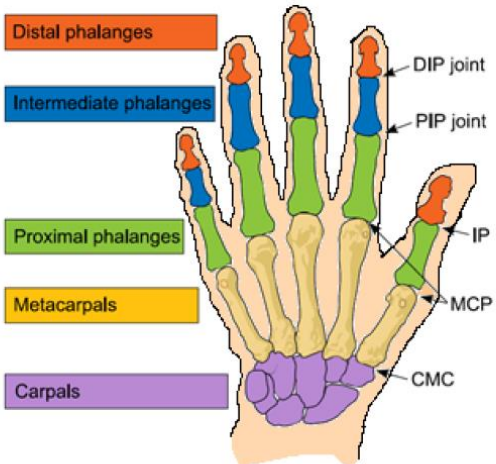
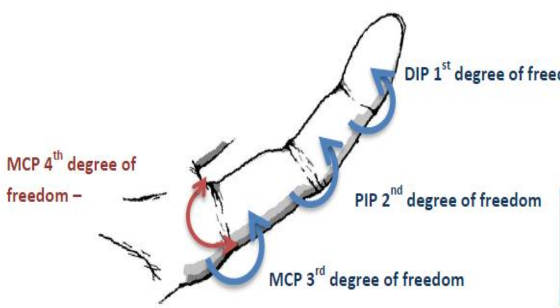
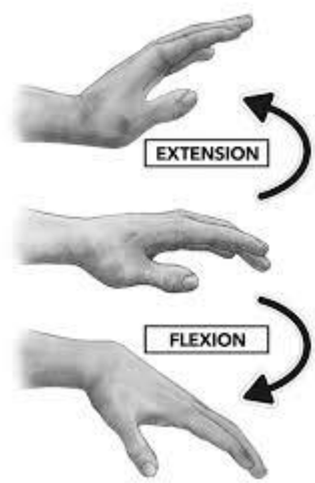
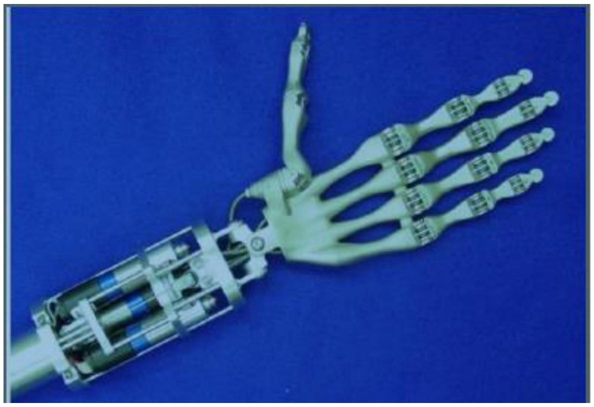


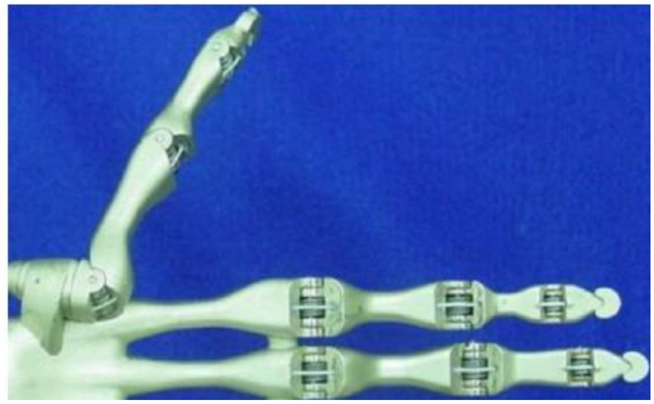
The human finger in total has 4 degrees of freedom. Three of these are the rotations of each joint (DIP, PIP, MCP) which combine to control flexion and extension of the finger. The knuckle (MCP joint) also allows for abduction/adduction. In the thumb the lower CMC joint also allows for abduction/adduction – which gives 5 DOFs in the thumb





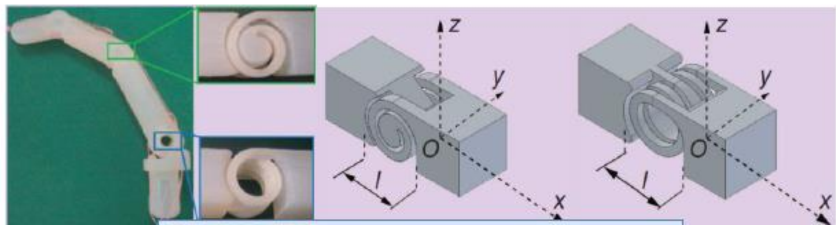
1st mechanism:



