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Multifunctional Human-Machine Interface Enabled by Magnetoactive Textiles

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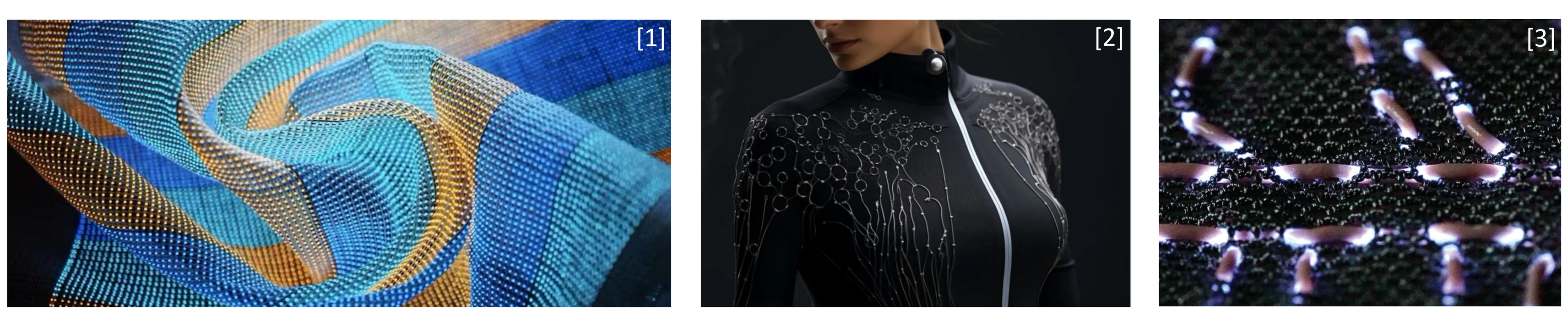
Motivation

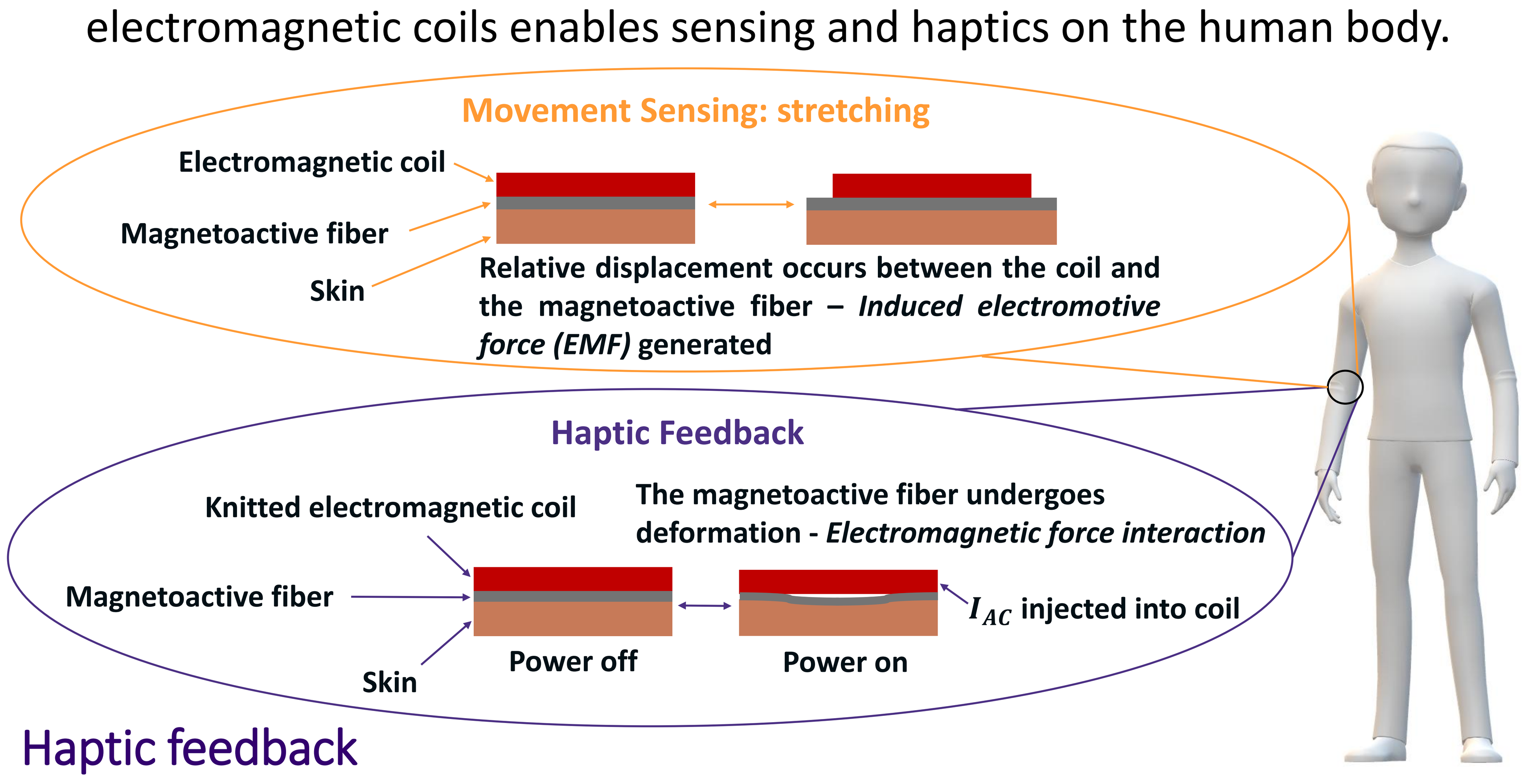
Smart textiles have gained significant attention in human-machine interfaces (HMIs) due to their flexibility, softness, and comfort, allowing for seamless integration into daily life.



