

Problem Statement

Hand motor impairments from conditions such as ALS, stroke, spinal cord injury, or muscle fatigue limit a patient's ability to perform daily tasks. Traditional therapy is expensive, time-consuming, and difficult to maintain without clinical supervision. A low-cost, lightweight, and safe device is needed to assist hand movement and support effective home-based rehabilitation.

Specifications

- Response time ≤ 50 ms
- IMU sampling 100–200 Hz
- Battery: 2–3 h continuous, 6–8 h intermittent
- Actuation pressure ≤ 80 –100 kPa; assist force 5–10 N
- Durability ≥ 100 cycles
- Ergonomic, lightweight wearable design
- **Adaptive assistance** based on user performance
- **Data logging** for progress tracking
- **System safety monitoring** for pressure, temperature, and reliability

Constraints

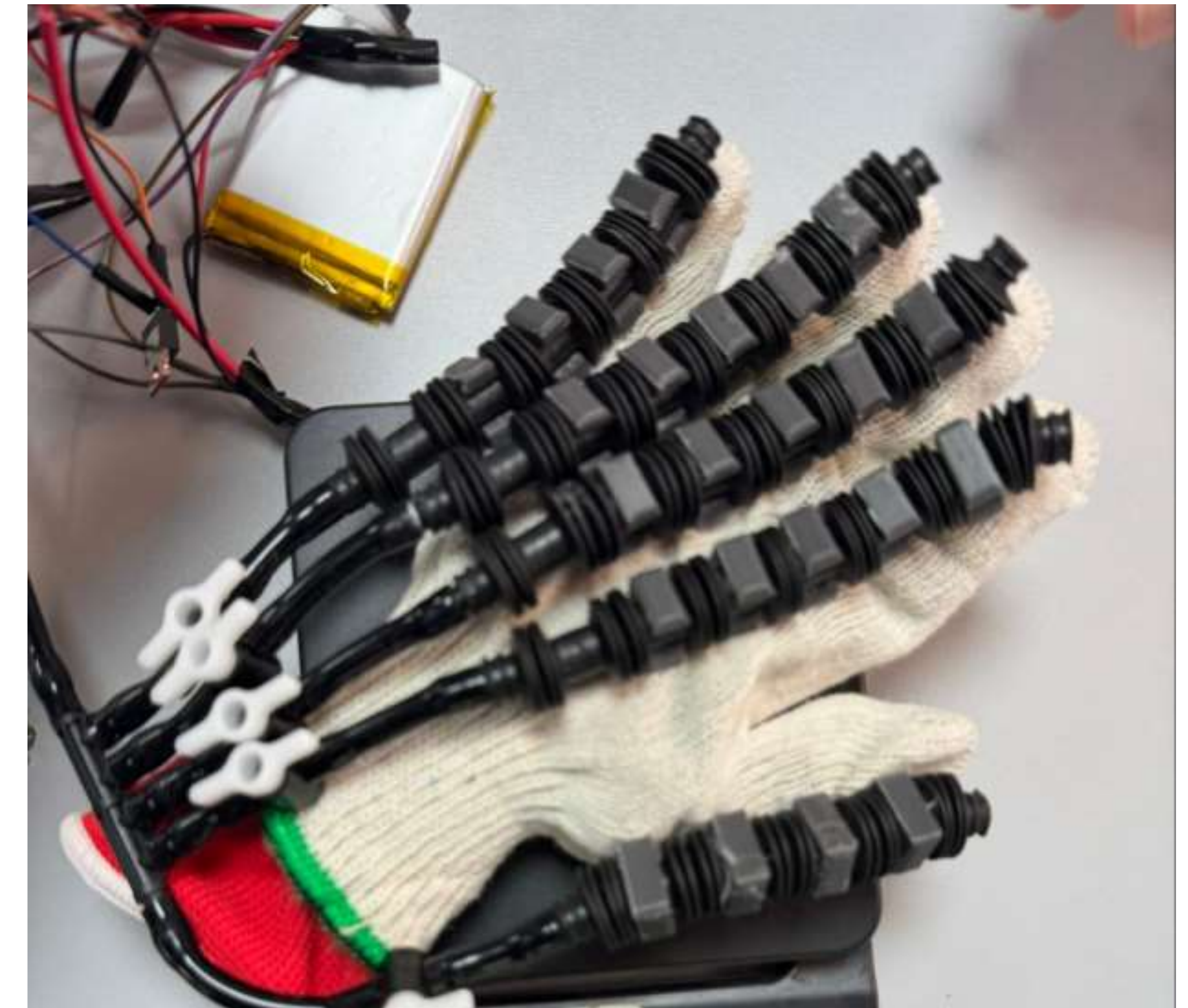
- IMU sampling rate ≥ 100 –200 Hz
- Weight ≤ 300 g on hand, ≤ 500 g total
- Skin-contact temperature 28–34°C; no hotspots $> 42^\circ\text{C}$
- ISO 10993 biocompatible materials
- Affordable off-the-shelf components
- Operates safely in 10–40°C ambient range

Verification

The prototype was tested to confirm that key constraints and specifications were met:

- **Pressure:** The pneumatic system operated safely below 60 kPa.
- **Response Time:** Activation delays consistently stayed within ≤ 50 ms.
- **Thermal Safety:** Automatic shutdown at 42°C functioned correctly.
- **Weight:** The full assembly weighed < 250 g, meeting the lightweight requirement.
- **Power Performance:** The battery supported the required short-session runtime for prototype operation.

These completed tests confirm that the prototype meets its core safety, performance, and responsiveness specifications.



Conclusion

The smart rehabilitation glove successfully demonstrates that soft pneumatic actuation can safely and effectively support assisted hand movement. Testing confirmed compliance with key requirements for safety, responsiveness, temperature control, weight, and overall performance. The prototype provides a functional and reliable foundation for home-based rehabilitation. The next stage is preparing the device for market readiness.