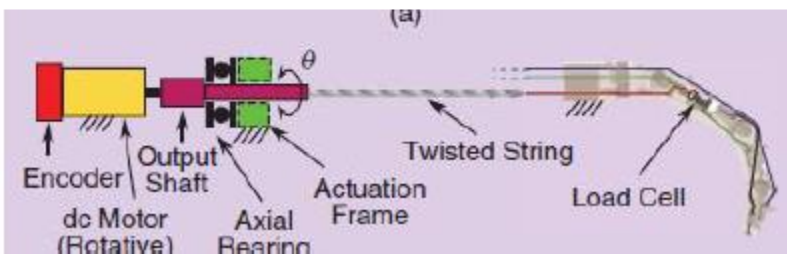


The above images show the tendons (white cables) running through the fingers and thumb. Brushed DC motors drive a pulley system which tensions the tendons. This tension results in all three finger joints closing simultaneously. In order to open the fingers, springs have been implemented into each joint. When tension is released in the tendons these springs return the finger to its initial open position. The third image shows the coiled steel springs incorporated into each joint. By incorporating springs, the energy stored in the joints during the closing phase is used to perform the opening phase without the need of further actuation

2nd mechanism



linear springs can be used to return fingers to an open position or the spring mechanism can be directly incorporated into the structure. A DC motor is used to twist two tendons together. This shortens the length of the tendons which generates tension and closes the fingers.



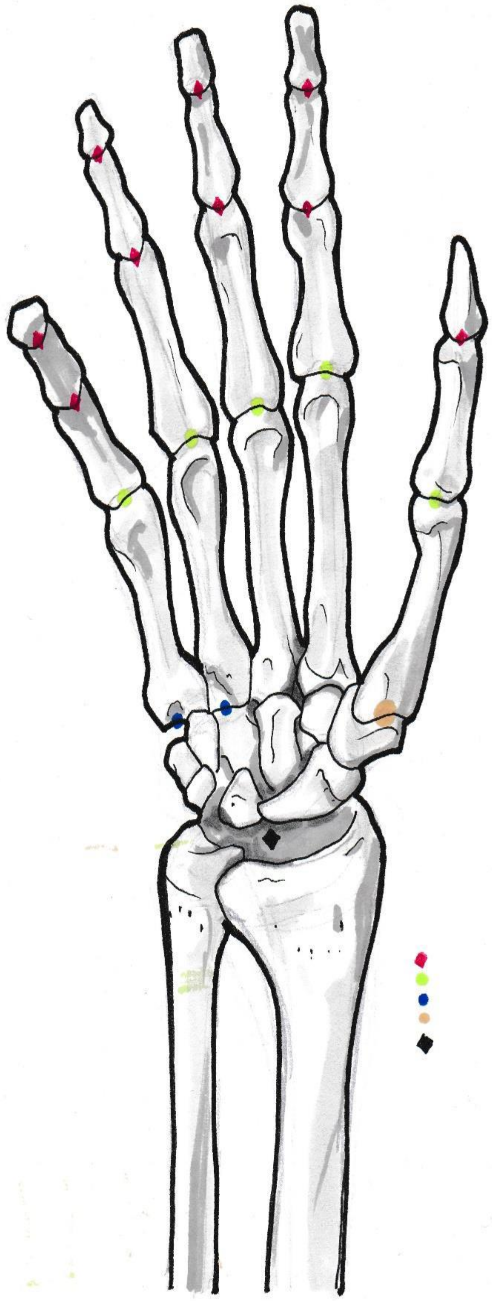
The big advantage of this method lies in the fact that there is a direct transformation of rotational motion in the motors to linear motion in the tendons – no intermediate pulley system is required to move the fingers. Another advantage is that large forces can be exerted by the fingers. Essentially, the tendon pair can continue to be twisted, increasing the force exerted by the finger – until of course there is a mechanical failure somewhere. However, this can be a slow way of actuating fingers since many rotations are required in order to fully close a finger.

3rd mechanism

This achieves a high number of DOF by using a large tendon network & achieves 20 DOF’s

As previously discussed the actuators used in this system are standard servo motors. These motors can be controlled to rotate to angular positions up to ± 90 degrees from rest. Since the artificial tendons move fairly little in order to open and close each finger, the angular precision of each servo somewhat affects how precisely the fingers can be controlled. Relatively inexpensive servo motors have been used in this system to maintain a low cost.

