A Soft Robotic Gripper Based on Bioinspired Fingers

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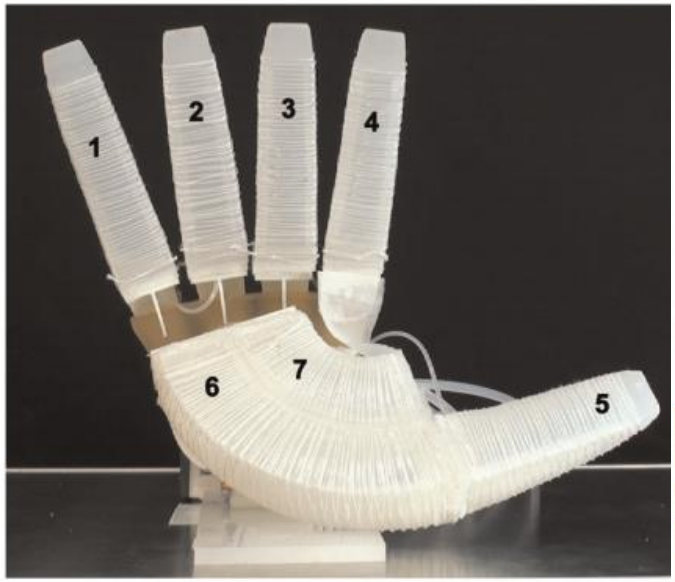
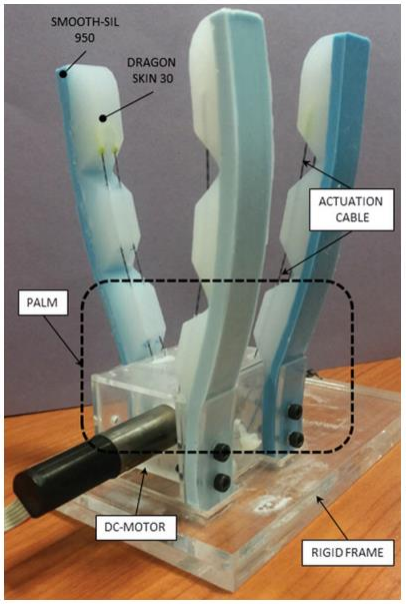
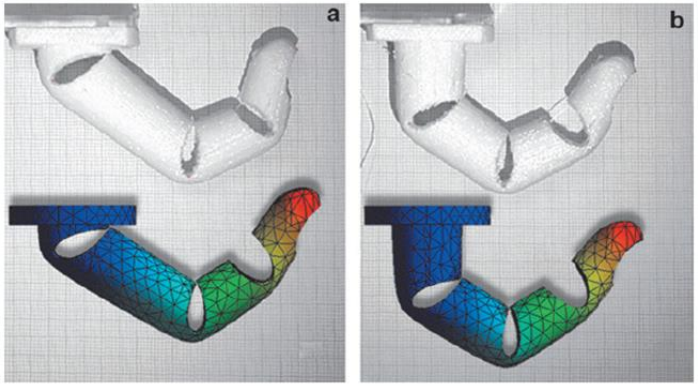
Current situation of soft manipulators

- **With a rise of applications where delicacy and adaptability are prioritized, soft manipulators have gained much research attention recently**



