

Fluidic haptic feedback system

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Abstract

We now created the *haptic feedback system* is *purely hydraulic driven* and can generate *mechano-tactile stimuli* to user.

When forces are applied to the fingertip sensor, fluidic pressure inside the system acts on the membrane of the feedback actuator resulting in mechano-tactile sensation to user.

Background and contributions

Background:

- Large number of upper-limb prosthetics users lack access to affordable and appropriate haptic feedback system.
- Low-cost haptic feedback system is less developed for amputees.

Contributions of this work:

- Creation of a purely mechanical haptic feedback system.
- System characterizing and human interaction test with the system.
- Analytical modelling of the fingertips compression.

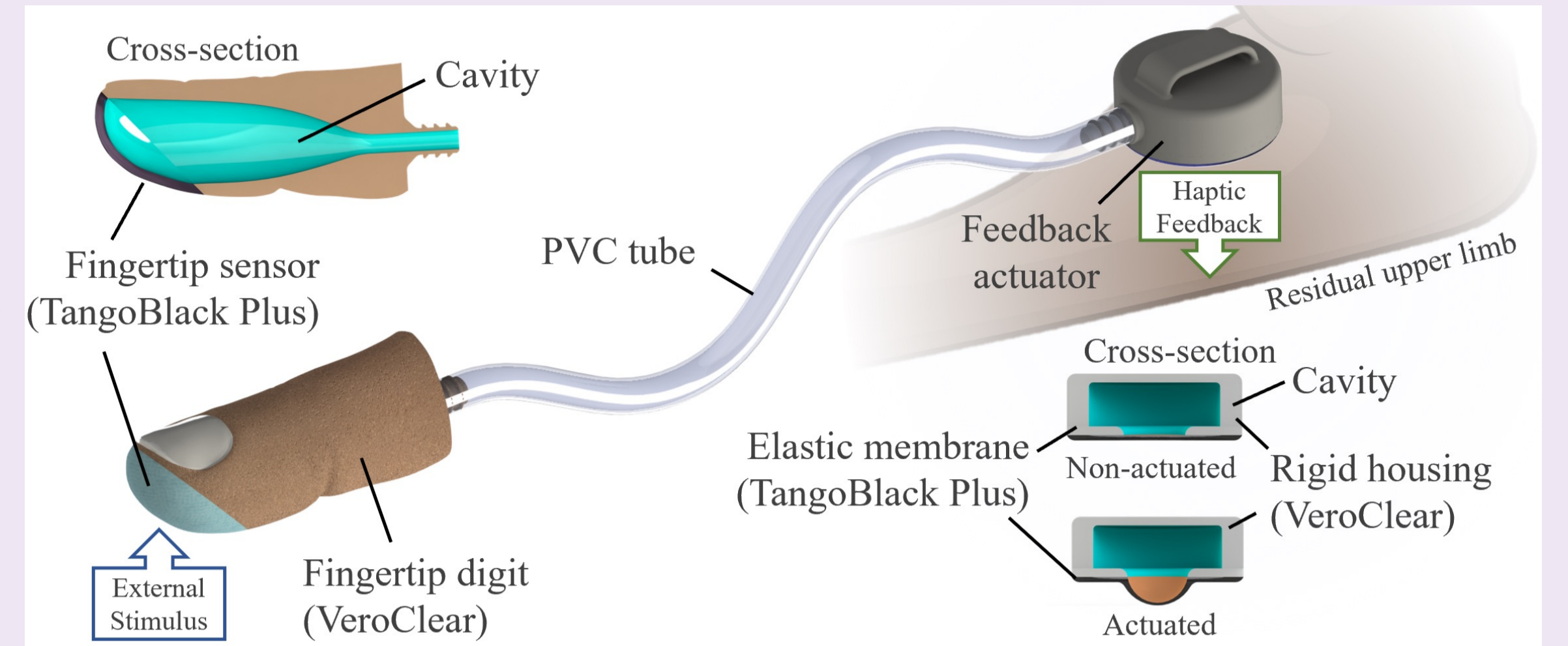


Fig. 1: CAD drawing of the haptic feedback system concept.

