

Scalable, Customizable Sensory Solutions for Dexterous Robotic Hands #1849417



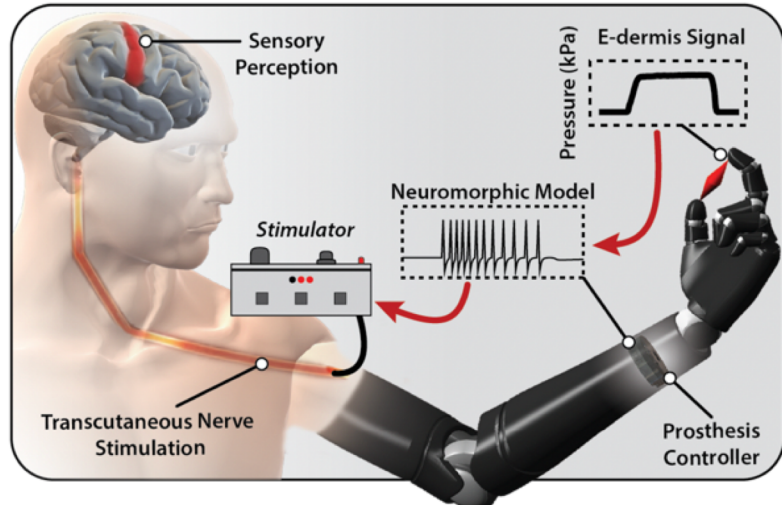
Nitish V. Thakor, Johns Hopkins University; Students: Mark Iskarous, Sri Sankar

Challenge

- Provide **enhanced tactile sensory perception** through sensor-enabled dexterous robotic hands

Solution

- **Flexible, multilayered e-skin** integrated with a pneumatically-actuated **soft biomimetic finger**
- Biomimetic artificial receptors for tactile sensing
- **Spatial-Frequency encoded sensor array** for scalable sensing
- **Neuromorphic encoding** and stimulation for object detection



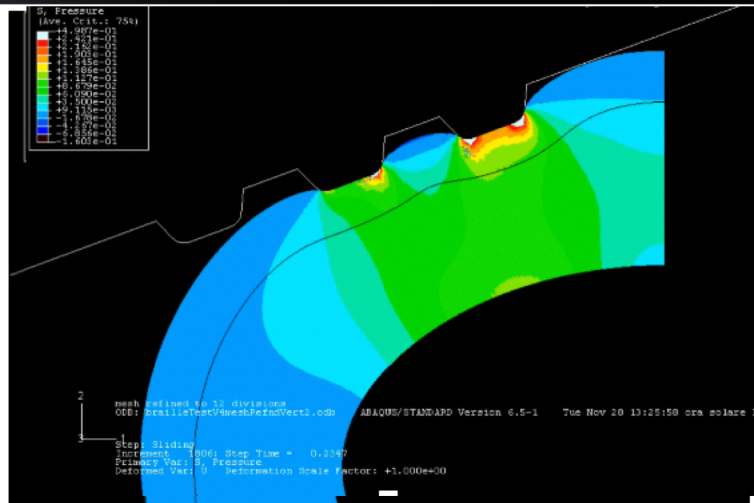
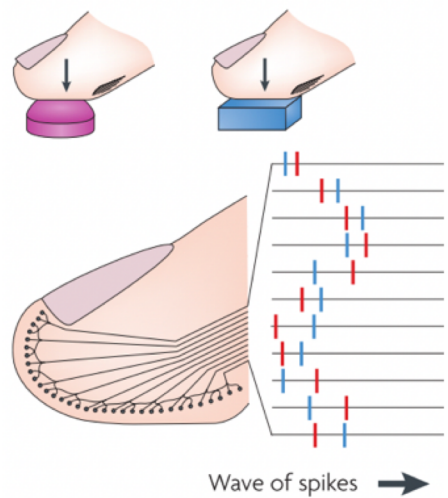
Scientific Impact

- **High-density taxel sensors arrays** and sensory feedback will enable multisensory capability for prosthesis and humanoid robots

