Foot Sole Pressure Sensor

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Introduction

Fullsoul is a **foot-shaped pressure sensing** platform designed for barefoot-style footwear [1]. The system employs a velostat piezoresistive matrix integrated by integrating the sensor into the Fullsoul running pad, acquiring into a thin leather sole.
Earlier iterations established feasibility raw data, and visualizing first trials against standard shoes.
Our upgrades: five major improvements across hardware, software, and experimental design.

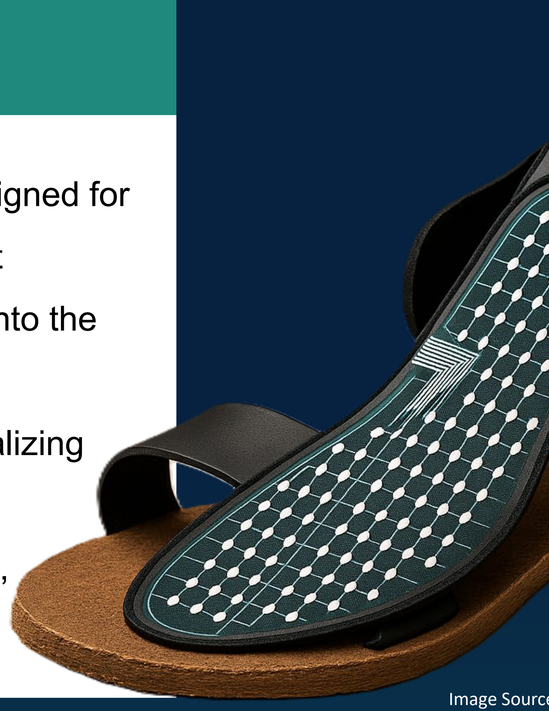


Image Source: Chatgpt

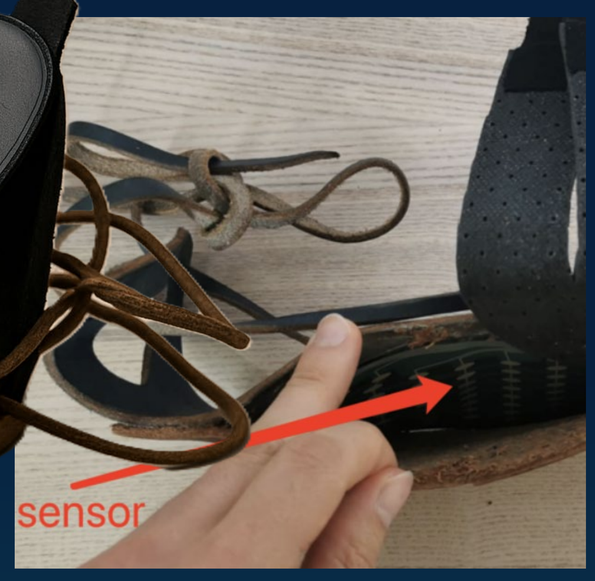


Image Source: [1]

Hardware

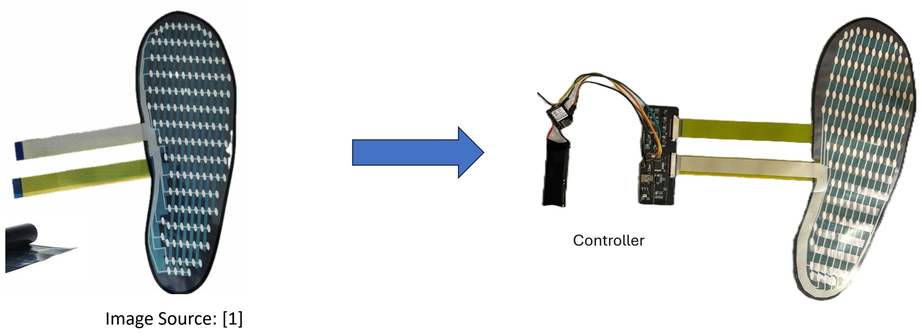
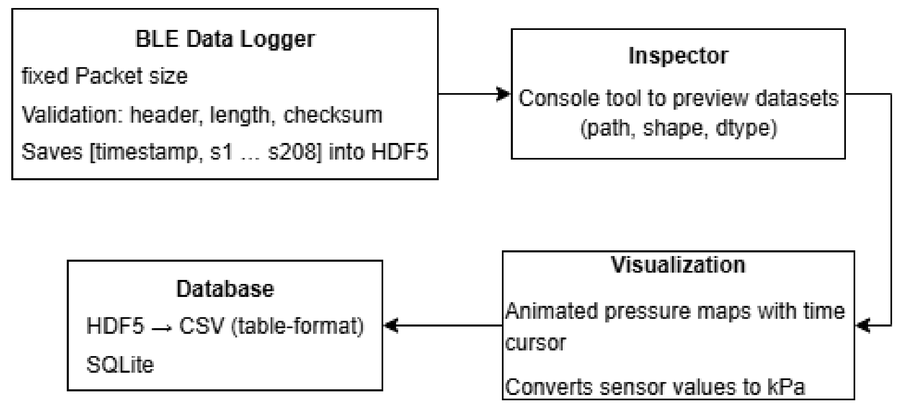


