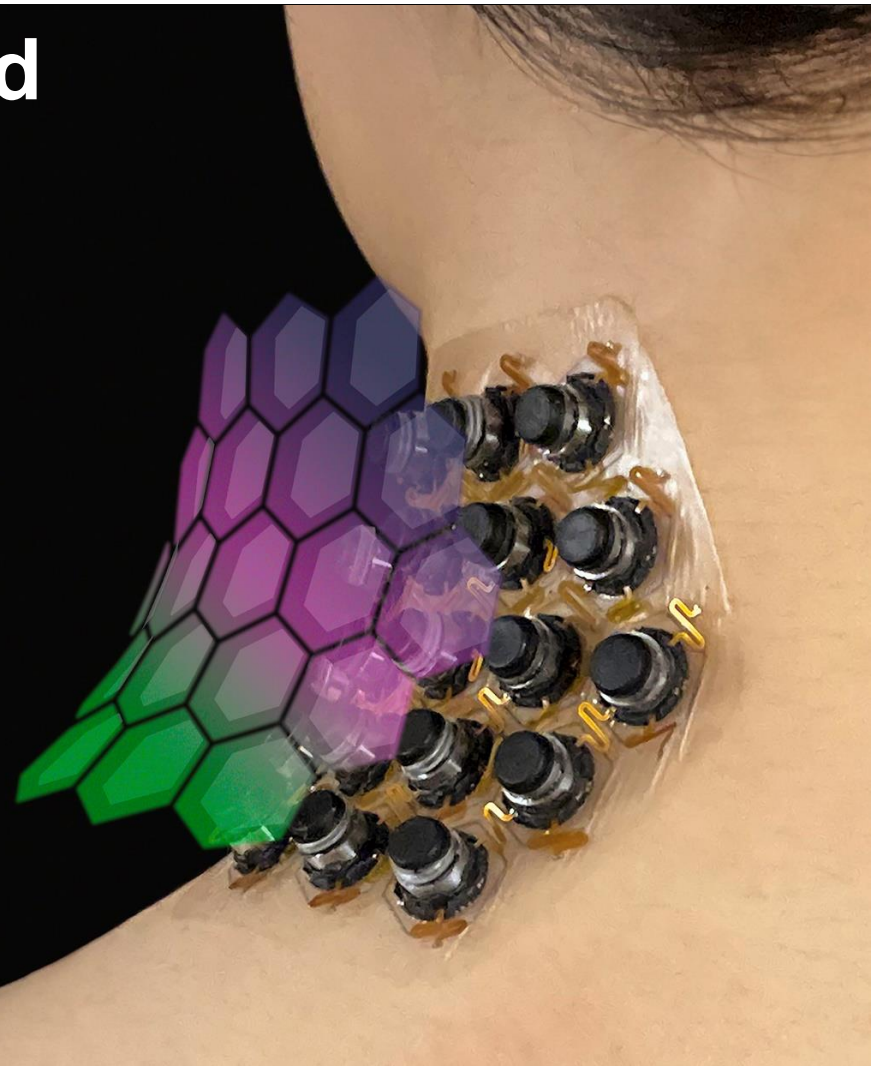
July 4, 2025

Wearable Mechatronics for Receiving and Transmitting Information Through the Skin



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Flavin Neuromachines Lab
https://flavinlab.io

