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Cyber Valley

Integrative Tactile Skin Using Computation

Combining Sensory Design and Machine Learning

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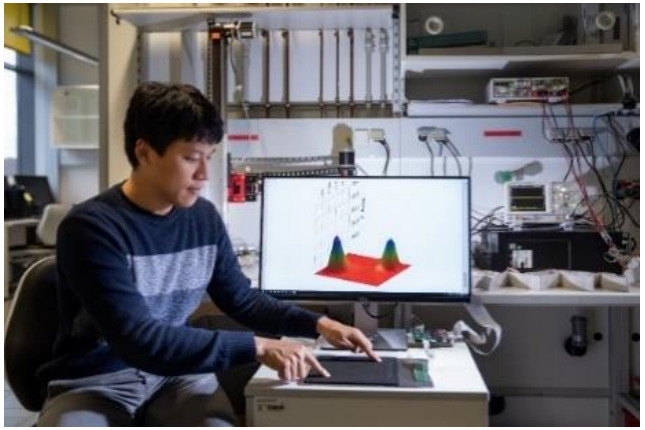
Who Am I



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Keywords for interests: Robotics, Tactile Sensing and Perception, Physical Human-Robot Interaction

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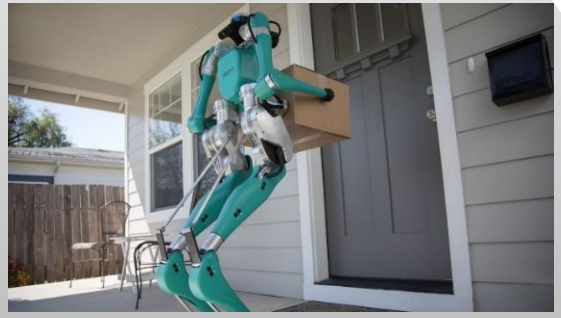
Importance of Tactile Skin

