i-Hand

2021

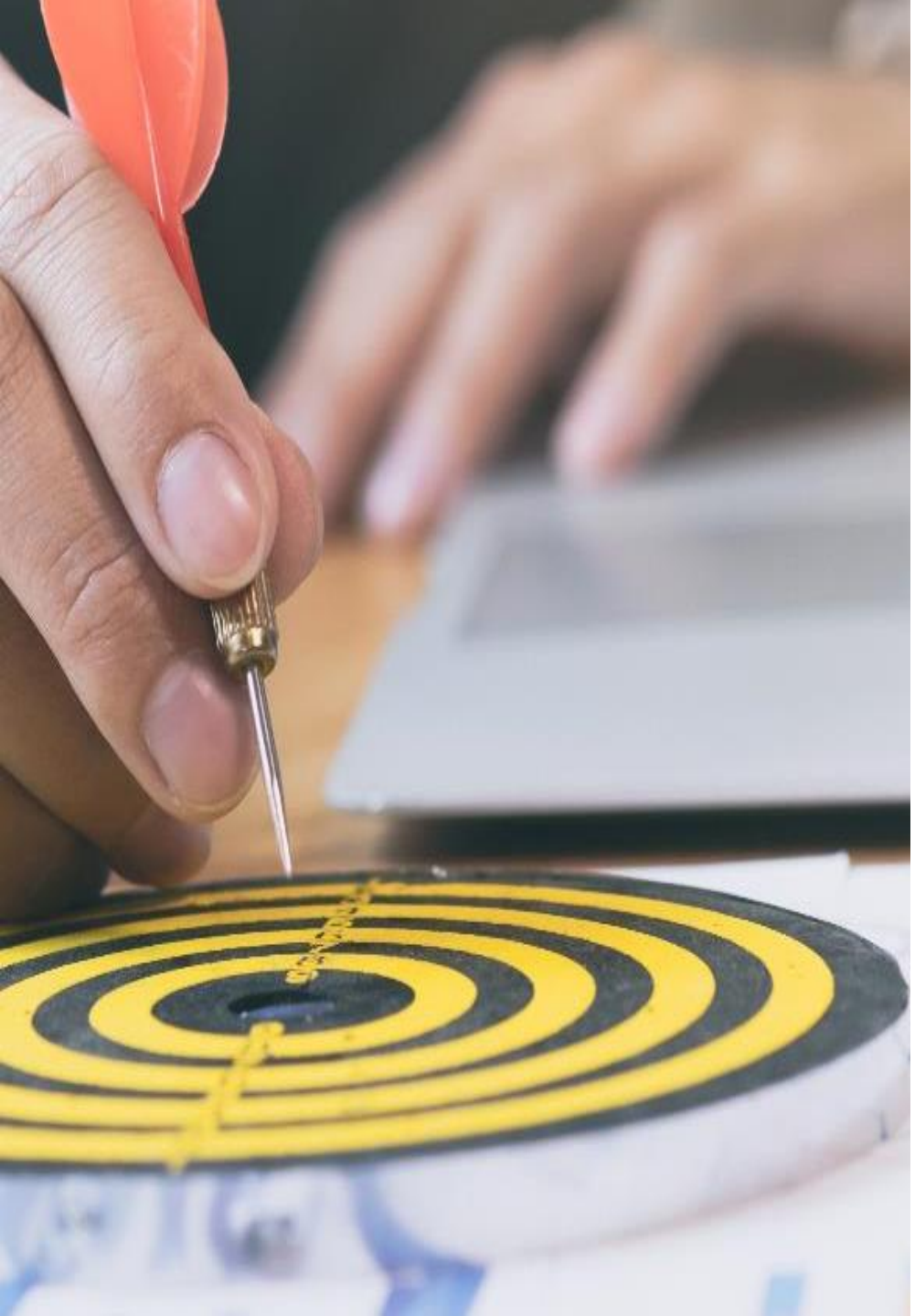
READY TO HOLD

My Story With Technology

- During my day job, I'm a R&D manager that works with technology for more than 20 years.
- I always had a passion for challenges and love sports, music and art.
- The technology always had a special place in my dreams and as a kid I always wanted "… to be able to invent my own smart toys".
- The playground of IoT related technology enables us to build our dreams and create almost everything using connected CPUs and sensors.
- In the past year I started playing with my 3D printer, Arduino CPU devices and sensors. I found that I can create anything: network/USB connected devices, video streaming, home automation and many other projects. The first project was controlling lighting using the ESP8266 devices combined with relays. Then I used an old RC toy car and made it autonomous using TOF distance sensors, PWM controller and had it connected to my phone.