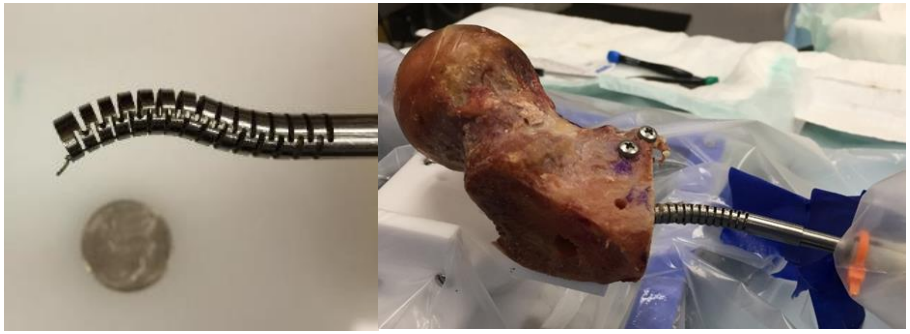




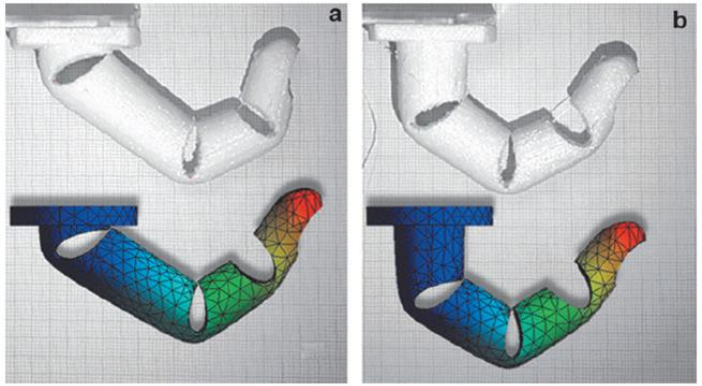
- **However, existing soft fingers often do not have enough DOFs and can only complete the bending movement in one plane compared with human fingers, which limits their dexterity**

Inspiration

- **Continuum dexterous manipulator has been used in surgical treatment**
- **3D printing technology has been widely used in the field of rehabilitation**



Alambeigi F, Wang Y, Sefati S, et al. A curved-drilling approach in core decompression of the femoral head osteonecrosis using a continuum manipulator[J]. IEEE Robotics and Automation Letters, 2017, 2(3): 1480-1487



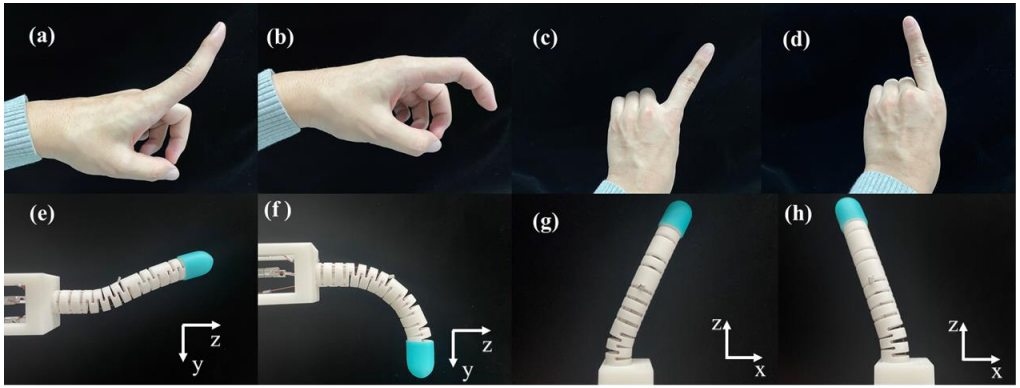
Mutlu, Rahim, et al. "3D printed flexure hinges for soft monolithic prosthetic fingers." *Soft Robotics* 3.3 (2016): 120-133.

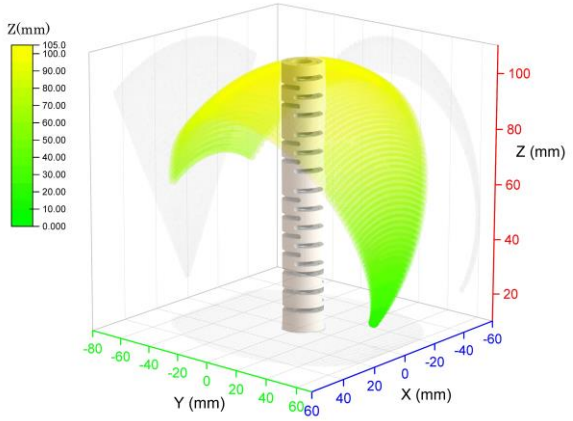
The structure of the soft finger

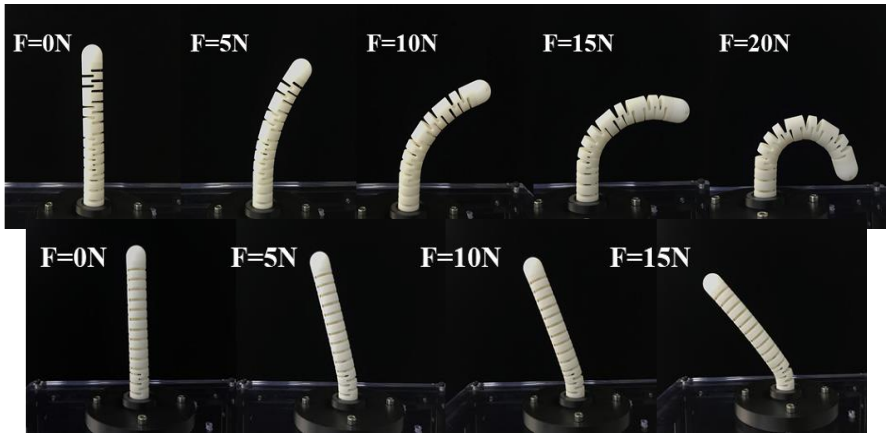
- Made of elastic 3D printed materials
- Similar size as a human finger

