Open NOE: An Open Source N-Finger Omnidirectional End-effector

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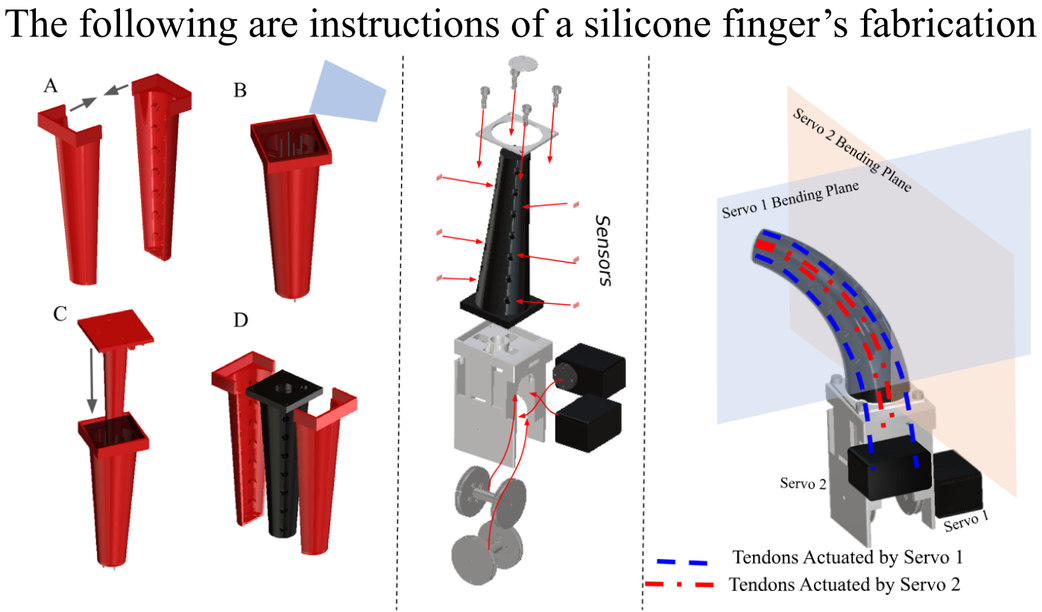
Abstract

- Soft robotic manipulators are useful in many delicate manipulation tasks like **handling fragile objects, grasping irregular objects, and for human-robot interaction**
- We present an open-source **N-finger Omnidirectional End-effector (NOE)** for a general-purpose soft robotic hand with n-many fingers.
- Unlike rigid hands, end-effectors allow for fewer perturbations
- **Acoustic** and **Strain** sensors can be added to the fingers so that it **does not suffer from internal occlusion**
- The hand is generalized and can support robot learning, soft feedback control research, and dextrous in-hand manipulation.

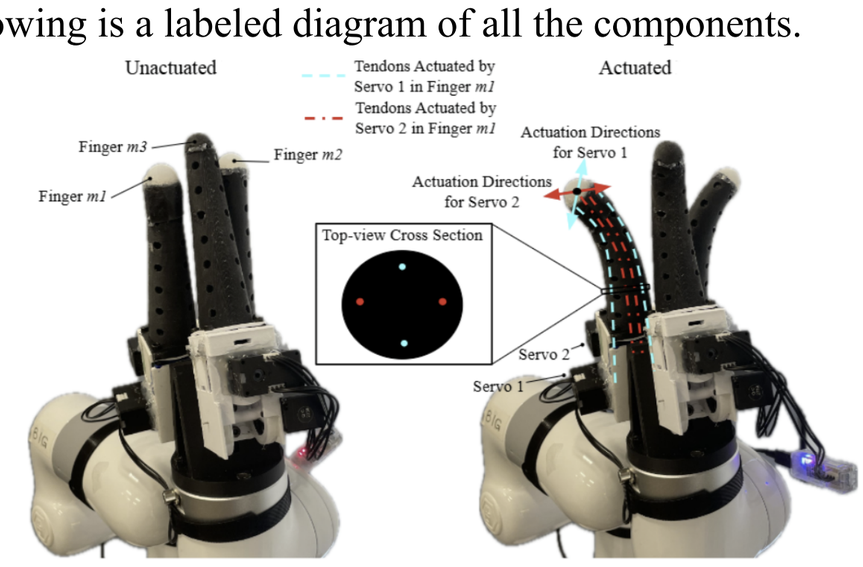
Design and Fabrication of Fingers

- Each NOE finger deforms with contact and is actuated by four tendons with a large semi-hemispherical workspace.
- Each finger is 110mm long, molded with a 3-part mold with silicone rubber, allowing them to be elastic and deformable. Nylon tendons are inserted into four cavities after curing.
- Each finger has a central conical cavity, allowing buckle-free bending, and serving as a channel for embedded proprioceptive sensors
- The following are instructions of a silicone finger's fabrication



NOE Hand

The NOE hand is modular to permit ease of fabrication and customizability by allowing the user to select the number of fingers and feedback sensors. The following is a labeled diagram of all the components.

