The number of pieces required for each light will be varied from four pieces to twelve pieces. A small battery-powered LED will be used to illuminate each folded design.

Each of Zushiki Light Art is designed using super light-weight, natural material coupled with low impact digital fabrication and making techniques, Zushiki Light Art presents a minimal carbon footprint and ecological impact. The main material is a type of tear-free Shoji paper called Hi-tec Kozo, which has a three-layer structure, with eco-friendly polyester film as core and Kozo Washi on both sides. Kozo Washi is a type of renewable material that is made from the inner bark of Kozo, a type of mulberry tree. Kozo plant grows more than three meters high in a year and can be sustainably harvested each year.

### Acknowledgements

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