- Use continuum structure for PIP and DIP joint
- Two sections notches perpendicular to each other conform the MCP joint

Kinematic

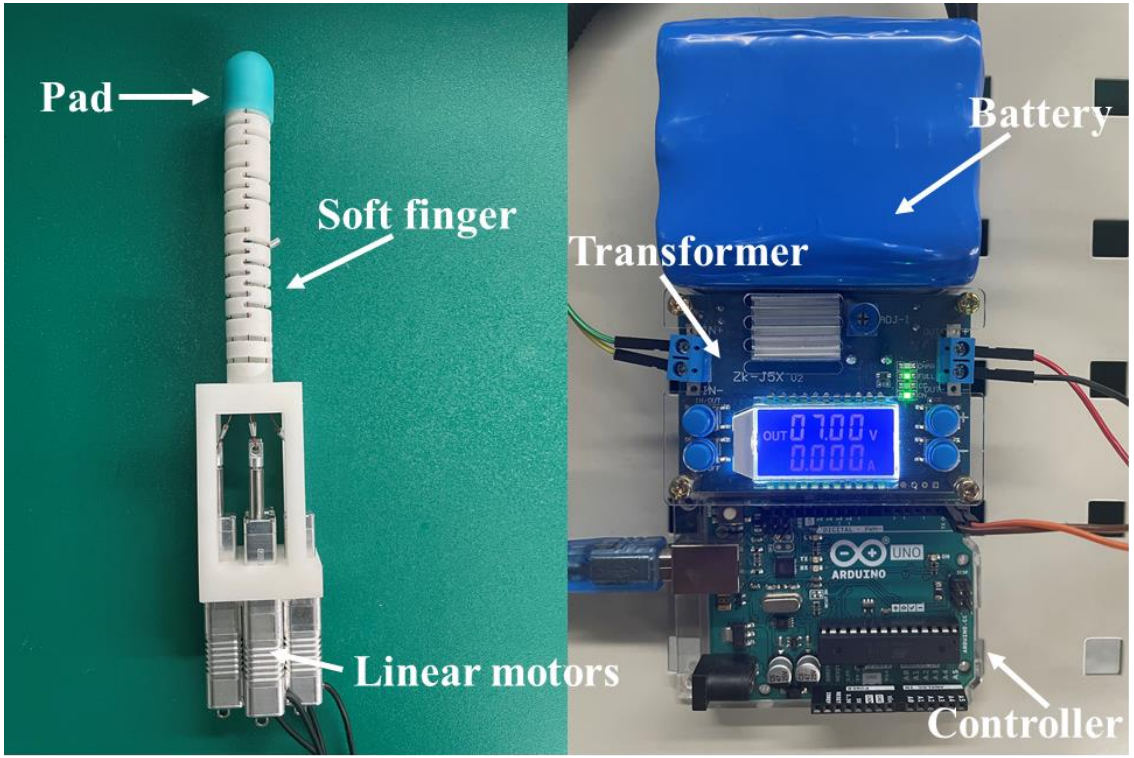






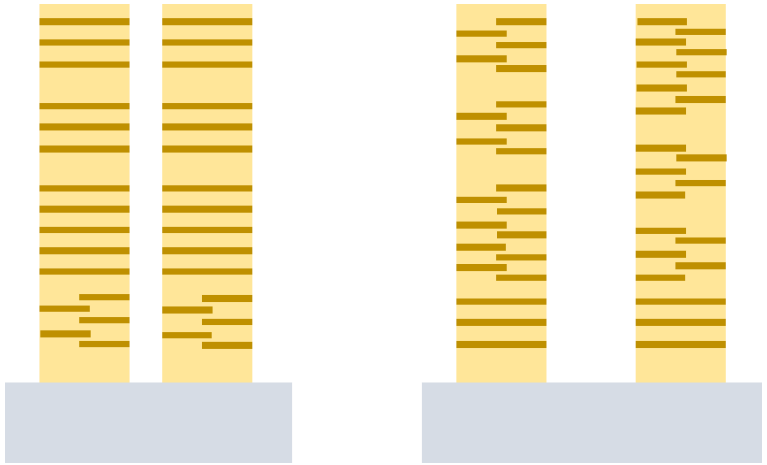
- **Capable of performing forward/backward bending, and abduction/adduction motions**
- **The workspace of the soft finger is a part of ellipsoidal shell**