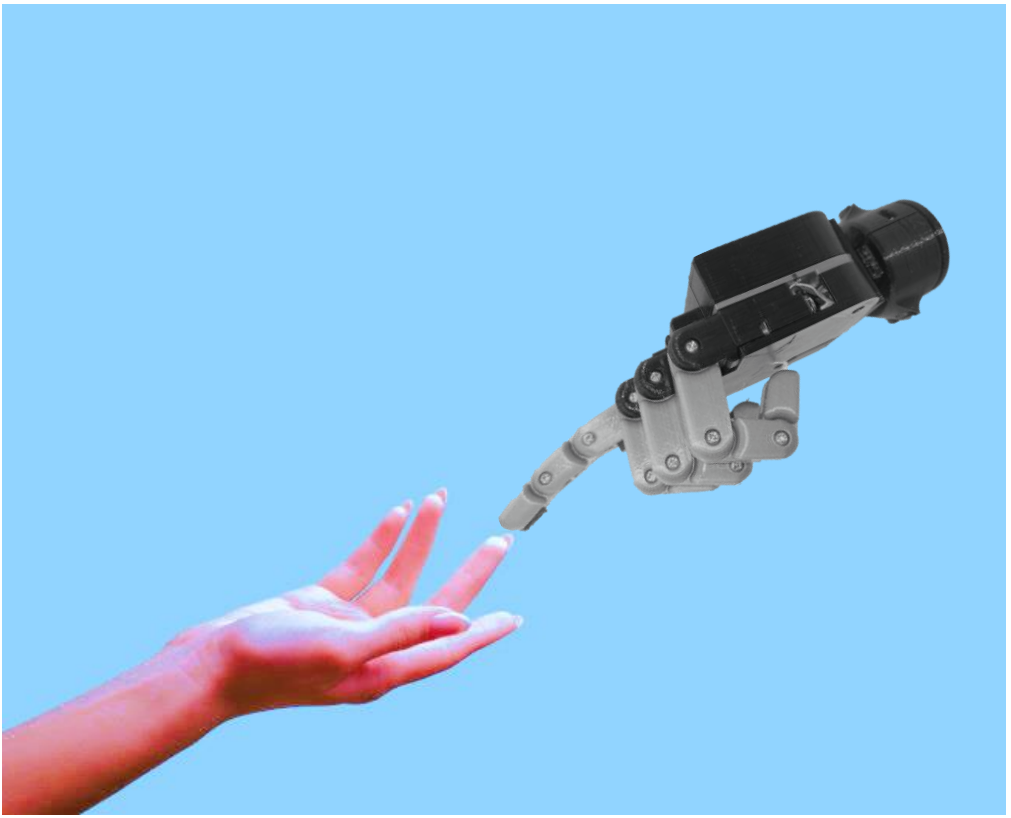
The Moment When Reality Hits

- Last year I came across a story of a soldier who was injured and lost his right hand. He lost his ability to perform some day-to-day tasks and basic functions like opening a bottle, tie his shoelaces, grab a coffee mug with his right hand and many more.
- According to statistics (www.amputee-coalition.org and similar) there are over 50 thousand every year who are born with a disability or suffer from a disease or an injury that end up with hand amputation.
- Hand prosthesis solutions are still considered expensive and hard to reach for many people, a basic prosthesis can range from several thousand dollars while a bionic prosthesis can cost 70 thousand dollars.



How a Dream and Reality meets

- Building a prosthesis project involves multidisciplinary knowledge with electro-mechanics, power and control loops, sensors and sampling electronics, efficient real-time software, communication, app design and more.
- My i-Hand journey started with building and testing actuation mechanisms, testing motors, exploring models for 3D printing and testing different versions of Arduino cards and sensors.
- My i-Hand combines months of effort and great challenge to bring an affordable and sophisticated bionic hand to the prototype stage.



