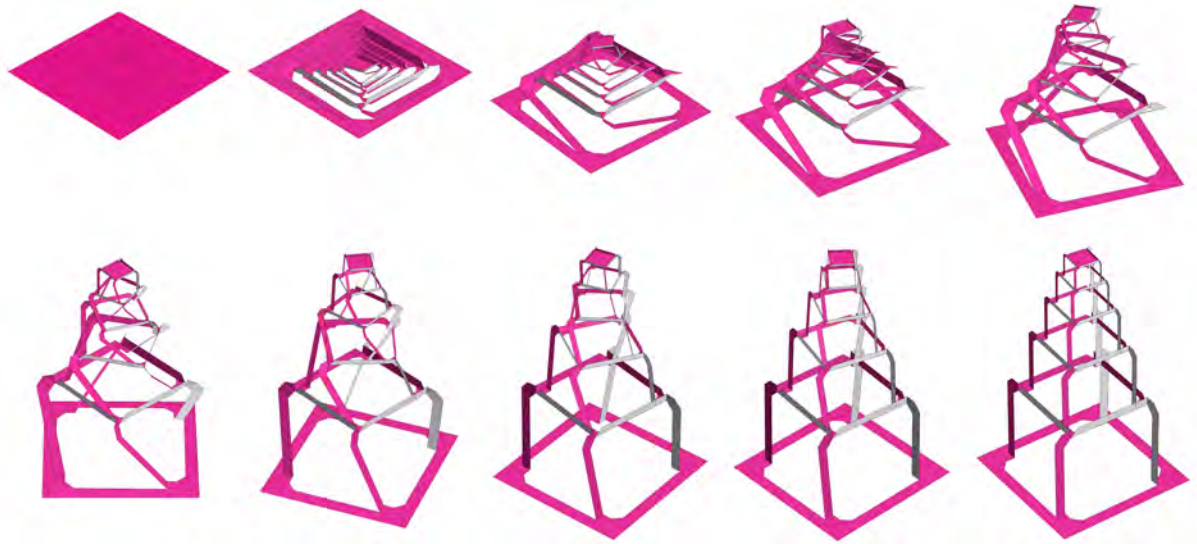


# Fast Interactive Origami Simulation using GPU Computation

*Amanda Ghassaei, Erik D. Demaine, Neil Gershenfeld*

keywords: simulation, visualization, physics



**Figure 1:** Simulation of a Miyamoto tower kirigami pattern.

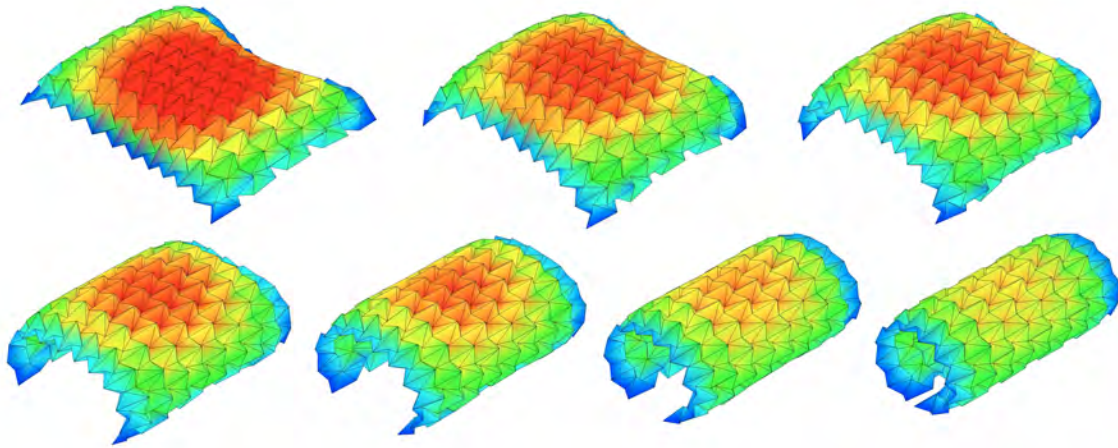
## Abstract

This paper presents a dynamic method for simulating origami that can be rapidly computed on a Graphics Processing Unit (GPU). Previous work on origami simulation methods (Tachi, 2006, 2010; Schenk and Guest, 2011) model the geometric or structural behaviors of origami with a focus on physical realism. In this paper we introduce a dynamic simulation method that emphasizes compute speed and interactivity. We do this by reformulating existing techniques for simulating origami so that they can be computed on highly parallel GPU architectures. We implement this method in an open-source, GPU-accelerated WebGL app that runs in any modern web browser.<sup>1</sup> We compare our method’s performance, stability, and scalability with existing simulation methods and demonstrate its capacity for real-time interaction through a traditional GUI and immersive virtual reality.

Our solver reframes prior methods by Schenk and Guest (2011) and Tachi (2010) into a dynamic form that is solved as a parallel process. As with prior work, we model an origami structure as a triangulated, pin-jointed truss network subject to distance and angular constraints. We solve for the folded state of the origami structure by forward integrating forces at each node of the truss network; these computations occur in parallel on a per-node basis, without a global stiffness matrix. Our solver runs continuously and updates the origami mesh dynamically, using a viscous damping term to converge on a static solution. Users may relax geometric accuracy through a tunable