[Thesis Final.pdf]



1 Single-axis hinge joint with elasticity

2 Dual-axis "Condyloid" joint with elasticity

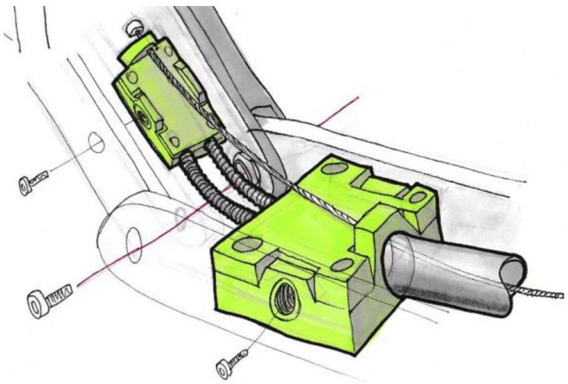
3 Dual-axis "Saddle" joint with elasticity

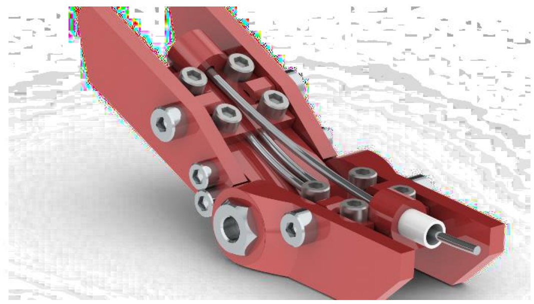
4 Three-axis wrist joint

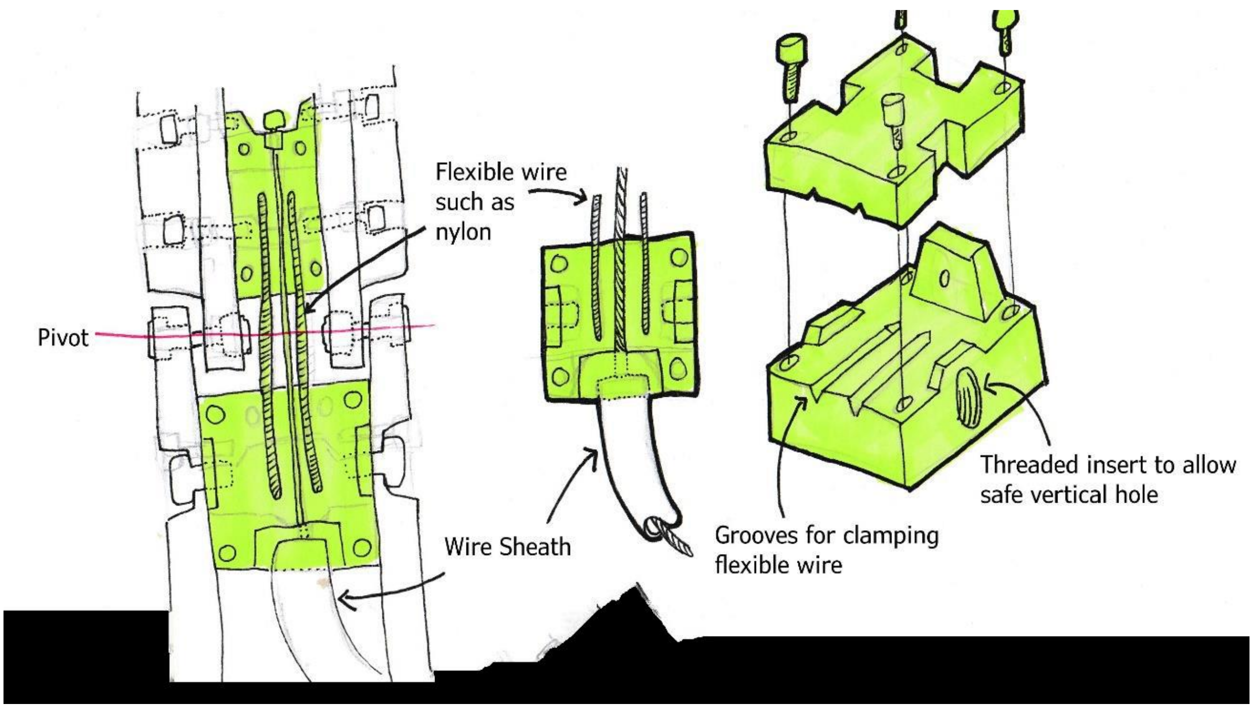
5 Actuation system

1 Tejoto(yeBHA)tavlepestugtoctantsaspesgaxgoptwebsytavlhutnejotoiseetpotowleseze