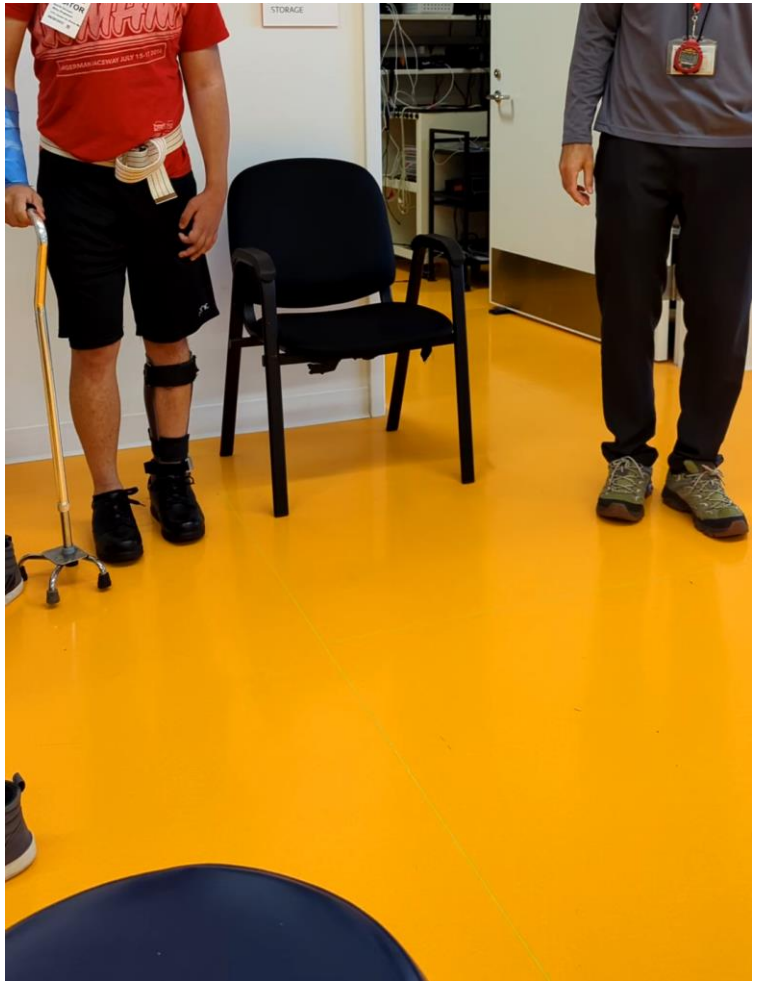
Flavin Neuromachines Lab at Georgia Tech

