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題目(和文)	伸展可能な折り紙の部材の干渉と変形を考慮した運動特性解析と伸展機構への応用
Title(English)	Kineto-elasto-static characterization of a deployable origami and its application to extendable mechanisms
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	松尾　博史		

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Soft-deployable origami structure is one of the types of deployable origami structure and can generate a multiple degree-of-freedom (DOF) motion with the deformation of components. It is expected to be applied to extendable devices, but its kinematic and mechanical characteristics have not been sufficiently revealed. A soft-deployable origami structure: Origami Spring is selected as the subject in this research, which can be modelled as a three DOF mechanism but performs like a single DOF mechanism. The objective of this research is to reveal the kineto-elasto-static characteristics of Origami Spring by modelling it with rigid and compliant components and revolute joints to consider the collision and deformation of components, which enables its design for extendable applications. Based on the revealed characteristics, to propose design strategies of extendable mechanisms inspired by a deployable origami beyond the characteristics of the original origami through the design of extendable mechanisms for two applications and their experimental studies is also the objective of this research. This thesis consists of 6 chapters.

In chapter 1 “Introduction”, the background and related researches of this research, the objective and contribution of this thesis, and thesis overview were introduced.

In chapter 2 “Origami Spring”, the basic definition and features of Origami Spring were introduced. Origami Spring consists of the right-angled triangles. The side of right-angled triangles which must deform due to the collision between other sides was identified, and the models of Origami Spring were fabricated by replacing the sides with rigid materials except the identified side. The extension motions of the fabricated models were compared with that of a paper model, and the validity of the structure was shown. In addition, the modifications of the folding diagram were introduced and their effects on the motion and shape were discussed.

In chapter 3 “Characterization with Consideration to Collision and Deformation of Components”, the three DOF spatial mechanism was proposed as the kinematic model of Origami Spring, consisting of the rigid and compliant components and revolute joints, based on the models which were fabricated in chapter 2. The configuration space of the mechanism

was derived with consideration to the collision between each rigid component, and the following were theoretically revealed; the thickness of components affects the range of extension motion, and the shape of Origami Spring is bending along the extension. In addition, the effect of the deformation of compliant components, which is caused by the collision between each compliant component, was evaluated by the strain energy of compliant components. It was revealed that the observed single DOF motion of Origami Spring can be explained by the magnitude and distribution of the strain energy with the deformation of components.

In chapter 4 “Application to an Extendable Arm for Working in a Narrow Space”, assuming an application to an extendable arm for working in a narrow space, the multiple DOF extendable mechanism was designed inspired by Origami Spring, which has a large extension ratio and a sufficient load capacity and can generate various configurations, including a large curvature configuration. Based on the result in the chapter 3, the extendable mechanism was modified to remove the deformation of components, reduce the collision between each component, and enable the mechanism to generate a large curvature configuration. The actuated prototype of the extendable arm with five DOF was fabricated, and the motion experiments showed that the extendable arm can generate a desired configuration. In addition, the tapered extendable arm was fabricated based on the modification of the folding diagram which was introduced in the chapter 2, and its positional stability and static performance were revealed by the experiments and the theoretical analysis.

In chapter 5 “Application to an Assistive Device for Fall Prevention”, assuming an application to an assistive device for older people to prevent a fracture by a fall, the actuation strategy of the extendable mechanism inspired by Origami Spring to achieve rapid extension and high load capacity in one mechanism was proposed focusing on the difference of the velocity ratio of output to input depending on where the mechanism is actuated. Based on the strategy, the prototype was fabricated where the pneumatic actuators for rapid extension and the lock elements to fix the extended configuration were installed. Through the experimental studies with this prototype, the desired rapid extension was achieved and the impact load characteristic assuming fall prevention was revealed.

In chapter 6 “Conclusions and Future Work”, the conclusions of this thesis, the outlook for the future, and the obtained and remaining problems were discussed.