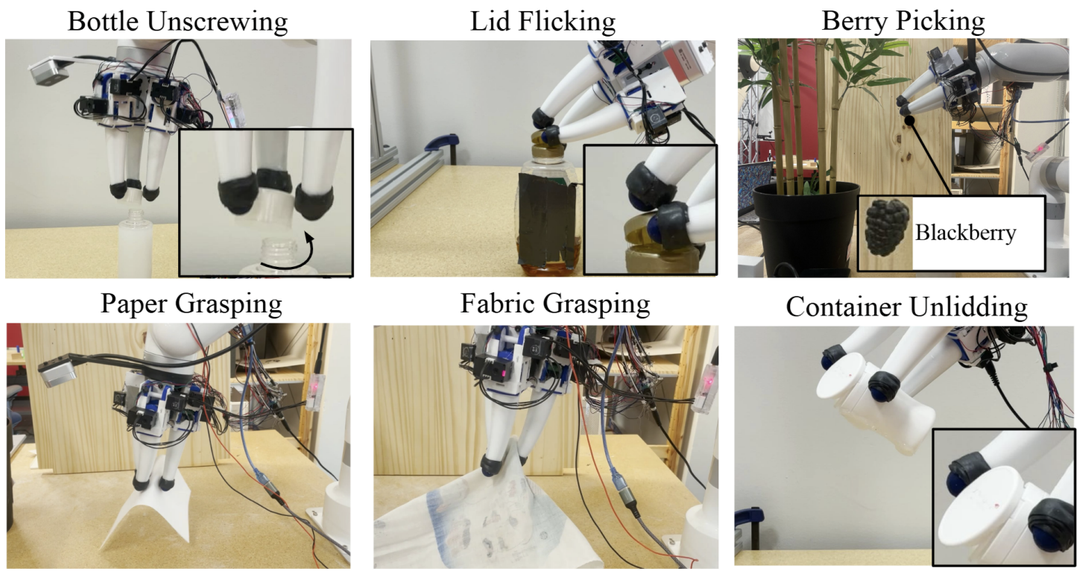


Why Open Source?

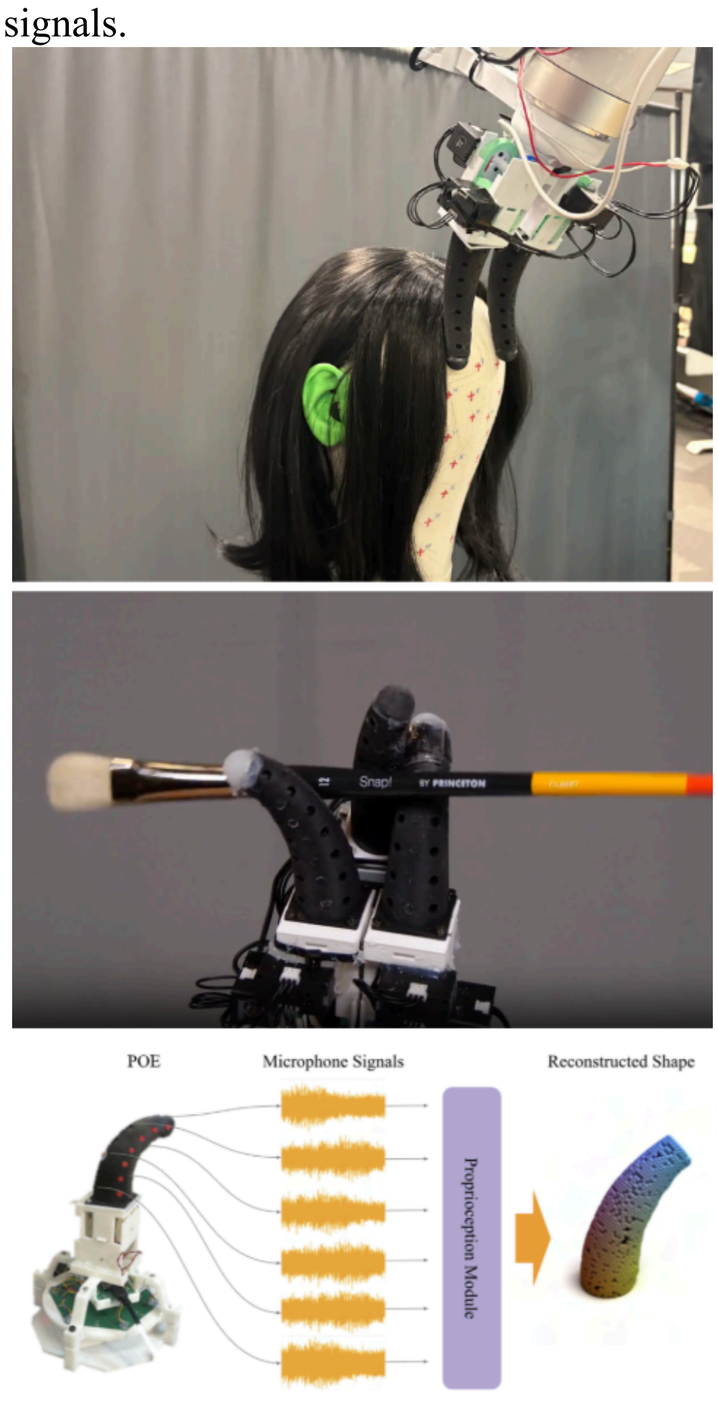
- Share NOE with other researchers looking to explore the soft robotics space
- Facilitate the manufacturing process to allow anyone to experiment with NOE
- Provide starter software and simulation environments to test and experiment with our protocols

Applications

The NOE hand is versatile and has been demonstrated to work in a variety of tasks involving actions such as grasping, unscrewing, and flicking amongst others as illustrated below.



The NOE hand framework has been used to conduct further research in areas such as robot learning studies, such as for kinesthetic learning, in-hand manipulation, and soft feedback control through non-occlusive acoustic proprioception. The following are illustrations of real-world tasks like hair manipulation, in-hand paint brush spinning, and a model for proprioception using acoustic signals.



Future Work

- Optimizing the robot design based on real use-cases to more closely simulate a human finger
- Experimenting with 3-D printable materials that can replace the current silicone material, which is often difficult to manipulate
- Developing CAD models that can replace the molds currently used
- Creating a testing environment for the starter hand to ensure it is assembled and operating correctly
- Developing starter code for specific implementations, which can be iterated on
- Researching new protocols like KineSoft, which can be used to influence the fingers' movements

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