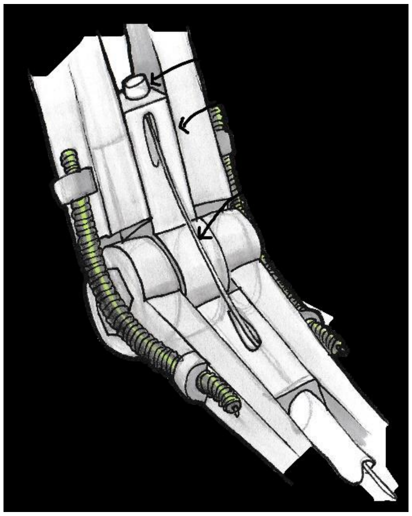
Tfstdegusedapticaivligpasgefwdxewes(casybnapsgnaicaectvie.Iuseadadsystatemenocdbesgetjoycamperbehaswdfeetepe

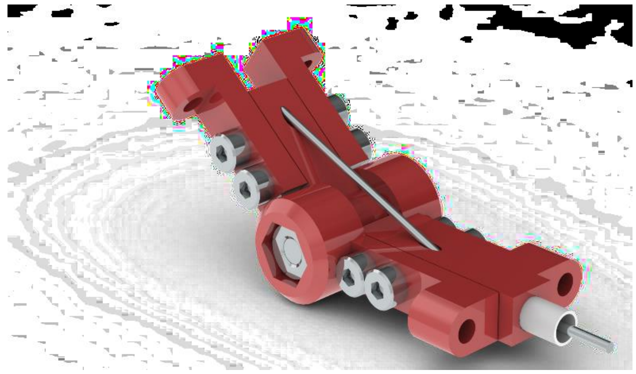


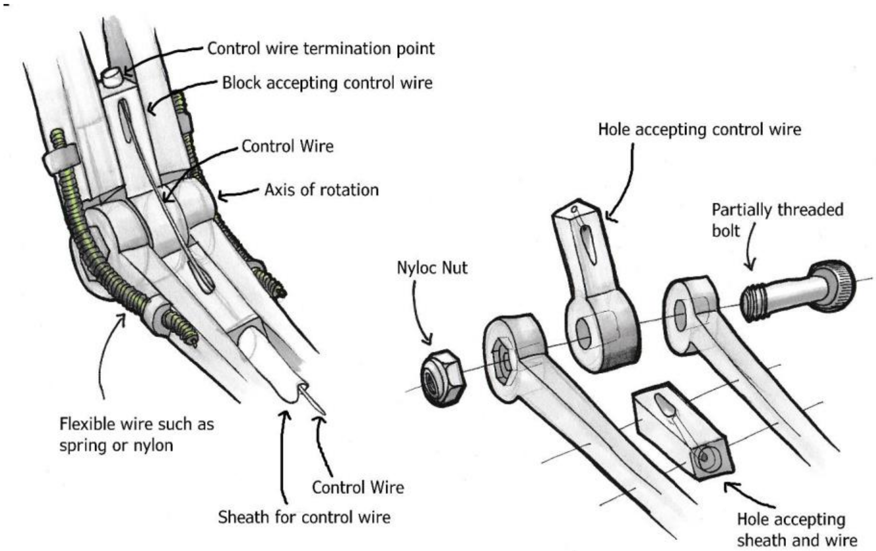




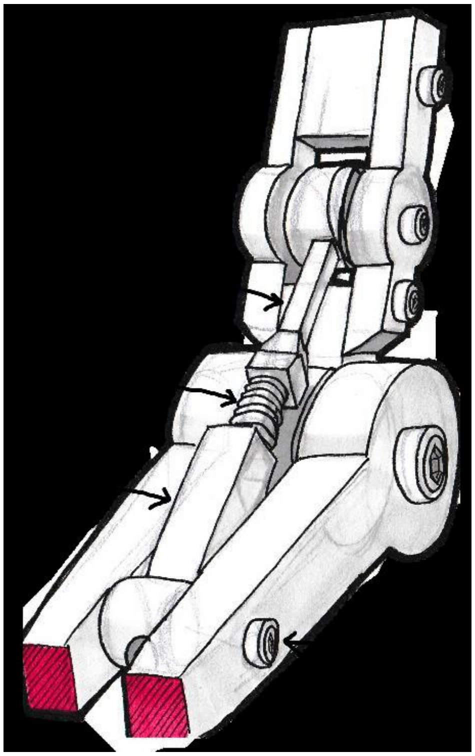
Teendogasplfautotefst.Faetaracpdosye,tsegahoyacetpvaotefxlevsengdeoiefejot