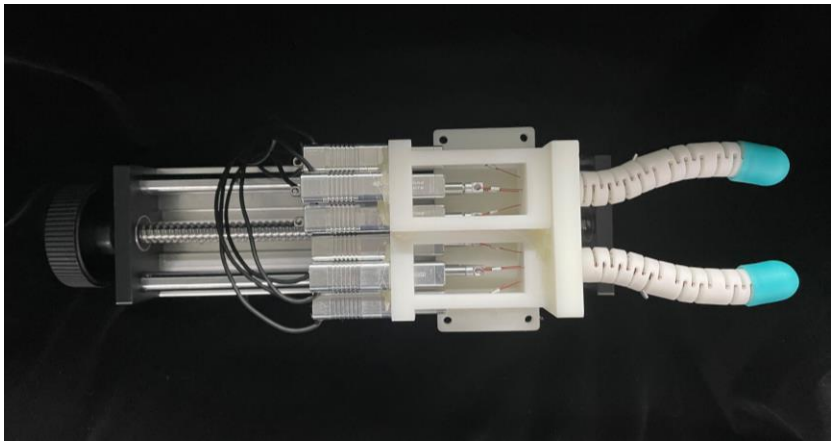
A single bioinspired finger module



- The soft fingers are made of nylon material by 3D printing technology
- A silicone finger pad is installed on the distal end of the finger
- Each tendon is actuated by a linear servo motor
- A battery is used as power source of the module which can provides a constant voltage through a transformer
- An Arduino uno is used as the controller of the system

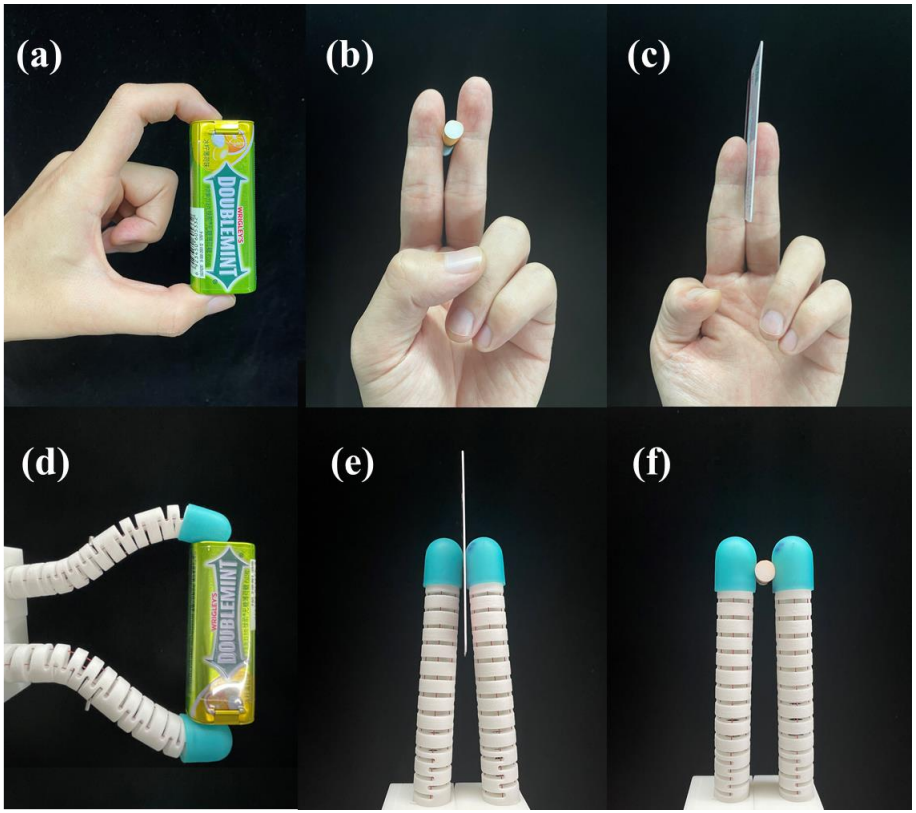
The two-fingered gripper





- Two assembly methods involving two fingers
  1. assembling two fingers face to face in the direction of forward bending motion
  2. assembling two fingers where the abduction direction of one finger opposite to the adduction direction of the other finger