Design concepts and experimental results

- **Fingertip sensor:** A soft elastic membrane shapes the outer surface of a rigid fingertip with an inner cavity.
- **Feedback actuator:** an elastic membrane is used for the base with a rigid housing on the top.
- Two components are connected by PVC pipe to form a closed system

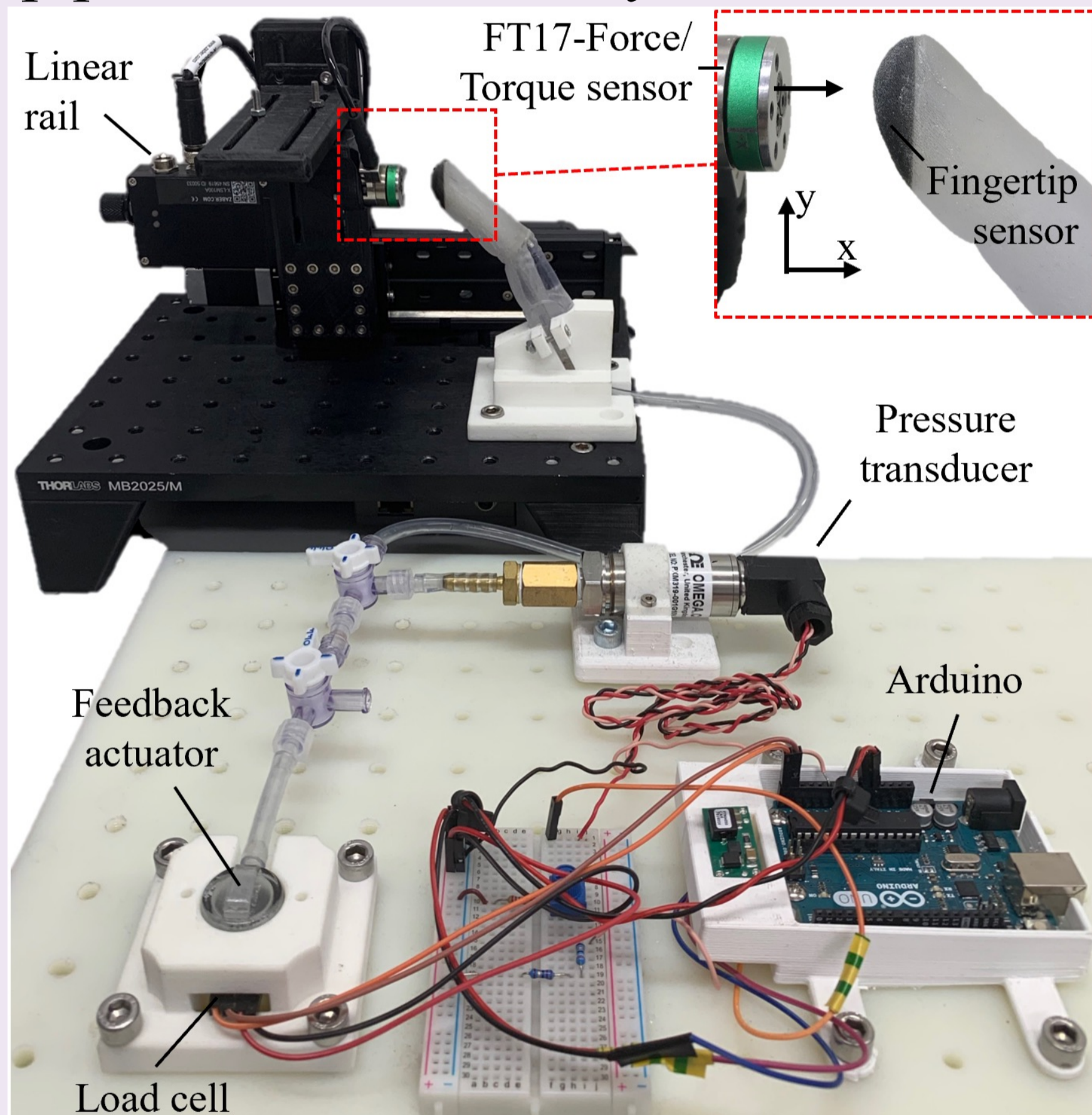


Fig. 2: Experimental setup: A Force sensor fixed to a linear rail opposes the fingertip sensor, indenting the sensor. A load cell measures the force from the feedback actuator. A pressure transducer monitors pressure change.