Georgia Institute of Technology

NIH National Institutes of Health

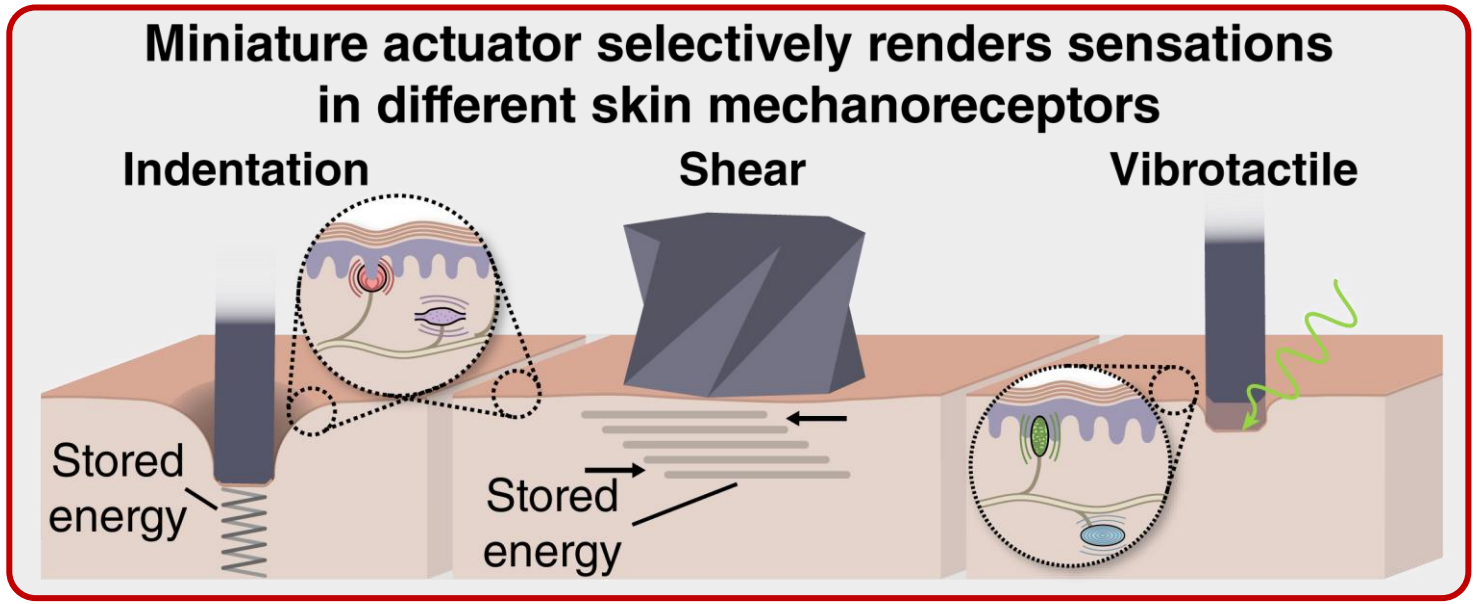
Motivation: Neurological disorders

Developing clinical interventions



Flavin et al. *Unpublished*

Multimodal somatosensory interfaces



- A rich composition of afferent mechanoreceptors that exist in the skin act collectively to define our physical perception of the world
- We address long-standing challenges in selectively rendering sensations in these afferent channels

Flavin et al. *Nature* (2024).

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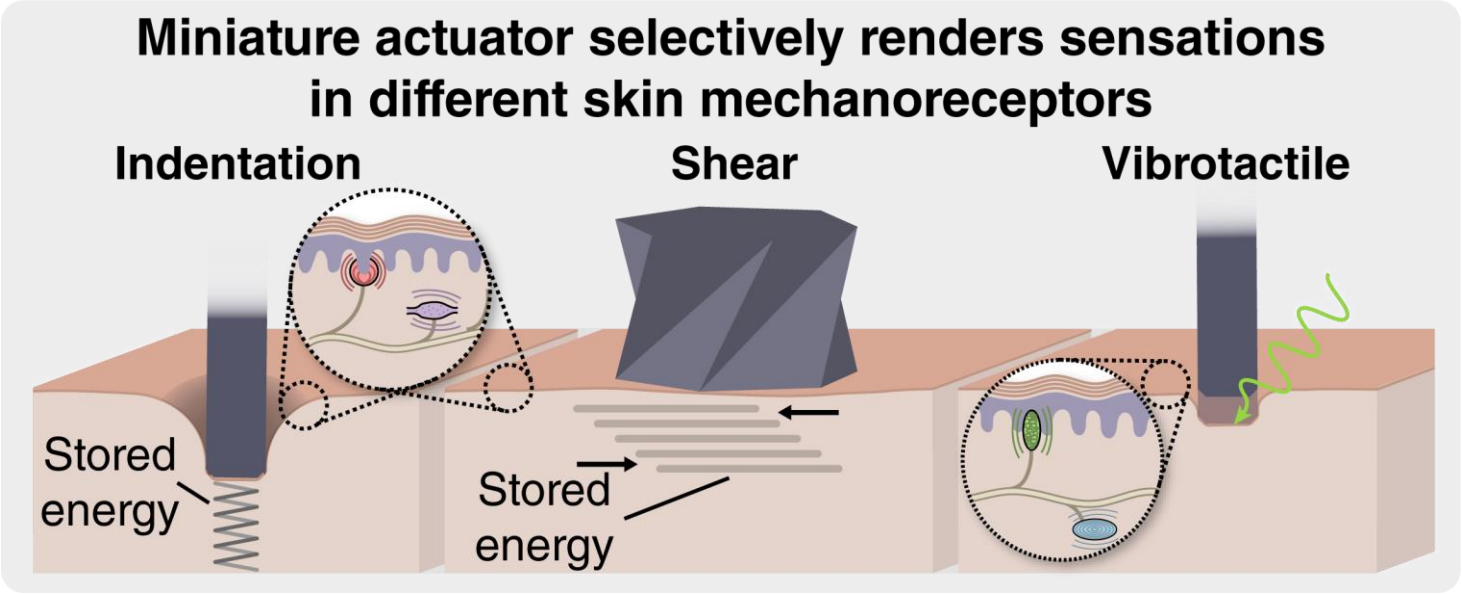