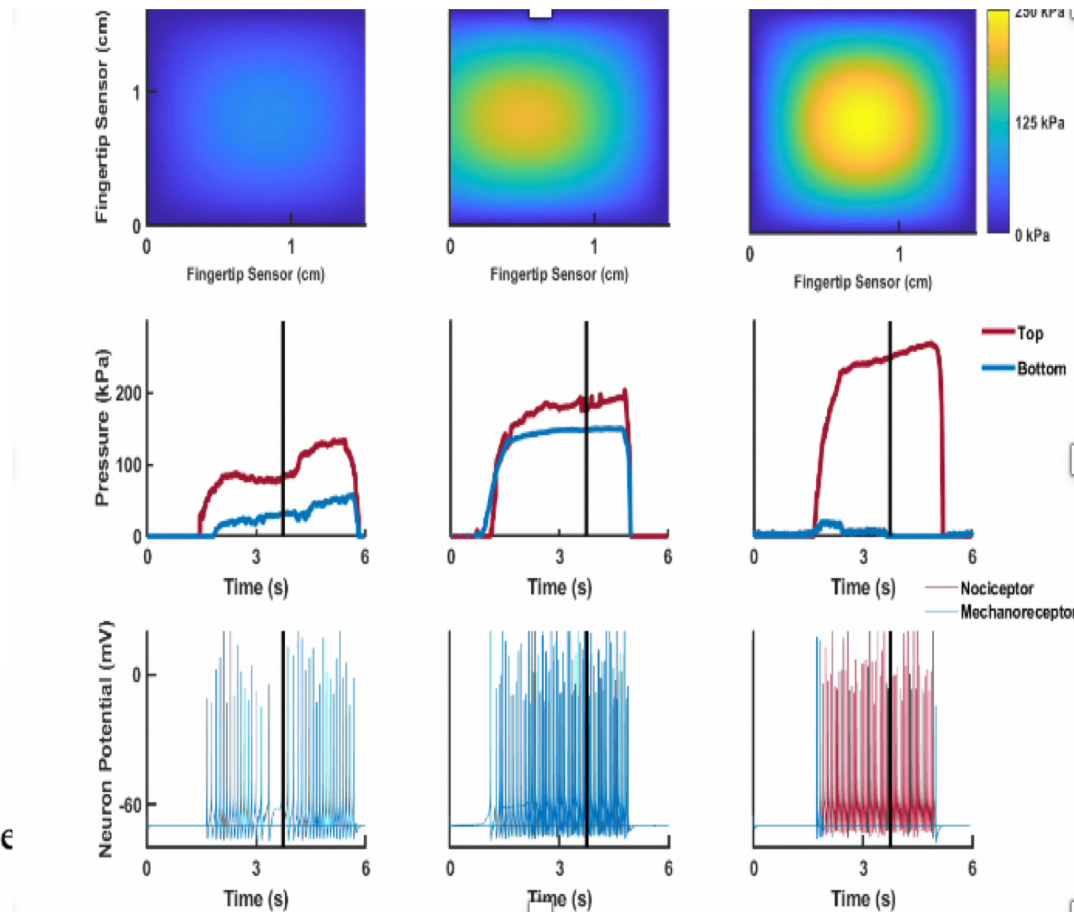
Broader Impact

- Natural tactile sensory feedback for **upper limb amputees**
- Foundation for multisensory skin and sensory perception in autonomous **sensorized robots and human interactions**
- **Educational impact** through Neural Prostheses class for undergrads (5 courses in the last 2.5 years) and student training for local high school students and REUs