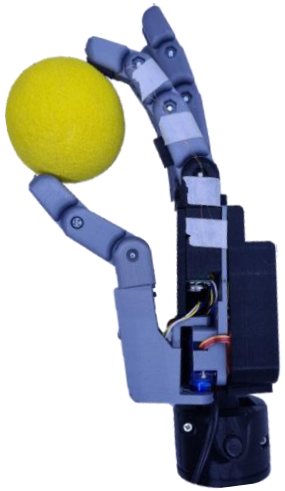
i-Hand Capabilities

The i-Hand prosthesis is a 6 DOF bionic hand with practical grips and gestures:

- Precise Grip using the pressure sensor and position control.
- Power Grip where each finger adapts the proximal, middle and distal joints around the object.
- Lock Grip for lifting weights like bags and suitcases.
- Lateral Pinch Grip for holding a key or a paper.
- Full control using an Android app through Bluetooth supporting predefined gestures, parametric setting and voice activation.

i-Hand Grips

Precise Grip



- ✓ Grabbing different objects
- ✓ Using pressure sensor to stop the hand movement

Power Grip

- ✓ Grabbing different object with maximum pressure

Lock Grip

- ✓ Grabbing bags and object by the handle
- ✓ This bag's weight is over 1900 grams

Functional Grip (Lateral Pinch)

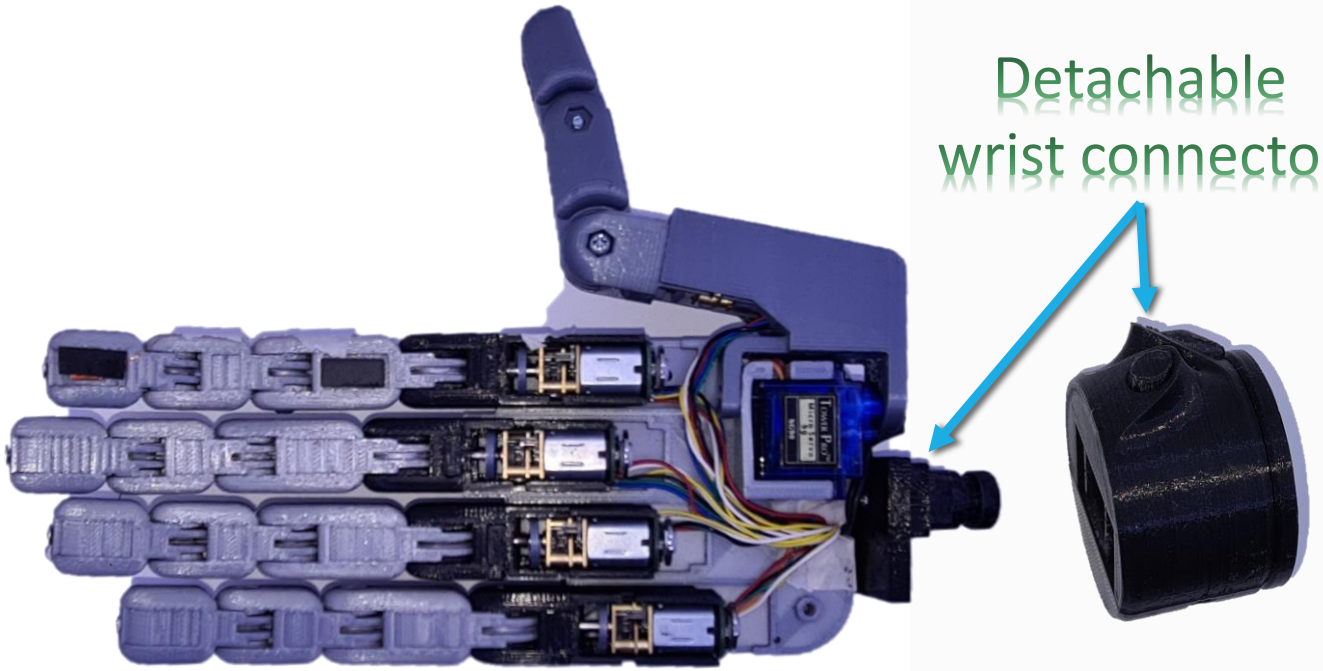
- ✓ Grabbing objects like keys using lateral pinch
- ✓ In this example, i-Hand is grabbing my diver card