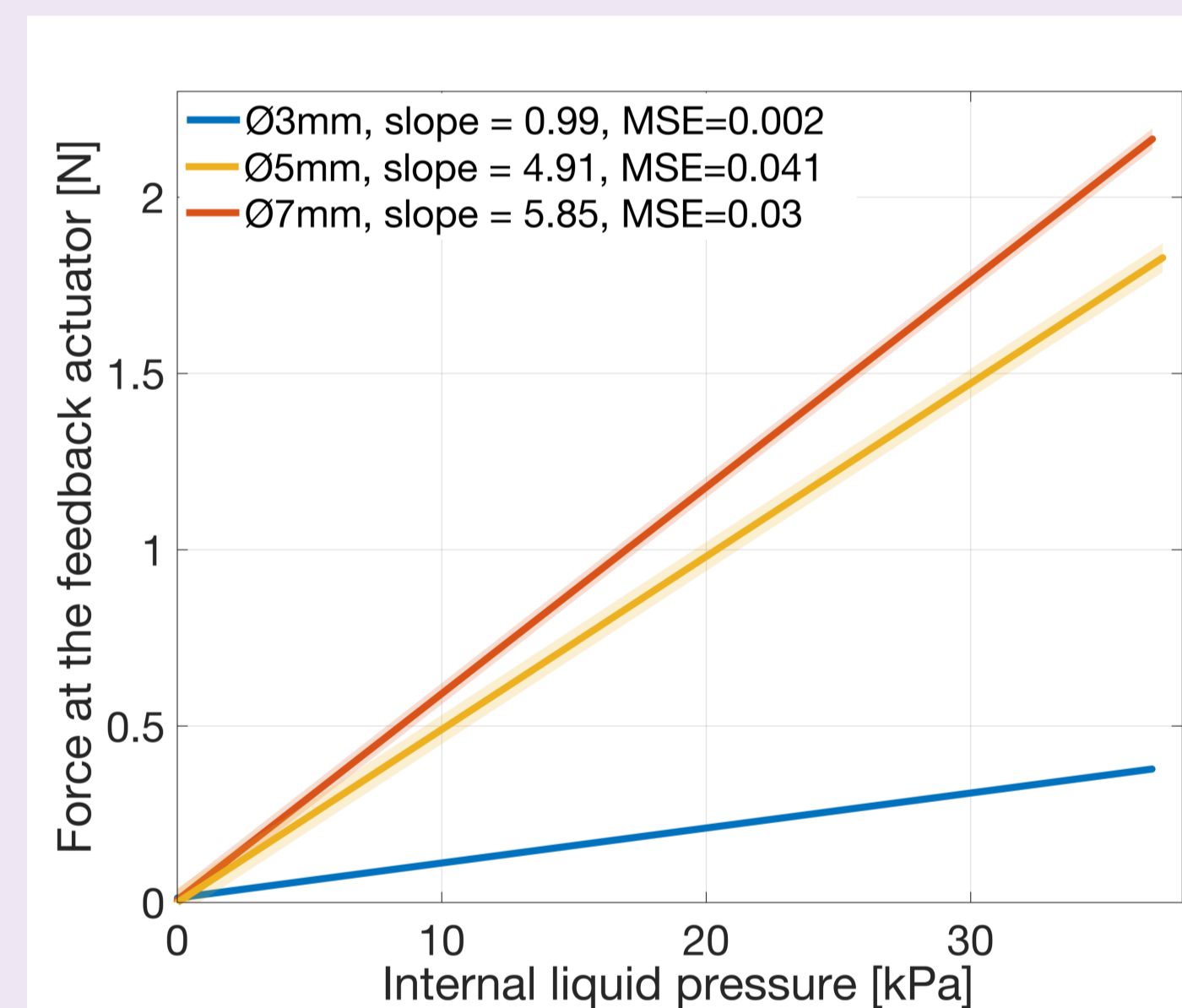
