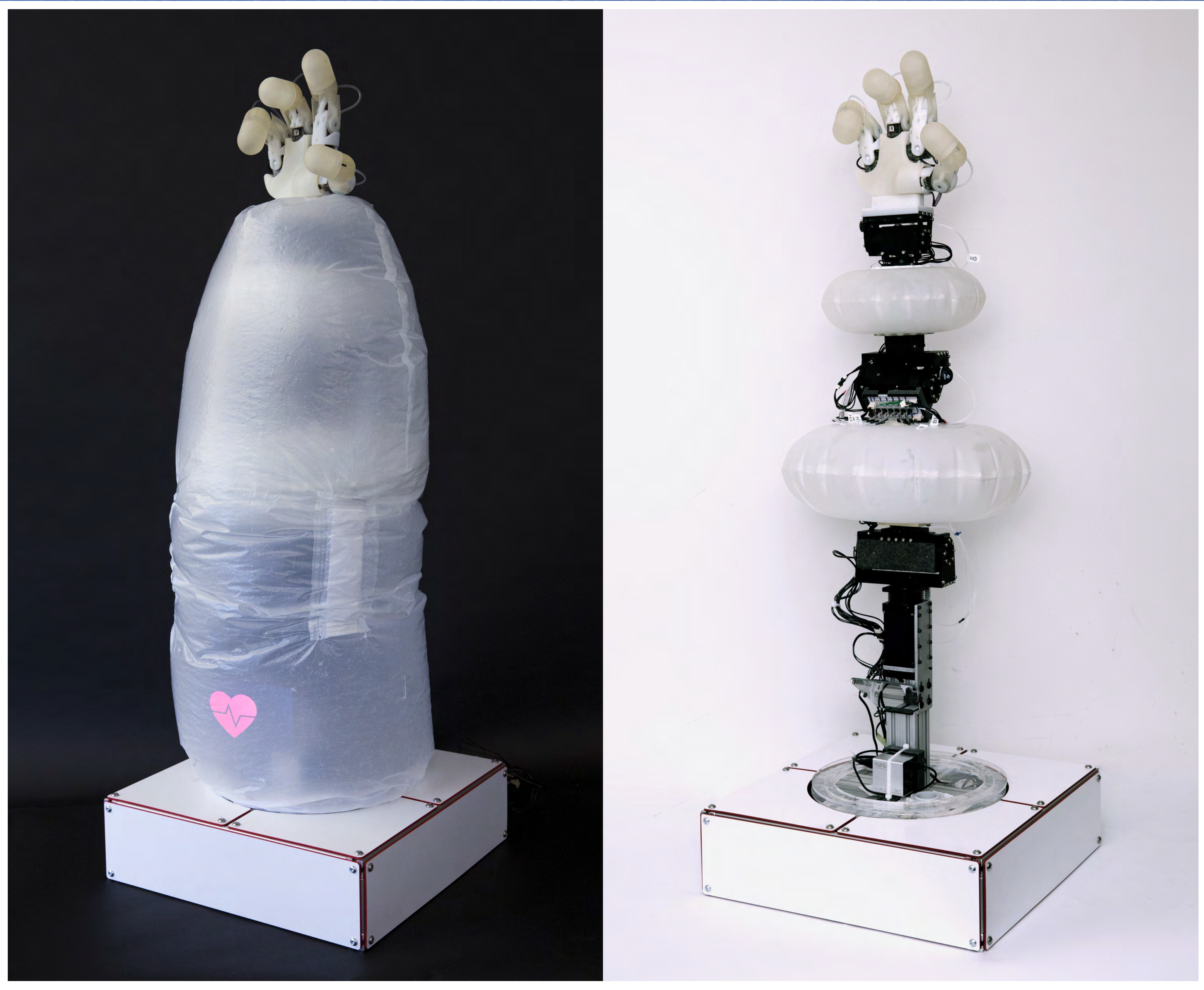
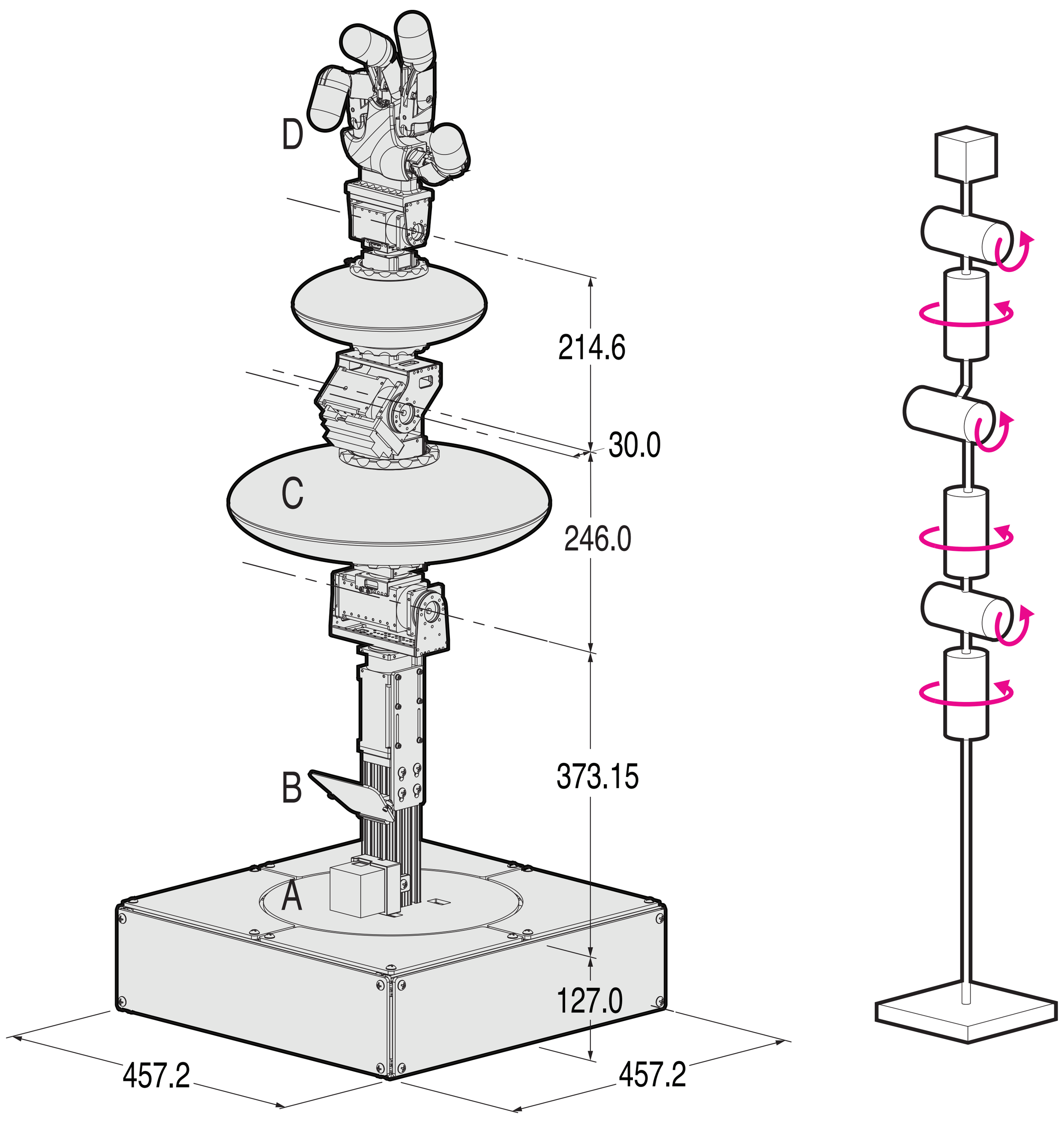
Design and Fabrication of a Soft Robotic Hand and Arm System