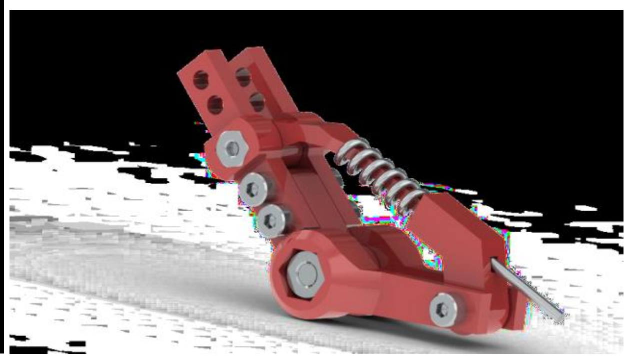


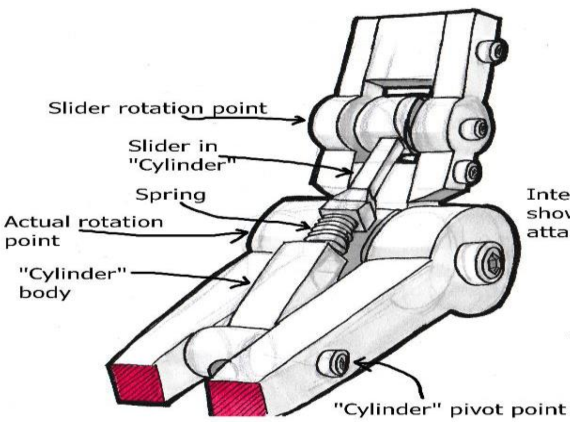


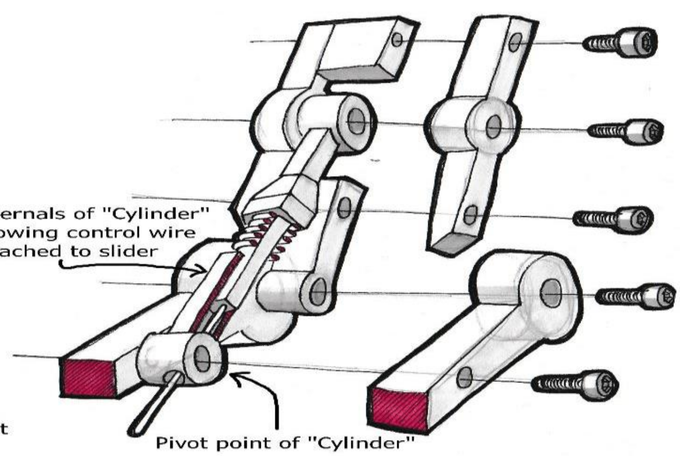

Control wire termination point
Block accepting control wire
Control Wire
Axis of rotation
Flexible wire such as spring or nylon
Control Wire
Sheath for control wire
Hole accepting control wire
Partially threaded bolt
Nyloc Nut
Hole accepting sheath and wire

[illegible]

