NRI: Integrated Soft Wearable Robotics Technology to Assist Arm Movement of Infants with Physical Impairments

PI: Konstantinos Karydis; Electrical and Computer Engineering (ECE); University of California, Riverside (UC Riverside); https://arcslab.org/
Co-PIs: Elena Kokkoni, William Grover (Bioengineering); Salman Asif (ECE); Philip Brisk (Computer Science and Engineering); UC Riverside

Motivation and Goal

- Need for highly adaptive pediatric devices that detect, measure, inform, and adjust to changes in learning and growth
- Iterative design, development and evaluation of the performance of a novel actuated, adaptive and user-centered pediatric upper extremity (UE) soft wearable robotic device

Intellectual Merit

- Lensless ego-centric wearable robotics imaging to inform and track human arm motion
- Pneumatic logic design of microfluidic circuits for soft robotic actuation
- Data-driven admittance control of soft wearable robotic devices
- Human-robot physical interaction in early human development

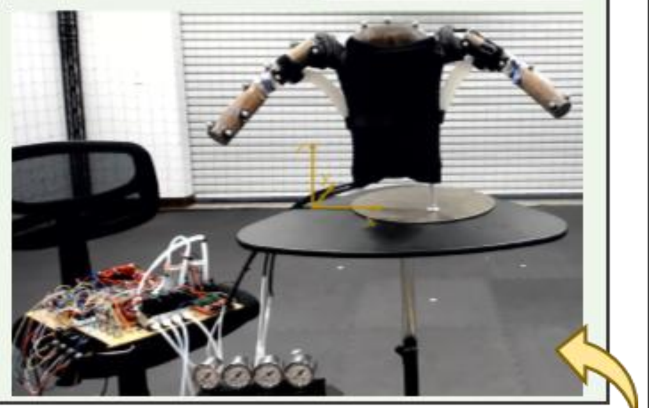
Proposed Approach and Aims

Multi-modal Sensing (Aim 1)

- Inferring intention of UE movement through multi-modal sensory feedback.
- Object recognition and tracking of infant arm motion via ego-centric lensless visual sensing.

Actuation, Control & Computation (Aim 2)

- Motion generation for the wearable robotic device via synergistic soft pneumatic actuators.
- Offering assistive feedback via data-driven shared human-robot admittance control.
- Onboard sensing and control via real-time embedded computation.

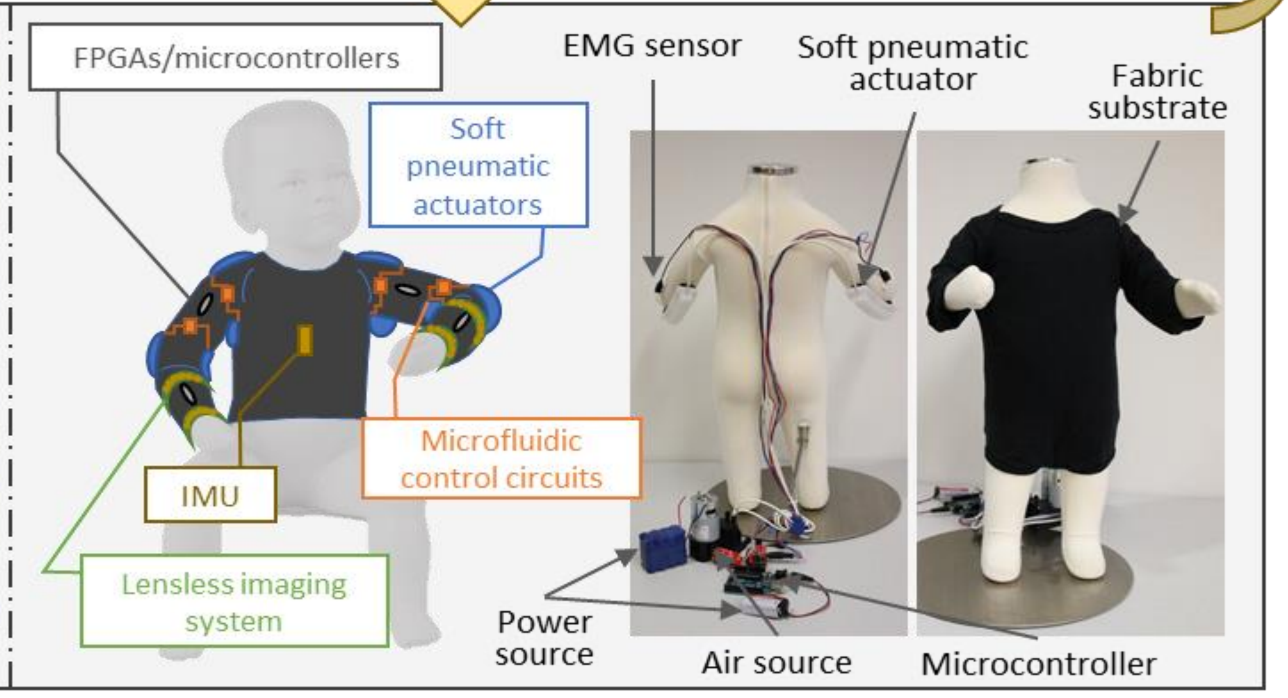


Participatory & Iterative Design Process (Aim 3)

- Collection of kinematic, physiological and behavioral data from infants.
- Evaluation of the device's potential to effectively assist infant arm movement.

