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The Multifaceted Applications of Origami

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Abstract: Origami, a traditional Japanese art of paper folding, has evolved from art to the area of study with broad applications across various fields. The paper comprises the applications of origami in engineering, medicine and design. Applications like miura-ori foldings for telescopes , origami-inspired designs for stents and solutions for solar cell efficiency have helped various fields excel in their new findings. With growing popularity, come challenges which is what this paper deals with- Applications and challenges.

I. INTRODUCTION

The term "origami" refers to the ancient art of paper folding. It originates from the Japanese words *oru*, meaning "fold," and *kami*, meaning "paper." In the course of its long tradition, it has been known by a variety of names, including *orisue* and *orikata*.[2] Since the invention of papermaking by Cai Lun in the Han Dynasty, China, origami has been developing and changing, and is still one of the indispensable cultural and artistic forms today. Origami was originally used in religious activities; it can be seen in Japanese sacrifices and Chinese Buddhist tributes. With the improvement of papermaking technology, origami technology gradually flowed amongst the people and was applied in daily life.[3]

However, the applications of origami are transitioning in this modern era. The integration of origami with mathematical concepts such as geometry and topology has paved the way for its application.[2] The study of three-dimensional structure now plays an important role in fields like engineering, medicine and the design industry. The review will address the real life applications of origami of its diverse applications and some of the challenges.

II. ORIGAMI TECHNIQUES

In origami, ‘mountain fold’ and ‘valley fold’ are the two most basic folding methods [8]. When folding, the paper is folded horizontally, and folded upwards or downwards to form an origami structure, forming ‘mountain fold’ and ‘valley fold’. ‘Mountain fold’ and ‘valley fold’ have become decorative representations of origami structure. Although their structure is simple and basic, they still occupy a place in art and design as representative decorative elements with geometric aesthetics, special light and shadow effects and unique language of form. [8]

III. APPLICATIONS OF ORIGAMI

A. *Origami in Engineering (Structure)*

Origami demonstrates the art of geometrical transformation. It presents a system in which one can create an artificial transformation between target geometries through folding. [2] Miniature models of bridges and stadiums are made out of origami. Japanese high-speed trains' pipes were made using origami techniques. To absorb the excess pressure, in-pipe supports were employed, lowering the chance of an accident.[5] There is a wide range of application of origami in engineering because-

1) Deployability: Deployability is a desirable characteristic in the design of space structures. Folded compact systems can be efficiently stored within the limited dimensions of launch vehicles and then deployed into their final desired shape once in orbit.[2]
2) Scalability: Due to their inherent geometrical properties, origami-based designs can be scaled from the micro to the meter scale. This property remarkably improves the range of applications for origami-based designs, making the implementation of their characteristics generally scale-independent. [2]
3) Self-actuation is the capability of origami-based designs to deploy themselves without external actuators. This property can be applied in the design of origami-based kinetic façades in the architecture industry.[2]
4) Tunability is the capability of origami-based designs to be tailored for a specific task by changing their geometrical properties. This feature is relevant for any application and optimization process, and is particularly interesting for the design of metamaterials and fold-core structures.[2]
5) Easiness in manufacturing: One advantage of origami-based designs is that they can be manufactured in 2D and then assembled into their final 3D configurations. This feature can substantially speed up fabrication processes, simplify production, storage, and material usage compared to conventional designs.[2]

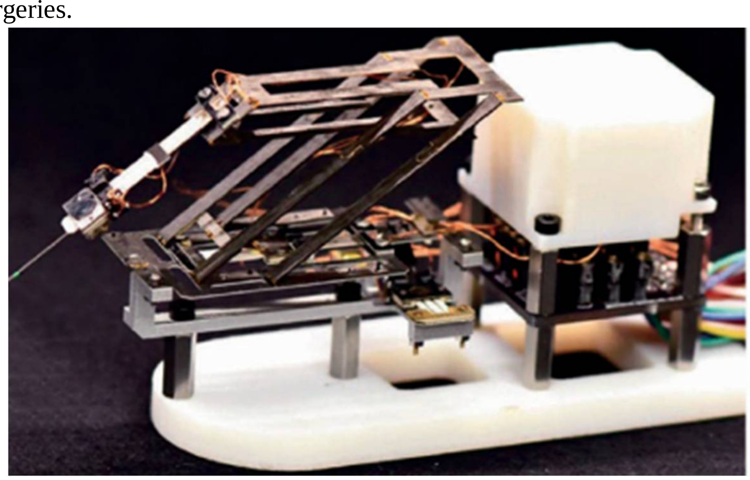
B. Origami in Bioengineering

The biomedical industry is likely one of the most advanced fields in the research and application of origami-based devices. Origami-based structures can be scaled and optimized according to specific design constraints, making them easily manufacturable and reconfigurable for innovative, flexible solutions. Origami-based designs have also been implemented for the development of novel surgical tools.[2] There are several inventions for origami in Bioengineering. Some of them are mentioned below:

Banerjee and co-workers proposed an origami-based deployable surgical retractor with the aim of improving the interaction between instruments and tissues in face-lift operations. (fig [2])

fig[2]

Suzuki and Wood extended the application of origami-based designs to smaller scales by proposing a millimeter-scale system for robot-assisted retinal microsurgeries.



fig[2]

Pesenti and co-workers presented an origami-based adaptive shading system capable of passively controlling indoor visual and thermal comfort.

fig[2]

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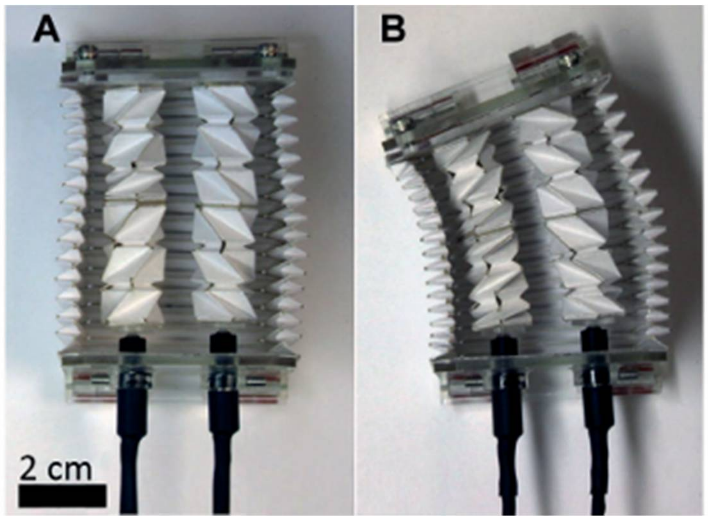
C. Origami in Robotics

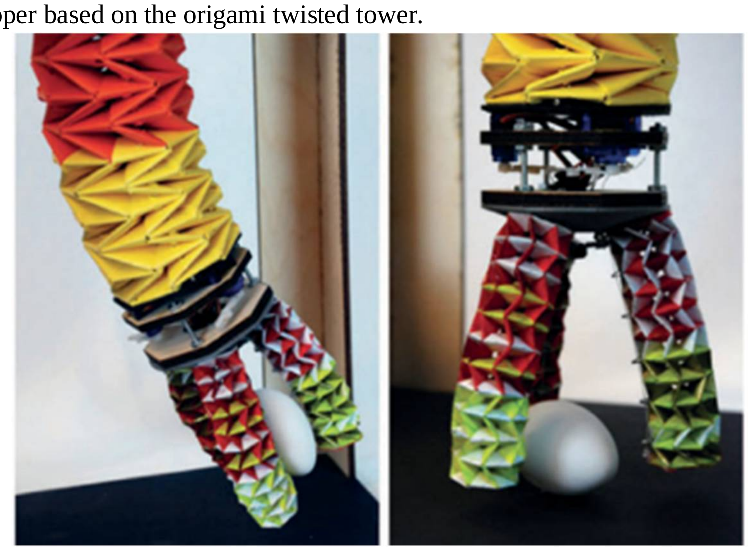
Folded microrobots, manufactured using lamination-based processes, were early precursors of origami robots. Fabricated in-plane and then assembled by folding, these robots are applicable to a wide range of typologies. Moving from a starting 2D to a final 3D configuration, they provide a simplified and efficient design process while ensuring fast reconfiguration and prototyping. [2] Some inventions for robotics in origami are mentioned below:

Pagano and co-workers proposed an origami-based crawling robot, fabricated by folding sheets of paper according to the Kresling pattern.



fig[2]

Jeong and Lee presented a gripper based on the origami twisted tower.



fig[2]

D. Origami in Design

Interaction design is a method that reflects the interaction mechanisms of any product or service. By considering human behavior, user experience, and psychological and other relevant factors, it aims to design and improve user satisfaction with products. Whenever a person uses a product, they interact with it in some way, and interaction design focuses on optimizing how people engage with it. [9]

1) *Direct Application:* Origami structures have a rich element of points, lines and faces, which can be directly used in interactive product design.[1] For example, Japanese fashion designer Issey Miyake designed a series of lamps for the Italian lighting manufacturer Artemide, called IN-EI.(fig 1)

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fig[1]

2) *Material Application:* Different materials can supplement the origami structures, bring completely different functions, and broaden its use scenarios and modes. Functional materials can be used to create unique interactions with origami structure.[1] For example, in the origami luminaire designed by Yael Akirav in the picture below:

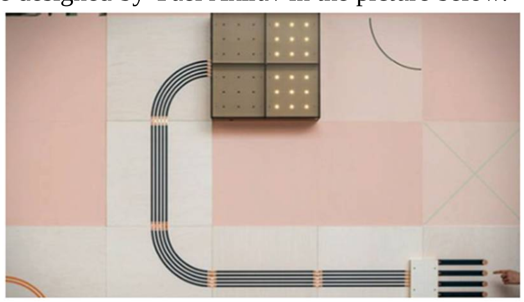


fig [1]

3) *Structural Application:* The structural changes in the origami structure itself allow for different forms of the product to be realized, thus producing different functions. Materials can bring more functional changes to interactive products. Such as a combination of an origami structure and a conductive ink.

E. Origami in Clothing

Origami in clothing design represents a fascinating intersection between traditional Japanese art and modern fashion. This technique involves intricate folding patterns to create three-dimensional textures and shapes in fabric, offering a unique visual and structural element to garments. Designers utilize origami-inspired methods to craft pieces that are both artistic and innovative, often resulting in striking geometric forms and sculptural silhouettes that challenge conventional approaches to fashion design.

The integration of origami into clothing not only adds aesthetic appeal but also explores new possibilities in sustainable fashion. By carefully manipulating fabric through folding, designers can minimize waste and maximize material usage, making origami a potentially eco-friendly design approach. However, the application of these techniques in practical, everyday wear remains an area for further exploration, as maintaining the structure and durability of these complex designs poses challenges, especially with different fabric types.[3]

Some general applications of origami includes:

1) Origami is used in mathematical concepts for the students as well as teachers.
2) Origami is used in manufacturing eco-friendly products
3) Origami is used in orbit technology to send origami-style aircraft into space
4) Origami is used for problem solving and behavioral skills.

Origami is good as it develops:[5]
1) Eye-hand coordination
2) Sequencing skills
3) Mathematical reasoning
4) Spatial skills
5) Memory, as well as patience and attention skills
6) Motor skills
7) Mental concentration

IV. CONCLUSION

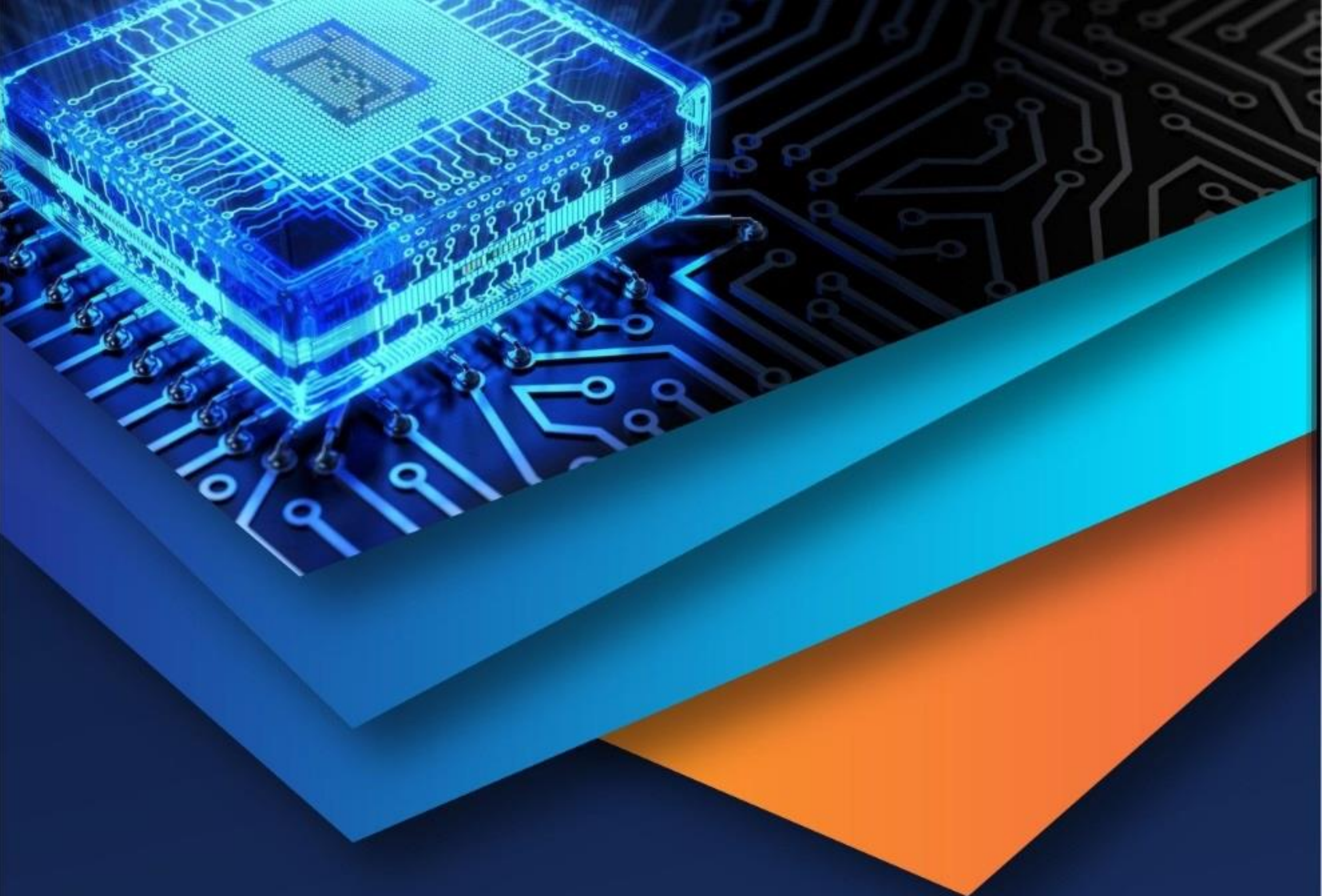
This paper explains how origami's geometric principles and structures are used in various fields. It starts by elaborating origami's history from a traditional art form to a modern useful tool in various fields such as ; engineering, education, robotics, and fashion design. This background helps explain why origami is one of the useful things in today's date. The paper then looks at how origami's multifunctional and unique structures can solve problems in various fields. Additionally, the paper explores future possibilities by combining origami with new technologies and materials. This could lead to more functional, durable, and visually appealing origami structures. These advancements could make origami even more useful in interactive design, creating products that are both beautiful and practical.In summary, while origami is already widely used in modern design and science, there are certain challenges for further innovation. Future developments in science and technology could open new opportunities for origami in interactive product design. This paper encourages ongoing research and development to explore origami's full potential as a versatile tool.