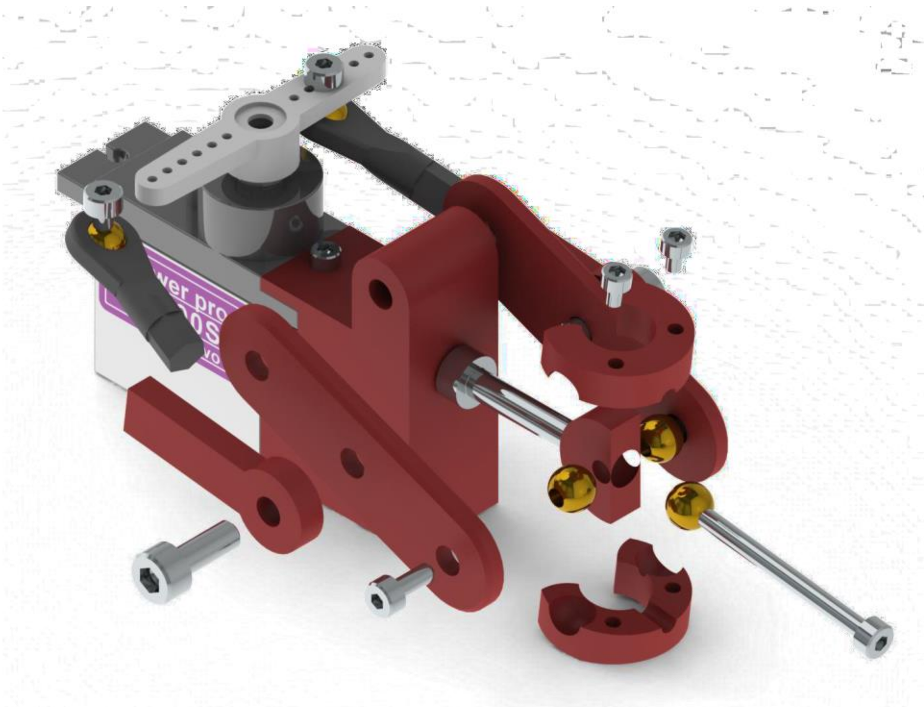


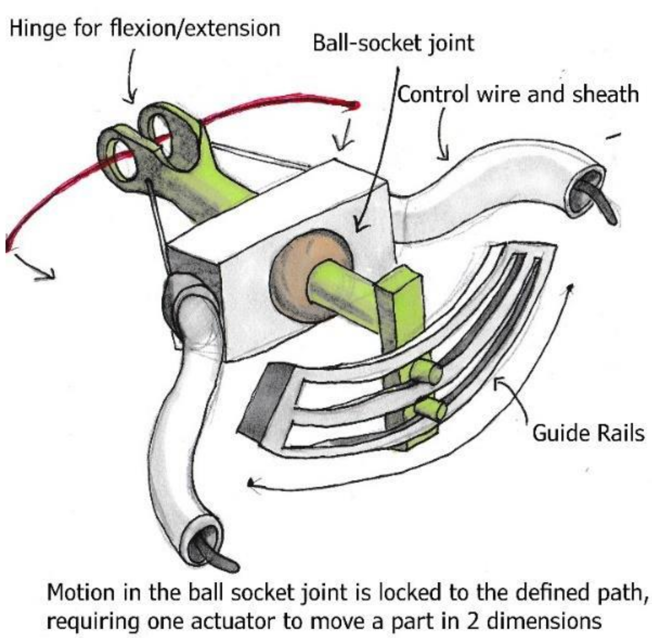


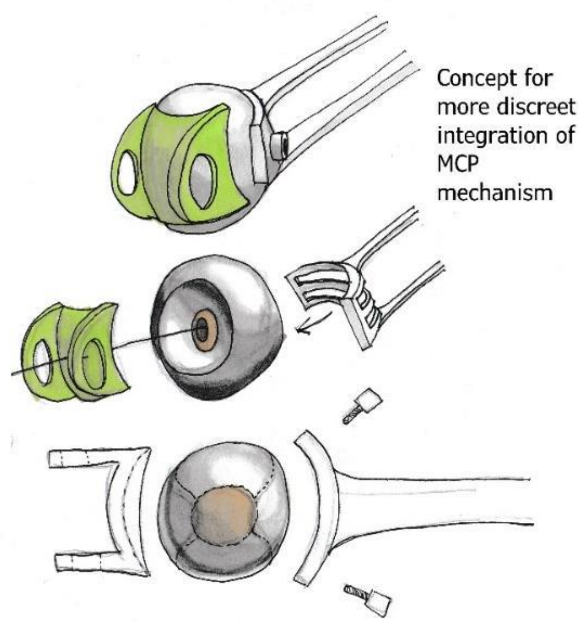

Slider rotation point
Slider in "Cylinder"
Spring
Actual rotation point
"Cylinder" body
"Cylinder" pivot point


Internals of "Cylinder" showing control wire attached to slider
Pivot point of "Cylinder"

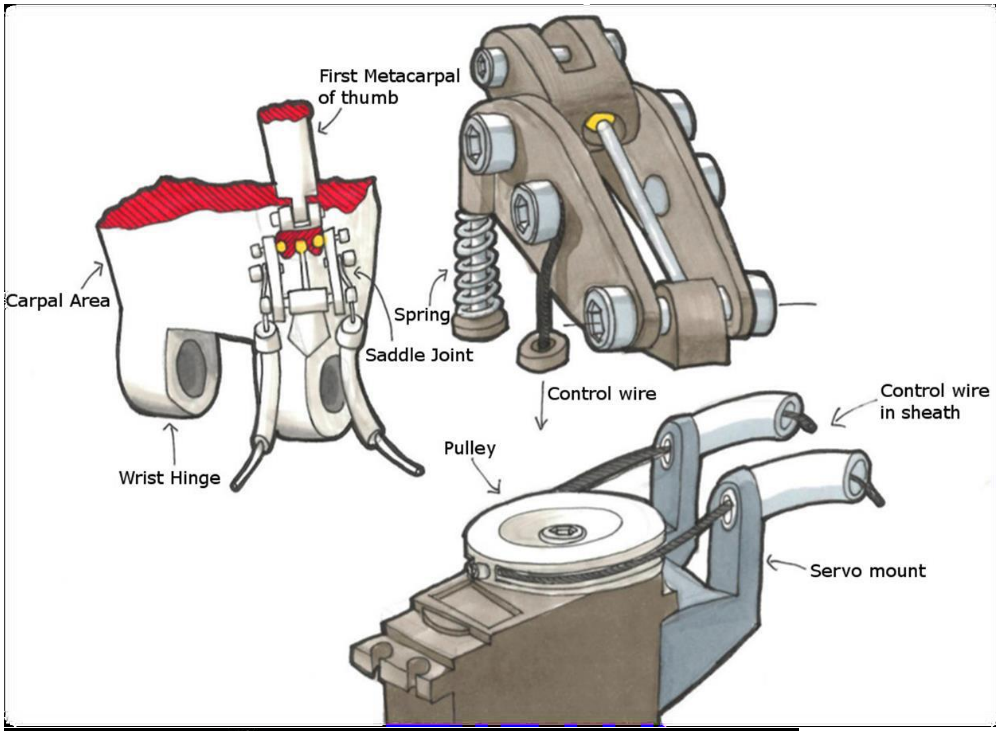
2 [illegible] (BHB) [illegible] *and* [illegible]