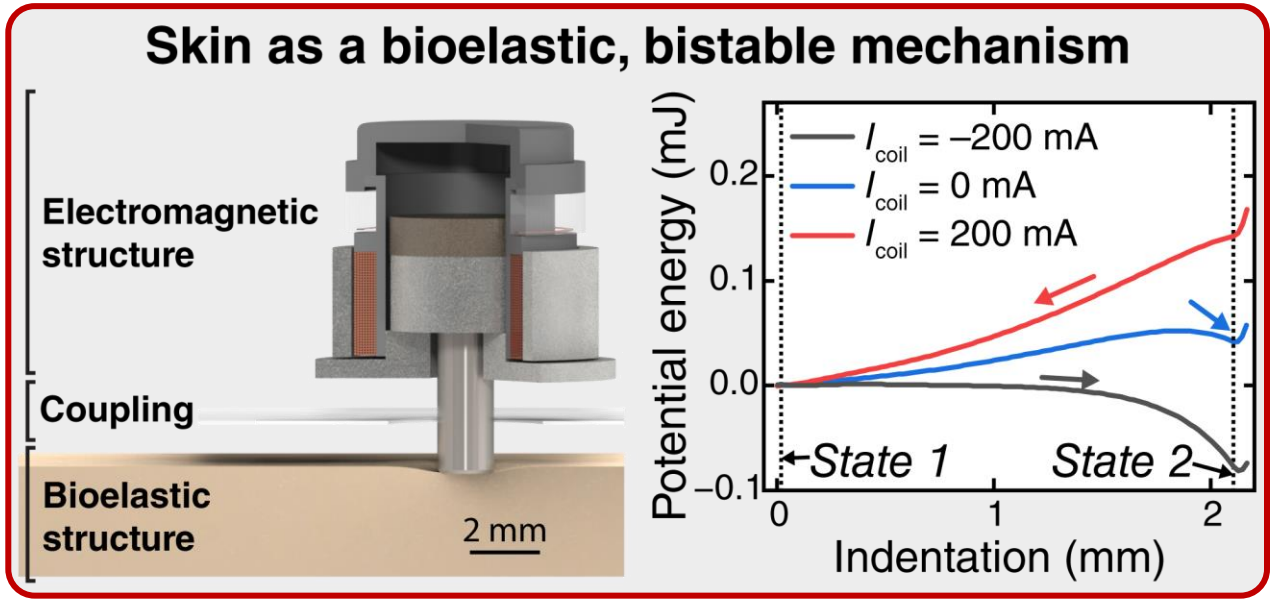

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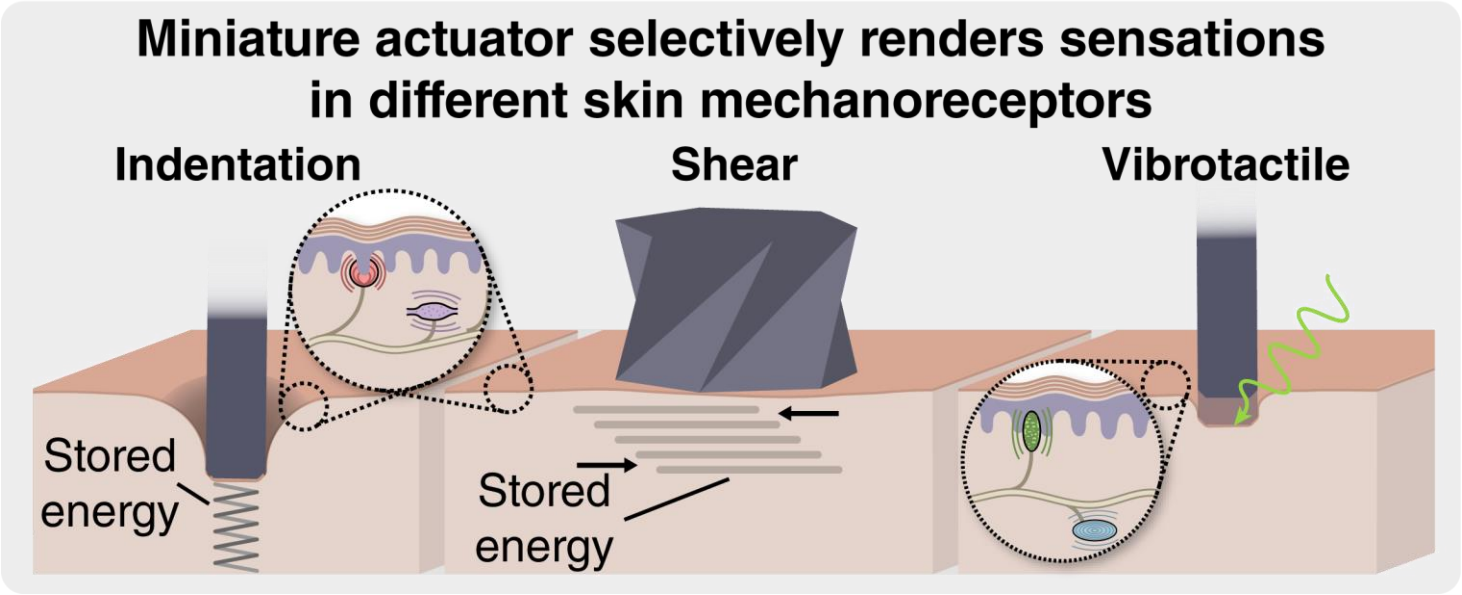