i-Hand Basics

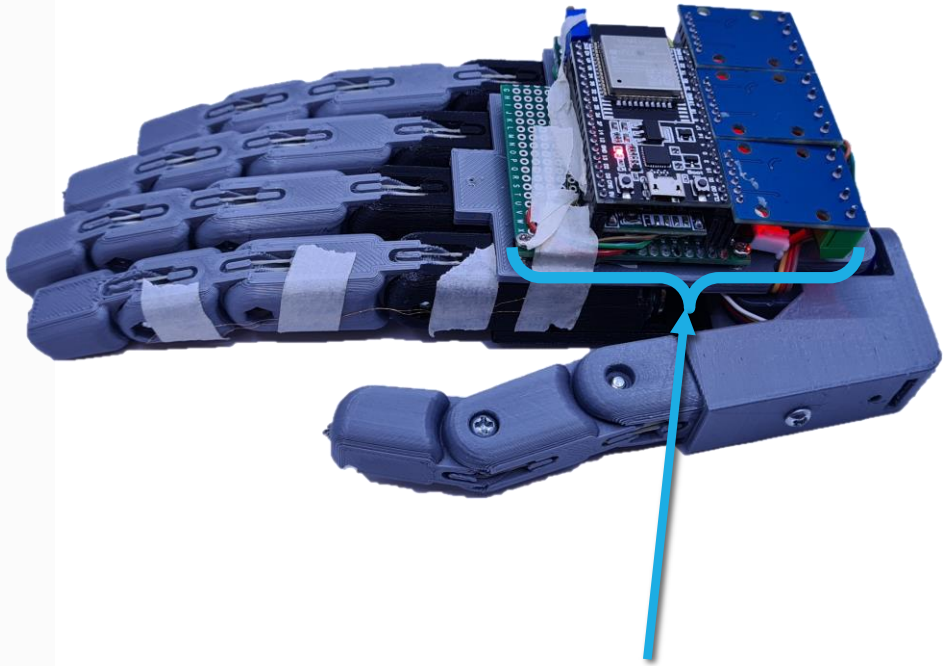
The i-Hand bionic hand was designed with the following KPIs:

- Each finger is motorized and supports position and speed control.
- The index finger tip includes a high sensitivity strain gauge for supporting precise object grabbing.
- Thumb servo to enable functional and lock grips.
- Embedded CPU and Bluetooth connectivity thus requiring only power line connection and fully stand-alone functionality.