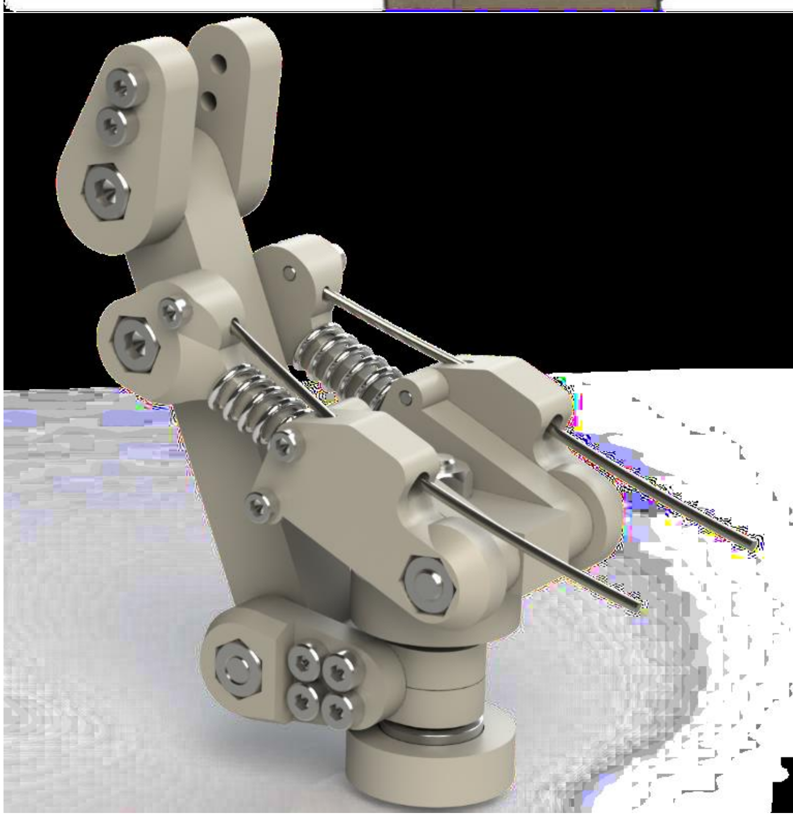



Hinge for flexion/extension
Ball-socket joint
Control wire and sheath
Guide Rails
Motion in the ball socket joint is locked to the defined path, requiring one actuator to move a part in 2 dimensions