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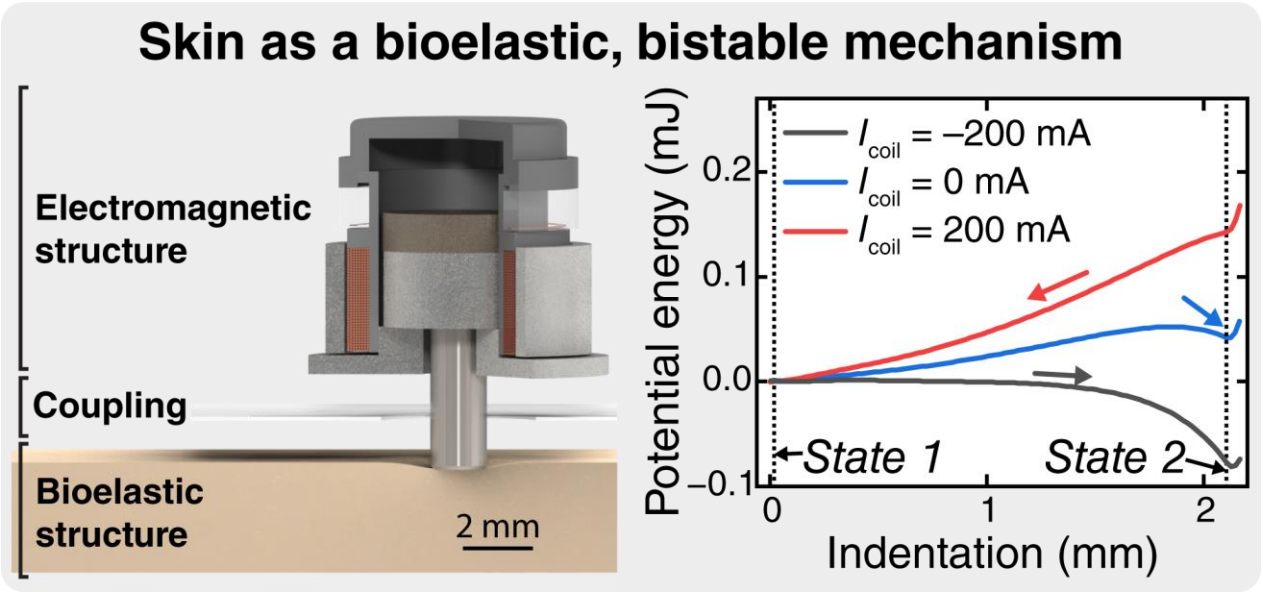


