VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Zhanwei Wang**

The public defense will take place on **Thursday 10th October 2024 at 4:00 pm** in room **D.2.01** (Building D, VUB Main Campus)

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ENCODING PHYSICAL INTELLIGENCE INTO SOFT ROBOTICS VIA SMART MATERIALS AND CONTINUUM MECHANICS

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Abstract of the PhD research

Soft robots, made from flexible materials like elastomers, can mimic the organism behaviors, but their actuation and control are challenging due to their flexible nature and numerous deformation possibilities. The research suggests embedding intelligence (including actuation, sensing, control, etc.) directly into robotic materials and structures to address this issue, allowing them to react to stimuli autonomously. This way encoding intelligence into an agent entity is named physical intelligence.

At the material level, the thesis uses smart materials that respond to stimuli. Specifically, elastic polymers with self-healing properties in diverse hardness were used to create soft robot components. These materials enable soft robots to self-repair if no vital damage (such as loss of material or inability to recover their original shape), as well as directional stiffness by multi-material fabrication with strong self-healing interfaces. Another advancement is variable stiffness materials, which can change the stiffness of robot skin, improving the sensing force range.

On the structural level, three innovative designs are presented. One involves a self-closing suction cup that conserves energy and maintains grip strength for vacuum grippers. Another proposes origami-inspired actuators for high flexibility, allowing reconfiguration, and can be integrated with self-closing suction cups to form an octopus-like tentacle gripper. The third design incorporates reflex mechanisms, enabling the soft robotic gripper to multiple action modes, and respond to specific object geometric features. Together, these developments aim to make soft robots more adaptive, responsive, and versatile in interacting with their surroundings.