Human-Robot Collaboration

Physical Human-Robot Interaction

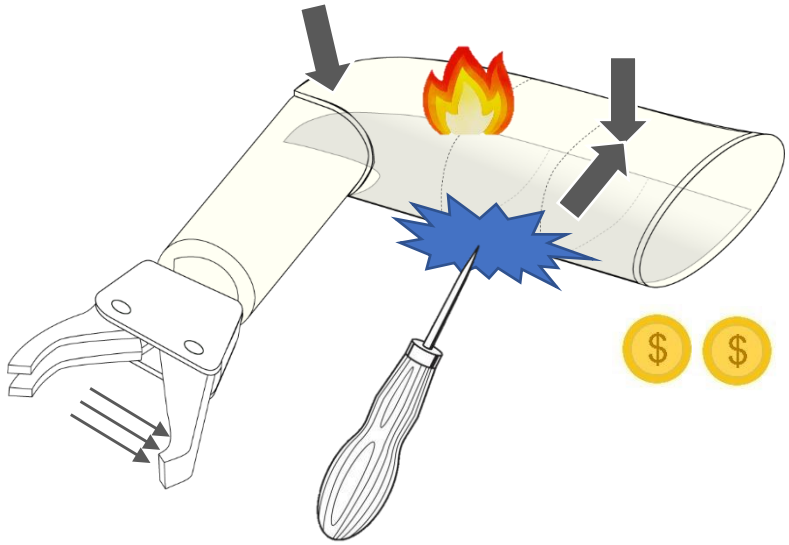


Outdoor Operation

Autonomous operations in contact-rich environments

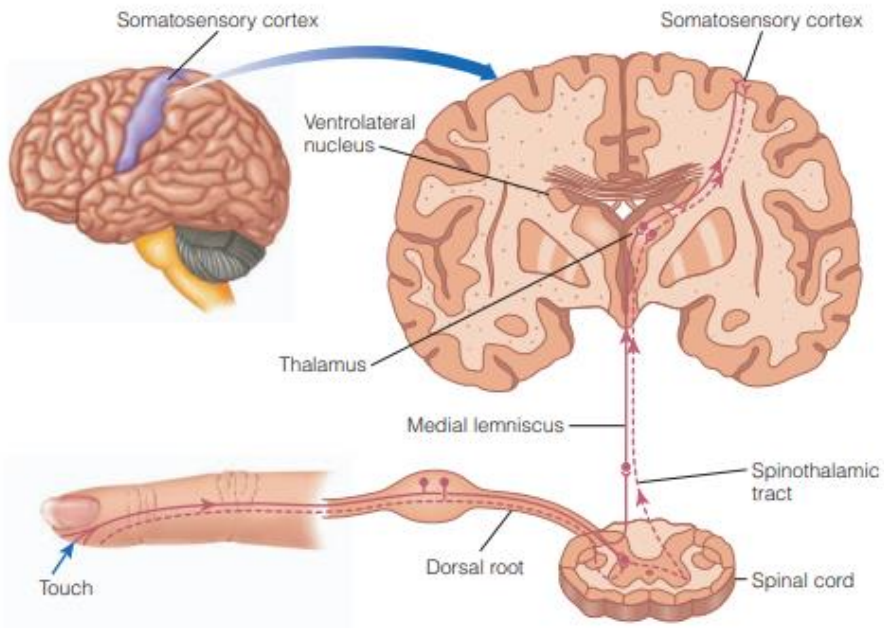
Requirements for Tactile Skins

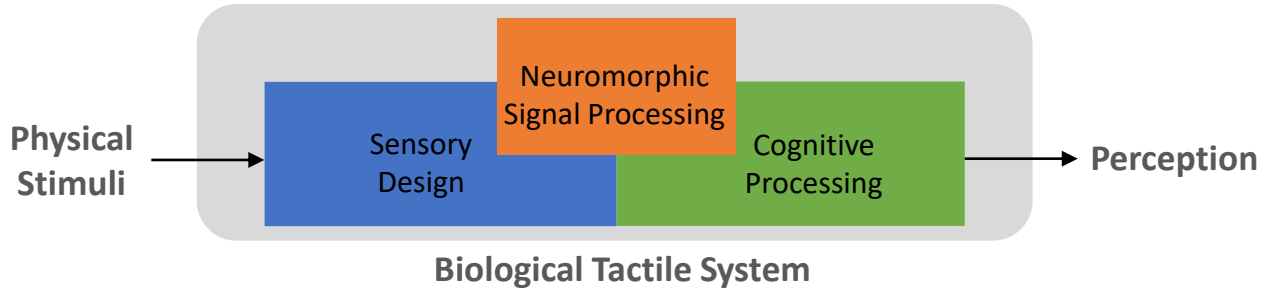
- Multi-contact
- Multi-directional (normal, shear)
- Multi-modal (pressure, vibration, temperature)
- Scalable: fingertip to whole-body
- Robust and repairable
- Economical