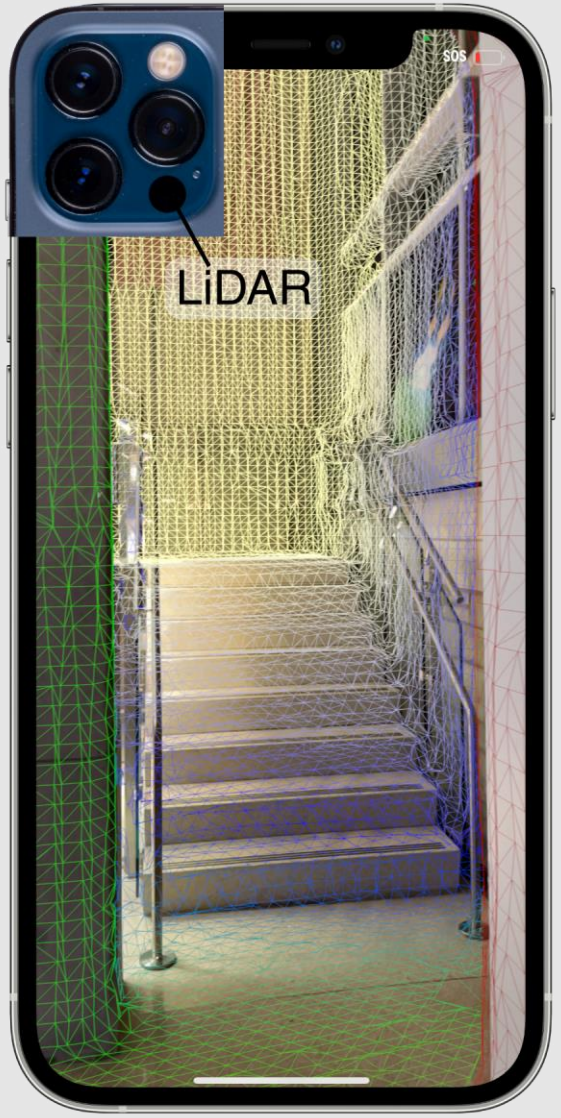
Key advances over alternatives

Ref.	Tethered	Mechanism	Size
This work	**No**	**Bioelastic transducer**	**Small size, low energy, large force**
Leroy et al. *Adv. Mater.* 32, 2002564	Yes	Electrostatic	Smallest thickness, low-energy, low force
Vechev et al. *IEEE VR Conference* (2019)	Yes	Electro-magnetic	Large, high energy, low force
Qi et al. *Adv. Sci.* 10, 2301044.	No	Pneumatic	Large, high energy, high force

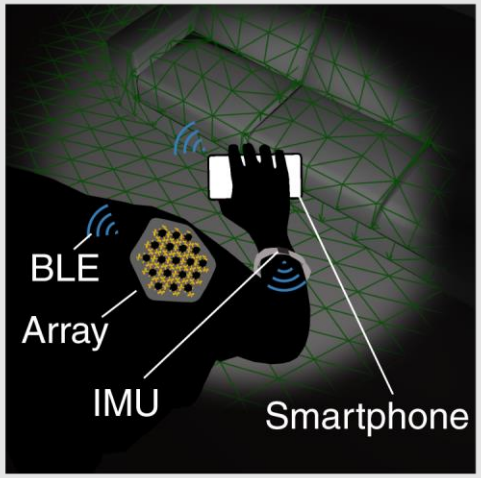
Probing anisotropic, viscoelastic, and plastic features

Small-scale, low-power electro-mechanical transducer arrays

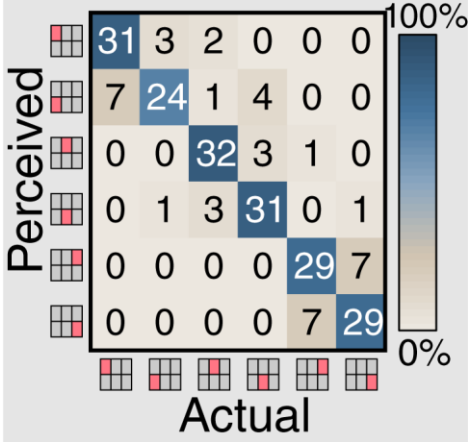
Scene reconstruction and tracking



Network of sensors and actuators



Improvements for visual impairment



- Created a small-scale, low-power actuator capable of new interactions with skin
- Demonstrated an array of actuators rendering input from virtual and augmented reality systems
- Improved outcomes for models of visual and proprioceptive impairments

Flavin et al. *Nature* (2024).

Flavin et al. *unpublished.*

Shin*, **Flavin*** et al. *Nature* (2025).