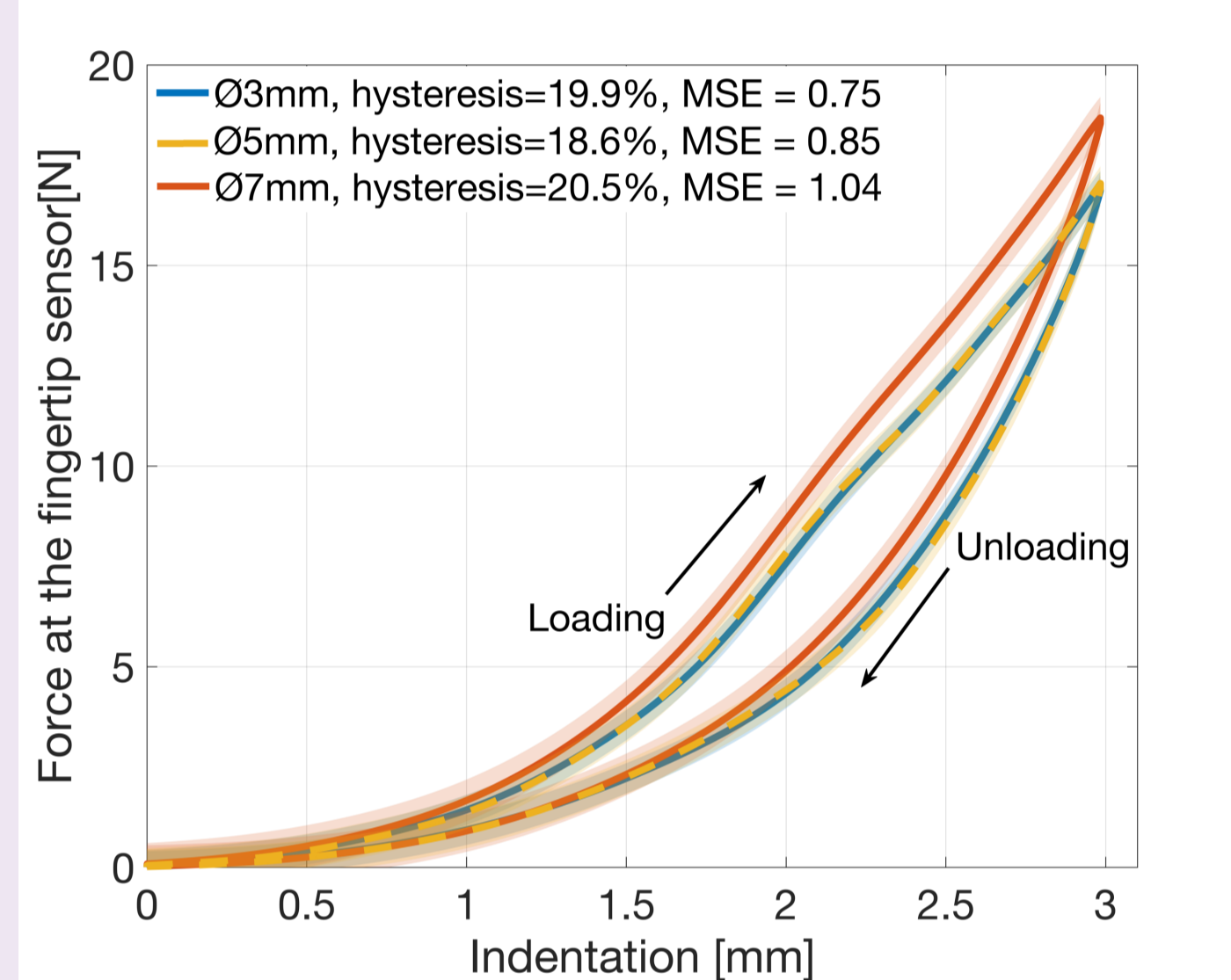