Challenges on system level integration

Biological Skin's Tactile Perception System

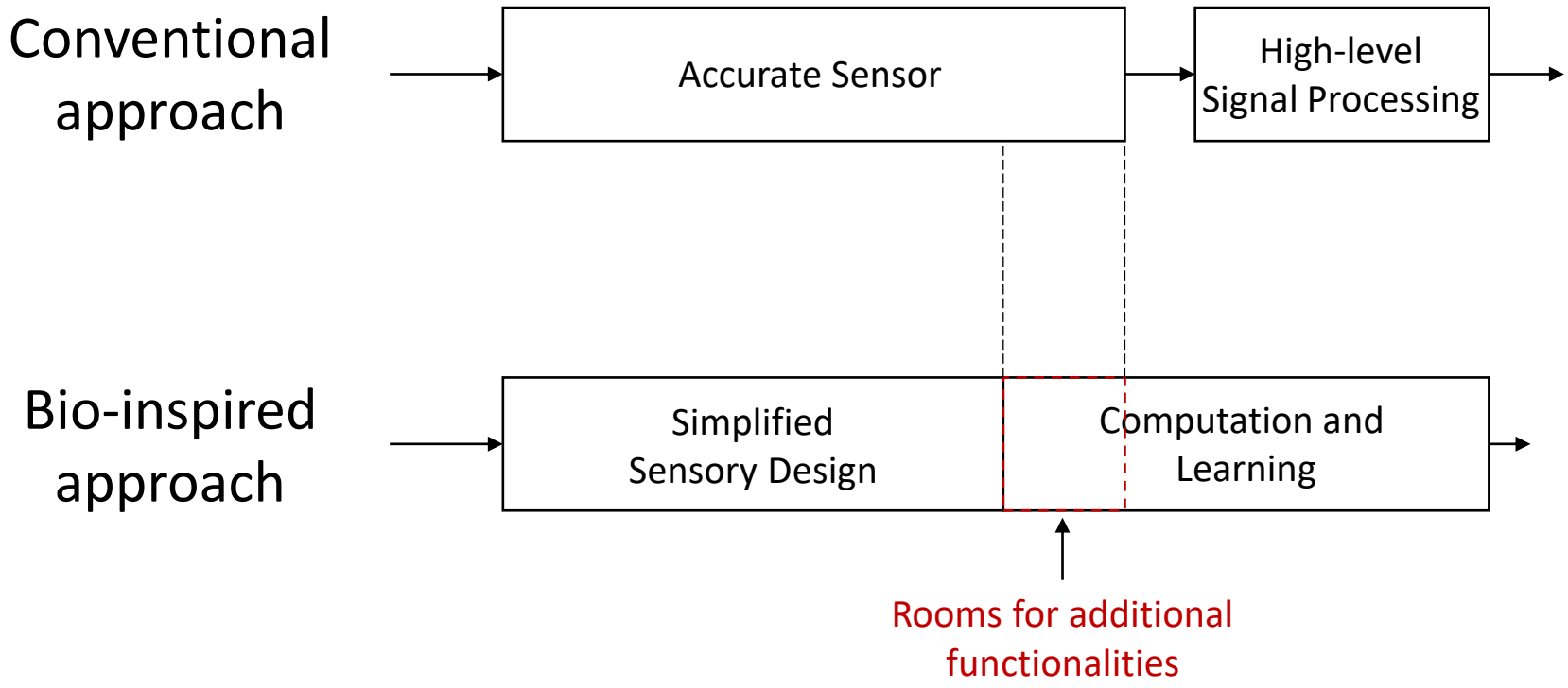




Coupling of sensory organ and cognitive system

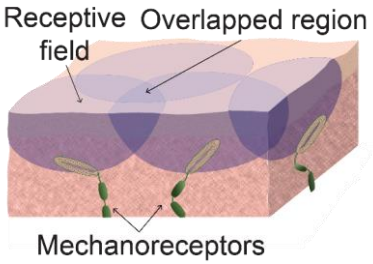
E. Goldstein et al. *Cengage Learning* (2021)
E. Gardner et al. *Principles of neural science* (2000)

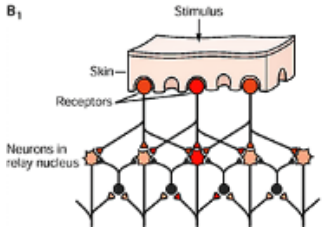
Lesson from Biological Tactile System



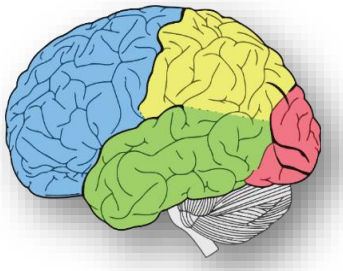
Computation can reduce hardware-level burden and enable integration of multiple functions