Sensory substitution clinical studies

Loss of plantar sensation leads to dependence on vision for balance

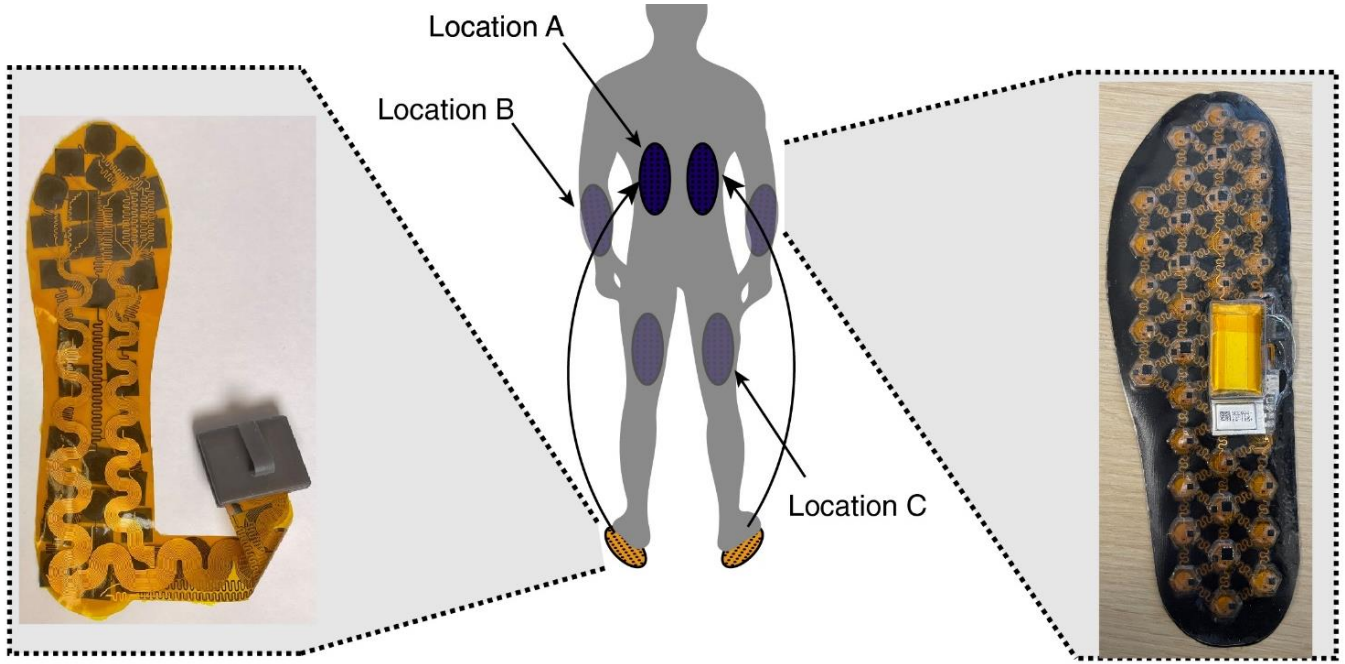
- Loss of plantar sensations occurs in a range of conditions, leading to mobility impairment and inflammation
- We want to help patients avoid these problems by substituting plantar sensation with a haptic system

Collaborators
Arun Jayaraman, P.T., Ph.D.
Shirley Ryan AbilityLab

Flavin et al. *Unpublished.*

Can sensory substitution improve balance without vision?

Distribution of plantar pressure projects onto haptic device wirelessly, in real-time



- Insole-based pressure array collects pressure distribution and transmits to the haptic device
- The haptic device is located on part of the body where the patient can still feel, and they receive the missing sensation as vibration

Flavin et al. *Unpublished*.