Fig. 3: (a) Non-linear loading and unloading reaction force curves against indentation. (b) Linear relationships between the output force at the feedback actuator and the internal liquid pressure

Analytical Modelling

- **Analytical modelling the compression of fingertips based on finite deformation theory**

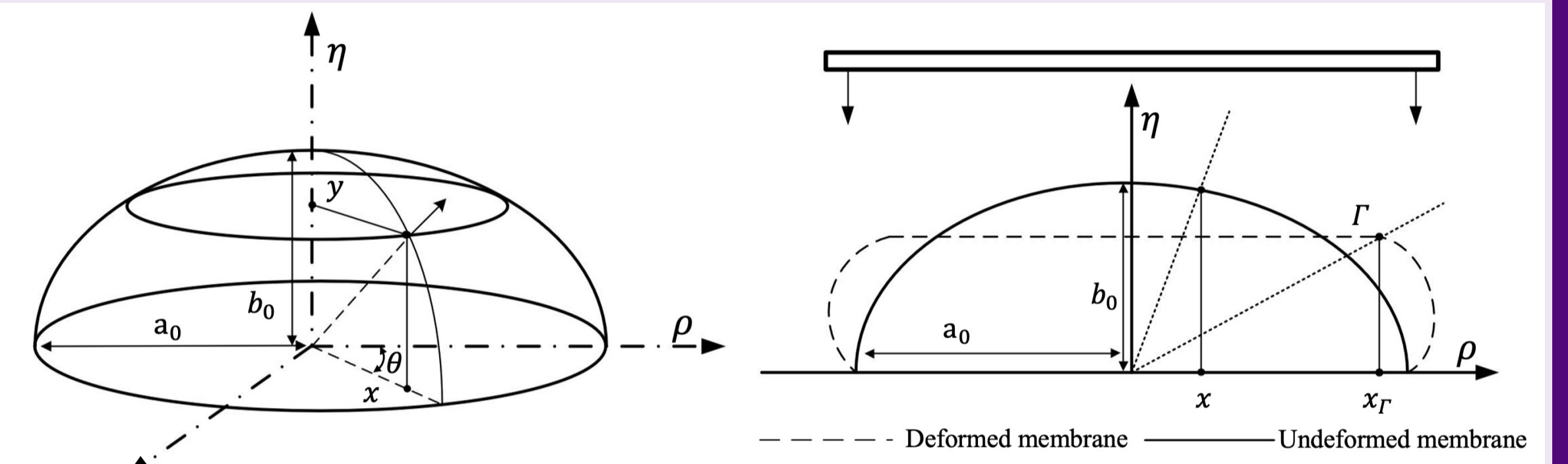


Fig. 5: (a) Overview of the ellipsoid membrane. (b) Schematic of the axisymmetric membrane model.