stiffness metric for increased compute speed (or vice versa). We make few assumptions about the topology of the folded structure, allowing our solver to simulate origami, kirigami, underconstrained patterns with undriven hinges, patterns with holes, and folded structures that cannot be constructed from a flat sheet. We use the FOLD format of Demaine et al. (2016) for input/output and as an internal data structure to maximize interoperability with other origami software; we also support SVG input/output.

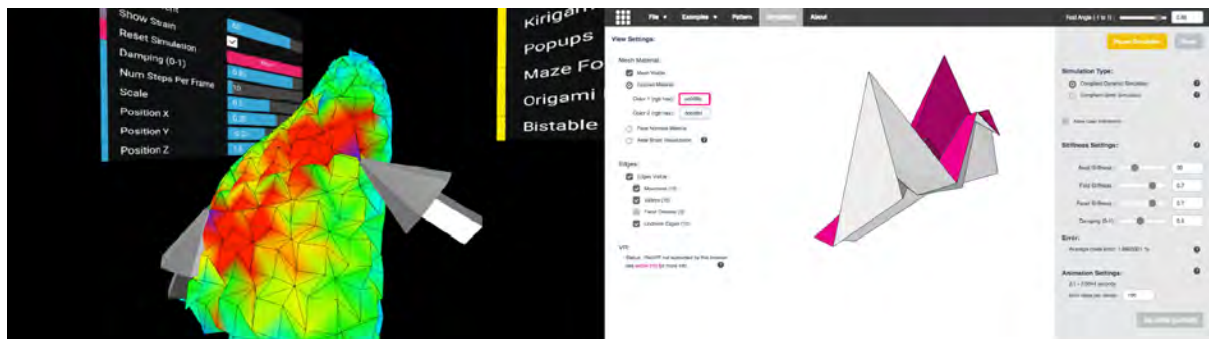
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<sup>1</sup><https://github.com/amandaghassaei/OrigamiSimulator>



**Figure 2:** Folding simulation of a waterbomb tessellation, showing areas of high strain (red) and low strain (blue). Overall material strain decreases as the origami curls.

The primary motivation for this work is to create a fast, interactive simulation environment that could aid in the design of folded structures. Physical simulations of folded origami allow designers to better understand how modifications to a crease pattern affect its folded state. Real-time simulation-based feedback can provide more intuitive ways to edit a folded pattern or to enforce desired geometric constraints, such as global developability. We introduce user interaction in our solver by modifying the boundary conditions of the simulation in real-time and graphically display localized strain information on the origami mesh. Future work will close the loop between design and simulation, allowing for interactive modifications to the folded structure.



**Figure 3:** Immersive virtual reality (left) and more traditional GUI (right) for the WebGL app. In both interfaces, users can manipulate the origami mesh and visualize material strain.

## References

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