A. *Challenges*

1) Limited paper constrained us from exploring numerous applications of origami.
2) Limited time constrained us from vivid explanation of applications of origami.
3) Complexity of origami constrained us from learning applications of origami in depth.

REFERENCES

[1] https://www.researchgate.net/publication/368975348_Research_on_the_Application_of_Origami_Structures_in_Interactive_Product_Design
[2] Meloni, M., Cai, J., Zhang, Q., Lee, D. S., Li, M., Ma, R., Parashkevov, T. E., & Feng, J. (2021). Engineering Origami: a comprehensive review of recent applications, design methods, and tools. Advanced Science, 8(13). https://doi.org/10.1002/advs.202000636
[3] Dilberoglu, U. M., Gharehpapagh, B., Yaman, U., & Dolen, M. (2017). The role of additive manufacturing in the era of industry 4.0. Procedia Manufacturing, 11, 545–554. https://doi.org/10.1016/j.promfg.2017.07.148
[4] Meyer, D., & Meyer, J. (n.d.). BRIDGES Mathematical Connections in Art, Music, and Science: Teaching Mathematical Thinking through Origami. In Department of Education, Cornell University. https://archive.bridgesmathart.org/1999/bridges1999-191.pdf
[5] Yinka, R. (2022). Origami in the science classroom environment and students' performance in senior Secondary School in Rivers State. www.academia.edu. https://www.academia.edu/82738936/Origami_in_the_science_classroom_environment_and_students_performance_in_senior_Secondary_School_in_Rivers_State?uc-sb-sw=23480636
[6] Song, Z., Jiang, H., Dai, L., Yu, H., & He, X. (2016). Studies of Origami and Kirigami and Their Applications. In A Dissertation Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy. https://core.ac.uk/download/pdf/79584215.pdf
[7] Wang, C., Yang, C., Li, J., & Zhu, M. (2022). Research on the Creative Application of Origami Performance Techniques in Clothing. Fibres and Textiles in Eastern Europe, 30(4), 43–53. https://doi.org/10.2478/ftee-2022-0035
[8] P. O. Vaccaro, K. Kubota, T. Fleischmann, S. Saravanan, and T. Aida, 'Valley-fold and mountain-fold in the micro-origami technique', Microelectronics Journal, vol. 34, no. 5, pp. 447–449, May 2003, doi: https://doi.org/10.1016/S0026-2692(03)00070-3.
[9] X. Xia and A. R. Ismail, 'Review on the Application of Interactive Design in the Design of Modern Furniture Products', in Financial Technology (FinTech), Entrepreneurship, and Business Development, Cham, 2022, pp. 189–201. doi: https://doi.org/10.1007/978-3-031 08087-6_14.



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