Calculation Results

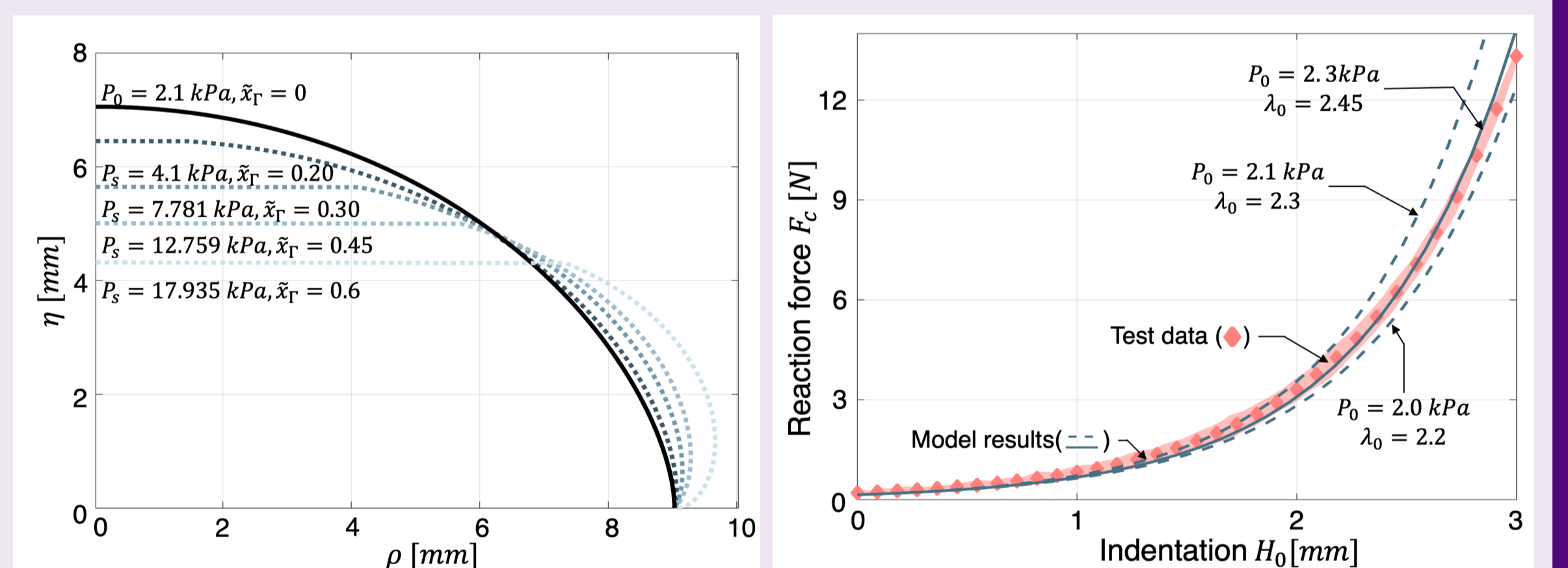


Fig. 6: Compressed membrane. With higher indentation, the membrane is flattened on the top and inflated on the side. (a) profiles of compressed membranes with different indentation and pressure. (b) Reaction force F_c on the membrane versus indentation H_0 .

