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論　　文　　題　　目	TASK-DRIVEN SOFT ROBOT INTERACTION THROUGH WHOLE-BODY COMPLIANCE AND TACTILE SENSING
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論文の内容の要旨

Soft robots are suitable and effective for operation in confined and sensitive environments thanks to their compliance. They can bend and conform to their surroundings, offering an inherent level of safety and adaptability. However, these properties create major challenges: how can such robots move purposefully when their bodies continuously deform, and how can they sense the surroundings when their compliant structure has no fixed shape to embed conventional sensors?

This thesis explores these questions through the lens of robot–environment interaction. The work begins with a soft, self-propelled eel-like robot designed to inspect confined spaces by using its own compliant body to move within tubes without damaging itself and the surroundings. The thesis then introduces a new form of continuum robot that doubles as a tactile sensor. This section introduces a new method for tactile sensing based on vision feedback to understand both the robot's deformation and contacts from the environment. Finally, inspired by the elephant trunk, a soft gripper is developed that achieves both safe manipulation and rich tactile perception over its entire surface, enabling it to grasp, explore, and be applied to a wide range of tasks.

Across these three lines of work, the thesis demonstrates that combining whole-body compliance with vision-based tactile sensing can unlock safe and meaningful interactions with

complex environments. The results provide not only concrete robotic systems but also conceptual foundations for future soft robots that are at once compliant, perceptive, and ready for deployment in practical scenarios.

Keywords: soft robotics, tactile sensing, inspection robot, continuum robot, soft gripper.

論文審査の結果の要旨

Soft robots are well suited for operation in confined and sensitive environments due to their compliance, which enables safe adaptation to complex surroundings. However, continuous deformation poses fundamental challenges for locomotion and sensing, as conventional control and embedded sensing approaches rely on fixed structures.

This thesis addresses these challenges by studying robot–environment interaction in soft robotic systems. First, it presents a self-propelled, eel-like soft robot that exploits body compliance to navigate and inspect confined tubular spaces safely. Next, it introduces a continuum robot that functions simultaneously as an actuator and a tactile sensor, using vision-based feedback to infer both body deformation and environmental contact. Finally, inspired by the elephant trunk, a soft gripper is developed that combines safe manipulation with distributed tactile perception across its entire surface.

Together, these works demonstrate that integrating whole-body compliance with vision-based tactile sensing enables robust, safe, and informative interaction with complex environments. The thesis contributes both functional robotic systems and general design principles for deployable soft robots that are compliant, perceptive, and adaptable.

The student prepared papers and the thesis and presented the work in English without difficulty; accordingly, the dissertation merits the award of the doctoral degree.