DEPARTMENT OF MECHANICAL ENGINEERING

ENME - E2 - Climbing Wall Assistance

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Motivation, Goal, Impact

Motivation:

- Visually impaired climbers struggle to locate route holds, limiting accessibility and independence in climbing environments

Goals:

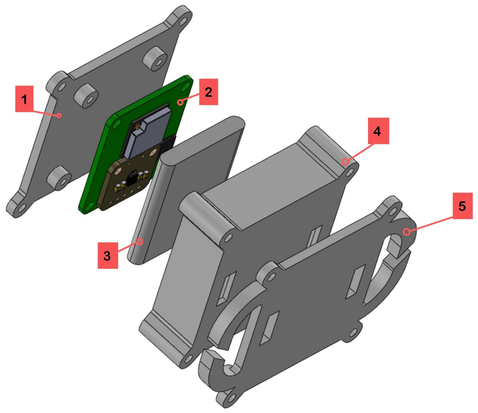
- Develop a wearable system that provides real-time haptic feedback to guide visually impaired climbers to route holds using UWB technology
- Ensure the device is accurate, responsive, comfortable, and durable for climbing use

Impact:

- Increases independence and safety for visually impaired climbers
- Promotes inclusivity in recreational climbing spaces by enabling non-visual route navigation

Requirements

- Provides feedback to climbers via haptic motors attached to limbs
- Comfortable, secure wristband for active use
- Not be restrictive in climber's movements
- Simple user interface and gym integration
- Small and lightweight (not to exceed 20 lbs for the entire system)

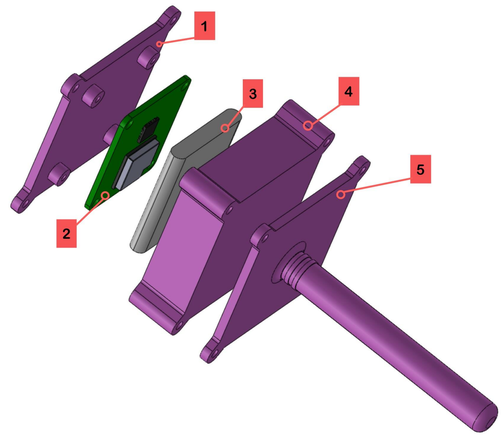


Limb Band

1. Housing Lid
2. PCB with ESP32, DW1000, & DRV2605L
3. LiPo Battery
4. Housing Box
5. Strap Holder

- Wrist-mounted system with UWB module, haptic motor, and LiPo battery
- Designed for ease of assembly
- Injection-molded Nylon

Final Design

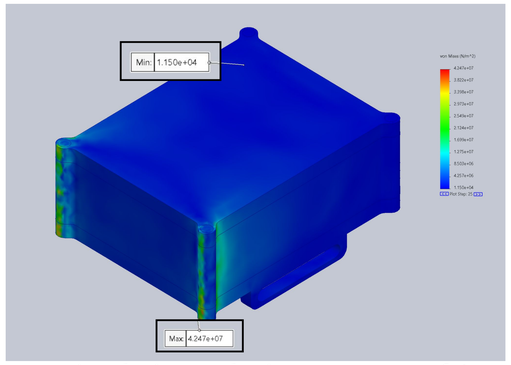


Bolt Hole Mount

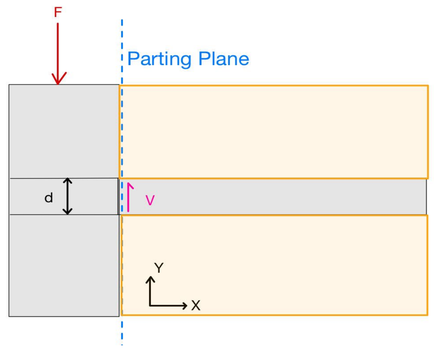
1. Housing Lid
2. PCB with ESP32 & DW1000
3. LiPo Battery
4. Housing Box
5. Bolt Attachment

- The Bolt Hole Mount interferes with the wall with a bolt
- Essentially the same design as the Limb Band without haptic related functions
- Injection-molded Nylon

Design Calculations & Decisions



Impact Simulation: Velocity at Impact 3 ft/s



2D Diagram of Bolt Hole Mount

Tolerances for Shaft and Hole: *ANSI B4.1 Standard*

(a) Hole Tolerance (H8):	(b) Shaft Tolerance (k7):
(i) Hole Maximum Diameter: Max Hole Diameter = Nominal Diameter + Hole Upper Limit = 0.384”	(i) Shaft Maximum Diameter: Max Shaft Diameter = Nominal Diameter + Shaft Upper Limit = 0.382”
(ii) Hole Minimum Diameter: Min Hole Diameter = Nominal Diameter + Hole Lower Limit = 0.375”	(ii) Shaft Minimum Diameter: Min Shaft Diameter = Nominal Diameter + Shaft Lower Limit = 0.376”

(1) $\sum F_y = 0$ (based on mechanics)

(2) $F = V = 0.4404\ kN$

(3) $A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(8)^2 = 50.26\ mm^2$ (based on geometry)

(4) $\tau_{max} = \frac{V}{A} = \frac{0.4404}{50.26} = 8.76\ MPa$ (based on mechanics)

(5) $S_{ys} = \frac{S_{yt}}{2}$ (based on conservative option for Maximum Shear-stress Theory)

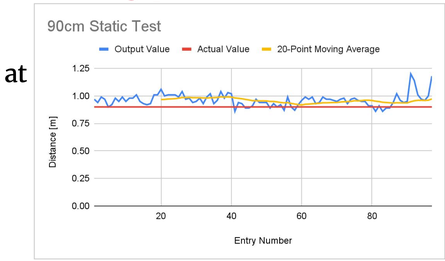
(6) $FS = \frac{S_{ys}}{\tau_{max}}$ (based on Maximum Shear-stress Theory)

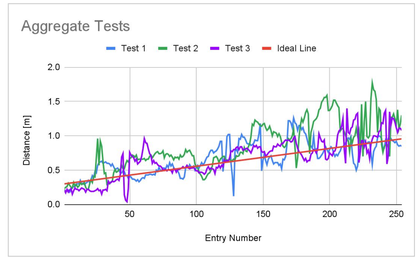
(7) $S_{yt} = 2(FS)(\tau_{max}) = 2(3)(8.76) = 52.57\ MPa$

Prototype & Test Results

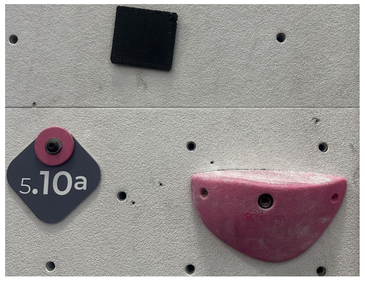
Distance Detection Test:

- On-wall static measurement at 90 cm
- Aggregate graph of moving Test





Low Fidelity Prototype



High Fidelity Prototype