Recent Work: Biomimetic Tactile Perception System





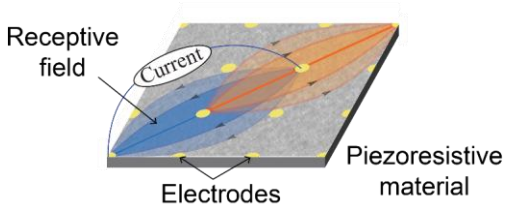
Learning from experience

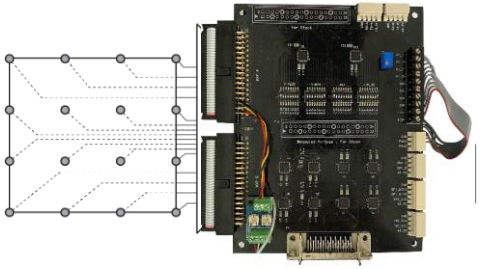


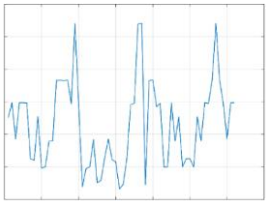
Overlapping receptive field design

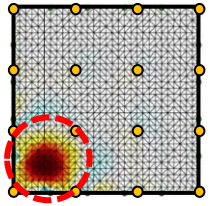
Signal processing

Inference









Computation from physics model and data

Computation enables the sensory design to have only a few point electrodes

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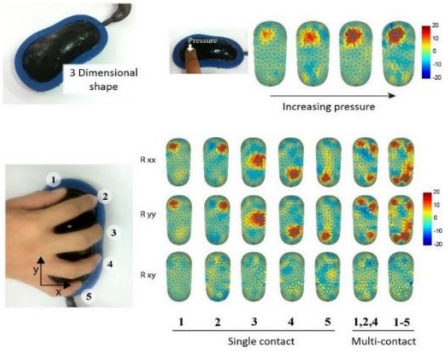
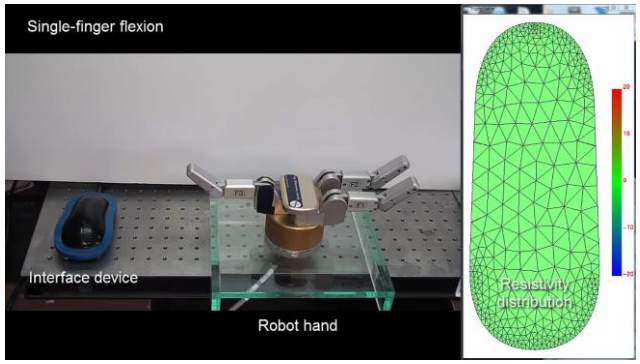
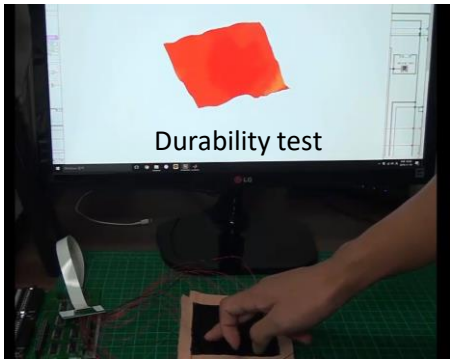
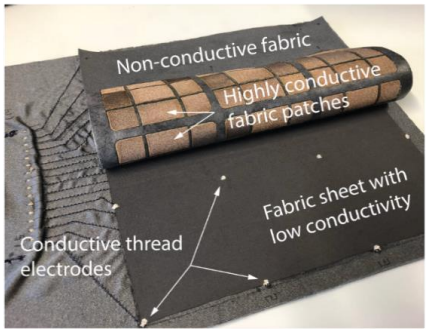
Demonstrations

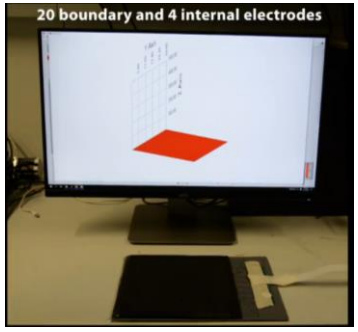




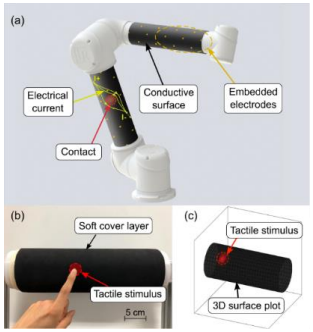
Soft tactile skin using conductive polymer

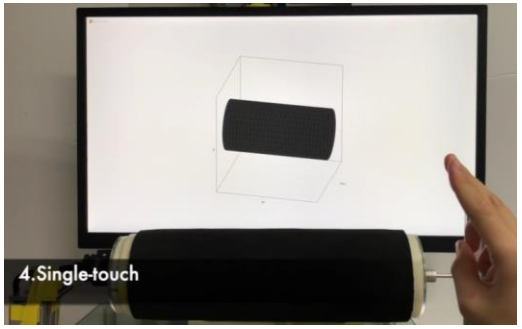






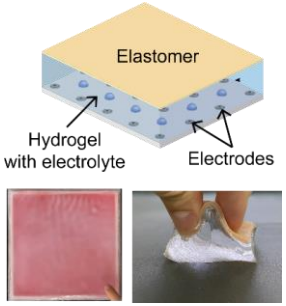
Wearable tactile skin using conductive textile

