

## 【Grant-in-Aid for Transformative Research Areas ( B )】

### Universal Origami

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Project Information		Project Number : 24B202	Project Period (FY) : 2024-2026
		Keywords : Computational Origami, STEAM collaboration, Digital Fabrication, Bio-Inspired Design, Structural Morphology	

### Purpose and Background of the Research

**Outline** We propose a paradigm shift from the mass-consumption model by creating new artifacts that adapt their form and function to meet the needs at each moment. As the key to realizing such new artifacts, we study the principle of “folding,” which is ubiquitous in nature and produces complex functions, such as the folding of DNA and proteins, insect wings, brain wrinkles, and plant leaves and flowers. The traditional Japanese art of origami is at the core of this folding principle.

“Universal Origami” will feature origami as a catalyst to integrate the STEAM fields of “Science” of origami ubiquitous in nature, “Math” that describes principles, “Art” that conceives the ideas, “Engineering” that guarantees manufacturing and multifunctionality, and “Technology” that integrates the information and materials. We will transform the academic framework of artifact design.

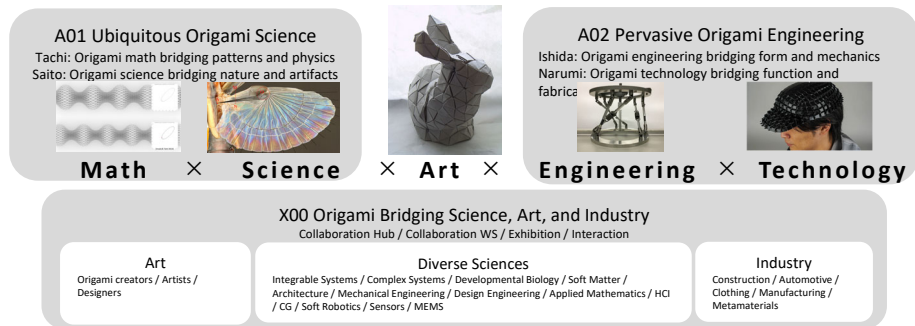


Fig.1 Project Overview

**Background** Origami has attracted scientific and engineering attention since the 1960s, with engineering applications in space, beverage cans, and medical stents for compact, lightweight, and strong structures that can be folded and deployed. Since the late 2000s, advances in “computational origami” have revealed origami’s dynamic and complex behavior (shape, dynamic deformation, and mechanical performance). It is now a hot international research field.

However, origami engineering today is limited to a single function and does not provide a holistic design theory for the diverse and complex requirements of the industries of the future society. Tracing back to this cause, the principles that explain why origami works and behaves in a specific way are still missing.

To overcome these limitations, we considered origami a system integrating complex functionalities such as design, manufacturing, materials, mechanical performance, fluid, heat, and light, just like a living organism. Integrating the STEAM areas and creating a framework beyond the existing academic disciplines is necessary to solve such complex problems.

**Objective** This research aims to create new artifacts that can freely change form and function by making it possible to explain why origami works and to design origami to meet complex requirements. We aim to organically connect various fields across STEAM through the traditional art of origami, to open up fusion fields using origami, and to revolutionize the academic framework.

1. In A01, "Ubiquitous Origami Science," the essential uniqueness of origami will be explained in terms of universal descriptions common to mathematics, nature, and artifacts. (PI: Tachi, PI: Saito)
2. In A02, "Universal Origami Engineering," the unique behaviors of origami can be designed and manufactured in various domains beyond scale, static and dynamic properties, heat, fluid, sound, materials, etc. (PI: Ishida, PI: Narumi)
3. X00 "Origami Bridging Science, Art, and Industry" will foster a venue for collaboration involving a wide range of science, art, and industry, engage experts from diverse fields, and discover and recruit human resources who bring new perspectives to this field.

### Expected Research Achievements

We create a framework in which science, art, and industry collaborate through origami. In the future, origami will realize “soft” artifacts tailored to each individual and each moment, thereby contributing to an inclusive and sustainable society. We will present the core vision during the three years and invite others to join us in this initiative.

**Ubiquitous Origami Science** delves into origami’s functionality and behavior from a systemic perspective. Our aim is to elucidate the self-organizing processes that nature excels in origami. As we move forward, we plan to incorporate insights from integrable systems, group theory, developmental biology, biomechanics, and soft-matter physics into the core of our project, creating a comprehensive system of origami science. We welcome and value our collaborators’ diverse perspectives and contributions in this endeavor.

**Pervasive Origami Engineering** paves the way for designing origami with multiphysics and multifunctional properties and develop self-folding technology that enable manufacturing in different scales. Prospective applications include transformers that can be programmed to take on various shapes and functions simply by printing creases on a flat surface and to return to a flat surface after use to perform different functions again. The origami culture is rich, with many artists possessing the seeds of new discovery and innovation, yet it has yet to be linked to science and industry.

**Origami Bridging Science, Art, and Industry** will promote STEAM collaboration with these artists and industries. The project will impact society by promoting art, science, and industry driven by Japan’s art and culture.

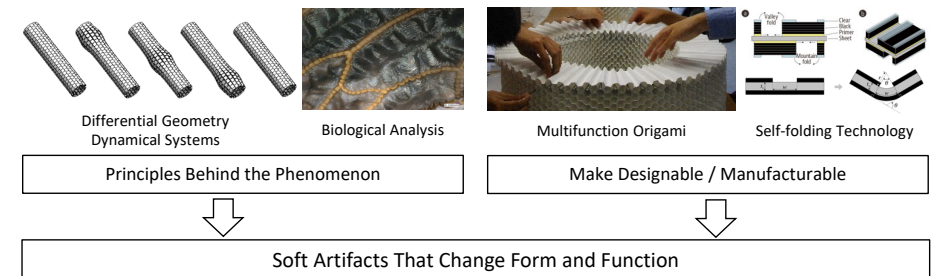


Fig.2 Research Approach

Homepage Address, etc.

Website of the Area “Universal Origami”  
<https://universal.origami.c.u-tokyo.ac.jp>