Precision grasp



(a) pinch a long prism object with the index finger and thumb

(b) holding a cigarette with the index and middle finger

(c) holding a card with the index and middle finger

- **Fingers with only a single bending joint can not complete these two operations because the work space is limited in a plane**

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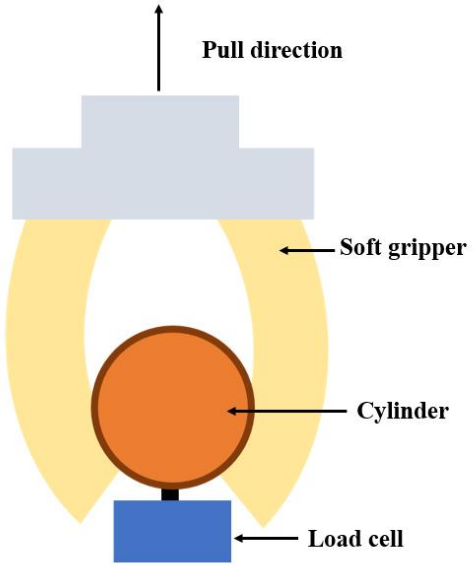
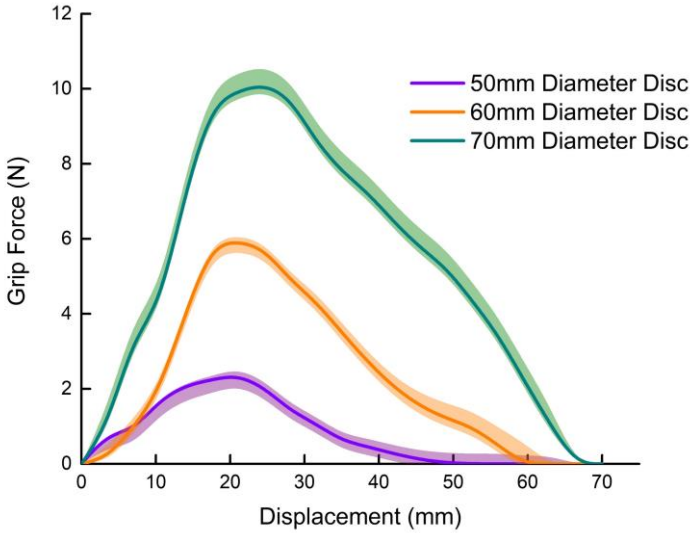
Experiments-grasp strengh





- **We test the grip force of the gripper by gripping discs of different sizes. Three types of discs are employed, they are right cylinders with equal height of 10mm, and diameter of 50mm, 60mm, 70mm respectively**
- **The characteristics of force variation reflect the compliance of the flexible gripper**

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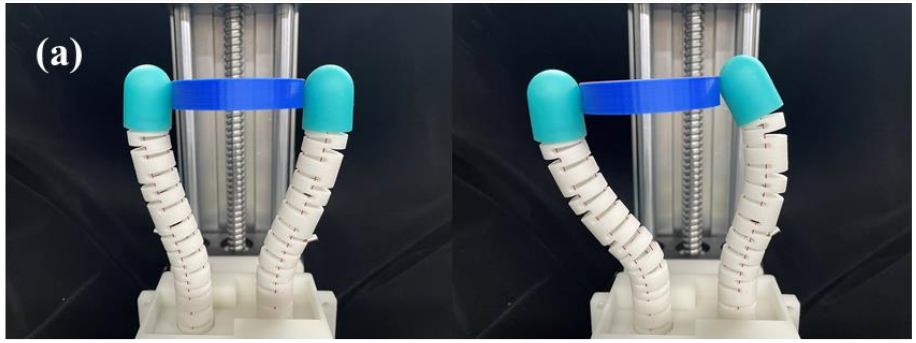
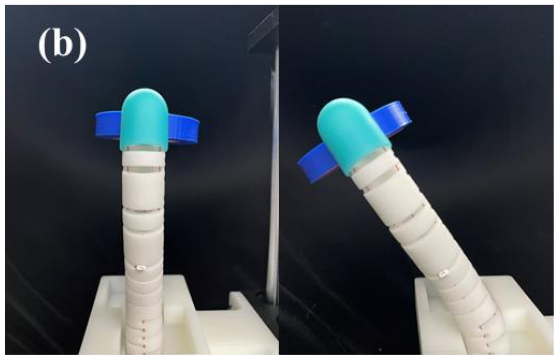
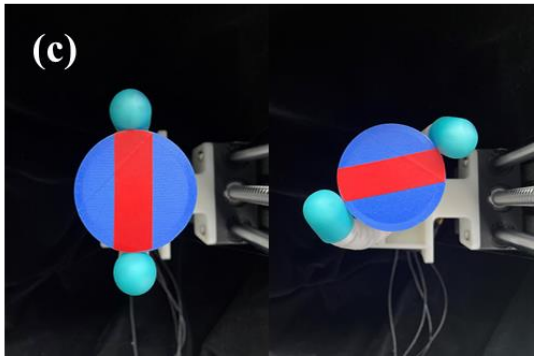
Experiments-in-hand manipulations