Alexander Alspach, Joohyung Kim, and Katsu Yamane

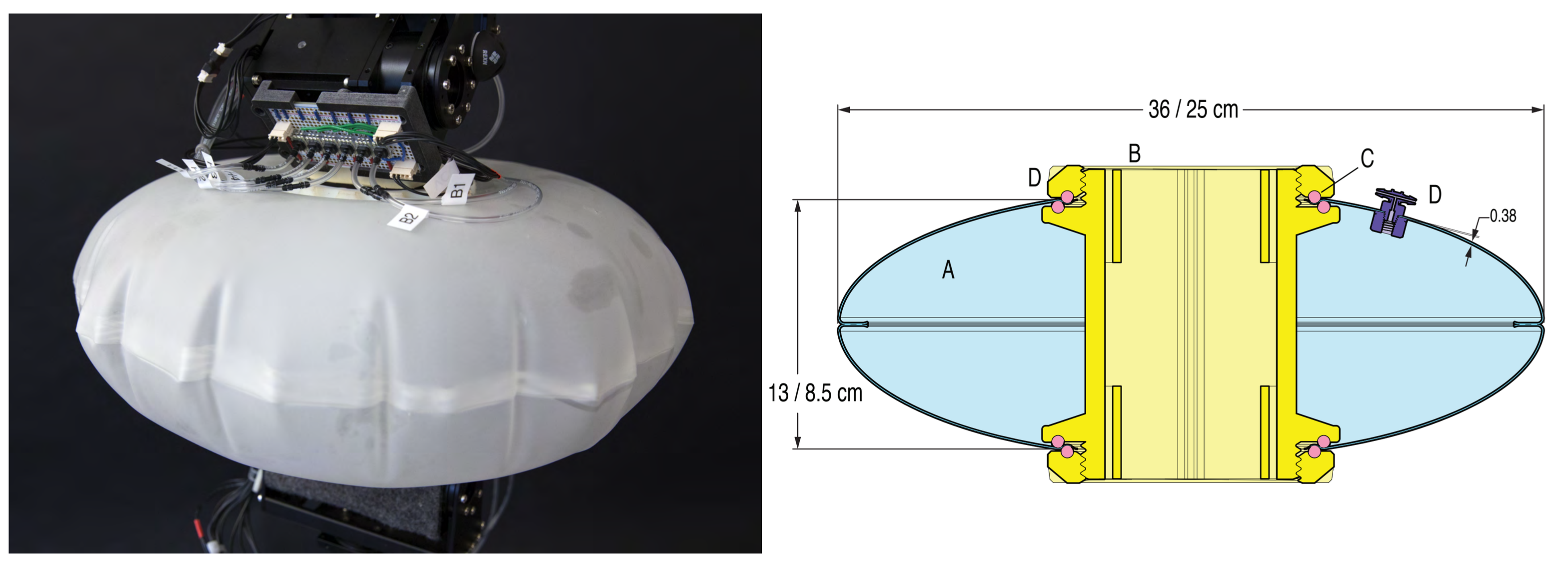
We present the hardware design and fabrication of a soft arm and hand for physical human-robot interaction. The six DOF arm has two air-filled force sensing modules which passively absorb impact and provide contact force feedback. The arm has an inflated outer cover which encloses the arm's underlying mechanisms and force sensing modules. An internal projector projects a display on the inside of the cover which is visible from the outside. On the end of the arm is a 3D printed hand with air-filled, force sensing fingertips. We validate the efficacy of the outer cover design by bending the arm to grasp an object. The outer cover performs as intended, providing enough volume and range of motion for the arm to move, and stretching at the elastic relief features heat-sealed into the cover. We also validate the hand design by implementing a grasping algorithm in which the fingers follow a trajectory, make contact, then hold their positions within a given range of fingertip pressure. Using this algorithm, the hand is able to gently grasp a soft object.



Soft robotic arm system with inflated outer cover, underlying pressurized force sensing modules and soft 3D printed hand. Our goal is the realization of a robot that can safely and robustly physically interact with people.