Future work

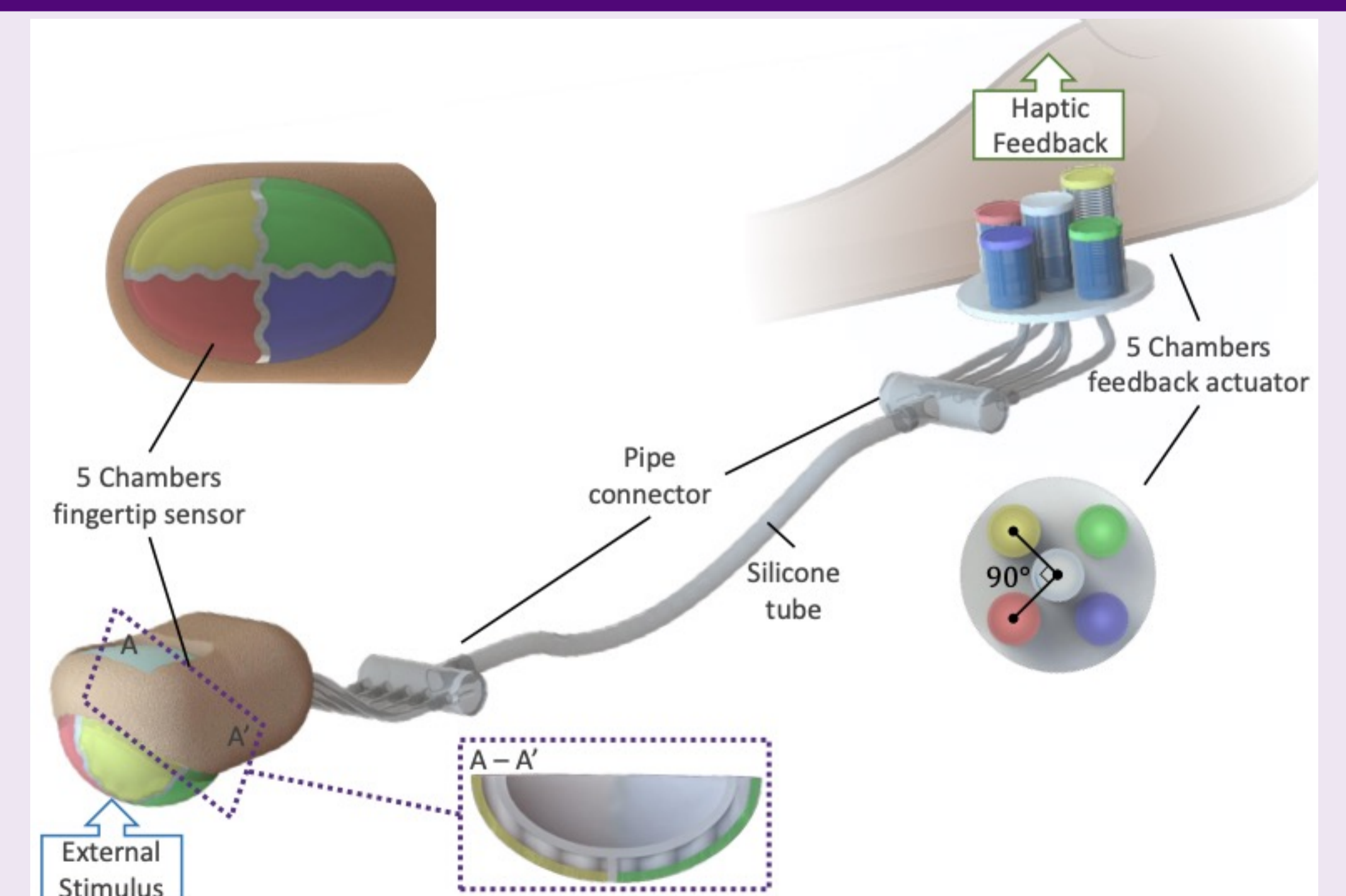


Fig. 7: CAD drawing of the five chambers haptic feedback system.

- **Multi-cavities haptic feedback system that can indicate force direction is coming soon**