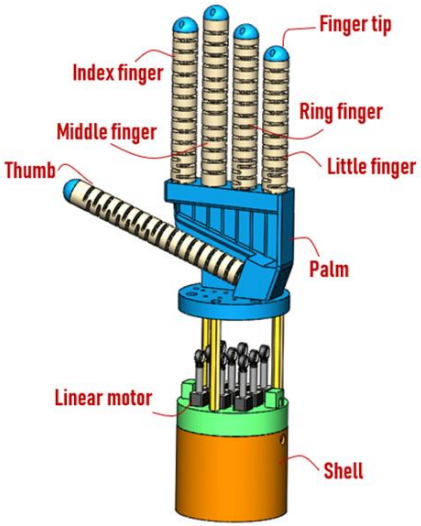


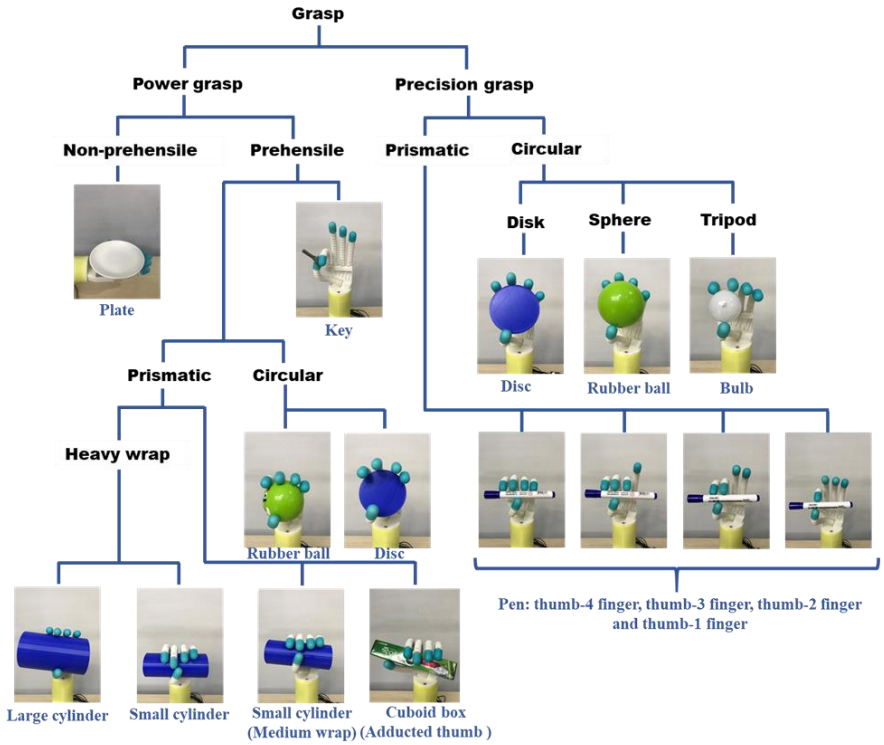




- **In-hand manipulation has been a challenging operation for dexterous manipulators**
- **3 types of in-hand manipulations are tested: moving along the x-axis, moving along the y-axis and rotating around the z-axis**

Extension and Application





- **The bionic finger can also be used to build a five-fingered prosthetic hand**
- **Complete 16 types of grasp based on grasp taxonomy**

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Conclusion

- A bioinspired, 3D printed, highly compliant and dexterous soft finger
- The workspace of the finger is expanded substantially, and the finger is capable of sophisticated tasks
- Results show that

  1) Capable of performing forward/backward bending, and abduction/adduction motions

  2) Enough compliance to grip objects with different diameters

  3) Realizing 3 types of in-hand manipulaitons

Thank you