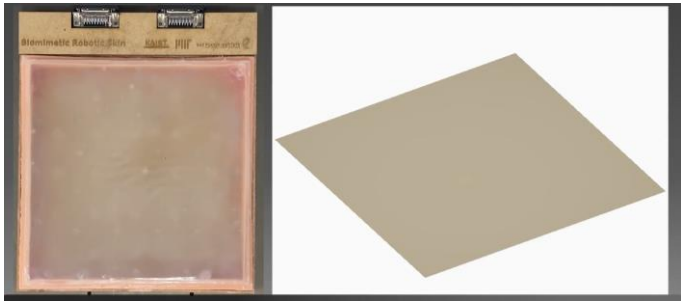




3-D geometry cover using conductive spray

Tactile skins with **functional materials** and **geometry**

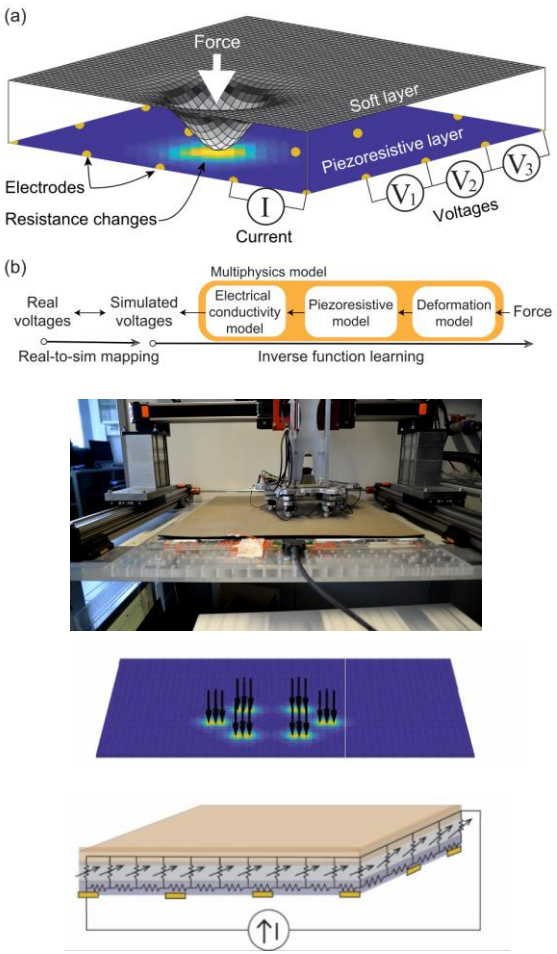


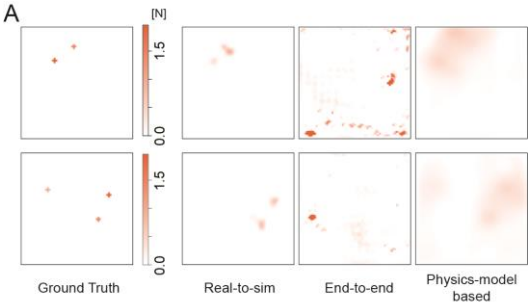


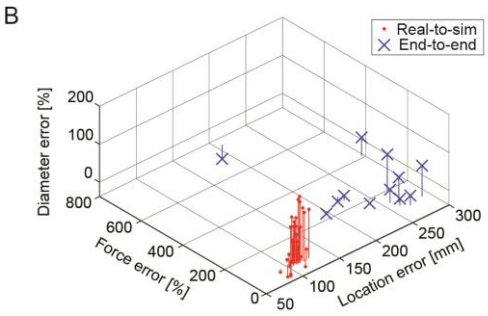
Tactile skin using hydrogel

Recent Work: DNN for Tactile Perception

- Data-driven approach to learn voltage to force mapping
- Combining real and simulation data to overcome data-deficiency
- DNN achieved accurate and stable reconstruction than physics-model approach







Combining tactile skin and machine learning is promising for high-performance tactile perception

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Lee, Hyosang et al. ICRA (2020)
Lee, Hyosang et al.T-ASE (2022)

Summary and Future Directions

- Tactile skin needs to **fulfill various functional-level and integration-level requirements** for future applications
- **Combining sensory design and computation** is promising to achieve **integrative tactile skin**

- Potential future directions related to ML
  - Evolutionary tactile skin optimizing sensory design and computation
  - Integration with motion and multi-modal sensors
  - Neuro-morphic signal compression and processing

Welcome your opinions and discussion!