Image Source: [1]

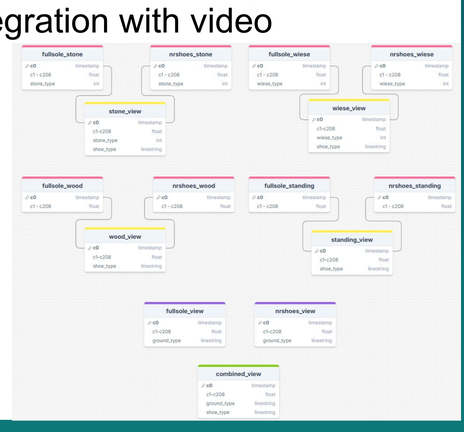
To improve usability, the wired connection between the sensor and the computer [1] was replaced with a wireless solution.
After evaluating several options, the ESP32-C3 microcontroller with built-in Bluetooth Low Energy (BLE) support was selected as the controller, together with a compatible Li-Po battery for mobile operation.
The components were hand-soldered and assembled, and a custom 3D-printed enclosure was designed to integrate the ESP32 board, sensor interface, and battery in a compact form factor. The new hardware is easier to handle, eliminates cumbersome cables, and allows more natural walking experiments

Software



The acquisition script scans for the ESP32-C3 device, subscribes to its UART-like characteristic, parses fixed-size packets (216 B), verifies headers and checksums, and streams validated data into an HDF5 dataset with nanosecond timestamps.
A lightweight inspector tool allows quick exploration of dataset structure and sample rows. Visualization scripts convert sensor values into pressure (kPa) and animate both time series and spatial maps, enabling frame-accurate playback of foot-pressure evolution.

Data logging was redesigned to support database storage (SQLite), allowing structured queries. This improves reproducibility and simplifies downstream analysis and integration with video synchronization.



Experimental Design

Goal: Evaluate whether foot sole sensitivity changes under different load conditions, and whether a thin leather fullsole + sensor alters perception compared to barefoot. The experimental design was inspired by [2] and [3].

Test 1 — Preload Sensitivity
- Setup: Foot pressed against suspended plastic foil → baseline pressure applied.
- Procedure: Apply monofilament stimulus at standardized sites (3× per site, randomized).
- Measure: Detection rate + intensity (1–3 scale).

Test 2 — Standing vs. Lying
- Setup: Sensitivity test repeated in two conditions:
  - A: Lying down (no load)
  - B: Standing with body weight (with load)
- Measure: Same 3-level intensity scale.

Test 3 — Effect of Leather Sole + Sensor
- Setup: Within-subject comparison:
  - Condition A: Barefoot + Velostat sensor taped to sole
  - Condition B: Leather sole + Velostat sensor inside shoe
- Procedure: Apply stimuli under controlled preload (~30% bodyweight).
- Data: Record participant rating (1–3) + sensor readouts (peak, mean, contact area).

Literature

[1] K. Burian, C. Ren, and A. Strauch, “Foot Sole Pressure Sensing Device and Its Usage in Barefoot Shoes: Fullsoul Runningpad,” *Clinical Applications of Computational Medicine (CACOM), Technical University of Munich*, Jul. 30, 2024.
[2] Lieberman et al., 2010 – Foot strike patterns and collision forces in habitually barefoot versus shod runners. Journal of Neurophysiology, 125(1): 207–217.
[3] Holowka N B, Lieberman D E. Rethinking the evolution of the human foot: insights from experimental research[J]. Journal of experimental biology, 2018, 221(17): jeb174425.