i-Hand Structure



Detachable
wrist connector

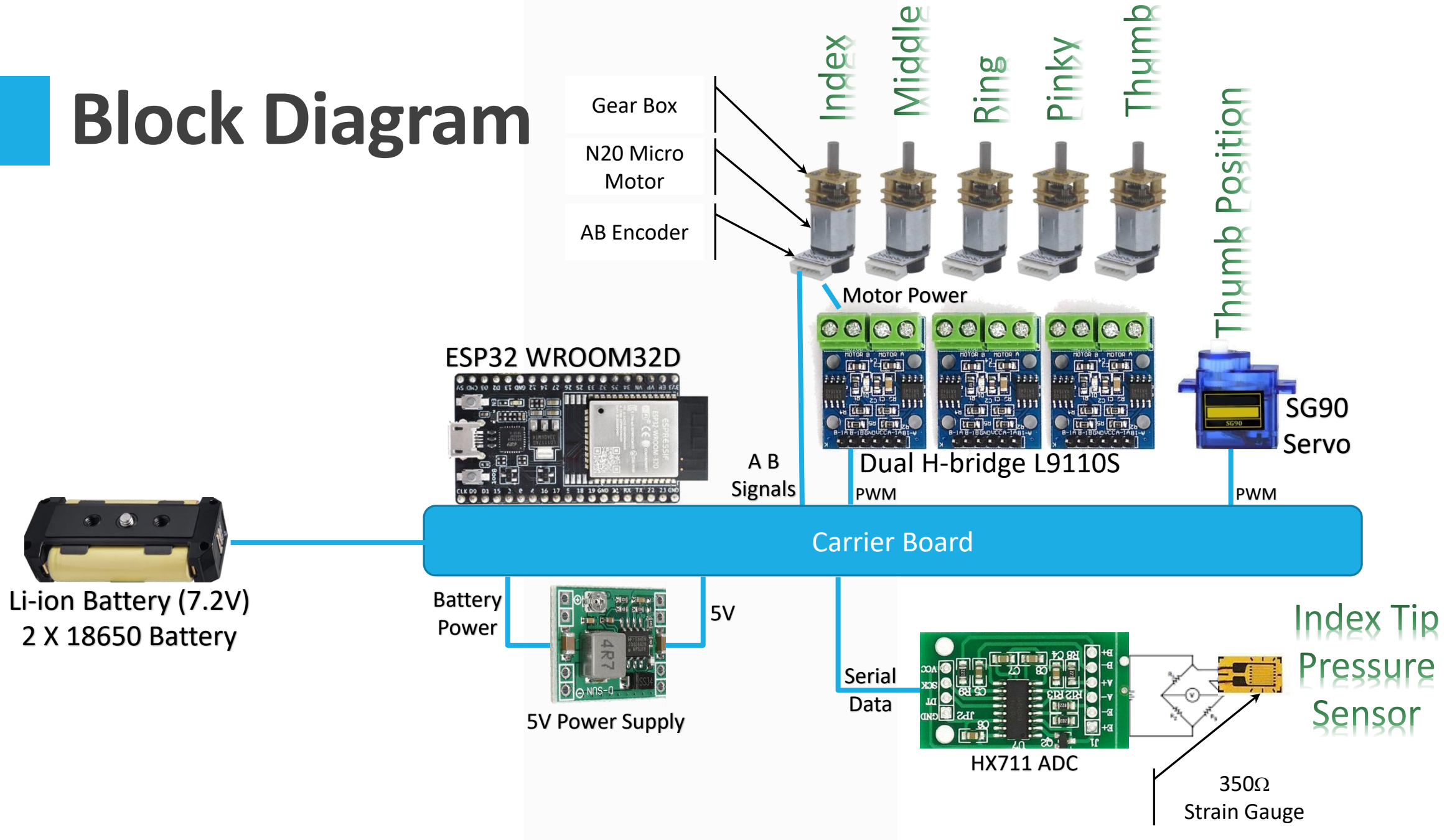


Compact Stand-Alone
Embedded Electronics

i-Hand Design

- Block Diagram
- 3D model
- Actuation Mechanism
- Pressure Sensor
- Software Structure
- Android App

Block Diagram

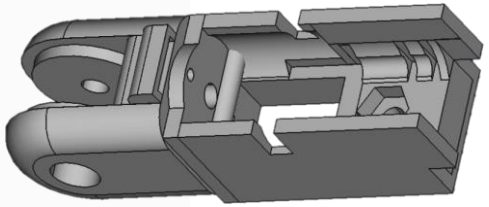


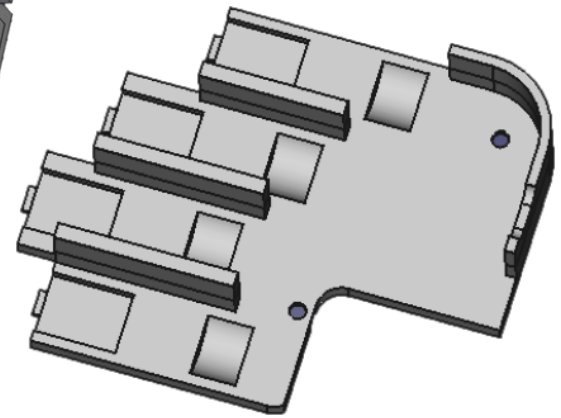
3D model

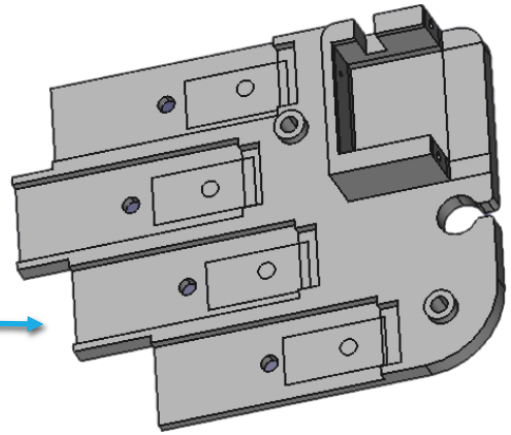
The 3D model is based on Dextra's model (https://github.com/Alvipe/Dextra). The model was modified to support the following:

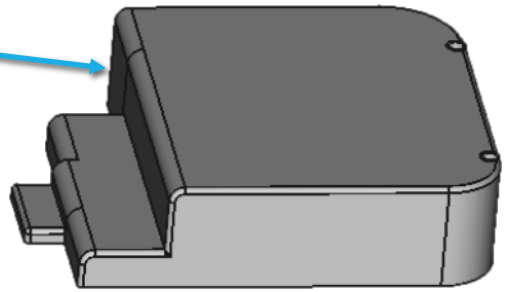
- Compact motor holder and kevlar string pulley.
- Palm cover with insertion pins.
- Updated dorsal
- Electronics compartment cover.
- Detachable and swivelable wrist connector.

The hand was printed with my modified Anet-A8 printer (Marlin 2.0 SW, Bowden configuration, Volcano hot tip, X and Y tighteners and more).



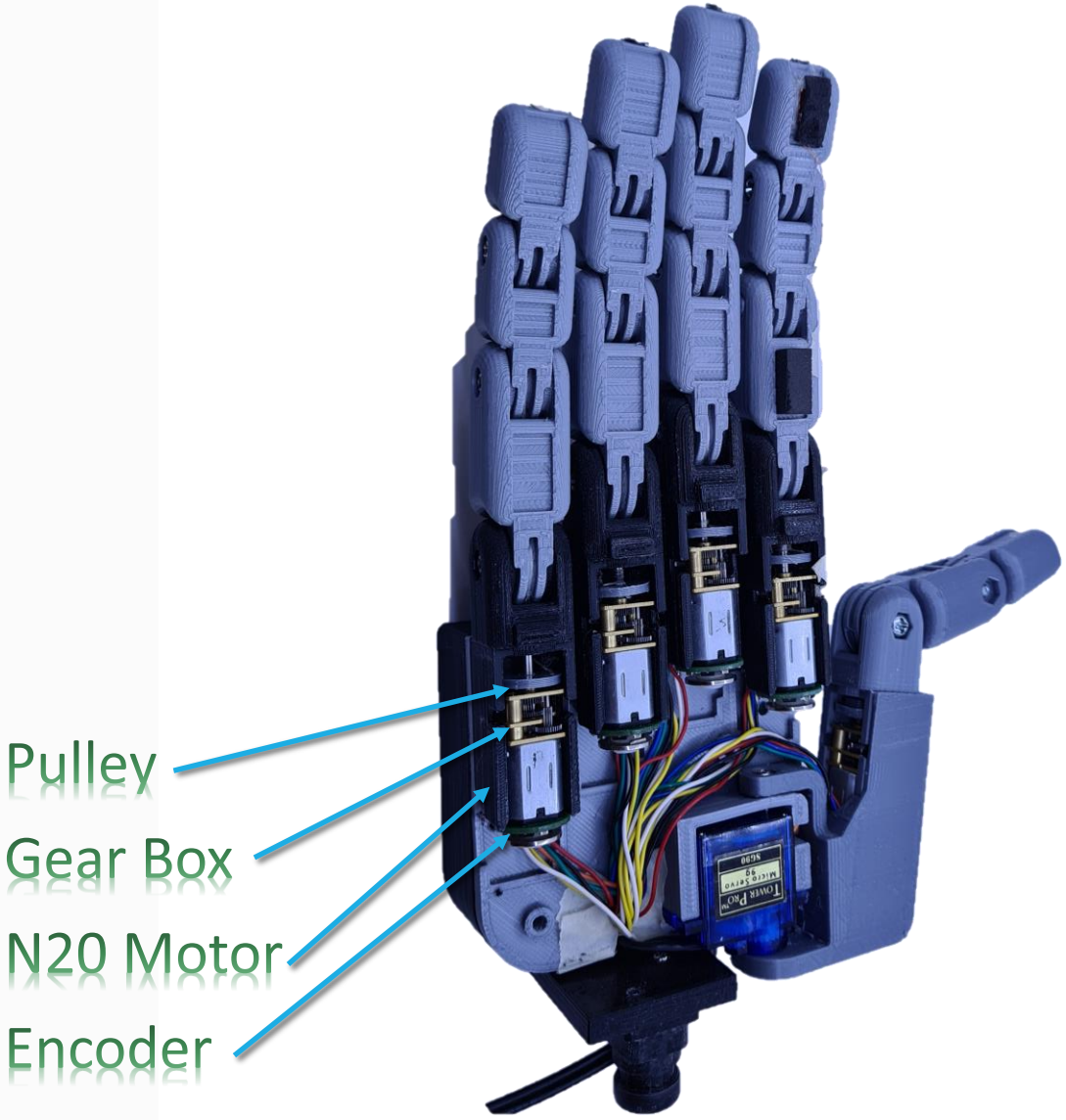






Actuation Mechanism

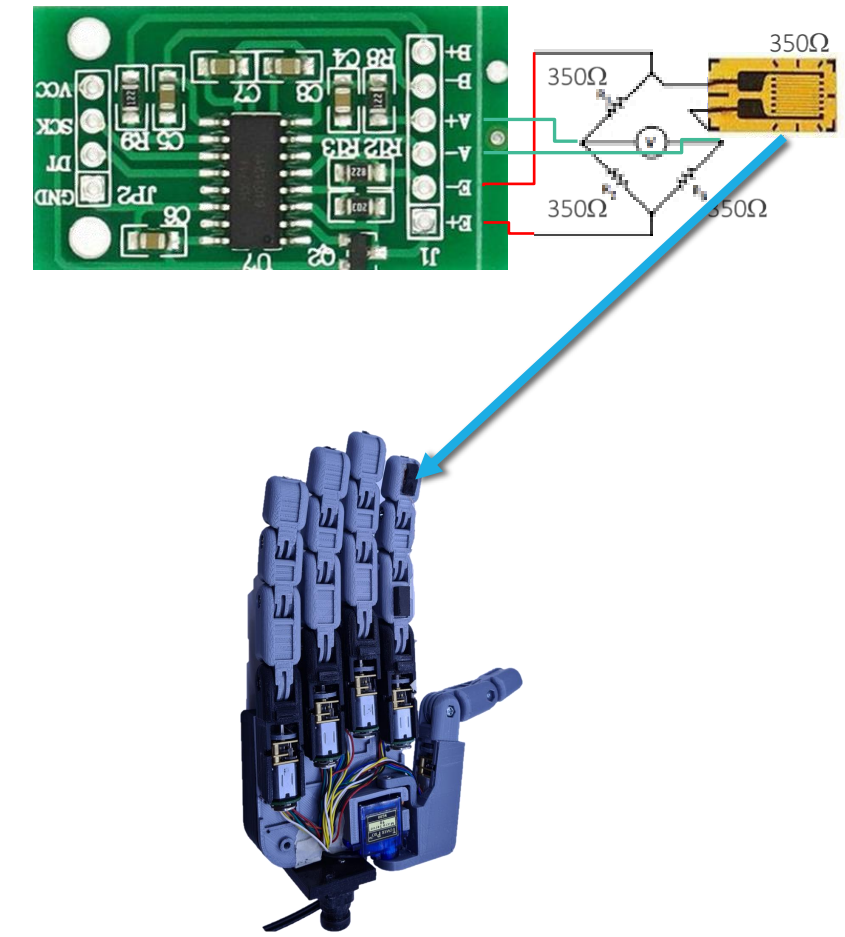
The finger actuation is a closed loop PID controlled mechanism. The N20 motors comes with an AB incremental encoder thus after a hand init, the SW tracks the finger position and can adjust the power using the PWM signals. The gear and the pulley diameter enables enough pull power thus PWM ratio is limited to 80% of the maximum power. The encoder function used an efficient coding using LUT without the use of “if … then” thus creating the best compilation and run time result.



