Kiri-Grip: Integrated Kirigami-EMG Robotic Hand With Geometric Optimization of Cut Topologies for Assistive Grasping

Yuan, Serena (School: Menlo School)

Assistive grasping of slippery, delicate, or thin objects remains challenging for hand-impaired individuals. Current prosthetic hands and soft grippers often rely on rigid linkages or bulky external hardware that limit compliance, portability, and accessibility. Kiri-Grip is the first integrated, wearable system combining an EMG-actuated robotic hand with a kirigami soft gripper whose cut geometry determines its encapsulating shape and grasping mechanics. Nine kirigami designs were parametrically modeled and laser-cut from 0.127-mm polyester film, then evaluated using standardized force-displacement measurements and pull-out tests. Grippers consistently displayed four-phase mechanical responses of bending, unfolding, locking, and stretching that were characterized by displacement-dependent strain-stiffening controlled solely by geometry. Long-ribbon topologies outperformed corresponding standard-ribbon designs; Wing_Long achieved the highest pull-out force (26N), geometric efficiency (86%), and repeatability (CV<15%). When integrated with the EMG-actuated robotic hand, the system utilized adaptive baseline detection to enable reliable myoelectric actuation across users without recalibration. In human-participant trials, individuals with musculoskeletal disorder, neuromotor deficit, and upper-limb difference successfully grasped objects that current assistive devices struggle with, including slippery, thin, and fragile objects. These results show that kirigami cut geometry can facilitate assistive grasping through soft, conformal contact and strong gripping hold within an EMG-controlled robotic hand system. By integrating rigid grasping with kirigami compliance, Kiri-Grip expands the range of everyday grasping beyond what current assistive devices can achieve.

Awards Won:

Third Award of $1,200