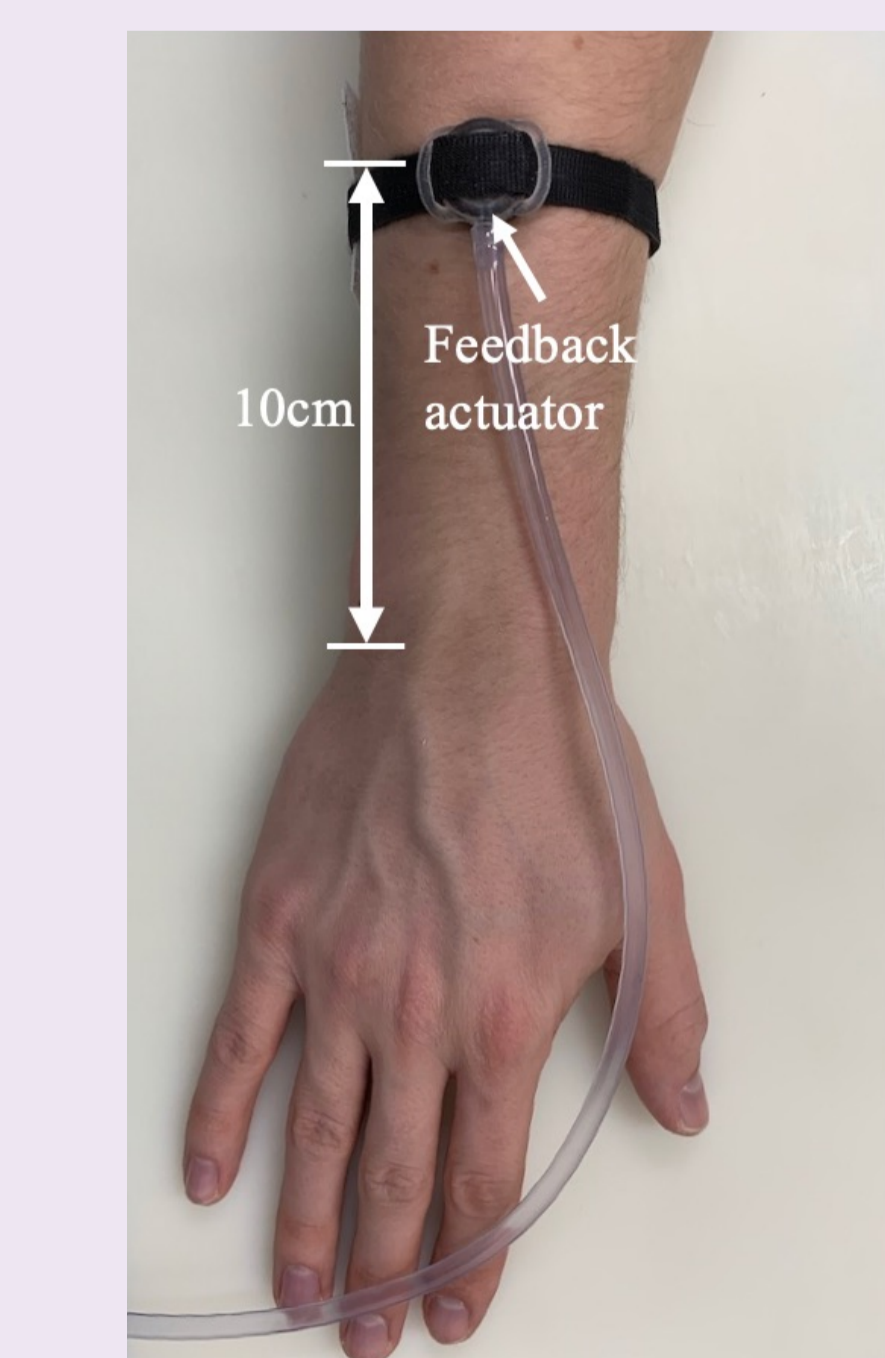


Fig. 4: Feedback actuator placed on forearm

GEN DER/ AGE	F_f/F_s (Ø5MM)	F_f/F_s (Ø7MM)
F/22	0.5N//2.9N	0.1N/0.6N
F/22	0.2N/1.2N	0.2N/1.22N
M/21	0.1N/0.58N	0.2N/1.22N
M/23	0.1N/0.58N	0.2N/1.22N
M/24	0.5N/2.9N	0.7N/4.5N
M/33	0.3N/1.8N	0.2N/1.22N
F/23	0.2N/1.2N	0.2N/1.22N
M/28	0.2N/1.2N	0.2N/1.22N
F/20	0.3N/1.8N	0.3N/1.8N
M/26	0.2N/1.2N	0.3N/1.8N

M: Male, F: Female,
F: Force of feedback actuator,
F: Force stimuli on the fingertip.

Test Results

Ø5mm: Median touching threshold is 0.2 N with IQR range 0.1

Ø7mm: Median touching threshold is 0.2 N with IQR range 0.175