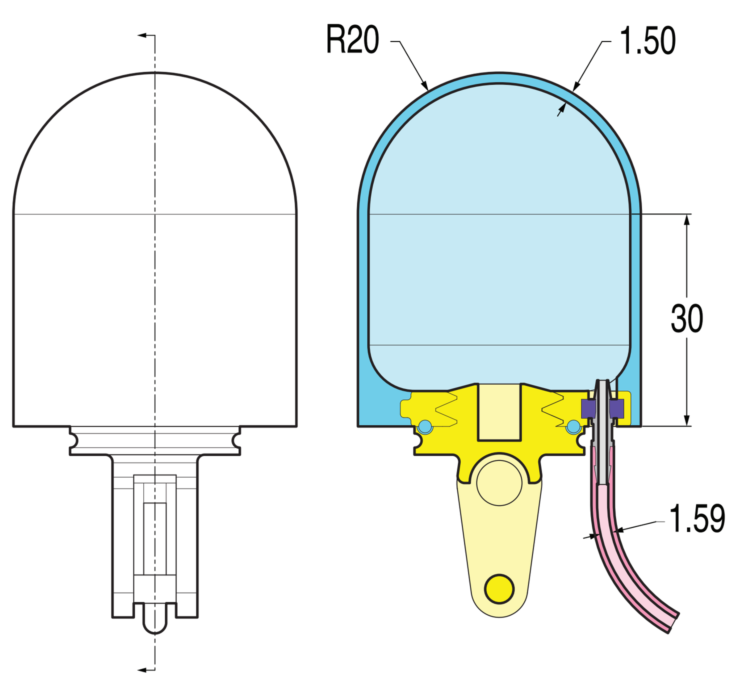


Soft robotic arm system dimensions and kinematic description. The system includes a projector (A), mirror (B), large (C) and small (D) force sensing modules, and a 3D printed soft hand (E).