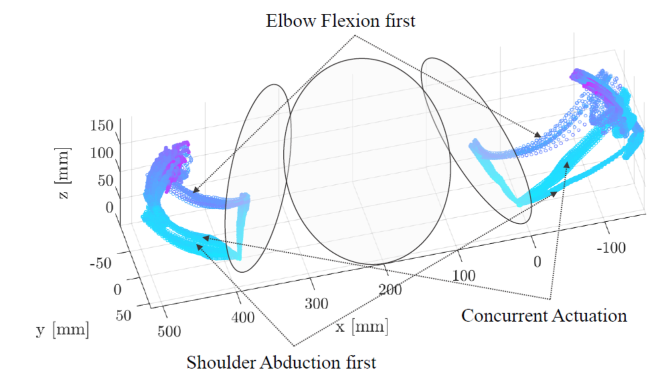
Infant reaching for an object from a seated position

In-lab pilot session testing feasibility of EMG sensors

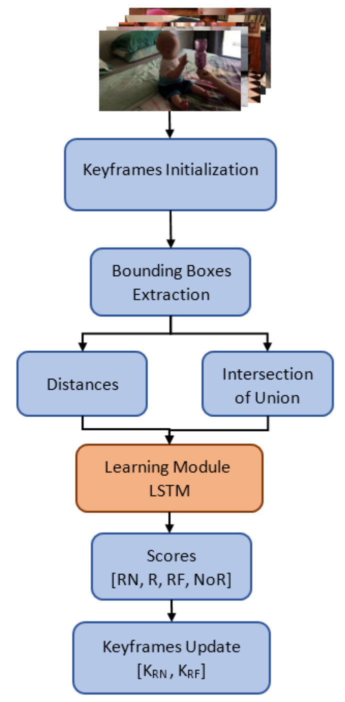


Preliminary Results

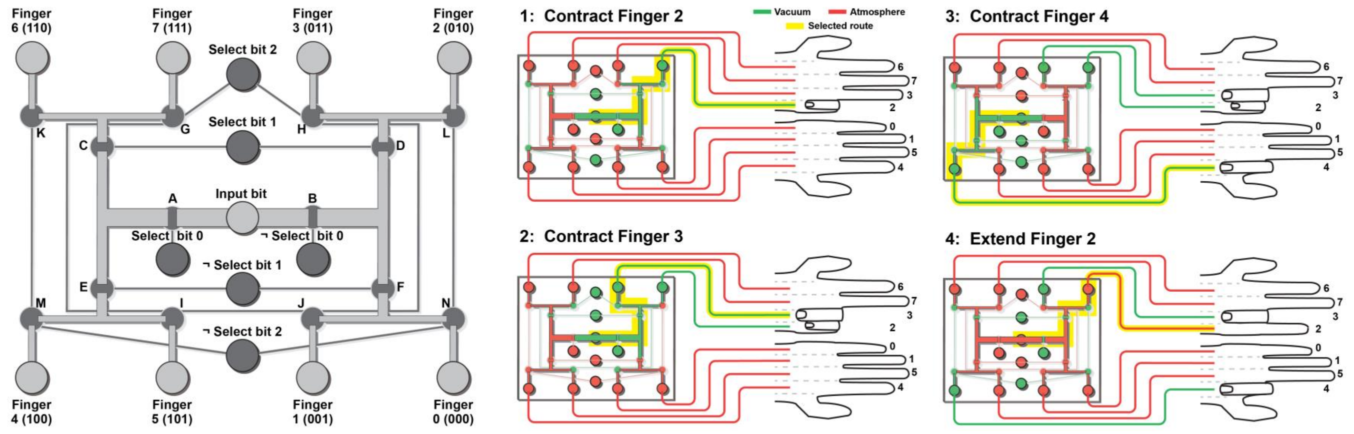
- Design of a soft-actuated wearable prototype and testing with a wooden mannequin in open loop control [1]

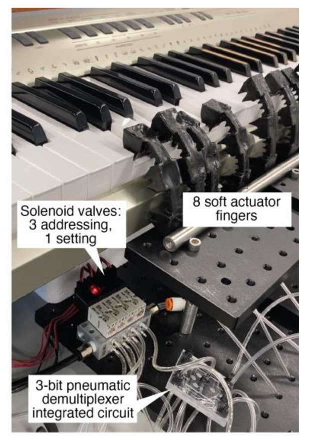


- Infant reaching action-recognition from stationary off-body cameras in unconstrained environments [2]



- Pneumatic soft logic circuit design and testing to operate multiple soft actuators with fewer valves [3]





Broader Impacts

- Advancing fundamental engineering knowledge of pediatric assistive devices via the use of soft robotics
- Creating significant potential for long-term impact on the pressing area of pediatric rehabilitation
- Broadening participation of underrepresented groups in highly interdisciplinary research

[1] E. Kokkoni, Z. Liu, and K. Karydis, "Development of a Soft Robotic Wearable Device to Assist Infant Reaching," ASME Journal of Engineering and Science in Medical Diagnostics and Therapy 2020.
[2] A. Dechemi, V. Bhakri, I. Sahin, A. Modi, J. Mestas, P. Peiris, D. Enriquez Barrundia, E. Kokkoni, and K. Karydis, "BabyNet: A Lightweight Network for Infant Reaching Action Recognition in Unconstrained Environments to Support Future Pediatric Rehabilitation Applications," IEEE RO-MAN 2021.
[3] S. Hoang, K. Karydis, P. Brisk, and W. H Grover, "A Pneumatic Random-access Memory for Controlling Soft Robots," PloS one 2021.

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