The textile-based multifunctional human-machine interface enables bidirectional interaction while ensuring wearability. In our work, we developed a wearable system that achieves sensing human body movements and providing corresponding haptic feedback based on a unified structure.

Methods

- Fabricate magnetoactive fiber through molding and magnetization of a silicone matrix mixed with micro magnetic particles (NdFeB).
- Designed and fabricate textile-based electromagnetic coils via digital machine knitting.
- Placing the magnetized magnetoactive fiber under machine-knitted electromagnetic coils enables sensing and haptics on the human body.

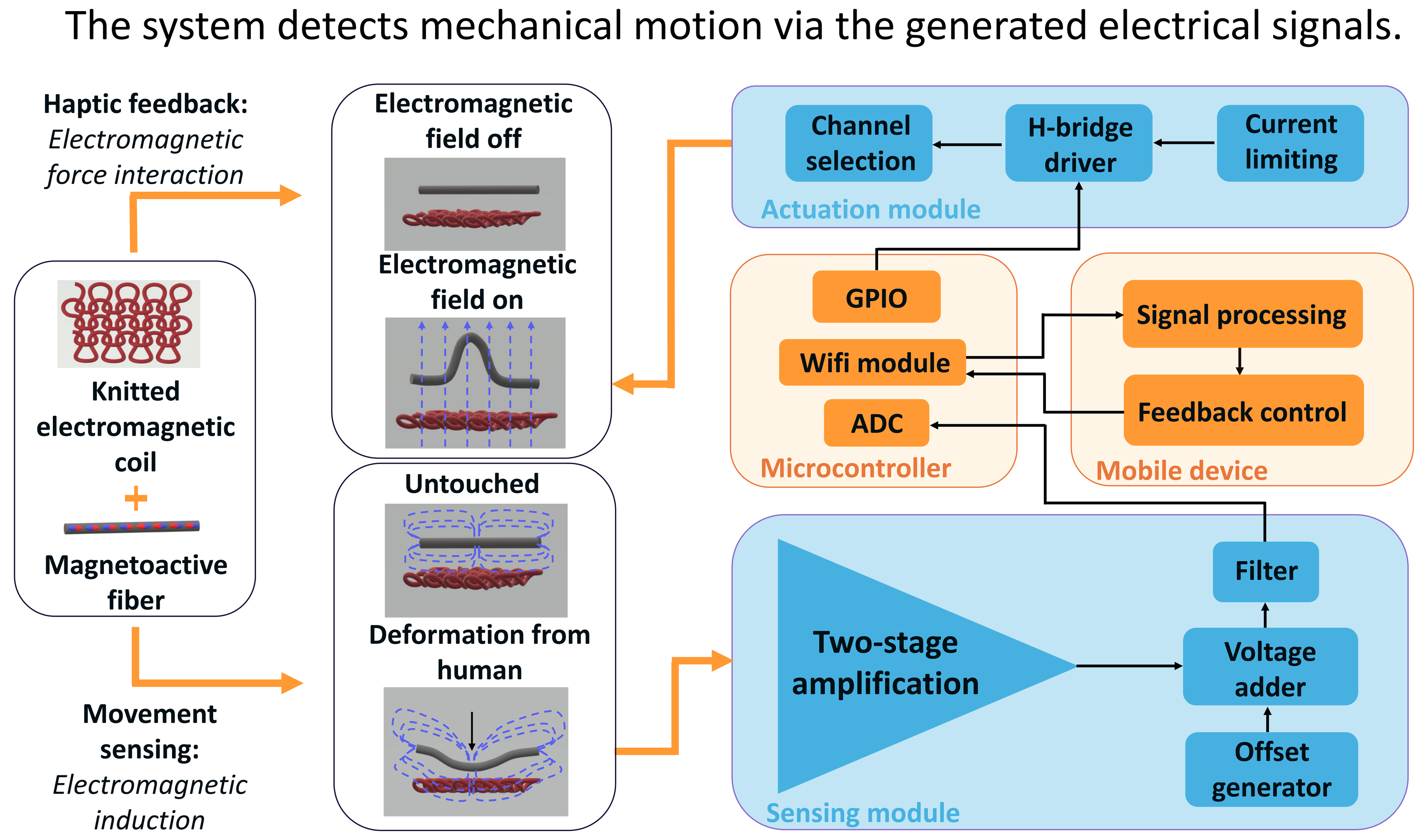


Haptic feedback

- With alternating current, the knitted electromagnetic coils generates fluctuating magnetic fields. Driven by electromagnetic forces, the magnetoactive fibers generates vibrations of different magnitudes and frequencies.

Sensing

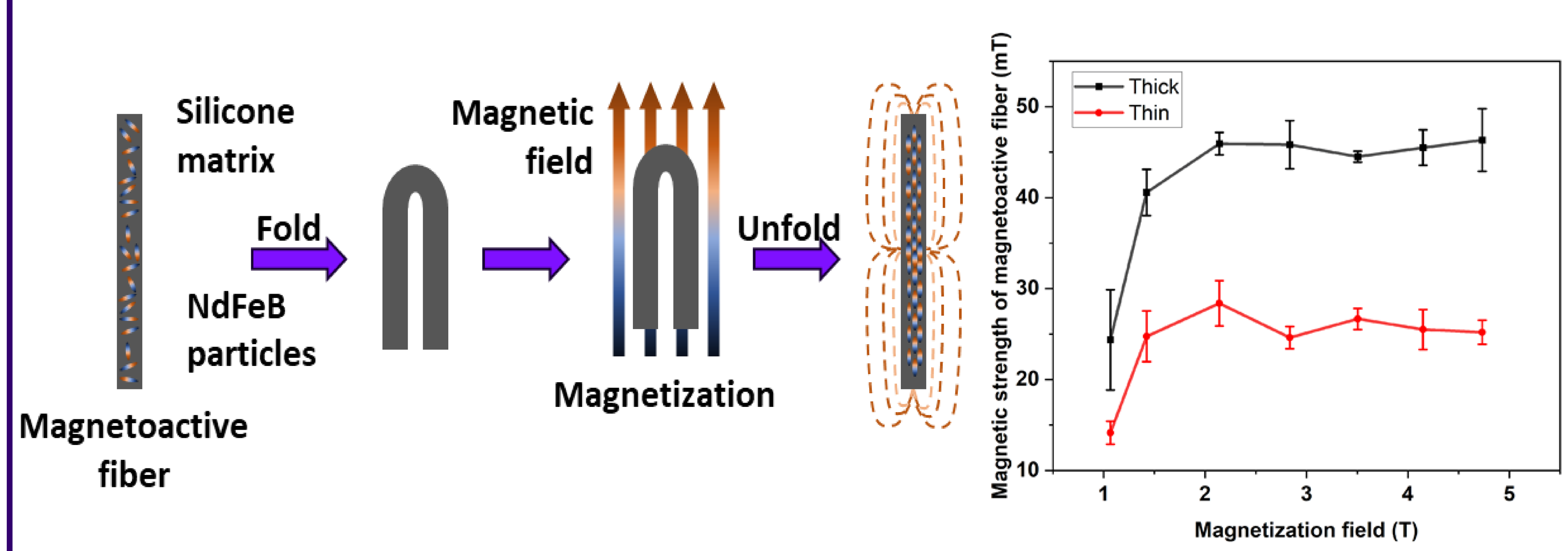
- When the knitted electromagnetic coils and magnetoactive fibers undergo relative displacement, an induced electromotive force (EMF) is generated. The system detects mechanical motion via the generated electrical signals.