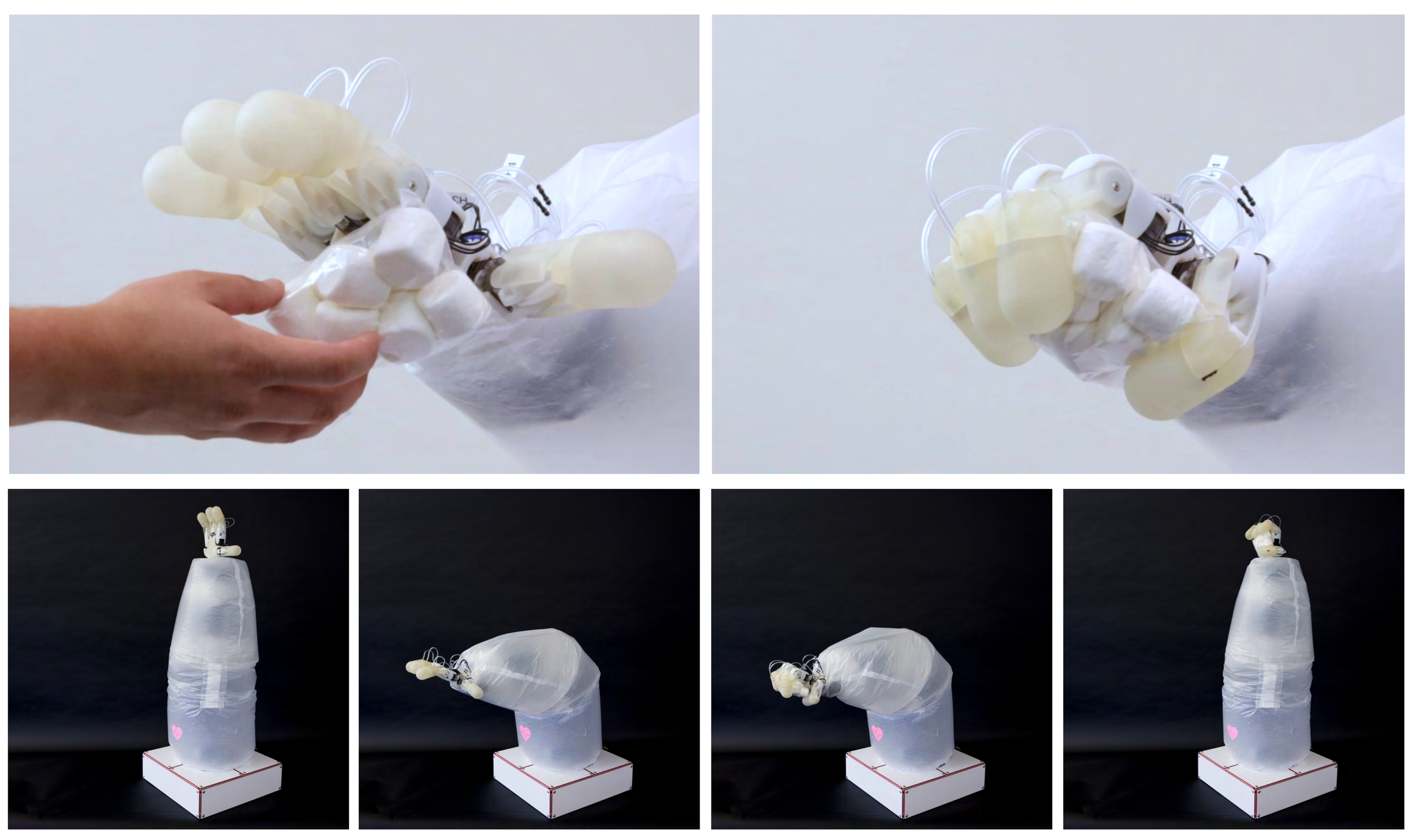


Air-filled force sensing modules encircle two links of the robot arm. These modules consist of a heat-sealed polyurethane membrane (A), a rigid 3D printed core (B), sealing O-rings (C) and caps (D), and a barbed tube fitting (E). The sensors are connected via tube to a 34.5 kPa pressure sensor.

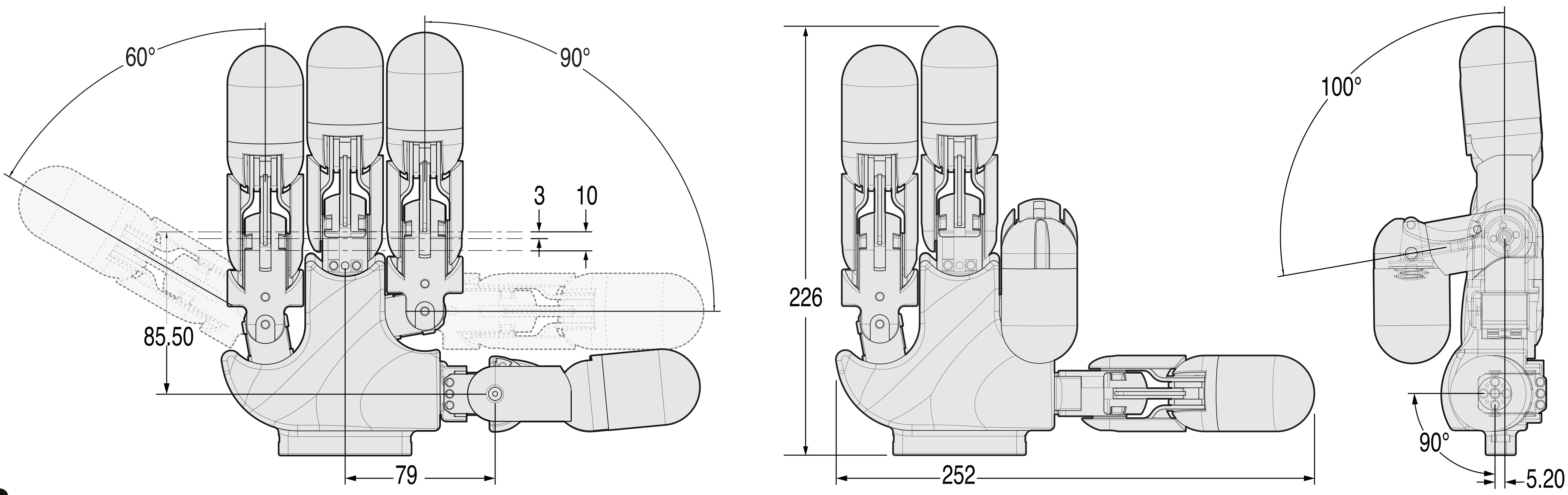
A 3D printed, seven DOF hand developed for gentle, controlled grasping. Each finger contains a four-bar linkage driven by a servo with a soft, air-filled force sensing module at the tip.



The 3D printed force sensing fingertip module is comprised of a rubber-like membrane, rigid female screw threads, 3D printed gasket for tube attachment and a 3D printed O-ring.



The images above are taken during the grasping of a bag of soft marshmallows. The hand modulates the grasping force of each finger independently based on the internal pressure of each fingertip force sensing module.



Disney Research

Work done at Disney Research in Pittsburgh, PA