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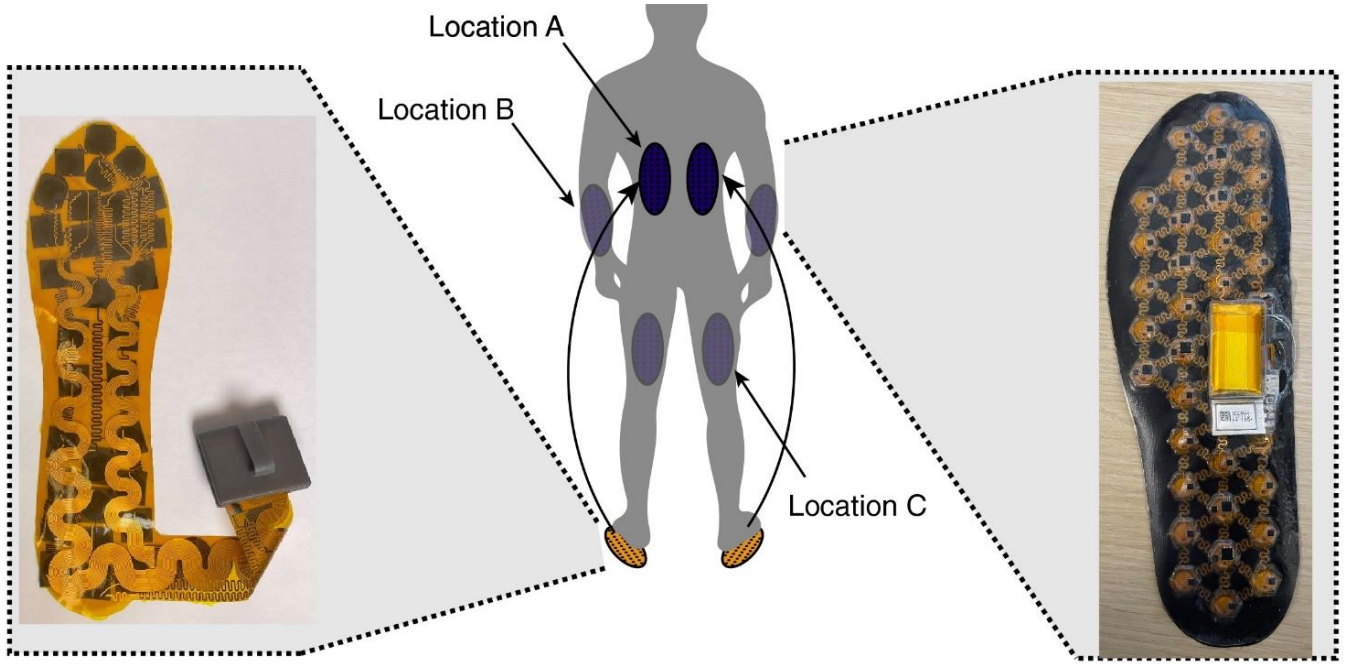
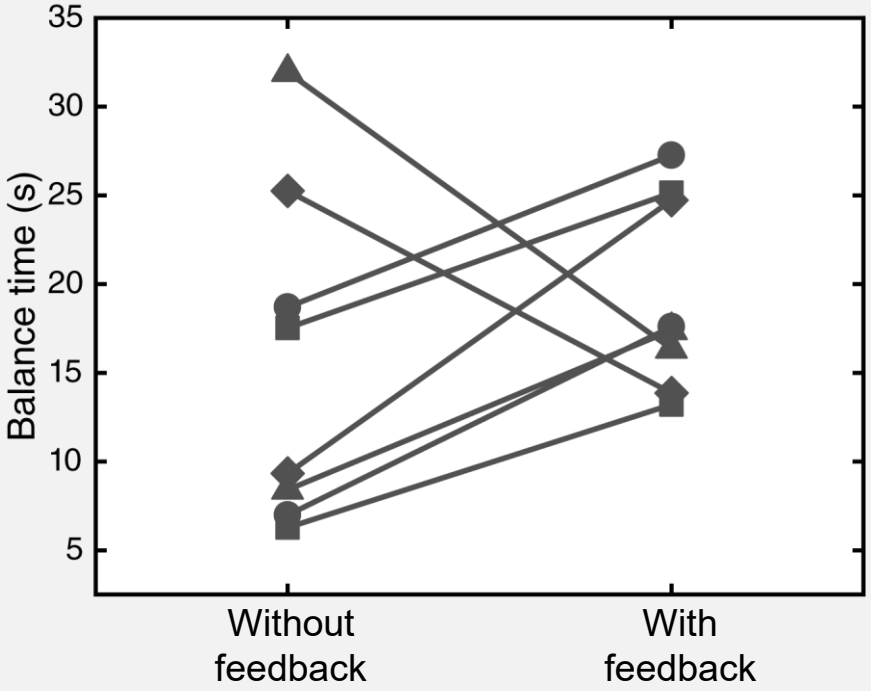


Exploratory results show interventional effect



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Flavin Neuromachines Lab

Graduate students

Aaron Huang
Dulani Wijayarathne
Fengyuan Shen
Timothy Weigman
Matt Chung

Undergraduate students

Amogh Kashyap
Andrew Liu
Chinmay Bandapalli
Nicholas Candello
Sarvesh Senthilkumar
Joyce Yang
Sam Allahverdi
Ethan Huang

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