Results

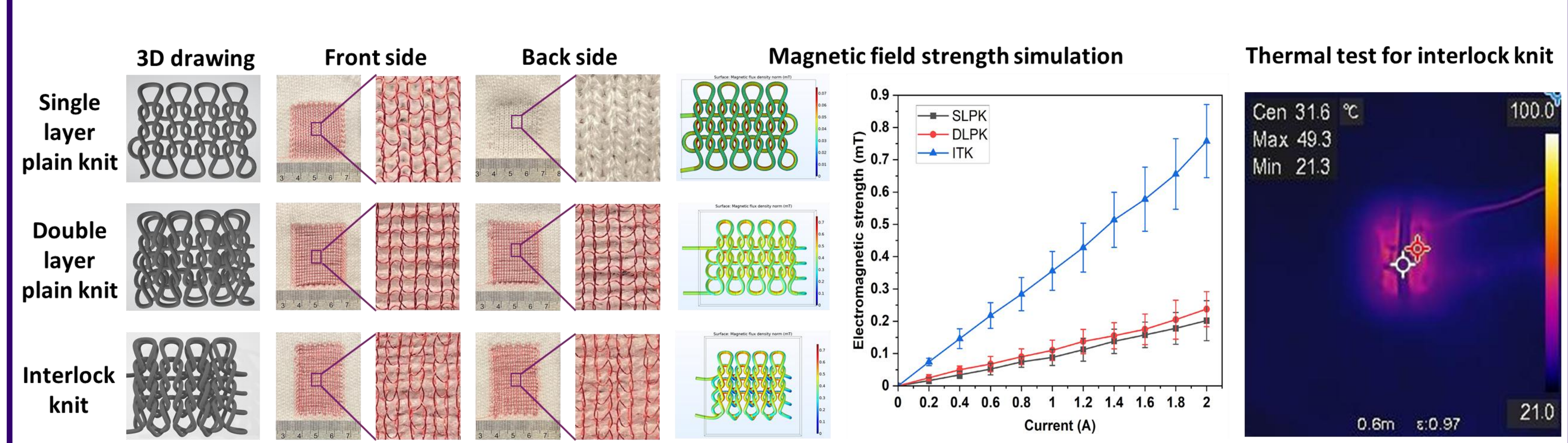
Magnetic field strength of magnetoactive fibers

- Thicker fiber diameter and higher magnetization field result in a stronger magnetic field in the magnetoactive fiber.



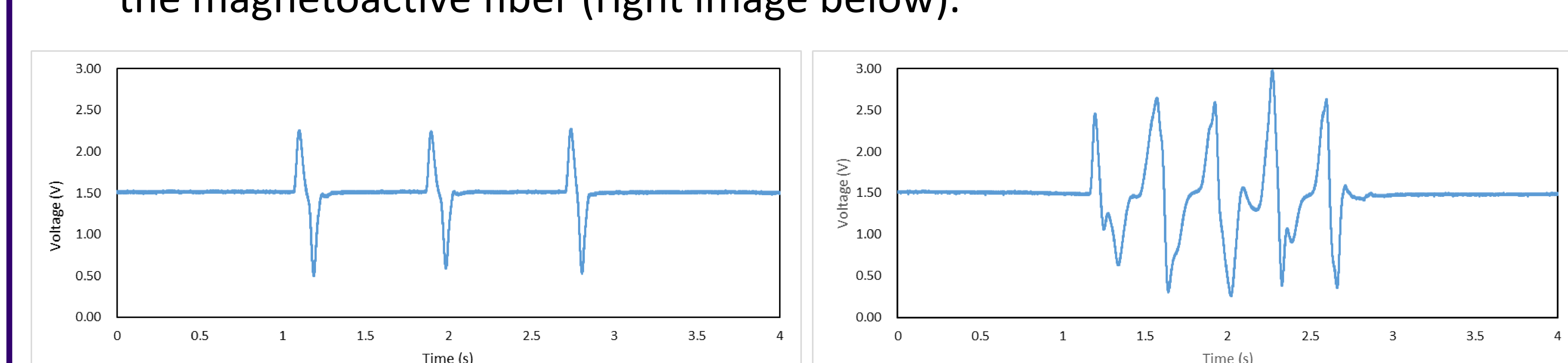
The influence of knitting structure on haptics

- The electromagnetic coils were knitted into three different structures using digital fabrication.
- The interlock structure produces the strongest magnetic field, making it the most favorable for generating high-intensity haptic feedback.
- In the temperature test of intermittently activated feedback, the maximum temperature of the coils in the interlock structure was controlled under 120.7°F (49.3°C).



Preliminary results from the sensing module

- It has the capability to amplify the original small induced electromotive force (EMF) from μV to V while suppressing noise.
- The amplified induced electromotive force obtained at the sensing module output from consecutive taps (left image below) and continuous rolling of the magnetoactive fiber (right image below).



Future work

- Integrate the scaled-up sensing and haptic functions into a unified system.
- Conduct signal processing and analysis to enhance system performance.
- Explore application scenarios.

Reference:
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