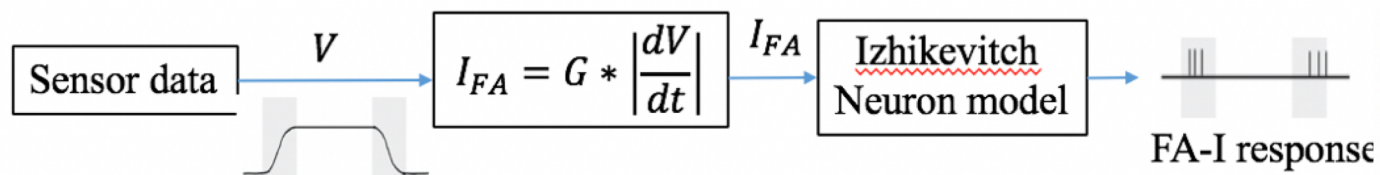
“Neuromorphic” or Nerve-like Encoding



Shape classification



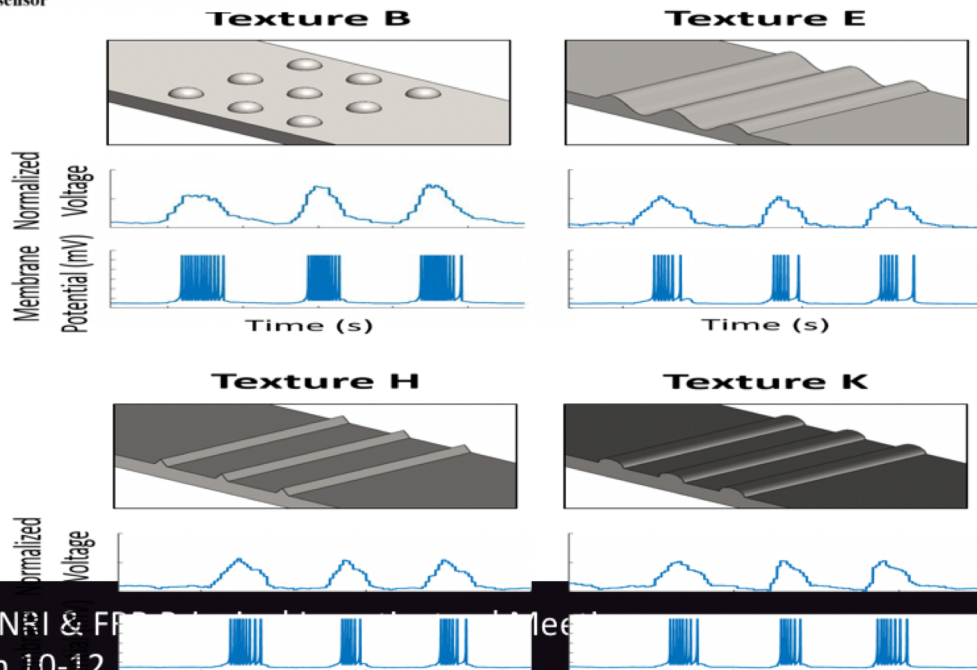
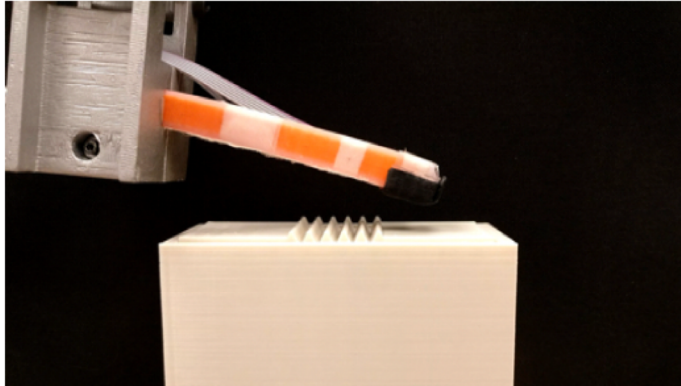
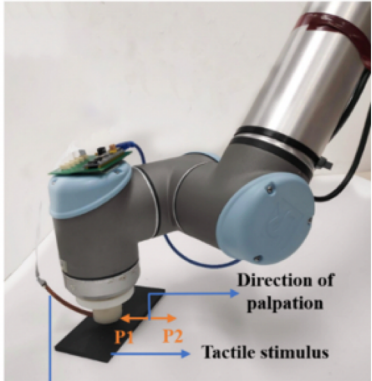
Tactile Palpation – Edge, Shape



Johansson, R. S., & Flanagan, J. R. (2009). Coding and use of tactile signals from the fingertips in object manipulation tasks.

Ongoing: Soft finger for Palpation

Publications



1. **Iskarous M.** and **Thakor N. V.**, "E-Skins: Biomimetic Sensing and Encoding for Upper Limb Prostheses," *Proc. IEEE*, Vol. 107 (10), pp. 2052 - 2064, Oct. 2019. [10.1109/JPROC.2019.2939369](https://doi.org/10.1109/JPROC.2019.2939369)
2. **Osborn L.**, **Bethauer J. L.**, and **Thakor, N.V.**, "Neuroprosthesis," *Wiley Encyclopedia of Electrical Engineering*, J. G. Webster (Ed). 21 February 2019 <https://doi.org/10.1002/047134608X.W1424.pub2>
3. **Osborn L. E.**, **Iskarous M. N.**, and **NV Thakor**, "Sensing and Control for Prosthetic Hands in Clinical and Research Applications," *Wearable Robotics*, 445-468, 2020.
4. **Adel Parvizi-Fard**, **Mahmood Amiri**, **Deepesh Kumar**, **Mark M. Iskarous**, **Nitish V. Thakor**, "A Functional spiking neuronal network for tactile sensing pathway to 2 process edge orientation," *Scientific Report*, 2020.
5. **Sankar S.**, **Balamurugan D.**, **Brown A.**, **Ding K.** **Xu X.**, **Low J. H.** **Yeow C. H.**, and **Thakor N.**, "Texture discrimination with a soft biomimetic finger using a flexible neuromorphic tactile sensor array that provides sensory feedback," *Soft Robotics*, 2020/9/23 (published online), 2020.
6. **Kumar D.**, **Ghosh R.**, **Nakagawa-Silva A.**, **Soares AB.**, **Thakor NV.**, "Neuromorphic approach to tactile edge orientation estimation using spatiotemporal similarity," *Neurocomputing* 407, 246-258, 2020.
7. **Slepyan A.** and **Thakor N.V.**, "Towards scalable soft e-skin flexible event-based tactile sensors using wireless sensor element embedded in soft elastomer," 8th IEEE RAS/EMBS International Conference for Biomedical Robotics and Biomechanics (BioRob), 2020.