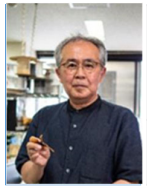
【Grant-in-Aid for Scientific Research (S)】

Deep Biomimetic Robotics



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Project Information	Project Number : 23H05445 Project Period (FY) : 2023-2025 Keywords : Biomechanics, Biomimetics, Robotics, Soft robotics, Zoology

Purpose and Background of the Research

●Outline of the Research

Biomimicry is a major driving force behind robot research. Many studies and robot developments have been conducted so far, but robotics is still unable to move away from mechanical movements and functions. The main reason for this is that conventional robotics has replaced living creatures' bodies with a collection of simple mechanical parts that mimic their external movements.

In this study, the body of the robot is regarded as a continuum in which various flexible tissues adhere to each other, and the tissues inside the body are imitated (deep imitation). We have already discovered that the imitation of the internal structure of the body, which is not visible from the outside, produces functions unexpected by designers and phenomena that are difficult to understand in conventional engineering and zoology through the anatomy and reconstruction of dog and horse legs.

Through the collaboration between soft robotics and zoology, we will unravel the dynamics and motion of flexible tissues inside the animal body and clarify the design theory of ambiguous flexible tissue, which is the opposite of conventional robotics aiming at accuracy and rigidity and will open a new field of robotics.

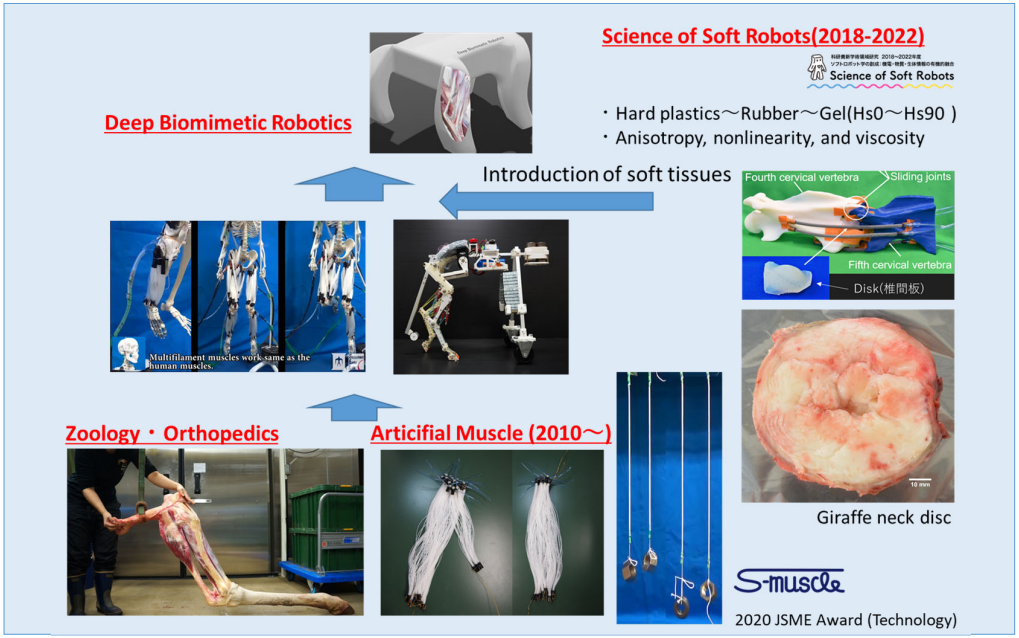

Figure 1. Image of the Whole Project

Expected Research Achievements

In this research, we will clarify the characteristics of the flexible tissues and movement mechanisms inside the bodies of living creatures, mainly dogs and horses, and based on these results, we will perform deep biomimetics of the forelegs, hind legs, and trunk (mainly around the spine). By conducting experiments and observations using these models, we aim to (1) elucidate the kinetic mechanisms and develop intelligent motions based on the flexible and ambiguous characteristics of the body, and (2) discover many new findings that overturn the conventional theories in robotics, zoology, and orthopedics.

Figure 2 shows the general flow of this study. The numbers in the text correspond to those in the figure.

(1) Dissection of donated bodies: Robot researchers and animal researchers will jointly dissect the legs and trunks of the donated bodies. Specifically, we focus on the adhesion between muscles and skeletons and their surrounding flexible tissues (fascia and adipose tissue), the boundaries and the distribution of mechanical tensor characteristics of flexible tissues, and mapping of mechanical parameters of tissue arrangement and distributed tissue is performed.

(2) Elucidation of deformation and dynamics of flexible tissue in living animals: We will clarify how the surrounding flexible tissue is deformed in the body and how the muscles move accordingly when the legs and trunk of dogs and horses move. We will move live dogs and horses and observe the behavior of flexible tissues using X-ray equipment, CT, and MRI. We will also use motion capture and force plates to clarify the dynamics and morphology of flexible tissues.

(3) Creation of various parts for deep biomimetic robots: Based on the results of (1) and (2), we will imitate the legs and trunk using two technologies that we already have: "flexible materials and their forming" and "artificial muscles". As a result of the research project “Science of Soft Robots.“

(4) Evaluation: We will perform evaluation experiments using the prototype deep biomimetic robot parts. This will include: (i) comparison with actual animal motion/deformation behavior in surface/deep layers; (ii) confirmation and elucidation of the phenomena that contradict the conventional understanding of zoology and robotics. ("reverse muscle action phenomenon", "leg movement by flexible tissue coupling", etc.).

Figure 3 shows an image of a deep biomimetic robot that integrates these elements.

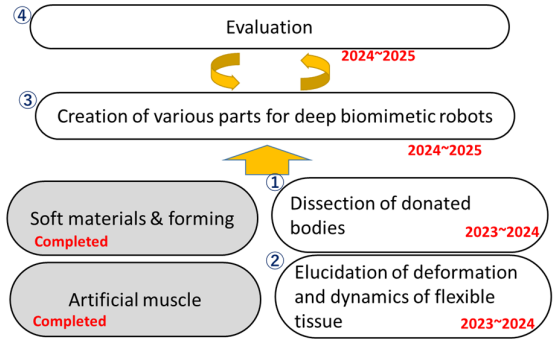

Figure 2. Research plan

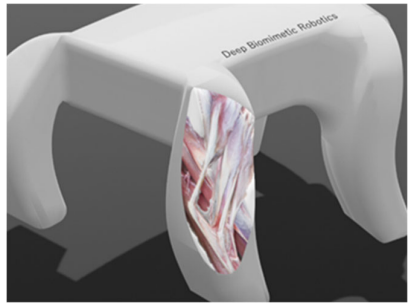

Figure 3. Image of Deep Biomimetic Robot

Homepage Address, etc.	https://deepbiomimetics.wixsite.com/