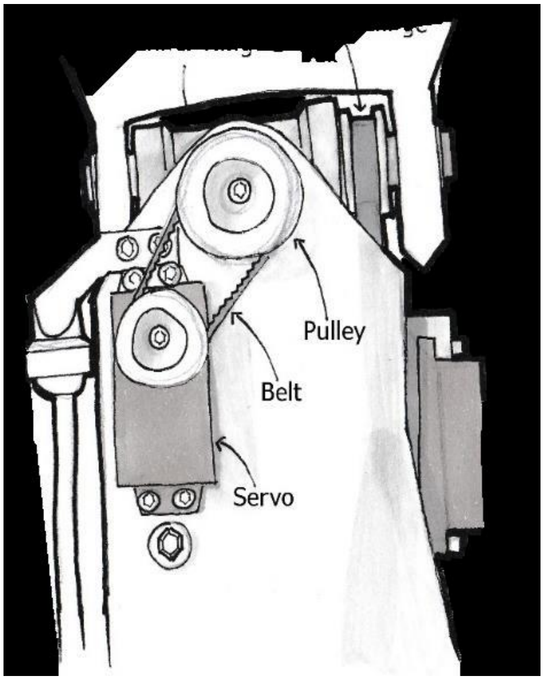

Concept for more discreet integration of MCP mechanism

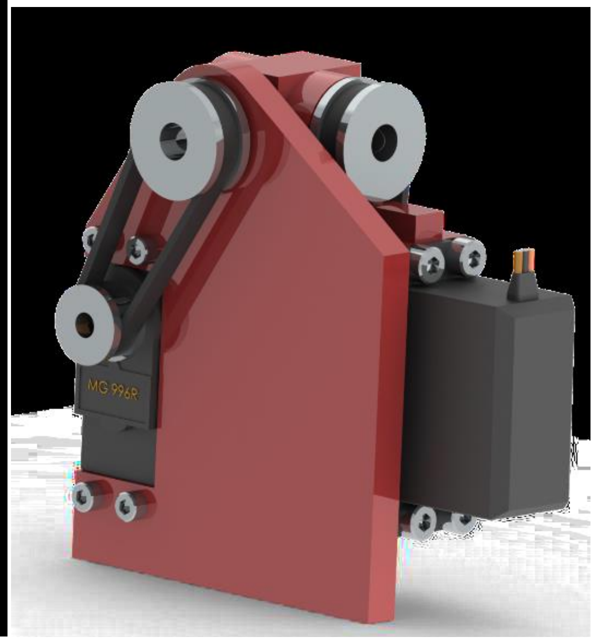
3 [illegible]

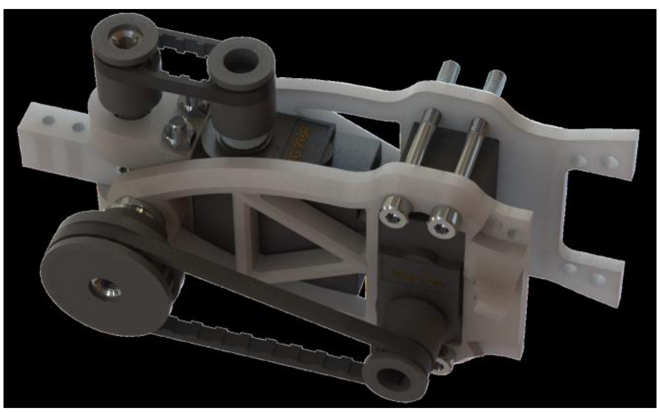

First Metacarpal of thumb
Carpal Area
Spring
Saddle Joint
Wrist Hinge
Control wire
Control wire in sheath
Pulley
Servo mount



4 [illegible] (BHD) [illegible]







Biomimetic Mechatronic Hand 2018 Report.pdf

Sensors:

The simplest and easiest way to obtain a force measurement, without adding mechanical sensor, is to measure the motor current. It is directly proportional to the applied load. As finger force increases, the current draw increases. For controlling the five servomotors, the micro controller read all the analog inputs coming from **acs712** current sensors. It then compares these readings with stored value for each motor for each grip pattern. If some obstacle stops the finger, motor current increases. Consequently, microcontroller change motor angle backward until current reaches its normal values.

However, the current sensors have some drawbacks, as they require some tuning and adjustment to become useful. They, also, shortly draw a large amount of current when the motor start to move even if the finger is still under no load condition. Moreover, the motor has to be gear down to provide enough torque; this will lead to inaccurate measures for the small loads.

In order to make the prosthesis as much as possible like a real human hand, the smart bionic is equipped with temperature feedback system. This enables the user to feel the temperature of what she holds with her bionic hand. **Amlx90614** infrared thermometer is then used for its capability of measuring temperature from a portion of the thermal radiation emitted by the object being measured without the need of physical contact with the object. These measurements are then converted to the user via a **thermoelectric cooler** known as *Peltier*. It consists of two ceramic plates with a series of P and N type semiconductor material between them. The module conveys heat from one side to the other, with consumption of electrical energy, relaying on the direction of the current.

Furthermore, **a vibrator motor** is integrated into the prosthesis itself that will vibrate whenever the fingers are moving or when the user changes the grip pattern, to make the user able to know that the signal coming from her muscles when flexing them is read and analyzed by the microcontroller. Tactile sensory feedback is an essential element of life.

Another way for the user to interface with the smart bionic to open, close and change the grip pattern of the hand is by a Bluetooth program on an android device connected with the hand by Hc-05 Bluetooth module. It uses serial communication to communicate with the microcontroller and the Android program. Moreover, it makes the user able to get a live feedback from her smart bionic throw her mobile phone or tablet like the temperature of what she touches as well as the battery percentage. To design the Android program, the *MIT App Inventor 2* is used to develop the layout and the user interfaces as well as the program blocks.