

#### Purpose:

- Four million chronic stroke survivors with hemiparesis or other similar conditions in the US.
- Another six million in developed countries globally.
  - Greatly inhibit activities of daily living (ADL)
- RTP (repetitive task practice) is used to improve hand strength, accuracy, and range of motion.
  - These methods are labor intensive, costly, and slow thus may cause patience challenge compliance.
- System: makes physical therapy more affordable, accessible, results driven, increasing potential.

#### Constraints:

- Weight of the hand mounted device shouldn't exceed 0.5 kg while that of the mounted components (batteries, controllers, valves ...) shouldn't exceed 3 kg (typical consumer electronic weight)
- Hand mounted device should allow a certain degree of customization for hand size
- Hand mounted device should be made with a soft and compliant material to allow some movement while unpowered.
- Soft actuators must have 3 bending degrees of freedom for each finger to follow range of motion of natural fingers. Similarly, at least 2 DOF around the CMC joint of the thumb to enable opposing grasps.

#### Points:

- A human hand can generate up to 300 N and 450 N in the cases of females and males respectively
  - However, maximum grip strength isn't necessary to reproduce in order to live a normal life since most objects of daily life do not weigh more than 1.5 kg.
  - Coefficient of friction of 0.225 and distal tip force of around 7.3 N per soft actuator is needed to achieve the grip

- About the control requirements, a minimum controller bandwidth of 10 Hz (or 20 times that of the soft actuator) is ideal.
- 30 open-close finger cycles every minute is sufficient for repetitive flexion/extension exercises.
- To support repetitive rehabilitation and assistance with ADL, two and six hours are required for continuous and intermittent operation respectively.
- Friction in the tubing is a factor affecting the response time of the glove. To reduce it a wider tube could be used or a higher fluidity capacity pump.
- Using a faster valve response time could reduce the overshoot that occurs due to pressure build up.

#### Design:

- Multi-segment joint actuators where a single actuator is split into multiple segments that can either extend or bend (this is done by adding or removing of strain limiting layer)
- Sliding mode controller was used since it doesn't require the system to be explicitly modeled, which is highly appreciated in complex systems.

#### Limitations:

- The required pressure needed to move the system is in the hundreds of kPa.
- Complex design compared to other options (fiber-reinforced actuators with limiting layers controlling it)

#### Pros:

- More customizable and versatile than other actuators in finger movements since strain layers can be added and removed to perform the required movement.

