A wearable pneumatic platform to automatically assess tactile sensitivity

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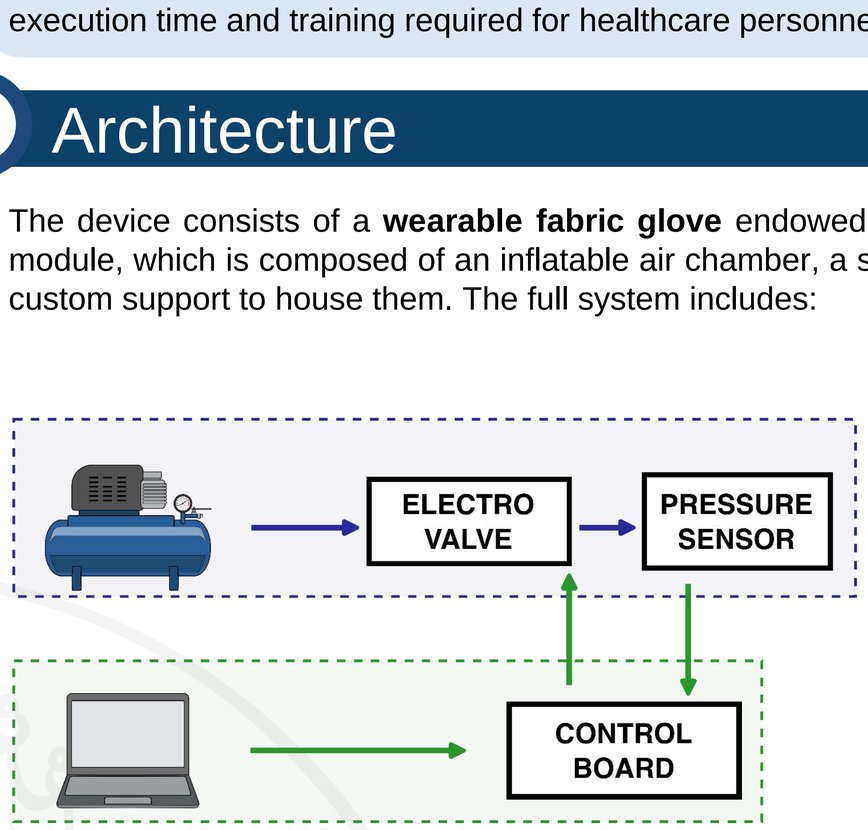
Introduction

Neurological disorders lead to motor and sensory impairments, hampering the overall progress in motor rehabilitation[1]. Current procedures for **evaluating tactile function** are not optimized in terms of equipment portability, test execution time and training required for healthcare personnel.

In this study, we report on the development of a **hand wearable, pneumatically-driven device** to assess tactile sensitivity in an **automatic and repeatable way**, as well as on its validation against the Semmes-Weinstein monofilament test, the gold standard in assessing tactile sensitivity[2].

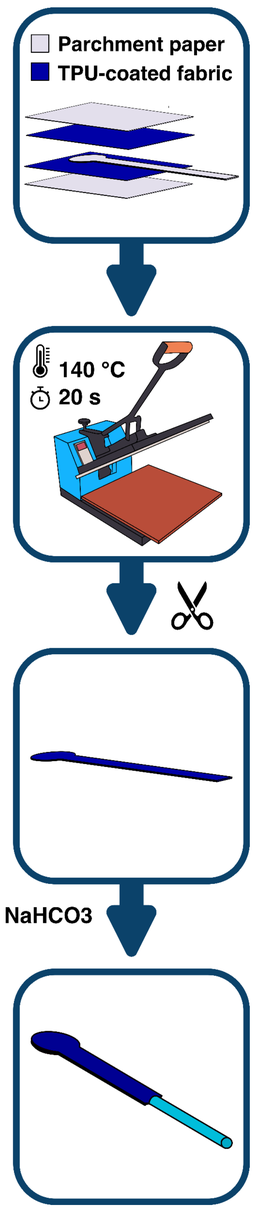
Architecture

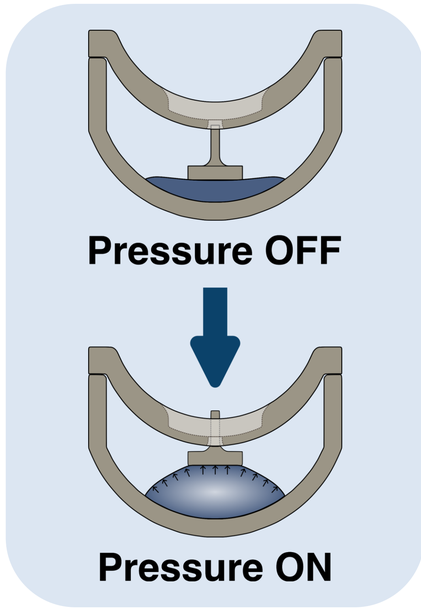
The device consists of a **wearable fabric glove** endowed with a fingertip stimulation module, which is composed of an inflatable air chamber, a sliding pin, and a 3D-printed custom support to house them. The full system includes:



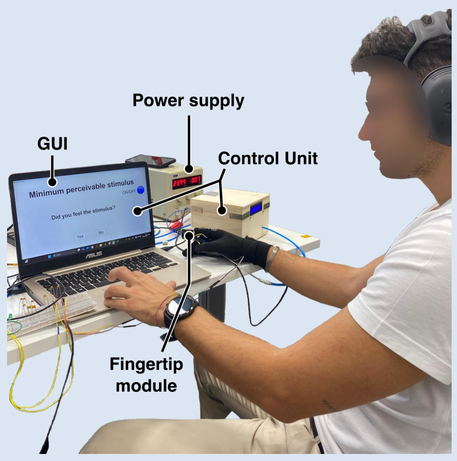
- **Pneumatic line**: Air compressor, reservoir, two solenoidal electrovalves, custom air chamber, pressure sensor.
- **Fingertip stimulation module**: TPU-coated polyester air chamber embedded into a fabric glove using a 3D-printed support with a sliding pin for fingertip contact.
- **Control unit**: Arduino UNO R3 with closed-loop PID control; pressure regulation based on a third-order transfer function[3] fitted according to the system's response to a chirp signal.







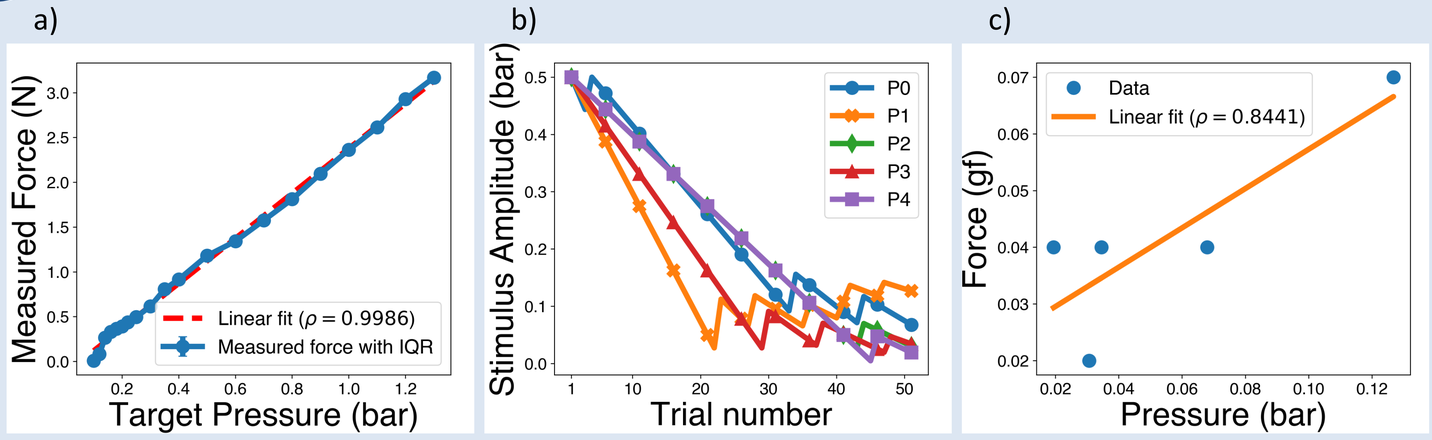
Experimental validation



We characterized the relationship between the air chamber's inner pressure and the contact force exerted by the pin using a load cell.

Five healthy participants were recruited under ethical approval. Their **tactile sensitivity** was assessed using the Semmes-Weinstein monofilament test. We then measured their amplitude perception threshold as the **minimum perceivable stimulus** upon fingertip indentation using our platform.

Results



a) Force- pressure characterization: The force-pressure curve was highly linear (ρ = 0.9986).

b) Testing procedure: A Two-Interval Forced Choice (2-IFC) procedure was used, with stimulus amplitude adaptively modified via the Stochastic Approximation Staircase (SAS) algorithm. The threshold was set at the 51st stimulus[4].

c) Correlation with standard test: results of our device showed a high correlation (ρ > 0.84) with the ones obtained using the monofilament test.

Conclusion and Future Work

We developed a wearable, pneumatically-driven device for assessing tactile sensitivity, using a small air chamber to transmit an indentation force to the fingertip. This platform allows for automated, repeatable, and controllable assessment of tactile perception thresholds.

Initial tests on five healthy participants showed promising results, suggesting the device's potential as a clinical tool. Future work will focus on expanding the study to more participants, adding more stimulation modules for other areas of the hand, and adapting the device to assess tactile acuity.

References

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This work was co-funded by INAIL (the Italian National Workers' Compensation Authority) under the HANDeVAL project (G.A. PR23-SVP1). The work of L.C. was co-funded by the European Union (ERC, MUSE, G.A. 101116249). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council. Neither the European Union nor the granting authority can be held responsible for them.