Pressure Sensor

The pressure sensor is composed of the following components:

- 350Ω strain gauge.
- Wheatstone bridge for high sensitivity measurements.
- 24 bit high-precision ADC with integrated gain amplifier.
- The sensor enables to measure as low as 10 grams of pressure.

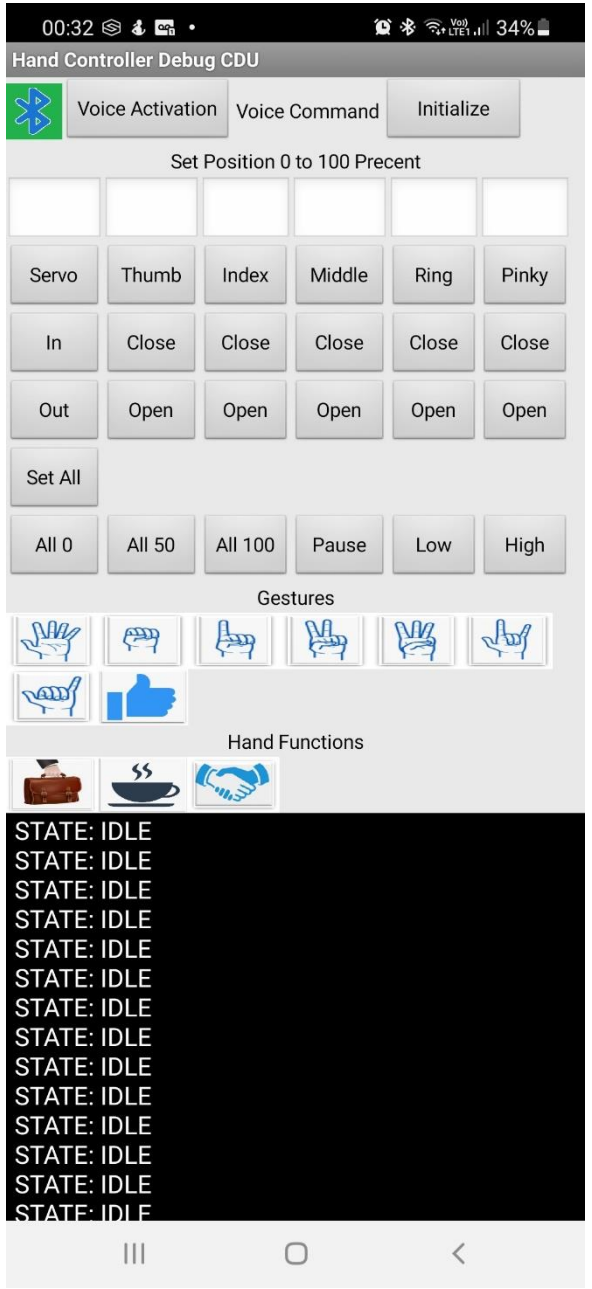


Software Structure

- The software was written to enable a minimum run time thus low jitter on the PID control loops and receive the ADC serial communication. The main function is a state machine with the following states:
  - ✓IDLE, INIT, MOVE XXX (a state for each finger), SERVO MOVE, OPEN, CLOSE, PAUSE, SLOW SPEED, FAST SPEED.
- Each state can be called through the serial communication (USB – Serial Over The Air).
- The finger position command is 0% to 100% of the movement range while 0% is the open position.
- The SW is using a low duty cycle PWM modulation to create a “beep” sound to signal the end of the initialization function.

Android App

- The app is a development panel (CDU) that enables the following functions:
  - ✓Connecting to the USB device
  - ✓Encoders INIT
  - ✓Setting the finger and servo position
  - ✓Sending command using “Speech To Text Dialog”
  - ✓Controlling the finger speed
  - ✓Calling pre-defined gestures
  - ✓Display debug messages



Plan Ahead

- The spiral design plan includes the following lines:
  - ✓Mechanical design for allowing the strain gauge signal wires
  - ✓Replacing the HX711 with multi channel ADC thus supporting multi pressure sensors
  - ✓Designing a detachable power connector
  - ✓Designing an arm adapter for a hand amputee candidate